Future Transport and Mobility Environment

Milestone 4
Final Discussion Paper

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SUMMARY

This Final Discussion Paper presents the background to the Future Transport and Mobility Environment (FTME) and referenced the trends, challenges, existing state of the art efforts, expertise and knowledge from several different perspectives in the FTME domain.

A limited but powerful stakeholder engagement was also undertaken which provides the opportunity to construct validate the thoughts, ideas and content of this paper.

The architectural section (Section 4) proposes a conceptual model grounded on ISO standards as well as many examples drawn from local and international experiences across a range of service domains. It further steps through roles and responsibilities, key activities and functional classes and identifies core elements in the future concept of operation.

The draft discussion paper has been reviewed internally by TMR and iMOVE and was subsequently disseminated for a limited circulation to jurisdictions, national agencies and selected industry and academic stakeholders for further feedback. The feedback was via (i) SurveyMonkey and (ii) personal communication to the authors. The comment period continued until 18 May 2020.

This Final Discussion Paper includes the Discussion Paper as well as the summary of discussion points from stakeholder feedback which can be found in Appendix H.

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1 INTRODUCTION

Transport and mobility management involves a combination of people, processes, systems and technology. With significant changes occurring in technology and mobility services, there is an opportunity and need to capture the current paradigm and plan for the emerging future transport and mobility environment. The Queensland Department of Transport and Main Roads (TMR 2015) identified several technological and societal changes that motivates the change in transport management, including:

- Transport authorities’ role has shifted to infrastructure operators
- Change in customer expectations to include reliable journeys, and generally a more user-centric service
- Improved and more varying data sources
- Big-Data-related technology
- Change in business models
- Technology disruptions in transport.

This project looks to explore and challenge our traditional approaches to transport operations and mobility. How do we move away from the way we do things today and think/act differently? The time horizon for the future transport and mobility environment envisaged is over the next 2-10 years.

1.1 OBJECTIVES

The objectives of this project (but not exhaustive) are:

1. To define conceptually the elements of the future transport and mobility environment (in the form of a discussion paper)
2. To capture what a future transport and mobility environment looks like and how these elements integrate with existing management and information services; including emerging technologies and concepts such as demand responsive transport, MaaS, connected vehicles, and so on
3. To define a conceptual and logical architecture, showing the key components and the interacting elements of the wider transport environment
4. Undertake an assessment of transport and mobility management against the above conceptual and logical architectures for Queensland TMR, an opportunity to understand what elements of this future environment are already being filled by existing solutions, but also the gaps and areas in need of attention.

This is aligned to the Austroads National ITS Architecture work and is intended to create a starting point for common understanding and further collaboration, hopefully, between states. TMR has asked ARRB to lead this project thorough the iMOVE CRC, based on their role as a trusted advisor to all transport/road agencies across Australia.

This project does not intend to replace or duplicate work already done by transport/road authorities, rather it is an attempt for improved service delivery by the state authorities, through common understanding of services, processes, information and systems of the various projects in planning or already underway in all our jurisdictions.

1.1.1 WHY DO IT?

The output of this project is to produce a conceptual architecture for a Future Transport and Mobility Environment, and to propose a program to further work to address the gaps and development required to meet the needs for the future. This is a foundational piece of work to enable identification and development of future solutions or research in consultation and engagement with jurisdictions and industry. The conceptual architecture will be beneficial for government in having a common language and understanding around the likely future state environment, and then for industry in engaging with government. This should assist in identifying gaps between current and future state, to inform future bodies of work. By working towards a national understanding of the transport and mobility environment, the project also intends to enable better coordination of transport technology activities and investments across jurisdictions moving forward, to maximise the benefits of this technology for Australians.

1.2 OUTPUTS AND MILESTONES

The outputs and milestones of this project are listed below.

Task 1 – Pre-workshop report/materials

- The document is intended to serve as a “thought starter” and discussion point for the upcoming workshops.

Output 1: Discussion paper for distribution to workshop participants.

Task 2 – Industry workshops

- Given the current COVID-19 environment, online consultations are proposed.

Output 2: Completion of workshops and summary of discussions documented.

Task 3 – Discussion paper, which includes proposed conceptual architecture

- This paper will propose the conceptual architecture of the Future Transport and Mobility Environment. The report will also include descriptions on the components, along with diagrams when necessary.
- At this stage, the paper may bring forward several options for the architecture.

Output 3: Conceptual architecture incorporating collaborative feedback from project participants.

Task 4 – Project final report

- This report will document all the outcomes and findings of the whole project as well as making recommendations on the preferred conceptual architecture.
- The report will also include a proposal for the future work program for Future Transport and Mobility Environment.

Output 4: Final project report outlining project findings and agreed architecture and roadmap.

1.3 STRUCTURE OF THIS PAPER

Following this section which introduces this paper, this Discussion paper is structured into four further sections, Section 2 – Background, Section 3 – Stakeholder Engagement, Section 4 – Architecture and Section 5 – Discussion. Further details on several items mentioned in the paper are further provided in the Appendices.

1.4 ABOUT ARRB

ARRB is the National Transport Research Organisation and is responsible for the delivery of infrastructure standards for State, Territory and Commonwealth Governments. ARRB was established 60 years ago and operates in all capital cities, with the headquarters in Melbourne. ARRB operates across six key strategic work groups that are listed below to service the Australian community.

1. Future Transport Infrastructure – what are our roads going to be made of in the future
2. Transport Safety – deliver a 50% reduction in fatal and serious injuries on our road system
3. Sustainability & Resilience – how do we keep communities connected and reduce our impact
4. Asset Management – how do we enhance the performance of the current road network
5. Future Transport Systems – how do we enable connected and autonomous vehicles to operate
6. Data Collection & Analysis – next generation intelligent data for road performance.

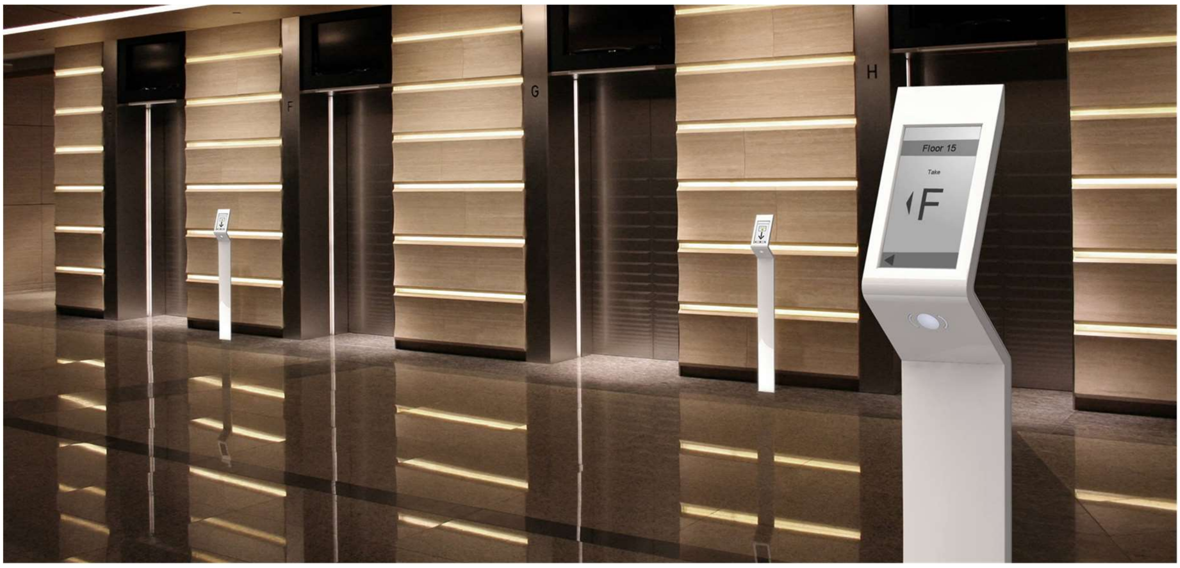
2 BACKGROUND

This section sets the background and context for the future transport and mobility environment.

2.1 TIME FOR A CHANGE

Digitisation and advances in mobile communications in recent times have changed our lives significantly, and there is a widespread sense that our world will be a much different place to live in, in the next 10-20 years. As this paper is being written, the unprecedented changes that are occurring to our everyday lives due to the global COVID-19 pandemic only serves to further bring forward the possibility of these changes.

Figure 2.1: Technology that changed vertical transportation



Most people have not realised that the biggest change in vertical transportation has been the console in the modern lift lobbies enabling passengers to declare to the lift operating system their destination floor within the building. With knowledge of the destination of each trip, the lift control system can better balance (in real time) the demands during the peaks and off peaks. This technological development has greatly improved congestion management and enables the building to readily cope with increased occupancies at short notice.

In a white paper by the World Economic Forum, '*Shaping a new global architecture in the age of the fourth industrial revolution*' (WEF 2019), the WEF reported that major shifts underway in technology, geopolitics, environment and society are combining to give birth to a new phase of globalisation. The trajectory of change will depend in large measure on how well governance at multiple levels – governmental, corporate and international – adapts to these changes. WEF noted that strengthening the governance architecture to ensure its effectiveness in this new era will require deeper engagement and heightened imagination by all stakeholders, beginning with robust and sustained dialogue among them. WEF also noted that the transformations driving this new globalization phase requires an "operating system upgrade" for global cooperation and domestic governance.

So, what does increasing globalisation of mobility mean for the transport domain and more specifically those of us practitioners in the local Australian transport domain? Many of us have often heard phrases such as "*Transport is a technology business*" (TfNSW 2018, Scales 2019) and others such as '*the most important transportation innovation in the decade has been the smartphone*', and '*the car is becoming a smartphone on wheels*'. It is undeniable that technology has enabled transport networks to deliver improvements in productivity, safety and efficiency though the many applications and services that are now becoming more available in our land transport networks.

Unlike mobile phones, transport systems and services in the past have remained unchanged for longer periods and have been characterised by slow incremental innovations. However, urbanisation, demographic and societal changes are some of the major trends that have had an impact on transport systems and services over the last 20 years. Electronic tolling first started in Melbourne in January 2000. In more recent times, the first automated vehicle, the Volvo XC90 was demonstrated on the Southern Expressway in Adelaide in November 2015. Combined with the implementation of Intelligent Transportation Services (ITS) services and Internet of Things (IoT), new transport concepts have been developed. User requirements on efficiency, availability and interoperability have also been driving forces for new transport concepts for integrated mobility like Mobility as a Service (MaaS) and Mobility on Demand (MoD).

A recent Australian stocktake of readiness for new mobility options found that in many states, significant investment has already been dedicated to modernise the way people move (L.E.K. Consulting 2019). As a result, each state has developed unique strengths, and areas where more work can be done. Each state government was found to have taken a different approach to tackling the challenge of adopting new mobility technologies and services. L.E.K. noted that the differences in approach explain the varying progress of certain technologies in each state, and while some states were relatively progressive across the majority of segments (for example NSW), others appeared to be specialising or strengthening their position in particular areas before turning to other trends. For example, L.E.K. claimed that SA had focused on autonomous trials and digital driving licenses, whereas WA had placed more emphasis on electric vehicles (EVs). It was also reported that some new mobility segments were relatively more advanced than others. Shared mobility, for example, was found to be particularly mature given the rising popularity of ride-sharing and car-sharing companies like Uber and GoGet. There was also increasing momentum noted around electric vehicles and AV trials.

Integrated mobility concepts are evolving around the world. Each concept develops and implements its own architecture, e.g. role and responsibility models and physical architectures. Hence, there is an urgent need for a generic, common and world-wide concept description mapping all existing and foreseen concepts for interoperable, integrated and seamless multimodal transport services (integrated mobility).

2.2 FUTURE VISION

The current transport systems and services have remained unchanged for a long period (100 years) with slow incremental innovations as shown in Figure 2.2. These pictures from Manhattan show congestion in horses and carriages in 1900, followed by similar scenes of congestion by 1920 with the introduction of the motor car. In the space of 20 or more years, cities all over the world ‘flipped’ to the motor car. And since that period, while cars are now more modern and connected (with technology), the traffic scene is relatively the same, albeit with some ITS technologies such as signals as shown in the 2018 photograph.

Figure 2.2: Land Transport changes over 120 years – Western example

Easter morning
1900

42nd Street
1918

42nd Street
11-Jan-2018

In the case of China, the change to modern technology was rather more recent as shown in Figure 2.3 below. The initial change from horse and carriage was to public transport in buses and active transport on bicycles.

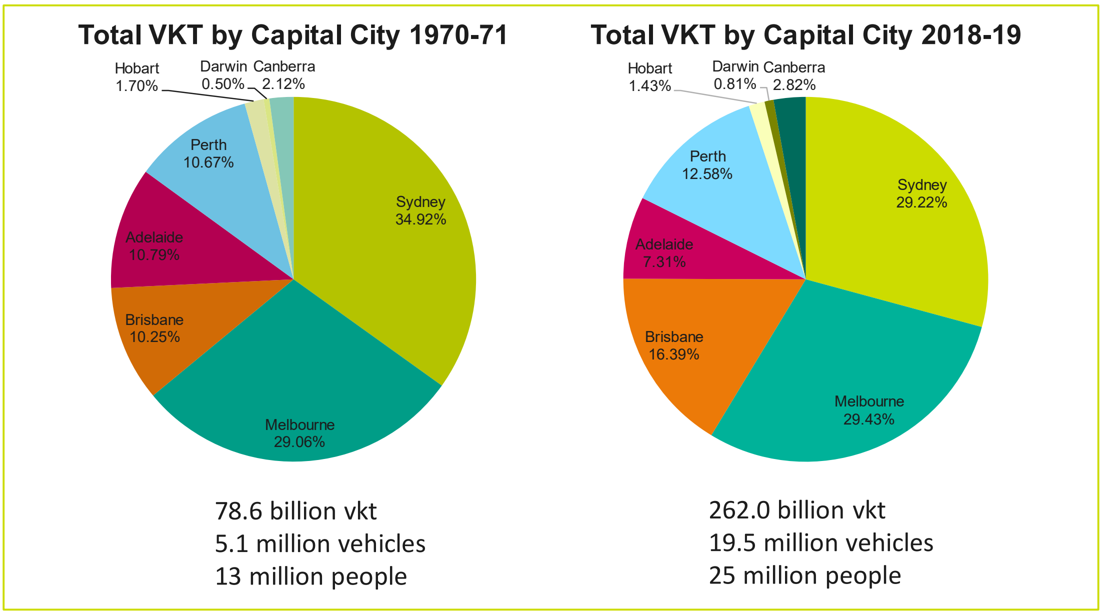
Rapid changes begun from the 1980s with strong economic growth and massive investment in transport infrastructure, such that the current Chinese road network is one of the most modern in the world and fully equipped with many of the latest technologies, as can be surmised in the final photograph of one of the major ring roads around Beijing.

It would not be uncommon to find senior traffic engineers in Chinese cities who started their careers in the 1980s managing buses and cyclists on their networks, and over the course of their 30-40 year careers have played a part in one of the biggest transformations in land transport the world has seen.

Figure 2.3: Land Transport changes over 120 years – China example

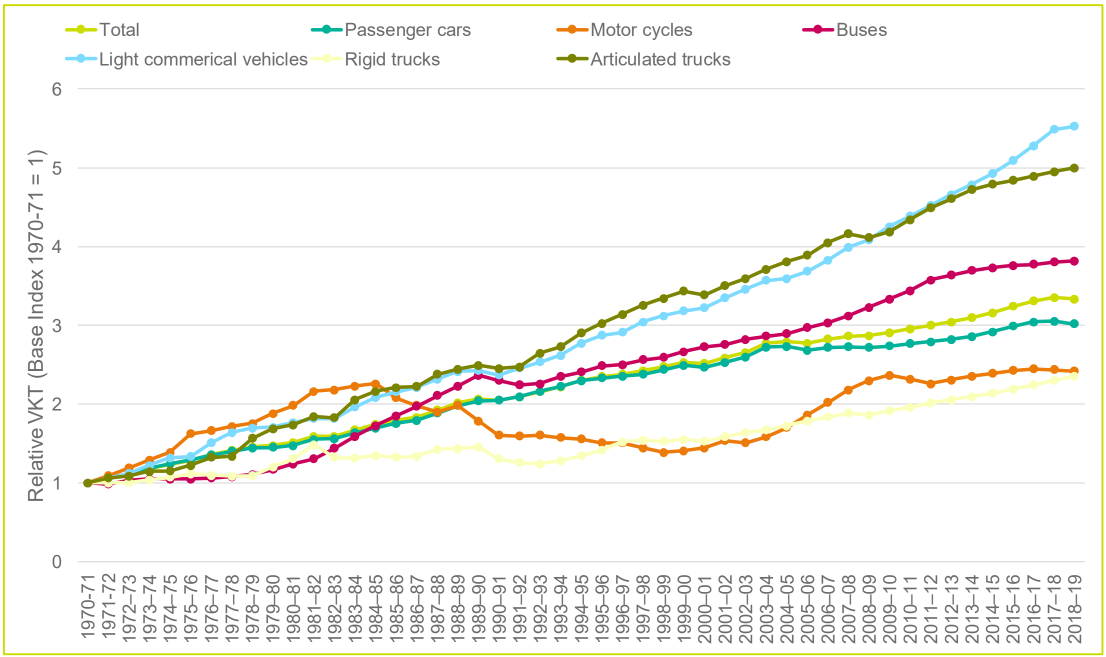
The statistics for the Australian transport and mobility environment show a similar picture. From 1970/71 to 2018/19 i.e. over the last 50 years, our population has doubled, the number of vehicles has increased four times and vehicle kilometres travelled (VKT) has risen by a factor of 3.35 as shown in Figure 2.4 below (BITRE 2014, 2019). However, the relative proportions of VKT in our capital cities have remained largely the same.

Figure 2.4: Vehicle kilometres travelled by capital city, 1970-2019



When we examine the increase in VKT by mode of transport over the last 50 years, as in Figure 2.5, we are able to note some interesting trends: (i) the largest increase in VKT by mode has been in the light commercial and articulated trucks sectors which continue on an upward trajectory and (ii) a flattening of VKT growth in other modes. There are a number of reasons for the above; for heavy vehicles, it is a fact that the introduction of single and multi-combination vehicles from the 1980s have delivered large productivity outcomes for the Australian freight tasks, while for light commercial vehicles, the causes are not as well understood, and could be as a result of (i) a trend towards more online purchasing, (ii) changed last mile transport distribution models, (iii) increase in service fleets and (iv) trends favouring utility vehicles over SUVs in more recent times.

Figure 2.5: Increase in VKT by mode (1970 = 1)



The key point is that like the existing road infrastructure, the vehicle assets we have in Australia will be around for some time to come, but it will be in the way we use our infrastructure and vehicle assets that will be changed. Today, the transport sector is in a period of unprecedented transformation – with connected and increasingly automated vehicles, big and open data, social media and 24/7 connectivity through smart phones. Transport business environments and models are also evolving rapidly, especially in the context of mobility as a service. As noted earlier, each concept develops its own architecture, roles and responsibility models and physical architectures.

There are concerns that legislation designed for different technical, commercial and social purposes is impeding the adoption of new products and services. For example, the rise of technology-enabled transportation services such as smartphone-based innovative mobility services often do not fit into existing regulatory structures (e.g. Uber and Lyft etc.). These services are expanding and have raised public policy issues such as:

- uneven regulatory playing field
- inconsistent requirement for incumbent taxis and emerging transportation network services
- equity implications of taxi industry decline
- public security
- employment status (Karl 2017).

The challenge for regulators is finding the balance between a more open regime that encourages innovation, while encouraging an open competitive marketplace and a sensible operating environment for domestic and international transport service providers.

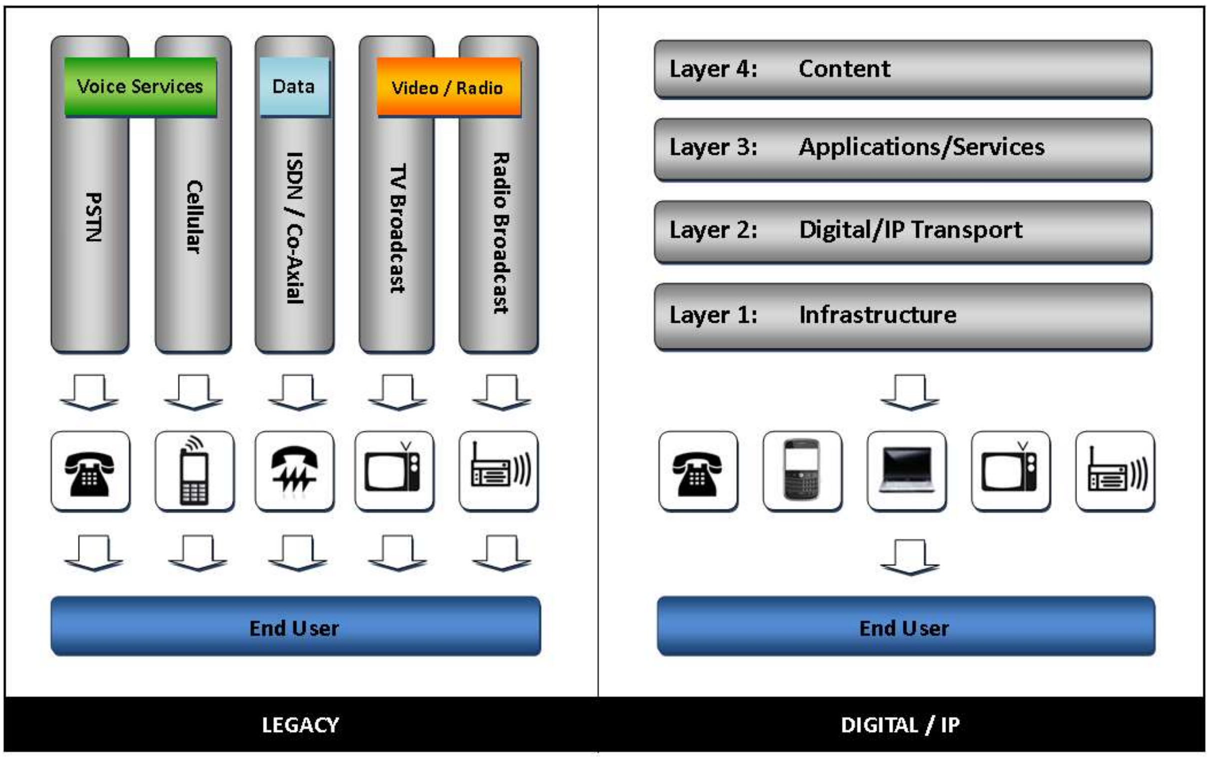
In the face of this tidal wave of technological change, new concepts of operations are possible, requiring attention to policy, regulatory frameworks, architectures and business models to truly maximise the full potential to deliver sustainability outcomes as cities get larger and larger. The New Zealand Transport Agency (NZTA) described the key challenges they faced in delivering better business outcomes in ITS as (i) uncontrolled disparate growth, (ii) vendor driven evolution, (iii) aligning technology advances with government programs, (iv) business systems alignment with physical infrastructure and (v) human factors in ITS (Griffith & Fehl 2016).

The changes occurring in transport and mobility have parallels in the communications domain. This is not surprising as both domains are impacted by the same technology (digitisation and ubiquitous connectivity). The Australian Communications and Media Authority (ACMA) in a 2011 report presented the change they were experiencing in their legislative landscape as shown in Figure 2.6. ACMA described the situation as follows:

In communications, "*legacy delivery arrangements followed service-specific networks and devices. Technological change in the form of digital transmission systems means that service delivery is now largely independent of network technologies. This can be conceived and depicted as a shift from the vertical, sector-specific approach to the horizontal, layered approach. One important consequence of this change is that regulation constructed on the premise that content could (and should) be controlled by how it is delivered is losing its force, both in logic and in practice. In practical ways, this is affecting the day-to-day work of the regulator in administering legislation and applying these concepts to innovative services and delivery mechanisms that were not envisaged at the time existing core legislation was enacted."*
(p2-3 executive summary, ACMA 2011)

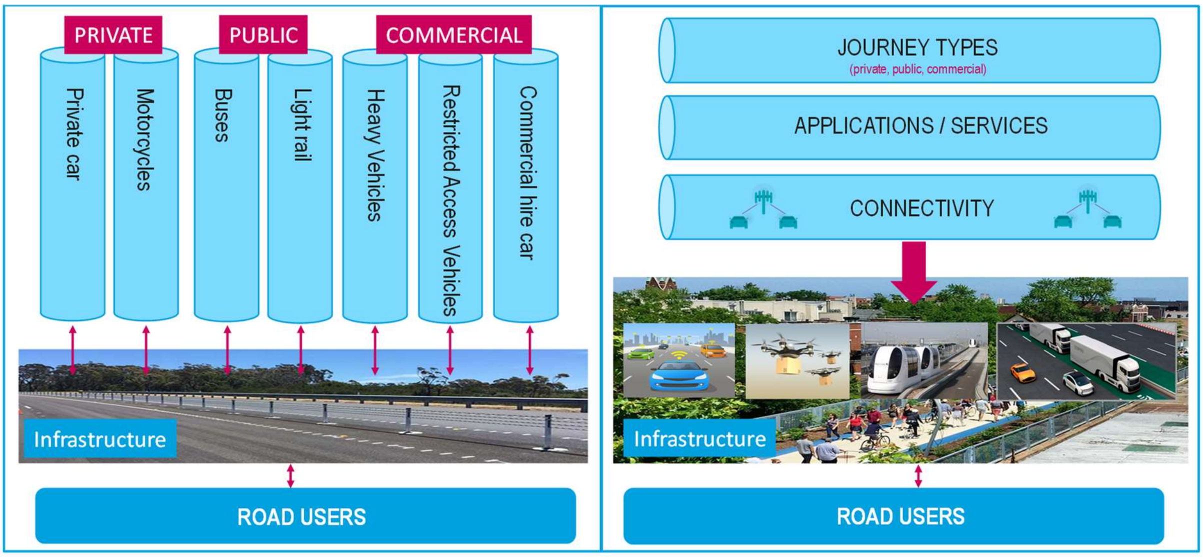
The silo based view of a regulatory and operational environment based on fixed line and cellular architectures shifted to a layer based view of the communications environment, which comprised of content, application, transport and infrastructure layers.

Figure 2.6: Convergence in networks and service layers (ACMA)



A similar approach for transport could possibly be represented in the figure we developed below, Figure 2.7. The current silos in land transport associated with private vehicles, commercial vehicles and public transport (road and rail) are now beginning to change whereby service delivery is largely independent of the specific transport silo. A car can be a private vehicle, a service, commercial or freight vehicle and a public transport vehicle all in the same 24 hours. Journeys (or mobility) are enabled by applications and services provided by Service Providers and supported by layers of digital and physical infrastructures.

Figure 2.7: Convergence in networks and service layers (ARRB version)



(adapted from "**Broken Concepts** – The Australian Communications Legislative Landscape, ACMA, August 2011, p7)

The change in thinking from a silo based view to a layer based view of the future transport and mobility eco-system requires alignment of technology and innovation with the other key elements of a system; policy and legislation, infrastructure and humans (shown as consumer acceptance in Figure 2.8). For the last few years, KPMG have developed an autonomous vehicle readiness index which takes into account the system readiness of countries for automated vehicles (see Figure 2.8). Note particularly that the top two countries, the Netherlands and Singapore, have high rankings across all four key elements. Australia ranked reasonably well at #14 in 2018 and #15 in 2019 (KPMG 2018, 2019), just below the large car manufacturing countries. The Dutch have been key players in the European Union in projects related to integration and harmonisation in the connected and automated vehicle space, while Singapore, being centrally managed, has had a very clear vision about its transport and mobility needs in the future.

Figure 2.8: Autonomous vehicles readiness index (KPMG 2018)

Overall rank	Country	Total score	Policy and legislation		Technology & innovation		Infrastructure		Consumer acceptance	
			Rank	Score	Rank	Score	Rank	Score	Rank	Score
1	The Netherlands	27.73	3	7.89	4	5.46	1	7.89	2	6.49
2	Singapore	26.08	1	8.49	8	4.26	2	6.72	1	6.63
3	United States	24.75	10	6.38	1	6.97	7	5.84	4	5.56
4	Sweden	24.73	8	6.83	2	6.44	6	6.04	6	5.41
5	United Kingdom	23.99	4	7.55	5	5.28	10	5.31	3	5.84
6	Germany	22.74	5	7.33	3	6.15	12	5.17	12	4.09
7	Canada	22.61	7	7.12	6	4.97	11	5.22	7	5.30
8	United Arab Emirates	20.89	6	7.26	14	2.71	5	6.12	8	4.79
9	New Zealand	20.75	2	7.92	12	3.26	16	4.14	5	5.43
10	South Korea	20.71	14	5.78	9	4.24	4	6.32	11	4.38
11	Japan	20.28	12	5.93	7	4.79	3	6.55	16	3.01
12	Austria	20.00	9	6.73	11	3.69	8	5.66	13	3.91
13	France	19.44	13	5.92	10	4.03	13	4.94	10	4.55
14	Australia	19.40	11	6.01	13	3.18	9	5.43	9	4.78
15	Spain	14.58	15	4.95	16	2.21	14	4.69	17	2.72
16	China	13.94	16	4.38	15	2.25	15	4.18	15	3.13
17	Brazil	7.17	20	0.93	18	0.86	19	1.89	14	3.49
18	Russia	7.09	17	2.58	20	0.52	20	1.64	18	2.35
19	Mexico	6.51	19	1.16	17	1.01	17	2.34	19	2.00
20	India	6.14	18	1.41	19	0.54	18	2.28	20	1.91

In response to the future of transport and mobility, there have been a range of studies by countries, local governments, industry associations and think tanks, especially over the last five years. A short listing of the various types of reports is shown Table 2-1 below and the front covers of those reports are shown in Figure 2.9. References to the reports are given in the References section at the end of this paper.

A good example of the desired outcomes in the strategic transport plans typically place the customers first and express outcomes such as:

1. Accessible and convenient transport
2. Safe journeys for all
3. Seamless, personalised journeys
4. Efficient, reliable and productive transport for people and goods
5. Sustainable, resilient and liveable communities (TMR 2019a, 2020a).

Table 2-1: A range of future transport industry plans, strategies and reports

Category	Country	Title
Transport	Australia	Transport Strategy 2030, City of Melbourne
		Our Strategic Plan 2019-23, Department of Transport (Victoria)
		Future Transport Strategy 2056, Transport for New South Wales
		National Land Transport Technology Action Plan 2020-2023, Transport and Infrastructure Council (Canberra)
		Queensland Mobility Framework (Queensland Land Transport Technology Framework – QLTTF)
		Strategic Plan 2019-2023, Queensland Government
		Department of Transport Strategic Plan 2019-22, Transport WA
		Transport Strategy (Draft), City of Hobart
	U.S.	The Road Ahead: National Highway Traffic Safety Administration Strategic Plan 2016-2020
	U.K.	Future of Mobility: Urban Strategy | Moving Britain Ahead
	Europe	How to decarbonise European transport by 2050
ZEVs	Australia	Advice on Automated and Zero Emissions Vehicles Infrastructure, Infrastructure Victoria
		Automated and Zero Emissions Vehicles | Transport Engineering Advice, Infrastructure Victoria
		ICT Infrastructure Advice for Automated and Zero Emission Vehicles, Infrastructure Victoria
CAVs	Australia	Future Transport 2056: Connected and Automated Vehicles Plan, Transport for New South Wales
	Canada	Automated Vehicles Tactical Plan, City of Toronto

Source: See References

Figure 2.9: Examples of Future Vision documents

In the following sections, the background to this paper is presented from specific domains in transport and mobility. The purpose of presenting these different domains is to both present the key issues and challenges as well as the common themes, approaches and efforts in place or underway.

These include traffic management, data, connectivity, mobility as a service, intelligent transport systems and a selection of project work that has already been completed.

2.3 TRAFFIC MANAGEMENT

Traffic management of road networks is an essential part of our everyday lives. In combination with road space allocation, road rules and access conditions, adaptive traffic management through traffic signals and variable message signs play a critical role on our local roads, arterial roads and highways.

In a 2015 discussion paper on future network management, the Queensland Department of Transport and Main Roads (TMR) noted that there was a growing acknowledgement across jurisdictions of the need to provide broader transport outcomes, as opposed to mode or user specific outcomes (TMR 2015). Where discussion previously revolved around traffic management and optimisation for personal motor vehicles along specific arterial or motorway corridors, the concept of transport system management, inclusive of all modes, user types and conditions, is increasingly accepted and must define a future transport network management system (TMR 2015).

Most of our current traffic management systems were developed from the 1980s, evolving from fixed time plans to more demand responsive or adaptive techniques based on information from sensors on the roads (SCATS and STREAMS). An end-to-end traffic management system has yet to be deployed as all traffic management systems are unable to be informed of the origin destination (OD) pairs of each trip on the network. By the time the roadside sensor detects the vehicle, the journey has already been initiated.

However, in other networks such as aviation, internet and mobile communications, the network operator is able to manage their network capacity based on a known demand (OD pairs). For example, in vertical transportation, the introduction of a console for travellers upstream of the lift lobby has enabled the lift management system to allocate and balance demand with the supply of elevators.

Noting the great advances in technology over the last decade and the advent of connected and automated vehicles, it is timely to revisit the future vision for traffic management of the road network. Two scenarios immediately come to mind; firstly (i) a cloud hosted system operating a virtual traffic management system and communicating with all road users and vehicles, and secondly (ii) an intermediate scenario with a cloud hosted system communicating with traffic lights that can think and talk, and vehicles that can listen.

Several cloud-based traffic management systems have already been developed (Ericsson 2017, Siemens 2019). These systems typically comprise of traffic signals and signage connected to a cloud-based traffic management system with data and information from a range of smart sensors, as well as apps (Traffic SA 2020) interacting with road users and providing information to them and vital journey information (OD pairs) to the traffic management system. As such, the envisaged system will be the first to deliver an end-to-end traffic management system for road operators and all road users. The approach will also enable the system to provide more timely information to road users, predicting and suggesting alternative routes and departure.

Investigations by the Bureau of Infrastructure, Transport and Regional Economics found that Australian investments in traffic signal co-ordination technologies over many decades have delivered BCRs above 10. The introduction of next generation technologies for transport also has the potential to generate other benefits which include:

- job creation in high tech industries of artificial intelligence, mobility, automation, telematics, connectivity and service provision
- changes in urban form with the potential for increased liveability and sustainability
- technology enabling all road users to make more productive use of the time spent travelling and reducing the cost of commuting.

Research will be necessary to better understand and plan for:

- induced travel demand from non-drivers such as the young, elderly and disabled
- changes in the value of time for existing road users
- the likely uptake of car, ride-sharing and other options based around demand responsive transport services
- the changes in the relative costs and benefits of road transport technologies in urban, regional and remote areas.

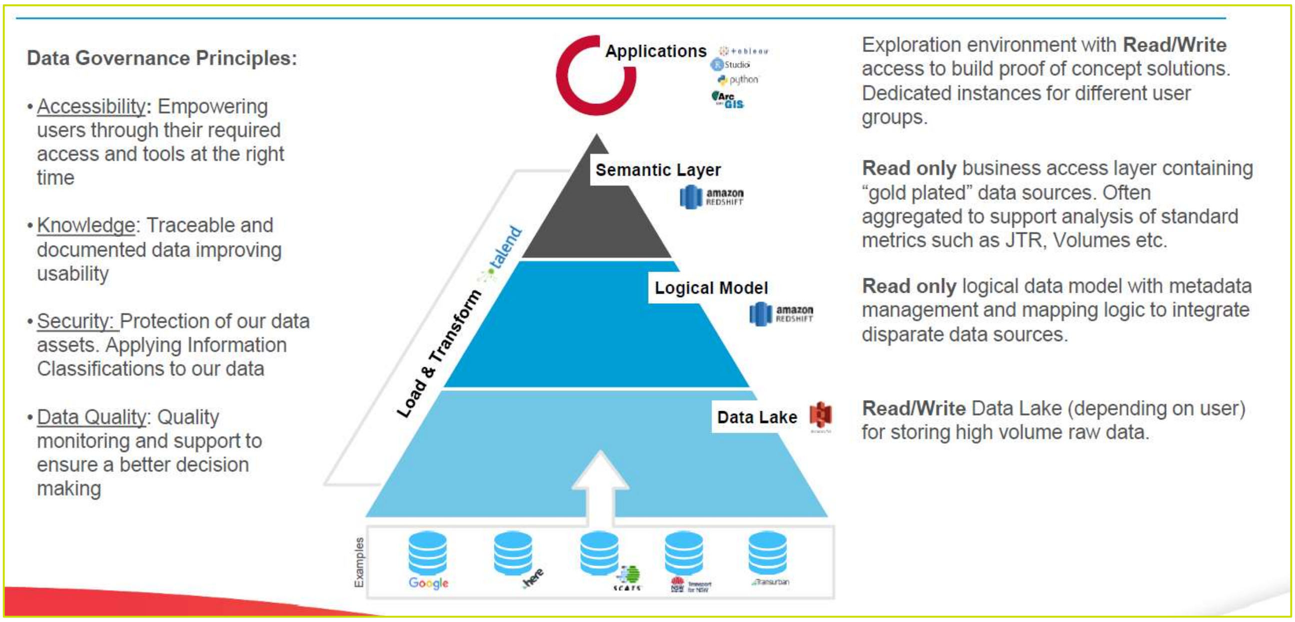
The current range of Australian Intelligent Transport System (ITS) technologies include signal co-ordination, high occupancy vehicle prioritisation, ramp metering, tidal flow lanes, variable speed limits, variable message boards, hard shoulder running and signal prioritisation for trams, buses and emergency vehicles. BITRE found that these ITS treatments typically cost between $13,000 to $130,000 per intersection or $140,000 to $440,000 per km (BITRE 2017).

The expected benefits include:

- Future proofing traffic management with a sustainable, scalable and plug and play architecture
- Improved traffic management opportunities and eventual integration with all land transport modes
- Fit with future transitions to connected and automated vehicles
- End-to-end traffic management solution that can be commercialised by industry
- Directly influencing and learning from the leading edge R&D developing new viable technology solutions, enabling future vehicles and smart traffic management for all stakeholders, including governments.

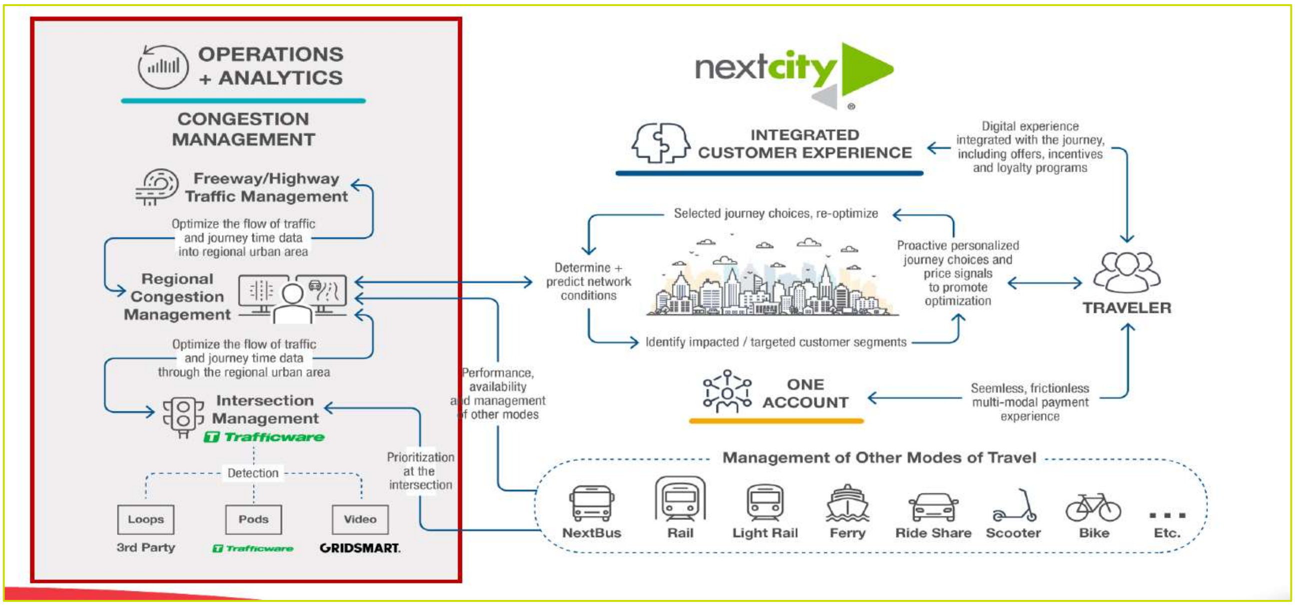
At a Special Interest Session (SIS41) on Delivering on Proactive Congestion Management in NSW, TfNSW presented a depiction of their data architecture in three layers (data lake, logical model and semantic layer) to support future transport and mobility applications as shown in Figure 2.10 below (Scott & Bax 2019). The figure also identifies four data governance principles which are (i) accessibility, (ii) knowledge of the data, (iii) security and (iv) data quality. These are the core data elements needed for any future transport management system.

Figure 2.10: Transport management data architecture (TfNSW)



Cubic's vision of the future traffic management system is shown in Figure 2.11, where the transport network information on the left-hand side of the figure is integrated with the 'nextcity' integrated customer experience system to deliver an end-to-end experience, wherein customer demand is balanced with network capacity in close to real time (Scott & Bax 2019).

Figure 2.11: Congestion Management in Transport EcoSystem (CUBIC version)



2.4 DATA

Data (or bits of information) are a unique commodity, especially in our modern world. Unlike a piece of coal, a piece of information can be used by an infinite number of people. Data also becomes more valuable when aggregated and connected to other pieces of data. This trait is similar to infrastructure networks, like the telecommunications network. The value of data continues to increase when it is analysed and disseminated. Original (or 'raw') data is valuable because there are so many potential uses, so long as that data is freely available and standardised in some way (to aid comparison, transfer and analysis). The data revolution of the past two decades is proof of the value-added inherent in data.

The Productivity Commission (2017) in its inquiry report *Data Availability and its Use*, noted these unique characteristics as follows:

- one person's use of data does not detract capacity of others to also use it
- data does not wear out; its value may increase or decrease over time
- digital data is costless to reproduce
- data is non-fungible (inter-changeable), it cannot be perfectly substituted for other data.

In recent years, governments in Australia and internationally have become interested in the potential of data from an economic management viewpoint. Modern cities produce vast amounts of data that can be used to optimise both their day-to-day operation and longer-term design. Technological developments such as the Internet of Things (IoT) rapidly expand the volume, velocity and variety of transport and mobility data.

Data can aid city operation, but it can also help inform the very design of cities and city services to be more efficient. Access to data is also crucial for the confident future-proofing of cities. Data analytics in scenario planning is helping calculate ways structures can be used more productively and in a relevant way as citizens' demands evolve. Effective and responsible use of the growing wealth of data requires successful navigation of a number of difficulties. Standardisation of data remains an issue, and more has to be done to address concerns over personal data privacy and security – including settling complex questions of ownership. With the convergence of some sectors, like transport and energy, joined-up planning, based on shared data, is essential to building flexible cities.

Big Data and IoT

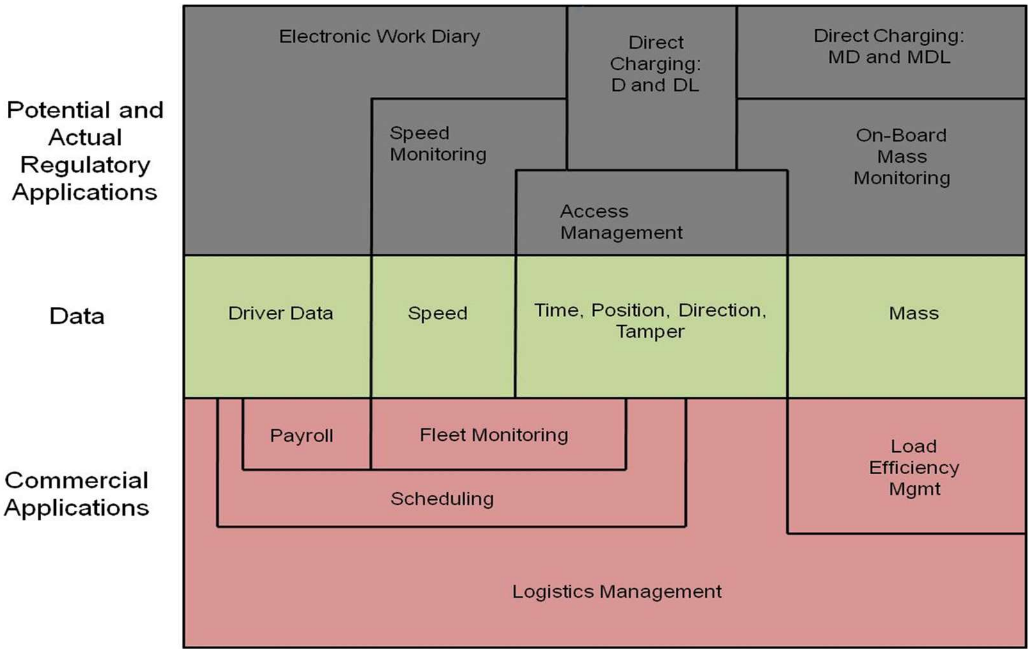
Over the last 10 years, we have experienced a significant growth in data. In November 2019, Ericsson forecasted that from an average worldwide monthly data consumption of 10GB/month in 2020, data consumption in five years will grow to 24GB/month in 2025, based on a growth rate of 19% per annum (Ericsson 2019).

This growth has occurred in areas such as: (i) social media posts, video and audio files and emails, (ii) in a huge increase in personal/nomadic devices such as mobile phones and in-vehicle telematics and most recently in (iii) physical objects embedded with sensors (Internet of Things). Supporting and enabling this growth has been the corresponding improvements in connectivity both in latency and bandwidth. The Productivity Commission categorised the data growth as a result of connectivity in three areas: (i) volunteered data, (ii) observed data and (iii) inferred data (Productivity Commission 2016, p.58).

The International Transport Forum at the OECD reported that the volume and speeds at which data today is generated, processed and stored is unprecedented and will fundamentally alter the transport sector (ITF 2015). They found that sensors and data storage/transmission capacity in vehicles provide new opportunities for enhanced safety, and multi-platform sensing technologies are now able to precisely locate and track people, vehicles and objects.

In Australian work associated with the Intelligent Access Program and other regulatory telematics applications (ARRB 2011), it was noted that data from heavy vehicles could be collected once, yet used many times as shown in Figure 2.12 below.

Figure 2.12: Collect once, use many times (ARRB 2011)



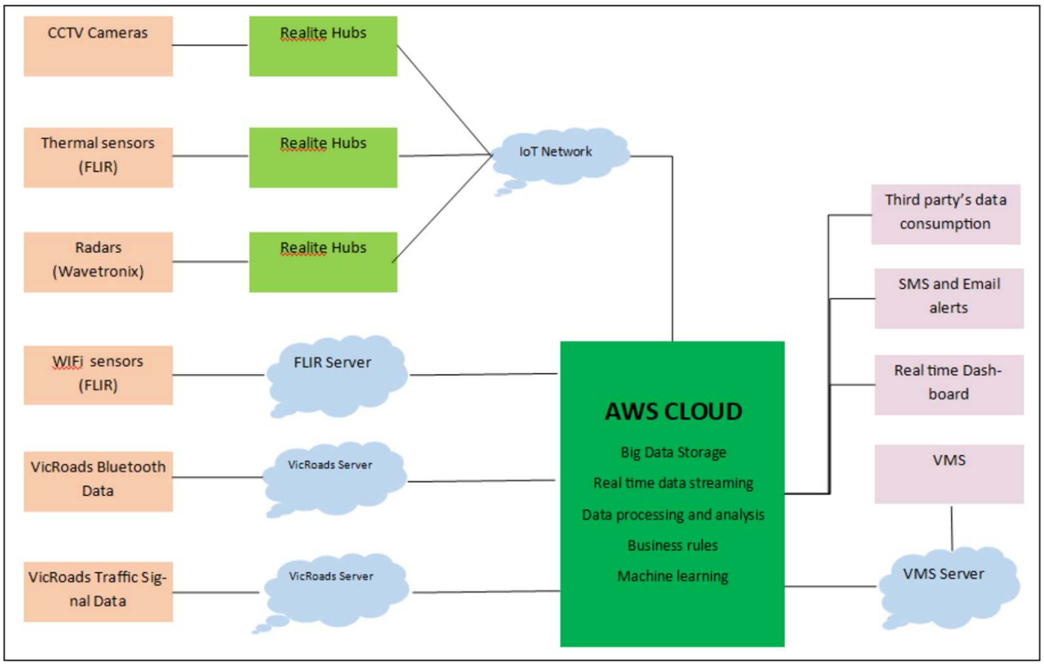
In addition to GPS and mobile phone data, studies are being undertaken on the use of Co-operative ITS technologies in transport (see the CAVI and CITI projects described in Appendices D and E). In these examples, data from vehicles and the roadside are used. In addition to the trialling of technology, it is also important to note that access to road users' data and privacy and security considerations are being addressed side by side with the technology trialling.

An example of the realisation of this integration for road traffic data can be seen in a platform developed by a Melbourne start-up Real Time Traffic, who presented their system at the ITS World Congress in Singapore last year (Lu & Dabic 2019).

The platform (Figure 2.13) comprises of three key elements:

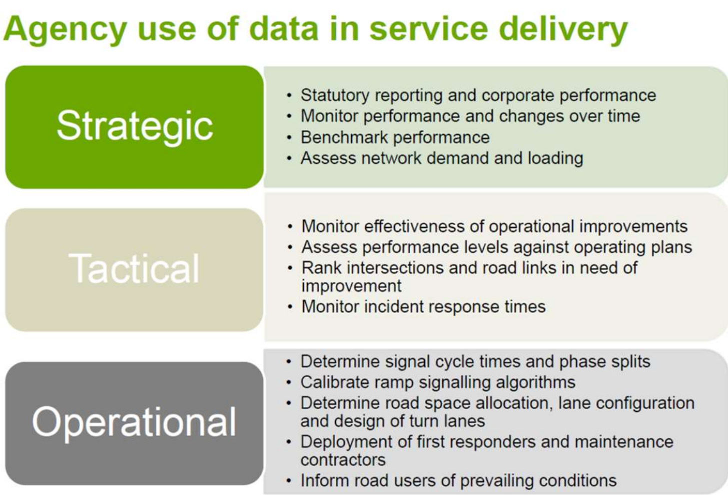
1. Inputs: collection of traffic data such as speed, volume, classification, origin-destination, and travel time in real time from publicly available government data, roadside detectors and other third-party data sources
2. Intelligent traffic algorithm and estimation models: sophisticated data aggregation processes, control algorithms, and real-time data-driven traffic estimation techniques to provide deeper insight into the network performance. This also comprises of an intelligent business rule engine to trigger instant actions and responses as conditions change
3. Outputs: meaningful traffic information is then disseminated to operators and commuters via various communication channels – customised web applications, road-side devices, website, social media, SMS, emails etc.

Figure 2.13: The real time traffic platform physical architecture (Real Time Traffic)



The data and information collected, analysed and transformed into information can then be utilised by Road and Transport Agencies in service delivery at three levels: strategic, tactical and operational as shown in Figure 2.14 (Walsh 2014).

Figure 2.14: Levels of data used by a transport agency in service delivery



In order for the physical platform/s to utilise the various data sources shown and the subsequent process of aggregating and fusion with other data sources, both private, commercial and from other government agencies in order to deliver data/information at a strategic, tactical or operational level, a governance framework needs to be in place.

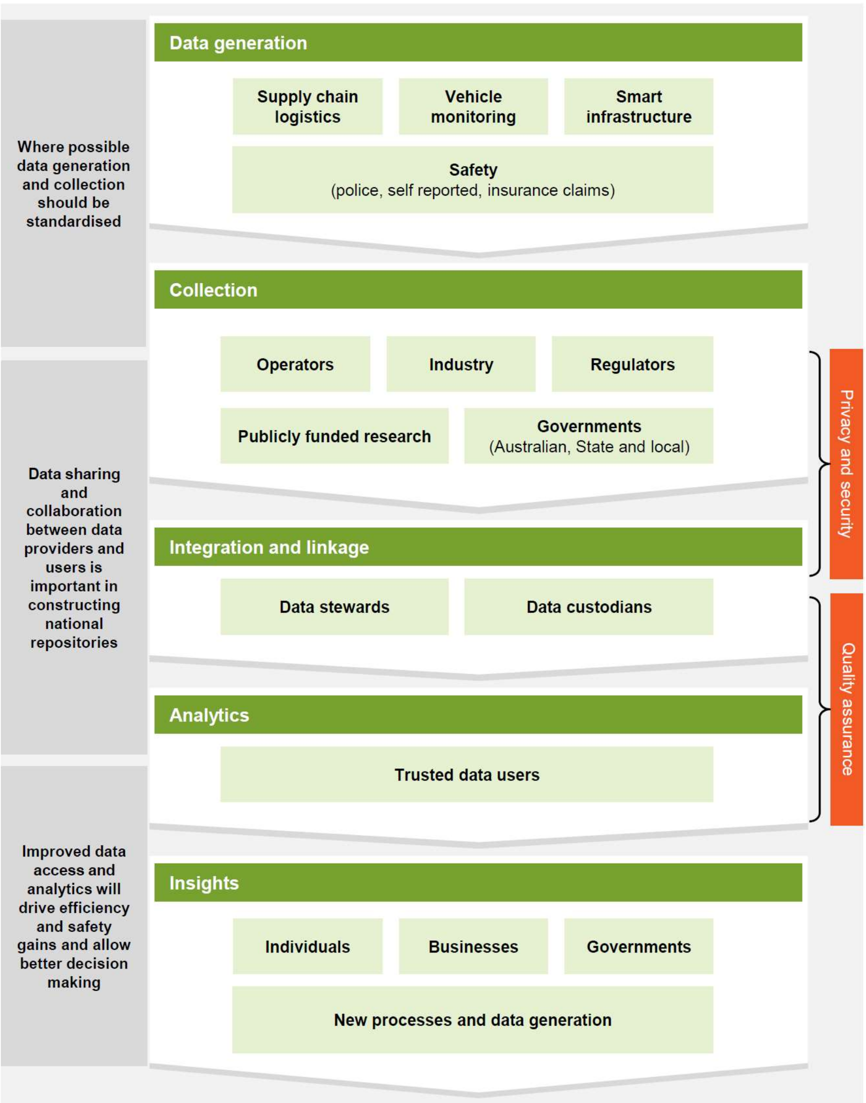
Data Governance

In 2019, the Productivity Commission was tasked to investigate the long-run economic impacts of transport regulatory reforms agreed by COAG in 2008-09 relating to heavy vehicle safety and productivity, rail safety and maritime safety, and to make recommendations for further reforms towards a more integrated national market for transport services (Productivity Commission 2019).

A major part of the PC's investigation focussed on transport data and its governance. The PC's November 2019 Draft Report contained a figure shown below which presented a powerful architectural representation of the different data layers as well as the roles and actors involved, as shown in Figure 2.15 (Productivity Commission 2019, p. 33). The layers are 'data generation', 'collection', 'integration and linkage', 'analytics' and 'insights'. The roles and responsibilities of actors such as Data Stewards, Data Custodians, Trusted Data Users in the figure below as well as 'National Interest Datasets' (Productivity Commission 2017) needs to be defined. By defining the 'layers' and the actors' roles and responsibilities, the system architecture or 'concept of operation' emerges.

We argue that unless these roles and concept of operation is recognised, accepted and set within a regulatory framework, so that there is the possibility of ingesting and utilising private, commercial and public data in a trusted and collaborative manner, many of the benefits of technology will be difficult to be delivered.

Figure 2.15: The transport data lifecycle



2.5 CONNECTIVITY

The ongoing digitalisation trend known in the industrial context as 'Internet of Things' or 'Industry 4.0', is taking to the world of road traffic under the name of 'Vehicle-to-X' or 'V2X' technology. The interconnection of vehicles to each other, to the infrastructure and to other traffic participants provides new possibilities for improvement and harmonisation of traffic flows. As the number of road users continues to rise, the optimisation of available infrastructure is needed to maintain a satisfactory level of service for traffic participants.

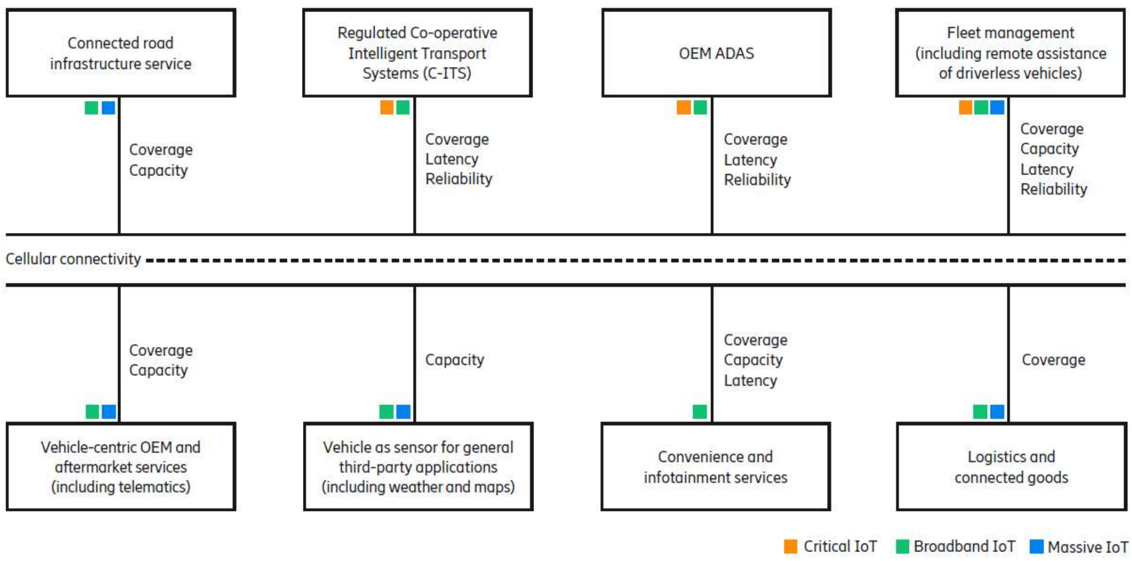
Allowing an exchange of data between vehicles, the infrastructure and traffic participants will not only help make our roads safer, it will also help to optimise traffic flow on our road network, advance the efficient use of existing infrastructure, and reduce the negative impacts on the environment from vehicle emissions (Manning 2019).

The connectivity needs of the automotive and transport ecosystem are diverse and complex, requiring a common network solution, rather than several single-segment solutions as shown in Figure 2.16. These include applications and solutions such as:

1. Road infrastructure messaging
2. Regulatory telematics applications
3. Advanced driver assistance systems (ADAS)
4. Fleet management
5. OEM and after-market services
6. Vehicle as a sensor for weather and road congestion
7. Convenience and infotainment services
8. Mobility and logistics services.

Vehicles can be seen as multipurpose devices in which several connectivity-dependent use cases are executed simultaneously as shown in Figure 2.16. Ericsson (2019) claims that deployment of 5G NR, interworking with existing 4G (LTE) networks, can satisfy the connectivity needs for those use cases. Other systems include ITS-G5 or CITS based on 5.9GHz.

Figure 2.16: Automotive and road transport services requiring cellular connectivity



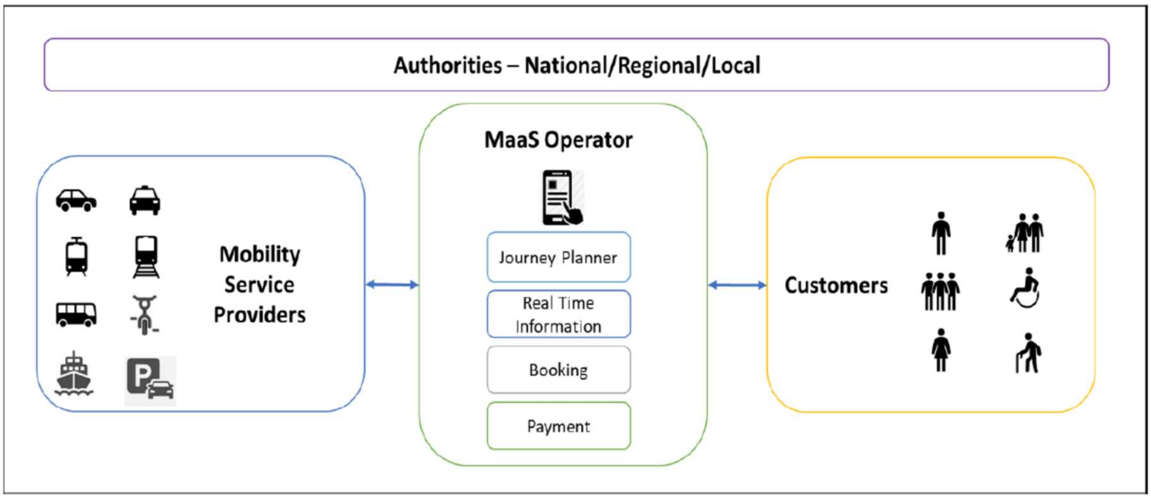
Just as advanced safety features such as on-board parking cameras and collision radars have become more widespread as vehicle fleets are replaced globally, this technology is predicted to gradually become commonplace, and even expected, in the near future. Virtual RSUs and the C-V2X platform use standard application programming interfaces, messaging and protocols, meaning that automotive OEMs can begin including the technology in their fleets sooner rather than later and scale it as the technology develops, including during the switch to 5G (Telstra 2020). The solution offers flexibility for OEMs and road authorities to decide on the road safety applications that they would like to deploy over time.

2.6 MOBILITY AS A SERVICE

As noted, the transport operation network continues to undergo significant transformation. Ride share companies are now commonplace, journey planning capabilities and real time travel information is readily available. There are four major components to the MaaS concept – the Mobility Service Provider, the MaaS Operator, the customer and the Authorities (ITSA 2019). Others have described MaaS as a shift in perspective from 'asset ownership' to the 'provision of access on demand' to the community where four components need to integrate and operate together in varying degrees; (i) public transport, (ii) shared mobility services, (iii) new mobility technologies and (iv) an institutional overlay (Henscher 2020).

MaaS requires a well-integrated system of service providers, operators and end users. As telematics, data analysis and AI technology become further integrated into society, MaaS will provide a means of transportation that is unmatched in its efficiency and scope (ITSA 2019). Carter and Wu (2019) present the key MaaS components in Figure 2.17 below where a range of transport (or mobility) service providers offer their services not just directly to customers but also via MaaS Operators.

Figure 2.17: MaaS components



Henscher (2020) simplifies the MaaS offering at a high level as being (i) 'Bundles' – mobility packages representing bundles of mobility, (ii) 'Budgets' – end user preferences and service provision possibilities and (iii) 'Brokers' – a new entrepreneurial model providing the aggregating function.

The identification of 'an institutional overlay' and 'a new entrepreneurial model providing the aggregating function' by Henscher are important considerations to note from the regulatory side. Further work underway in iMOVE is provided in Appendix G and covers areas in MaaS such as:

1. *The viability of different business models*

   The role of ownership and access for MaaS providers e.g. B2C (business to customer) where the provider owns and operates transport services, or P2P (peer to peer) where the provider facilitates access to multiple independently owned transport services.

2. *The role of different actors in the MaaS ecosystem*

   What is the role of the public and private sector? How might the role of the public sector differ across local, state and federal government, and across urban, regional and remote contexts?

3. *Data management*

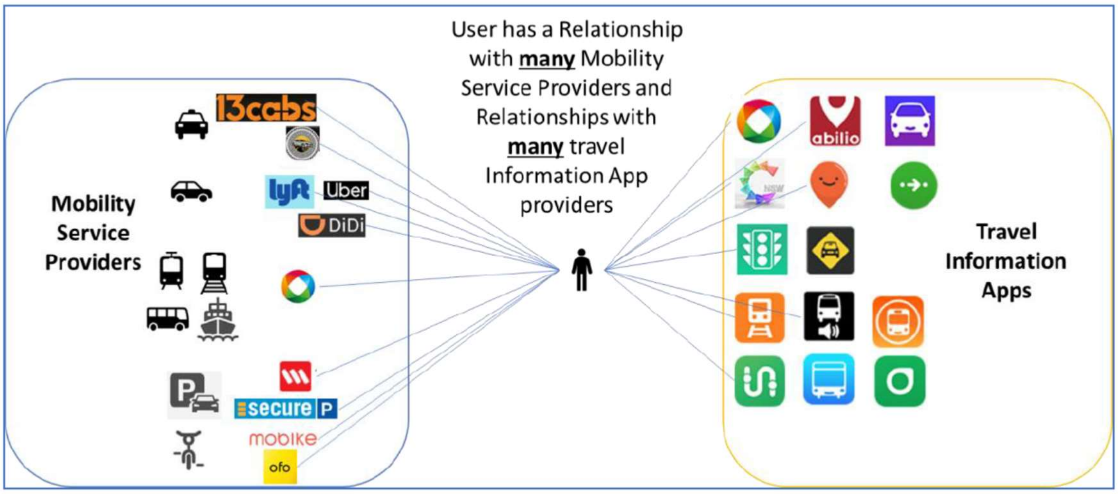
   What kind of data is needed to support integration between different transport services for planning, booking and payment, and how can this data be securely stored and managed?

In a study of MaaS operations worldwide, Austroads (2019) identified four key themes about MaaS:

- **Integrating travel modes** – a key objective of MaaS platforms is the integration and bundling of all available public and private transport services into a single, centralised platform. An integrated MaaS platform should ideally allow multiple modes of transport to be combined into a single door-to-door journey, with the flexibility to provide different options for modes, price and travel time.
- **Technology-enabled** – MaaS is driven by advances in technology that enable integrated real-time journey information, journey planning, service reservation, backend product management and payment platforms. Existing modes of transport such as public transport should be integrated with new, technology-based services including bikeshare, car-share and rideshare.
- **Customer-focused** – MaaS should ultimately be focused on the customer, providing personalised mobility solutions that make use of this wide range of mobility options. MaaS should bring every kind of transport together to improve freedom of mobility.
- **Future-ready** – although not technically a requirement of Mobility as a Service, every MaaS system should be ready to incorporate Shared, Connected and Automated Vehicles.

Austroads (2019) reported that public transport forms the backbone of many MaaS offerings and that it could be more complex (and thus slower) to integrate public services into MaaS platforms, compared with private sector participants. This was particularly the experience in North America. It was noted that Australia's mobility environment is more like that in North America than in Europe – has high levels of private car ownership, lower levels of public transport infrastructure, polarised populations of very sparse regional settlements, and highly dispersed, urbanised cities. A typical example of the current MaaS market in Australia was depicted in Figure 2.18 by Carter and Wu (2019).

Figure 2.18: Customer relationships



The scan of literature and observations of international MaaS schemes by Austroads indicated that MaaS models are working best where there is an environment with:

- A wide range of transport services
- High level of customer access to digital infrastructure and personal devices
- Open and secure data access
- Available online journey planning for trips combining multimodal fixed public transport, flexible public transport, and personal services including private car trips
- Operators offering contactless payments and e-ticketing
- Jurisdictions that are open to third parties selling their services.

In approaching the rollout of MaaS is it interesting to note a roadmap for MaaS developed in Sweden which identifies four levels of integration necessary for MaaS operations (Drive Sweden 2016). They are:

Level 0 – No integration, no MaaS

Level 1 – Integration of information

Level 2 – Integration of booking / ticket / payment

Level 3 – Integration of agreements

Level 4 – Integration of policy and control.

Table 2-2 presents the four levels of maturity and provides a brief description of what needs to be achieved at each maturity level. This understanding has been built up through experience and shows the realisation of efforts which need to commence with a sharing and integration of the necessary information, all the way up to the need for policy and control by a 'System Manager' who 'steers' the system development towards the city/public sector's objectives.

Table 2-2: MaaS maturity levels

Maas Level	Description
Level 4: **Integration of Policy & Control**	Incentives and instruments (from the public sector) integrated in agreements and the service. The purpose is to steer towards the city's/public sector's objectives. Conditions for resale of the public sector's services.
Level 3: **Integration of Agreements**	Offer alternatives to car ownership. Subscription or packaged. Responsibility for the entire service. In relation both to customer and transport service provider. Combined payment for all services. Focus on household mobility requirements.
Level 2: **Integration of Booking/Ticket/Payment**	Booking of and payment for services integrated in a service/app. No responsibility for the travel services, but for payment. Focus on individual journey A to B.
Level 1: **Integration of Information**	The services integrated at information level (e.g. multi-modal travel planners). Users have agreements and relationships with various transport service providers. Separate payment solutions
Level 0: **No Integration**	Separate mobility services. Users have agreements and relationships with various transport service providers. Separate payment solutions.

An example of key high-level objectives is listed below. They are sourced from TfNSW's Future Transport Strategy 2056 (TfNSW 2018) and provide good guidance not only for MaaS but also for the likely objectives needed to be set for a future transport and mobility environment. The objectives are:

- Develop and connect real-time information, navigation, payment and engagement platforms that are simpler to understand, easier to use and can give personalised services relevant to individual needs and preferences.
- Transform mass-transit networks to improve their efficiency, deliver better service frequency, and reduce transit times, increasing the attractiveness of these services for the customers.
- Foster shared, demand-responsive services and offer customers a greater variety of mobility options and flexibility of choice that matches their needs.
- Pursue national standards for the road infrastructure, systems, and regulatory frameworks needed to adopt greater levels of vehicle automation earlier and identify how best to deliver community benefits that autonomous vehicles will bring.
- Create intelligent transport networks, managed with data, that enable increasingly efficient, flexible and dynamic service delivery with improved safety, availability, reliability and responsiveness.

On governance arrangements, Austroads identified that the core responsibilities the public sector needs to exert on the MaaS environment could take different forms depending on the level of regulation and legislation:

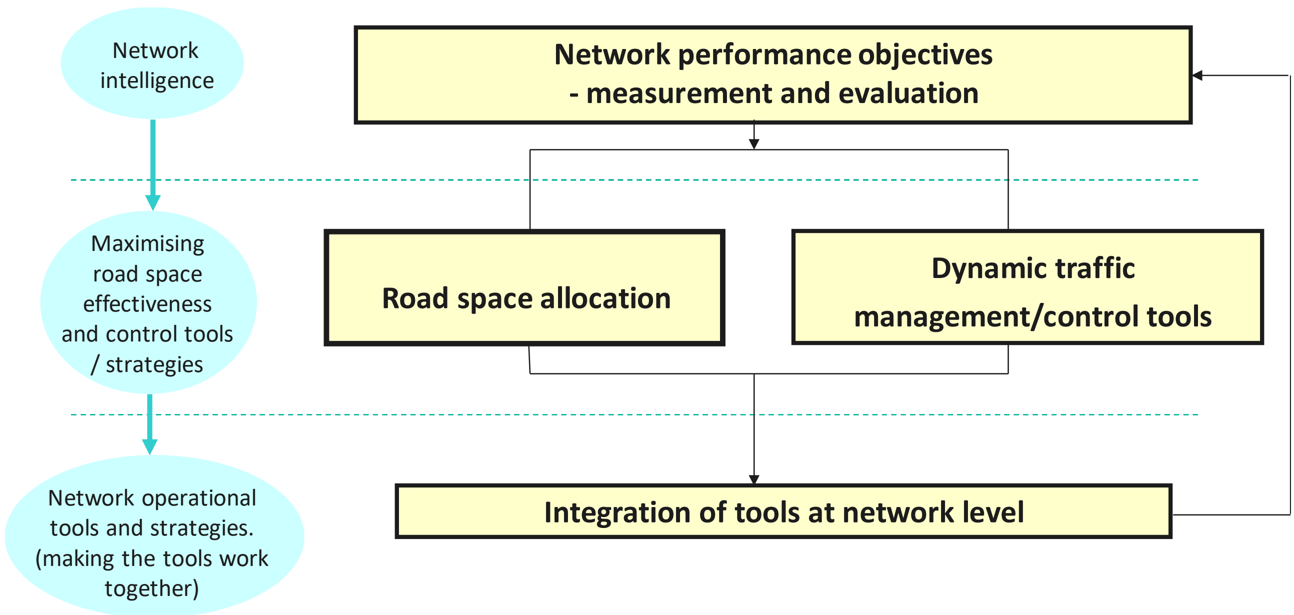
1. **Legislated Open Ecosystem:** Government legislation requiring real-time publishing of service offerings (trip, schedule, cost, etc. data) in an open format. Legislation would ensure travellers can access all transport services and mobility options via a single platform. This scenario offers the most comprehensive open-data solution.
2. **Walled Garden:** A 'walled garden' is a closed proprietary digital ecosystem resulting from a lack of coordination between industry participants, analogous to Apple's app store versus Android's equivalent (Google Play). Walled Gardens would arise when a MaaS broker controls which services can and cannot be offered through its customer-facing portal, limiting or preventing access to transport services considered competitors. This would increase the need for end customers to access several MaaS platforms to search for their preferred trip offering and would likely produce suboptimal efficiency in terms of trip-matching, ride-pooling and cost.
3. **Brokered Coordination:** A partnership between government and transport service providers and/or MaaS platform operators, in which the parties in agreement negotiate openness of data related to MaaS service offerings. This brokered coordination would be intended to collect trip, schedule, cost, ridership and similar data with which to facilitate a single MaaS platform offering mobility options from several or all service providers. Without legislation to require such coordination, this approach would require negotiation with the private sector. It is the mid-point between the Legislated Open Ecosystem and Walled Garden scenarios.

2.7 INTELLIGENT TRANSPORT SYSTEMS

Intelligent Transport Systems or ITS is a term to describe a large collection of systems covering many areas of application in transport. In the early days it mainly related to the emerging systems related to traffic control with signals (1980s, SCATS, STREAMS, BLISS, SCOOT etc.) and expanded to include a range of dynamic traffic management and control systems (e.g. contra flow lanes, traffic advisory messaging, traveller information, compliance and enforcement and, by 1999, the introduction of free flow tolling systems).

In an investigation to develop a better understanding of how various traffic management tools and operational interventions and treatments to the road network affected the performance of the entire road network, with a focus on roads operating under congested conditions, Austroads (2007) reported on a suite of tools and how they all worked together as shown in Figure 2.19.

Figure 2.19: Tools that impact network performance



The tool box for the traffic manager contained approaches which either utilised road space allocation treatments or ITS tools (dynamic traffic management/control tools) and Austroads (2007) found that there was increasing integration of treatments which used a combination of road space allocation and ITS tools. These became known in Australia as Smart Motorways or elsewhere as Integrated or Active Corridor Management.

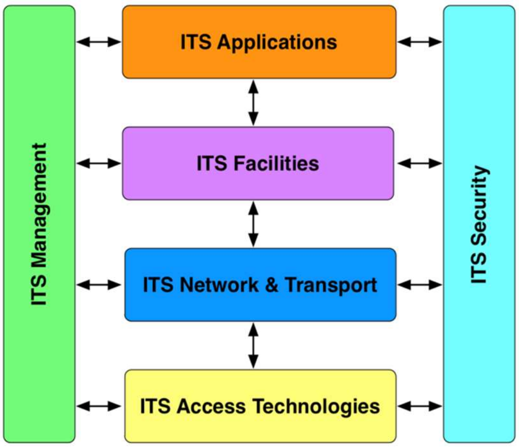
Since that time, there has been a huge development of many more areas emerging within the ITS domain as information and communication technologies advanced. Last year, the ITS industry held its 26th World Congress in Singapore which attracted over 14,500 delegates and covered eight key ITS themes (ITSWC 2019):

1. Intelligent, Connected & Automated Vehicles
2. Crowdsourcing & Big Data Analytics
3. Sustainable Smart Cities
4. Multimodal Transport of People & Goods
5. Safety for Drivers & Vulnerable Users
6. Policies, Standards & Harmonisation
7. Innovative Pricing & Travel Demand Management
8. Cybersecurity & Data Privacy.

Intelligent transport systems (ITS) service domains and groups reflect the evolution of technology-oriented transportation practices and applications. So far this has been in the road transport domain, but ITS is beginning to appear in the maritime and rail transport domains. This has become of increasing importance and interest as the scope of ITS expands beyond its original range of services in road traffic management, traveller information and electronic payment systems (ISO 2014).

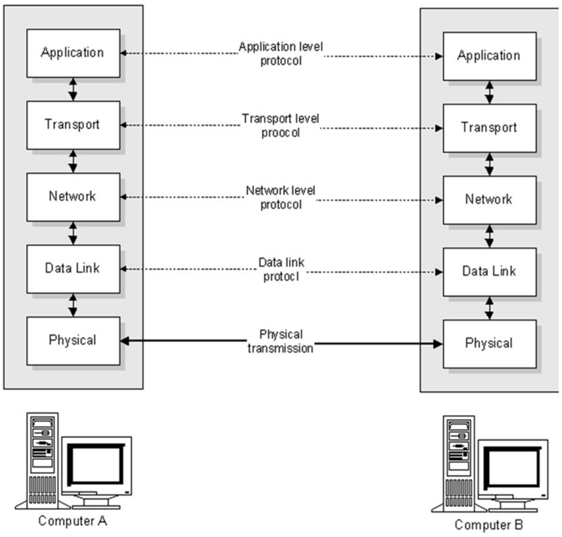
With such a large domain in ITS, attempts at harmonisation and standardisation are critical. An ITS station concept (ISO 21217) was developed by the International Standards Organisation and its architecture is shown in Figure 2.20.

Figure 2.20: ISO station concept (ISO 21217)



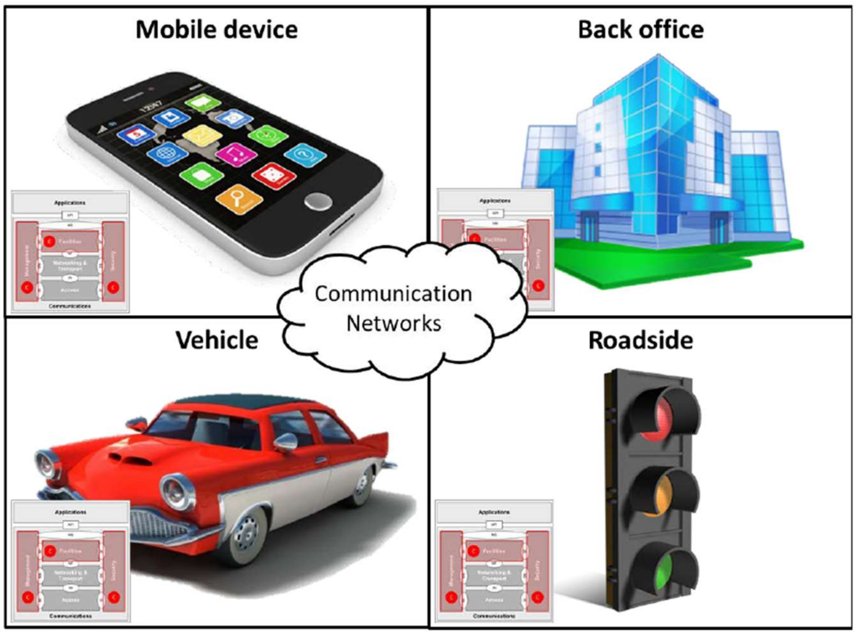
Having mentioned before that 'transport is a technology business', it is important to note that the ITS station architecture concept developed by ISO was based on the OSI stack or Open System Interconnection model that was developed in 1984, as in Figure 2.21, also by ISO to support the interactions of computers with other computers as the world moved from main frame computers to desktop computers.

Figure 2.21: OSI stack (circa 1984)



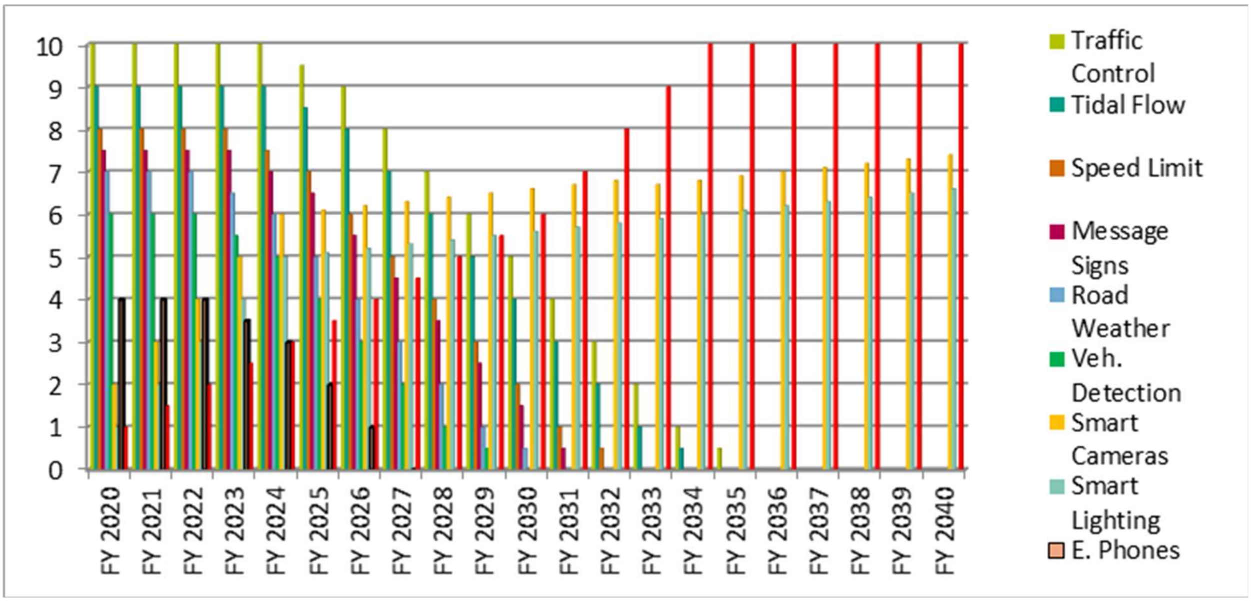
A physical view of how ISO 21217 works in the real world is shown Figure 2.22. By standardisation of the ITS station concept, it is possible to appreciate various instantiations of ITS stations in devices at the roadside, in-vehicle, at the back office and used as personal hand held nomadic devices operating within an ecosystem where communications, integration and interoperability is enabled via adherence to standards, common definitions and roles and responsibilities made explicit.

Figure 2.22: Physical representation of ISO station concept



In response to these developments in ITS, Wazirzada (2018) found that there is a need to start planning the alignment of infrastructure and roadside technologies to the demands and requirements of the CAVs. This would entail synchronising the growth and improvement and renewal plans of ITS with the introduction of new ITS and connected and automated vehicle functionalities. Undertaking an assessment of the utility of current ITS assets, Wazirzada reported on findings that showed that the most commonly used ITS would diminish in its utility over the next 10 to 20 years as shown in Figure 2.23. These estimates were based on the knowledge of the current technologies, their functionalities, and their usage and how these would deteriorate with time considering the technologies being added to the vehicles over the same period (Wazirzada 2018).

Figure 2.23: End of utility dates of commonly used ITS assets



The traditional ITS systems from the 1980s are changing to modern ITS systems architected to technology architectures such as ISO 21217 standards, based on a layered approach and regulated and operated by actors in roles and responsibilities within a new system concept of operations.

2.8 WORK ALREADY COMPLETED

Both Austroads and the National Transport Commission have been active over many years in efforts to harmonise and standardise approaches in operations and regulations across the road transport sector.

It is not possible to cover the entire list of relevant activities, but a listing of selected activities of relevance is presented below to show an understanding of the issues and examples of relevant activities.

2.8.1 HARMONISATION AND STANDARDS

Harmonisation of pavement markings and national pavement marking specification, Austroads AP-R578-18

Pavement markings constitute a key element of safe system infrastructure. Specifications for pavement markings and materials differ between jurisdictions and the intervention levels for the replacement/remarking of pavement markings also differ. A project was undertaken to achieve national harmonisation through the development of national performance specification/criteria for pavement markings with the intention of becoming an Australian Standard.

Standardisation of ITS Technology Asset Management Datasets, Austroads AP-R608-19

The objective of the project was to develop standardised condition and performance datasets for ITS assets that contribute to journey planning, congestion management and traffic control. The data specifications cover 155 ITS asset data items including 56 inventory, 20 condition and 39 performance items, and 40 key performance indicators (KPIs). The specifications also categorise the asset data requirements into core, desired and optional requirements, which allow a level of harmonisation, comparison and benchmarking across jurisdictions. The core specifications cover 28 data items including 12 core KPIs, which are agreed minimum measures required for the development of asset management plans, reporting on asset performance and the programming of proactive asset management and maintenance (i.e. reliability-centred maintenance (RCM)).

To support the adoption of the data specifications by individual jurisdictions, a business case was developed, and BCA was conducted for different implementation options. The BCA found that all three options are viable and yield positive net present values (NPV) and quite attractive benefit-cost ratios (BCR) over the 15-year evaluation period. It also showed that investment in data specifications has the potential to achieve quite a high impact, and the higher the level of investment the higher the potential returns in terms of NPV.

Data Standard for Road Management and Investment in ANZ, Austroads AP-T315-16

This Data Standard for Road Management and Investment in Australia and New Zealand was developed in response to a need to standardise and harmonise data sets that support common road management and investment activities. Specifically, this Standard establishes a common understanding of the meaning or semantics of the data, to ensure correct and proper use and interpretation of the data by its stakeholders.

The scope of the data items included in this Standard are confined to those required for effective road management and investment. Function groups include:

- Network (the road network and its links)
- Classification (the hierarchy and purpose for the links)
- Inventory (the assets)
- Condition (the condition of the assets)
- Performance (the technical performance of the assets)
- Performance (the customer service performance of the assets)
- Access (any road user access restrictions)
- Demand (the current road user profiles and vehicle volumes)
- Works and Costs (the physical works plan/achievements and related estimated/actual costs

Implications of Traffic Sign Recognition (TSR) Systems for Road Operators, Austroads AP-R580-18

Traffic Sign Recognition (TSR) is an in-vehicle technology that attempts to read and interpret road traffic signs. This report investigated the possible changes to Australian and New Zealand traffic signs needed to support the use and results of introducing TSR systems. Recommendations were found to enhance traffic sign readability (including electronic signs), installation and maintenance, positioning and location, sign face design, vehicle mounted signs and other advisory signage.

2.8.2 ARCHITECTURE

National ITS Architecture – Context and Vision, Austroads AP-R467-14

This Context and Vision document was the first step in the development of the National ITS Architecture and described (i) the Vision for the Australian National ITS Architecture, (ii) the International ITS Architecture Context, helping to understand how other ITS architecture initiatives could inform and guide the development of the Australian National ITS architecture, (iii) The Architecture Development Methodology and (iv) Recommendations for how the development of the Australian architecture should continue in this context.

National ITS Architecture – ITS Business Architecture, Austroads AP-R468-14

A key initial step in the development of the National ITS Architecture for Australia is to build the conceptual ITS Business Architecture platform on which subsequent and more detailed architectural models can be built. The ITS Business Architecture is considered a reference architecture. The proposed ITS Business Architecture described in the report is intended to allow transport agencies and ITS–related organisations to describe and develop ITS solutions using a consistent approach and terminology.

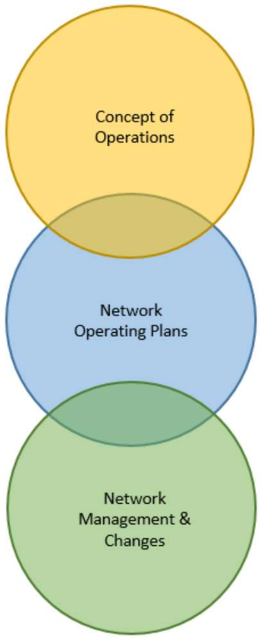
National ITS Architecture Stage 2 Module 2, Mapping Frame to TOGAF, Austroads AP-R546-17

The National ITS Architecture FRAME Content to TOGAF Mapping project was commissioned by Austroads as a key project in stage 2 of the National ITS Architecture development. The project's purpose is to map FRAME content (European ITS FRAMEwork architecture) into the National ITS Architecture (NIA) TOGAF model based on the findings of the previous NIA initial enabling work project. The Open Group Architecture Framework (TOGAF) is an industry standard enterprise architecture development methodology.

2.8.3 CORE FUNCTIONS IN CONCEPT OF OPERATIONS

Current Practice and Developments in Concept of Operations across Road Agencies in ANZ, Austroads AP-R553-17

Figure 2.24: ConOps for Network Operations



Though network operations is growing, there is a perceived disconnect between those who work at the strategic end of the process and those involved in the tactical or operational day-to-day end. Roles and responsibilities are not always clear and defined, feedback loops not always transparent, and stakeholders seem to have relatively low visibility of what goes on at each end of the process and the respective challenges faced by those people who operate the road network. A Concept of Operations (ConOps) document would bridge the gap and provide a best practice resource for all those involved in network operations planning.

The ConOps describes, in easily understood language, the characteristics of each part of the network operations planning process from the perspective of those people involved. It considers the key stakeholders associated with the road system including those who operate, use, influence, or are affected by it. The ConOps exists to ensure all modes of transport are recognised for their unique attributes and the contribution they provide through moving people and goods, and to ensure these modes operate in a complimentary fashion as far as practicable.

Figure 2.24 illustrates a high level approach for where a ConOps for Network Operations would fit within the planning, design, operation and maintenance of a road network. It is acknowledged that the development of a ConOps for each jurisdiction could look quite different due to the different roles each jurisdiction may need to perform. For this reason, the second part of the guidelines has been developed to set out principles that one would consider in the development of a ConOps rather than prescribing a detailed methodology for pulling a document together.

Concept of Operations for C-ITS Core Functions, Austroads AP-R479-15

The purpose of the project was to define the C-ITS platform core functions including their objectives and capabilities, identify user needs and describe how the system will operate. The Concept of Operations is intended to be an input to future decision making and System Engineering documents, including system requirements and design documentation. Inputs include the *Policy Framework for Intelligent Transport Systems in Australia*, the *C-ITS Strategic Plan*, the Austroads *National ITS Architecture* project (NS1696), the FRAME ITS architecture and a range of consultations and reviews.

2.8.4 ROAD OPERATIONS

Assessment of key road operator actions to support automated vehicles, Austroads AP-R543-17

To best support a wide range of AVs and their use cases, the report identified the following physical infrastructure design and maintenance elements as requiring consideration by road operators:

- **Physical attributes:** road and intersection design may need to be considered differently depending on the AV use case that may need to be supported.
- **Road pavement and structures:** consider changes to loads on bridges, pavements, and barriers, if automated heavy vehicle platoons are to be supported. Road and asset maintenance programs may also need to consider increased loads from platooning. Feedback also suggested that road condition could affect the operation of some AVs.
- **Signs and lines:** need for consistency in design, implementation and maintenance of road signs and line marking. Existing infrastructure is noted to be problematic for a number of AV manufacturers. There appear to be issues with readability of electronic signs, and therefore greater consideration of machine readability is required when designing signs.

- **Roadworks:** there is a need for consistency of traffic management treatments which vary significantly between projects and across different jurisdictions. The need for real time information about current road conditions was also highlighted (and further detailed under Digital Infrastructure).
- **AV certification:** Some agencies have mentioned their consideration of the possible need to "certify" roads as AV compliant. Another approach could be to provide some guidance or framework, outlining where certain AV use cases should or should not operate.

The report identified data management, positioning services and communication technologies as important areas to be considered. The following issues were identified that required further consideration:

- Network management approaches such as Movement and Place, and supporting tools like Network Operating Plans, may need to be reviewed and amended to ensure they appropriately consider future AV use cases.
- A range of standards, guidelines and regulations will need to be reviewed and updated to ensure the best possible outcomes in implementing AVs. These processes will support consistency of operations, which is paramount for AVs.
- Roadworks are a key aspect noted to be of particular concern to AV manufacturers and system suppliers. It is necessary to ensure that roadworks become well planned events and real time information is provided to AVs. This information should include physical changes to the road layout, which may be more complex for an AV to negotiate.

Operations of Automated Heavy Vehicles in Regional and Remote Areas, Austroads AP-R578-18

The following key forms of digital infrastructure were found to directly relevant to the effective and safe operation of AHVs, and these should be considered by road operators in their planning for AHVs:

- **Data management and access:** this refers to the data required by an AHV to operate effectively and safely. This includes not only data about the physical road environment (e.g. mapping data attributes), but also road traffic condition data, weather data, and other data required to support operation of the vehicle's systems such as software updates, security certificates, diagnostics etc. Note that this might necessarily be the responsibility of road operators.
- **Positioning services:** this refers to wireless services that enable a vehicle's driving system to know its absolute position, which it may then use to match against a map representation of the road network, and/or to fuse with relative positioning data that it receives from its on-board sensors. Absolute positioning services are commonly satellite-based services but could also include terrestrial services.
- **Communications technologies:** this refers to the use of wireless communication technologies, such as cellular, DSRC, RLAN/Wi-Fi, radio broadcast, satellite etc. This digital infrastructure may be necessary to facilitate the reception and exchange of a range of data required by AHVs.

2.8.5 CERTIFICATION AND ASSESSMENT

Development of product assessment techniques for road network devices, Austroads AP-R471-15

Operationalising Austroads' Product Acceptance Process, Austroads AP-R524-16

Harmonised ITS Technical Specification (HITS) Artefacts, Austroads IR 262-16

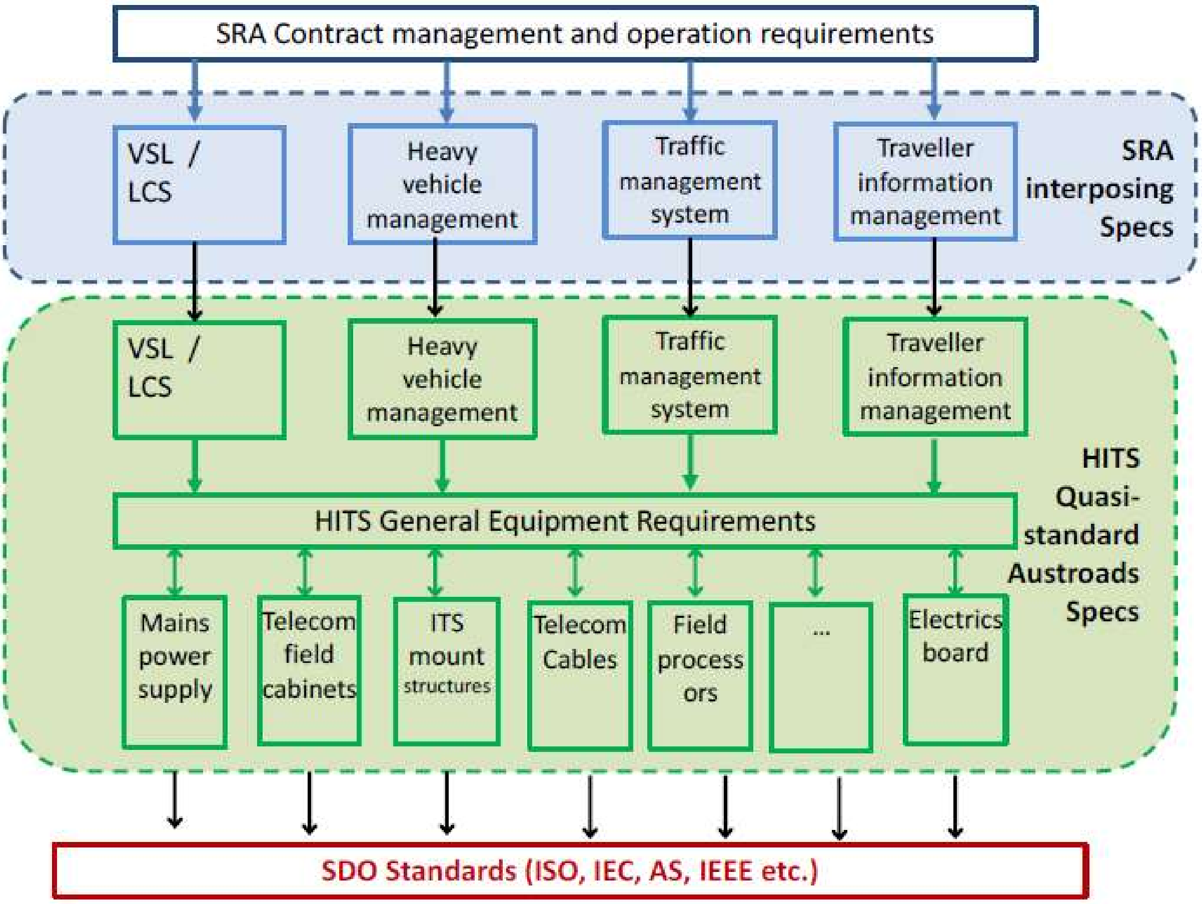
In order to realise the benefits that the national harmonisation of ITS product evaluation process could deliver, Australian road agencies have been working collaboratively to setup a national ITS product type approval process (NIPTAP).

NIPTAP was developed from three Austroads projects, NT1803 Product acceptance technique for road network devices, NS2049 Operationalising Austroads product acceptance process and NS2022 Harmonised ITS technical specifications.

The reports documented a harmonised Austroads product acceptance process for ITS products in the road network. The process covered six steps including determination of performance requirements based on agreed key performance indicators (KPIs), preliminary product assessment, desktop audit, laboratory test, field evaluation, and reporting and entering an Austroads register. The process should be transparent, rigorous, collaborative and defensible. The process is applicable to both current and emerging technologies. In due course any product that successfully passes the process conducted by a road agency would be entered into an Austroads assessed product register. Austroads would publish and maintain a list of assessed products on its website. Key players and activities included in each step of the process have been discussed and agreed to by the Austroads project team. Details of the testing regimes and results would only be shared amongst Austroads members.

The project also mapped out a pathway to the specifications becoming standards as shown in (Austroads 2016a).

Figure 2.25: HITS documents hierarchy



Intelligent Access Program – Feasibility Study, Austroads AP-R223-03

This report presented the conclusion and recommendation of the Austroads Intelligent Access Program (IAP) feasibility project. The objective of the IAP was the implementation of a voluntary system that would monitor freight vehicles using satellite-based telematic services to ensure they are complying with their agreed conditions of operation. The feasibility project identified the specific applications and assessed the IAP from a business, regulatory and technical perspective. Explicitly, IAP was about providing alternatives to better manage the existing road transport compliance task. Implicitly, IAP has potential to go beyond the transport portfolio and to government as a whole. IAP is about exploring new ways to pursue important policy issues. Consequently, the IAP would have significant influence on subsequent uses and telematics in the transport sector. The overall findings of the feasibility project were that the IAP was feasible. It was also recognised that feasibility would be reliant on a staged implementation.

Feasibility Study – Heavy Vehicle Charging in Australia, Austroads AP-R384-11

The study was to:

- Identify and analyse the critical drivers of a Mass, Distance and Location (MDL) charging scheme

- Identify and assess the feasible of MDL charging
- Identify potential models for MDL charging
- Analyse and assess these models in more detail with respect to implementation, operation, and costs and benefits.

The study did not aim to cover the design of the charging system itself, but rather focused on possible business models for road user charging. It is noted that while feasibility has been examined, a number of implementation issues required further investigation and resolution. These issues included, but were not limited to:

- The suitability of using multiple services providers for Charging Data Services (CDS)
- Billing and charging of interstate vehicle
- Implementation issues, such as development costs, charging processes, billing processes and fund distribution and timing.

2.8.6 ROAD USERS – DRIVERS

Education and training of drivers of assisted and automated vehicles, Austroads AP-R616-20

The report documented the outcomes of research designed to examine what role, if any, registration and licensing authorities should undertake to ensure that licence applicants are competent in the use of advanced driver assistance systems (ADAS; SAE Levels 0-2) and automated driving features (ADF; SAE Level 3) and determine whether there is a need to review the current driver licensing framework to address gaps (perceived or real) in driver competency when operating these systems and features.

The study concluded that registration and licensing authorities have a potential role to play in the learning and assessment of the use of ADAS/ADF by light and heavy vehicle drivers, but that there is no need to review the current driver licensing framework; however, research and crash data in relation to ADAS/ADF should be monitored to identify if future changes are justified. Options for specific learning and assessment initiatives are proposed.

Registration, licensing and CTP insurance issues associated with automated vehicles, Austroads AP-R540-17

The report considered the potential impacts on vehicle registration, driver licensing and compulsory third party (CTP) insurance arrangements that might arise from the introduction of automated vehicles (AVs) in Australia and New Zealand. The key vehicle registration issues identified revolve around vehicle standards, compliance at market entry, compliance in-service and vehicle ownership. The key driver licensing issues revolve around driver training, driver testing and licensing. For CTP insurance, the critical issues concern the impact of AVs on no-fault and at-fault schemes, the impact of no driver being in the vehicle if a crash occurs, the impact of changing vehicle ownership models, the assignment of liability, and the impact on insurance premiums and determination of risk.

The report examined the rules and processes put in place by overseas and local jurisdictions to facilitate the testing and deployment of AVs on public roads and assesses their relevance and suitability to Australia and New Zealand. It concluded that the registration and driver licensing processes examined were generally suitable for supporting trials and deployment of AVs but that some amendments would be required as we progress towards supporting market deployment. The report provided guidance to Austroads' road agency members and other key stakeholders on the changes required to support the testing of AVs on public roads in the short term and the mass-market deployment of AVs in the longer term.

2.8.7 REGULATORY - NTC

In presenting the National Transport Commission's paper on 'Land Transport Regulation 2040', Paul Retter, the NTC's CEO, stated that automation, data availability and sharing, shared mobility and consumer demand for convenience and new services will be key drivers of change over the next 20-25 years. He considered that governments need to be guided by the view that in future, 'mobility' will be seen very differently. "It will probably be seen as a market, a service and a utility. Technology will drive new and more responsive business models, and governments should encourage this innovation, while ensuring our transport systems and associated infrastructure are safe and sustainable".

Some of the related NTC work for a future transport and mobility environment are listed below.

Assurance models (NTC 2019b)

The NTC reported that in an assurance framework, responsibility for risk management is shared between the regulator and regulated parties. Assurance schemes give regulated parties options for demonstrating their capacity to comply in an alternative way to the same standard. Regulated parties can choose the option that is most suitable to their operations.

A regulator is able to hand over risk management responsibility to a regulated party because they are given assurance (confidence) in compliance capacity through the regulated party's participation in the scheme. This leads to efficiencies for both the regulator and the regulated parties because each one is able to take on the role best suited to them.

Robust governance is critical to providing confidence and trust in an assurance scheme. Auditing and role allocation have to be appropriate for the level of assurance needed.

A risk based approach to regulating heavy vehicles (NTC 2019a)

The NTC noted that a risk-based approach to regulation centres on the principle that regulation should target the more significant risks to safety. This ensures regulations are effective and efficient. Risk-based regulation is being applied across regulated sectors around the world.

The different styles of regulation can be expressed in terms of who owns the various roles of risk management.

Prescriptive regulation leaves the roles of risk identification, analysis and controls with the government (the law states exactly what you must do), with regulated parties required to apply the controls.

Performance-based regulation transfers the responsibility for the detail of the controls to the regulated parties (the law allows some flexibility), but leaves the outcomes required to be determined by government.

Principles-based regulation requires the government to set a high-level purpose, but regulated parties are charged with the entire risk management process. They will typically report to (and be audited by) governments to ensure risk management is adequate.

Safety Assurance for Automated Driving Systems Decision RIS (NTC 2018)

In this investigation, the NTC considered approaches to regulating highly automated vehicles and listed four options.

Under our current regulatory environment, there are risks when automated vehicles become ready for deployment: i) Unsafe ADSs will be deployed, (ii) A lack of consumer confidence in the safety of ADSs will reduce or delay their uptake and (iii) ADSEs will face inconsistent and/or uncertain regulatory barriers at the national and international levels when supplying ADSs to the Australian market.

These risks may need to be addressed to support the uptake and safe operation of automated vehicles on Australian roads and unlock their broader benefits.

Options to address the problem

The Regulatory Impact Statement (RIS) assesses four options to address the problem statement, which relate to the future role of the Australian Government in assuring the safety of ADSs. They are:

- Option 1: Baseline approach – Using existing legislation and regulatory instruments with no explicit safety assurance of ADSs.
- Option 2: Safety assurance system in existing frameworks – A safety assurance system based on mandatory self-certification that relies on the existing vehicle certification framework.

- Option 3: New safety assurance system – A safety assurance system based on mandatory self-certification. This would include new or amended legislation to allow for the inclusion of specific offences and compliance and enforcement options against noncompliant ADSEs.
- Option 4: New safety assurance system + primary safety duty – A safety assurance system that includes all elements of option 3, plus a primary safety duty on ADSEs to address risks not identified at first supply. The primary safety duty would place an overarching and positive general safety duty on ADSEs to ensure the safety of their ADSs so far as reasonably practicable.

2.8.8 DATA PROJECTS

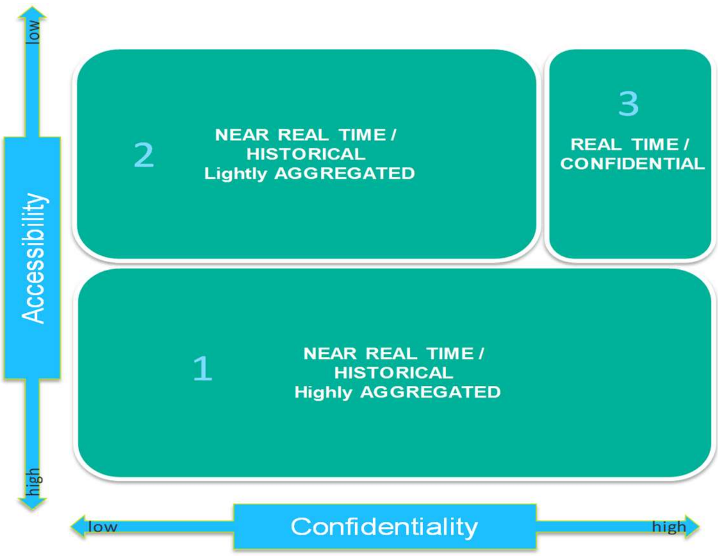
As part of the evidence base informing the development of key actions and pragmatic implementation options for better data for operations, planning and investment in transport of people and goods, ARRB (Karl & Kutadinata 2019) undertook a high level review of 52 Australian projects either in operation or in final stages of development related to transport data. See Appendix B for the 52 projects in three groups; Group 1 (Appendix B.1), Group 2 (Appendix B.2) and Group 3 (Appendix B.3).

By classifying each data project according to their data accessibility, and data confidentiality, ARRB discerned three distinct groupings:

- Group 1 - Highly aggregated freight data/information (historical or near real time); for example, road link travel times, weigh-in-motion data by axle groups and vehicle classification
- Group 2 – Lightly aggregated freight data/information (historical or near real time); for example, Bluetooth data, truck telematics data, mobile phone data at SA1 level, supply chain data along a key route
- Group 3 – Confidential freight data/information (real time); for example, identifiable compliance and enforcement data, individual supply chain data, image data, e-tag data, individual tracking data.

Figure 2.26 below sets out this classification framework. On the x-axis, the factor '*confidentiality*' runs from low (not confidential) to high (highly confidential). On the y-axis, the factor '*accessibility*' runs from high (easily obtained) to low (not easily obtained).

Figure 2.26: Data classification framework



There were 23 projects listed in Group 1 (being the single bottom quadrant), 15 projects in Group 2 (top left quadrant) and 14 projects in Group 3 (top right quadrant). Group 3 data is personally identifiable and therefore confidential to the operator or business and has highly restricted access. Group 2 has lightly aggregated data, but such data is still sensitive or confidential as it relates to commercial operations, products and $ values. Finally Group 1 data is more highly aggregated and of a less sensitive commercial value.

The common elements and differences in the groups were:

Common elements: Groups 1 and 2

Investment and planning focus – information and reports – Projects in these groups were to enable the collection, integration and presentation and dissemination of specific data/information for purposes related to planning and investment.

Larger perspective e.g. supply chains, infrastructure investment – The projects had a larger perspective or scope - e.g. national or state level, a supply chain, infrastructure access, asset pricing, platforms for exchange, aggregation of specific data and information, network performances etc.

*Products and services (*in development and mature) – The projects also include more mature data/information products and services that once started as proof of concepts and trials. In Groups 1 and 2, we can find examples where private, data lightly aggregated, is available as a service or product which is then utilised in the creation of new data/information required in addressing other data/information gaps.

Data standards / guidance / methods – In these two groups we also see projects developing standards, processes, platforms and tools for interoperability and scalability across many stakeholders.

Combining datasets to inform for information gaps – A few projects involve integration of disparate data collections which when presented together provide more insights for government and industry. Modelling, crash data, traveller information data, road use and road condition data, mass data, freight type data, congestion data and incident data are some such examples.

Proof of concepts / trials – Some projects involve real world, in field trials requiring sensors, infrastructure, collection systems and connectivity to provide the content for transformation into data and information. Some projects also work the opposite way and disseminate the information back to roadway systems, message boards and road users.

Common elements: Group 3

Group 3 data/information needs are for real-time operational needs, be it as part of the supply chain and logistics operations, or government operations in traffic management (priority, green light progression, incident management), monitoring and compliance.

Thus, some of the issues raised by industry in terms of timeliness and reliability, are key areas that can be addressed with the data and information generated from Group 3 projects. The data in Group 3 provides the feedback loop for fine tuning business and technical solutions to supply chain logistics and network operation.

A further point is that real time data/information, if stored in a data collection, can be increasingly aggregated and used by projects in Group 1 and 2.

The key observations were:

1. We should increase our knowledge of and learnings from these 52 projects and position ourselves to invest wisely in future projects.
2. There are some common functions within each of the projects which should become the key functions in the overall system for freight data/information. We need to support a national approach to strengthen the key common functions.
3. The projects can be unpacked across several layers: (i) data, (ii) platforms and technology, (iii) supply chains and (iv) issues. Therefore, the selection of specific projects for implementation can be assessed or ranked upon a selection criterion based on those elements

Subsequently, in its April 2019 budget, the Australian Government announced a commitment of $8.5m to settle the design of a national freight data hub ($5.2m) and the establishment of a freight data exchange ($3.3m). The funding includes coverage of arrangements for data collection, protection, dissemination and hosting.

Connected and Automated Vehicles (CAV) Open Data Recommendations, Austroads AP-581-18

This report laid out the strategic context for the supply of road operator data for use by CAVs in Australia. This included background research, engagement with road operators and industry, summaries of relevant Open Data policies and recommendations for next steps.

2.8.9 CONNECTED AND AUTOMATED VEHICLE TRIALS

Since the November 2015 Automated Volvo demonstration in South Australia, most jurisdictions have become actively involved in legislation and trialling of connected and automated vehicles. Both the NTC and Austroads have undertaken many projects and investigations, followed by trials across Australia. Based on ARRB's knowledge of past and current activities, Table 2-3 provides a listing of 40 CAV projects.

To the best of our knowledge, no comprehensive review of the learnings has been undertaken.

Table 2-3: CAV trials in ANZ

	State	Trial	Partners involved
1	NSW	Regional AV trial – Armidale	EasyMile
2	NSW	Regional AV trial – Coffs Harbour	EasyMile
3	NSW	Automated Vehicle Prototype	IAG, UNSW
4	NSW	Automated Shuttle Bus Trial	HMI, NRMA, Telstra, IAG and Sydney Olympic Park Authority
5	NSW	Sydney Motorways Automated Vehicle Trial	Transurban, NSW Govt
6	NSW	CITI trial - Illawarra	Centre for Road Safety, TfNSW
7	NSW	Freight Signal Priority using DSRC	TfNSW
8	NSW	AMEY Dubbo trial	Not commenced yet
9	ACT	CANdrive Driver Monitoring	ACT Govt
10	ACT	Driverless Electric Bus Trial	RACT, Navya
11	ACT	IRT Kangara Waters Retirement Village	IRT, EasyMile
12	VIC	Towards Zero CAV trial – Lexus	Toyota, Telstra
13	VIC	Towards Zero CAV trial – Bosch	Bosch
14	VIC	ITS Grants Program – AVs on Eastlink	ARRB, ConnectEast, La Trobe, VicRoads
15	VIC	ITS Grants Program – Tram Priority	ARRB, Yarra Trams, La Trobe, VicRoads
16	VIC	ITS Grants Program – Green Light Optimised Speed Advisory (GLOSA)	Intelematics, VicRoads
17	VIC	ITS Grants Program – Autonobus	ARRB, Keolis Downer, HMI, RACV, La Trobe, VicRoads
18	VIC	ITS Grants Program – AV Sign Recognition etc.	Transurban, VicRoads
19	VIC	Highly Automated Driving Vehicle	TAC, VicRoads, Bosch
20	VIC	AIMES test bed	Uni of Melbourne
21	VIC	Monash Uni Shuttle	EasyMile, Monash
22	NT	Driverless Shuttle Trial	EasyMile
23	QLD	Driverless Shuttlebus Trial	EasyMile, Transdev
24	QLD	RACQ Smart Shuttle Trial	RACQ, EasyMIle
25	QLD	Cooperative and Automated Vehicle Initiative (CAVI) – Ipswich Connected Vehicle (ICV) Pilot	DTMR, QUT
26	QLD	CAVI – Vulnerable Road User (VRU) Pilot	DTMR, QUT, iMOVE
27	QLD	CAVI – Connected and High Automated Driving (CHAD) Pilot	DTMR, Bosch
28	SA	Flinders Express (FLEX)	Navya, Flinders University

	State	Trial	Partners involved
29	SA	Driverless shuttle and interactive transportable bus stop	SAGE
30	SA	FMLF Tonsley Cargo Trial	Aurrigo, Flinders University
31	SA	Port Elliot retirement village	Aurrigo, Lendlease
32	SA	Playford Connect	EasyMile, City of Playford
33	SA	Holdfast Bay Olli Trial	Local Motors, SAGE
34	SA	Renmark 'Murray'	EasyMile, SAGE
35	SA	Automated Vehicle and CITS	Cohda
36	WA	Curtin Driverless Bus Trial	Curtin University, Easy Mile
37	WA	RAC Electric Shuttle	RAC, Navya
38	WA	UWA Open Day	UWA, EasyMile
39	WA	Intellicar Autonoms Trial	Navya, RAC
40	NZ	Driverless Shuttle Bus Trial	HMI (Ohmio), Christchurch Airport

2.8.10 COMPLIANCE AND ENFORCEMENT

C-ITS Compliance Assessment Framework for Australia and New Zealand, Austroads AP-R585-18

This report describes a compliance assessment framework (CAF) model for cooperative intelligent transport systems (C-ITS) for Australia and New Zealand, covering key literature and stakeholder consultations. The options set out for CAF cover status quo, self-regulation, quasi-regulation and regulation. Recommendations to further develop and implement an ANZ C-ITS CAF are provided.

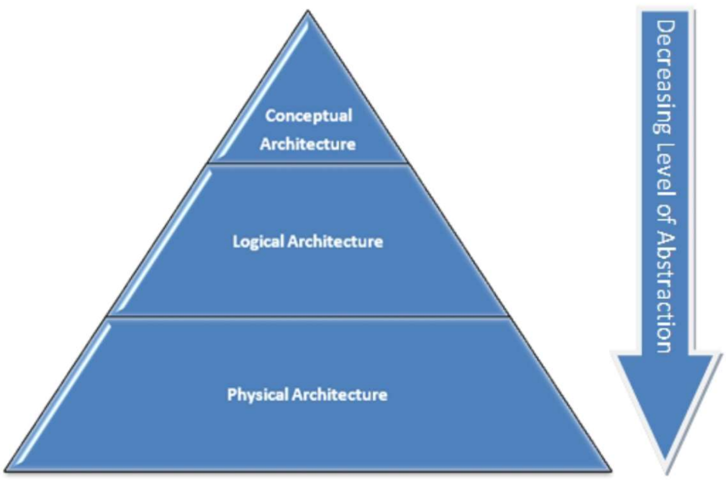
2.9 STANDARDS

Standards enable and provide society with efficient ways to get work done while maintaining the safety of producers who create and provide goods and services, as well as the end-users receiving the benefits from these goods and services. Standards boost productivity, improve performance and help organisations by removing technical barriers to trade, improves consumer and business protection, creating regulatory support and manages organisational risk.

2.9.1 SYSTEMS ARCHITECTURE

A typical systems architecture provides three views at decreasing levels of abstraction as shown in Figure 2.27 (Austroads 2014a).

Figure 2.27: Systems engineering architecture



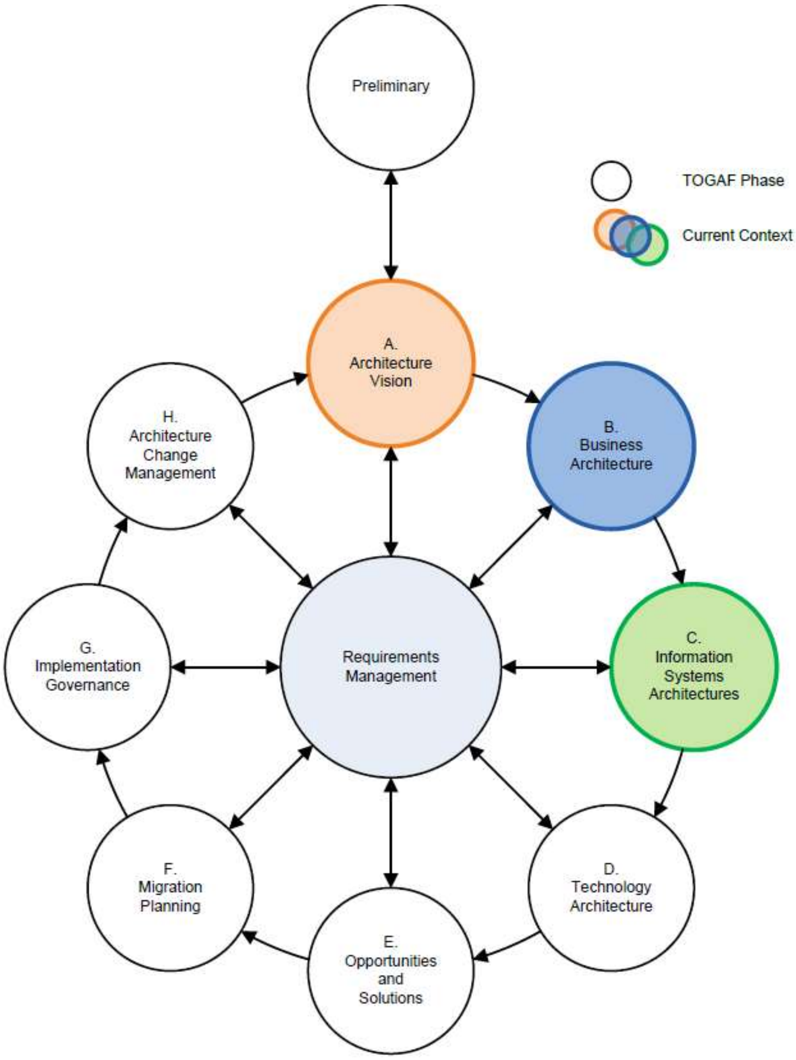
The three layers are the conceptual, logical and physical architecture. The conceptual layer is a highly abstracted view of the system with the most significant components or entities. The conceptual view provides a high level understanding of the system's purpose or objective which should be clear and concise, thereby supporting communication and comparison with other concepts.

The logical layer is more detailed and incorporates all the major system components or entities and the relationships that exist between them. The purpose of the logical architecture is to ensure that all the components are captured and described, that the relationships between the components are specified and that the information that will be exchanged between components is detailed.

Finally, the physical layer is the most detailed and provides the detailed specifications required to build and implement the system.

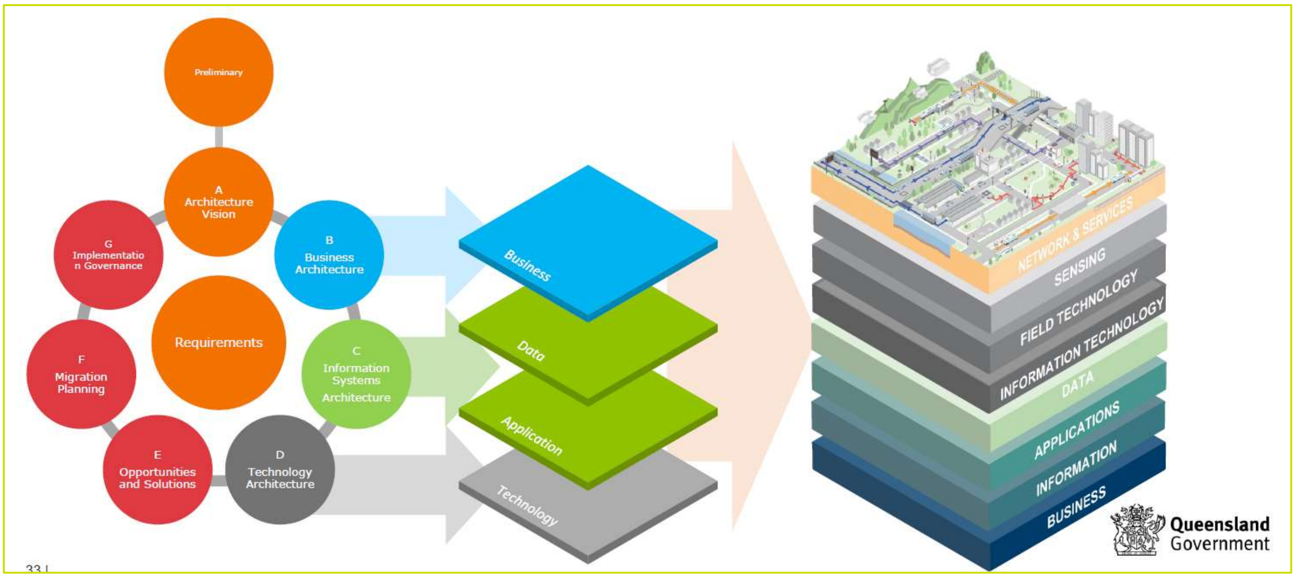
The Australian National ITS Architecture (NIA) has adopted The Open Group Architecture Framework (TOGAF) as its base (Austroads 2016b). The architectural development methodology for TOGAF is outlined in Figure 2.28 (Austroads 2017a). It steps through a process which starts with an architectural vision (A) followed by the business architecture (B), information systems architectures (C), technology architecture (D) and so on.

Figure 2.28: TOGAF architecture development method



The alignment of the National ITS Architecture can be seen with the Queensland Transport Technology Framework as shown in Figure 2.29 (TMR 2019a). The layered QLTTF contain business, data, application and technology layers that align with the TOGAF architecture development method.

Figure 2.29: Alignment between NIA and QLTTF



2.9.2 CONCEPT OF OPERATIONS

Concept of operations for transport and mobility

The Concept of Operations or ConOps brings all relevant stakeholders together to set the aspirational vision of the road system, agree on guiding principles, and establish a roadmap to classifying and operating the road network (Austroads 2017b). It is used to gain stakeholders agreement and understanding as well as to clarify their respective roles. The ConOps sets the intent and the footing for the key building blocks of the road system's operation.

The process in developing the ConOps gives the coordinating jurisdictions and stakeholders a shared platform to describe their proposed method of operation and desired experience from the viewpoint of their customers. Ultimately, through this process a unified methodology should drive action for all stakeholders, acting as a benchmark for people involved in the operation of the road network.

The ConOps is a catalyst to identify what steps, engagement and investment will be necessary to turn operational concepts and strategic intent from paper to reality. The process highlights, at the outset, the key questions and issues that need to be overcome and the next steps required to develop the concepts further. The challenges, constraints and next steps should be included as part of a research, development and implementation roadmap for the next phase of operational planning. It can be a springboard for further exploration of ideas and to exploit the continued emergence of new technologies and innovations.

All senior stakeholders need to come together to encourage a customer-led approach, challenge old ways of thinking and avoid organisational silos. There is a need for all people involved in operating the road network to work in close collaboration, facilitate open workshops and carry out intensive stakeholder interviews to generate the mix of principles, standards and ideas, and be cognisant of all strategies associated with the road network.

Setting a formal structure and method to the process is critical. This ensures the management and working groups are in place, demanding a high level of participation and commitment from key decision makers and operational experts. It provides the forum to set the agenda, make key decisions and build engagement across the management teams.

Concept of operations for systems

A 'Concept of Operations' is a user-oriented document that describes system characteristics for a proposed system from the users' viewpoint (Austroads 2015). This describes stakeholders, their roles and responsibilities, an overview of the emerging system design, a high-level description of how the system will operate, and it should highlight identified issues with the operational framework that will need to be addressed.

The Concept of Operations is part of the initial phase of the Systems Engineering process and includes:

- an overview of the existing ITS system
- a justification for a C-ITS core
- a description of the proposed core functions
- the system's stakeholders, their roles and responsibilities.

This lays the foundations for the system requirements for the core functions and consequently the high-level and detailed design. It defines the boundaries of these systems and provides an understanding of who the stakeholders are and identifies their needs.

For example, in work undertaken by ARRB on freight data, it was identified that there are similar core functions in data and governance, hosting and dissemination that presented in business areas such as freight and logistics, traffic management, and connected and automated vehicles (Karl and Brannigan 2019) as shown in Figure 2.30.

Figure 2.30: Core functions in transport services

2.9.3 MOBILITY INTEGRATION

Mobility will be the biggest driver of economies in the next decade. Innovative mobility services are expanding travel choices and are being widely embraced by millions of drivers. Shared mobility services have the potential to change our long-term travel patterns. However, providing mobility as a service is never easy for any single player as mobility needs to combine everything from public transport, car ownership, rental and sharing to payment flexibility, system interoperability, public security, disparity between access for users with disabilities and other travellers etc. Increasingly, players in the private sector are keen to work with governments and become more involved in policy, standards and regulation processes.

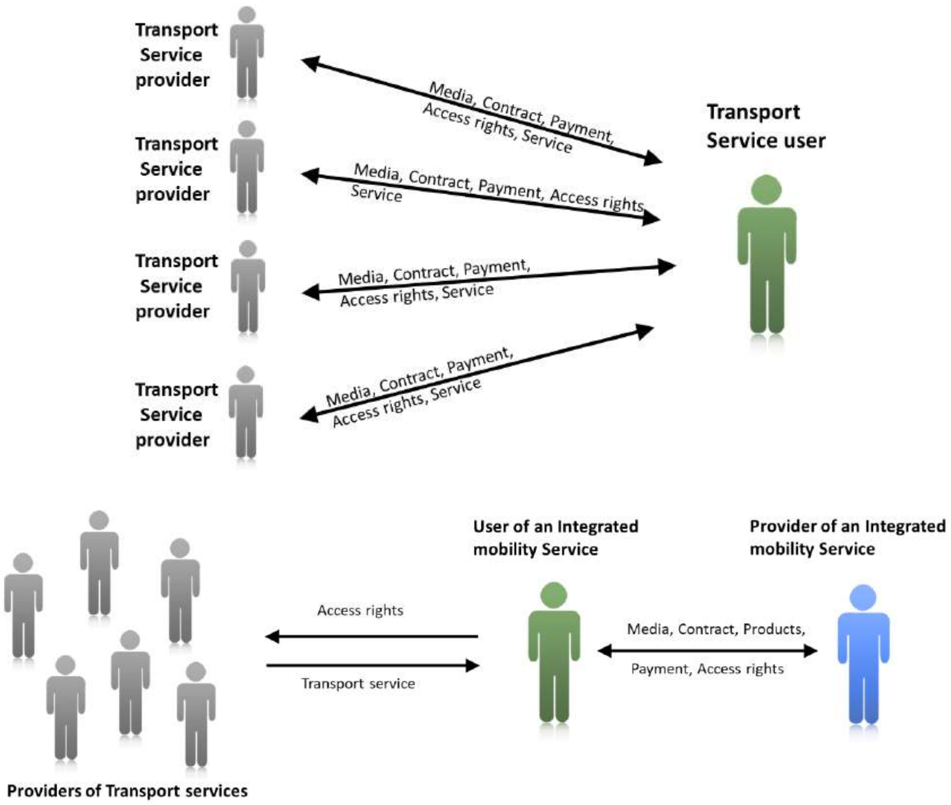
The travel of a person or goods often uses a range of transport services from differerent providers in the one trip. For example, a traveller going to work may drive to a nearby train station, take the train to a bus stop, from which they will make the last trip by bus to the office. This chain of transport services requires different explicit or implict contracts between the traveller and providers, different media having access rights to the service, as well as different payment methods.

Following the completion of standards development for 5.9GHz C-ITS in 2016, the European Union began to initite a new suite of standardisation activities in urban ITS, specificlly traffic management, traveller information and freight and logistics. This was renamed to Integrated Mobility in 2018, and in the same year a joint working group of CEN TC278 (WG17) and ISO TC204 (WG19) was established to co-ordinate EU standardisation with ISO standardisation. Among the work items, two deliverables of relevance are (i) ISO TR 4447 Integrated Mobility Concept and (ii) ISO TR 4445 Role Model of ITS Service Application.

The main goal of integrated mobility is to have seamless, optimised and efficient transport of people and freight from A to B in a multimodal and multi-service provider environment. This may be achieved by the person or goods sender having one contract, one payment entity, one or a limited number of medium carrying access rights (e.g. smartphone, wireless smartcards), possibly one app to plan and book the service, all which bundles the requested transport services under an entity.

The CEN/ISO Intergrated Mobility Service Concept is shown in Figure 2.31 (ISO TR 4447) depicting the relationships and key functions between users and the service providers.

Figure 2.31: One to many relationships in an integrated mobility service, and its simplification



The integrated mobility service builds on and is dependent on other services as in Figure 2.32.

Figure 2.32: Main services in an integrated mobility service

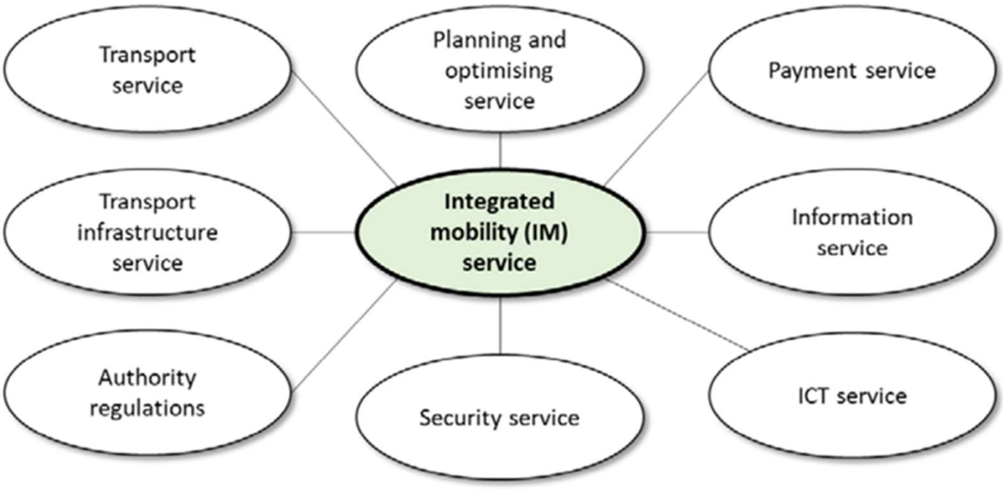


Table 2-4 details the range of integrated mobility services together with their roles and functions. This table was developed out of ISO TR 4447 which was only released as a working draft (i.e. the first daft) on 2 April 2020. There are still many parts that are still be to be completed and it is only now going to circulation to the wider community of international experts.

Table 2-4: Integrated mobility services, roles and functions

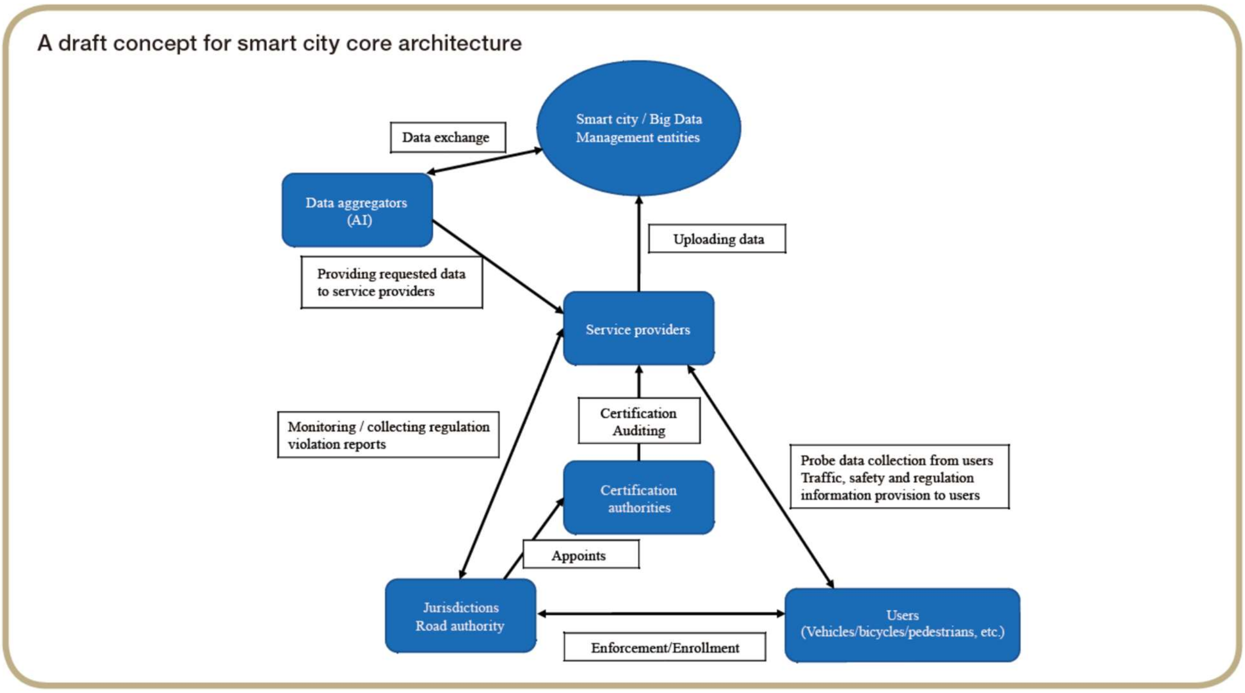
Service	Description	Roles	Functions
Transport service	The core service in integrated mobility; the mode / means of transporting a person or goods from A to B. e.g. car, truck, bicycle, tram, train, ship, plane	• Develop and optimise transport services based on user preferences • Offer and provide transport services to the IM service provider and user • Manage, execute and monitor required transport operations • Acquire and manage a fleet of transport means • Collect and manage information related to the provision, availability, reliability and quality of the transport services • Implement reporting and security framework specified by regulators and Security service	• Develop and offer transport services • Validate IM service user access rights • Send claim on provided IM service • Manage and monitor transport service provision • Collect and manage information on transport service provision • Report to authorities
Planning and optimising service	A set of alternative integrated mobility services from which a user chooses based on price, comfort, travel time and route, transport mode and means, sustainability etc. which is then booked, and the service is given	• Develop a model for optimisation of the IM services based on availability and user preferences • Receive user requests for the IM services • Collect information on transport service and infrastructure statuses • Prepare and present alternative IM services to user to choose and book • Implement security framework specified by the Security service	• Develop and maintain a model for optimisation of the IM service • Plan and optimise IM service alternatives • Prepare and present a set of relevant and alternative IM services
Payment service	Enables payment of the service when booked	• Offer online services for accepting electronic payments with a variety of payment methods • Enable the user to pay at specific times (see left) • Receive claims from the IM service providers for IM services sold or used • Check and pay claims from IM service providers	To be developed
Transport infrastructure service	The provision of a safe, secure, available and effective transport infrastructure with the necessary quality and maintenance e.g. traffic management of cars in a city	• Plan, build and maintain the transport infrastructure, including road networks, terminals etc. • Manage infrastructure to provide optimal utilisation of capacity and avoid overloading • Provide status information to stakeholders e.g. users and service providers • Implement security	To be developed
Information service	Collection of information, information management and information distribution to other core services that are dependent on	• Collect, manage and distribute relevant / required information • Implement security	To be developed

Service	Description	Roles	Functions
	this for their own processes e.g. public transport service information provided by the operators		
Information and communication (ICT) service	The provision and operation of equipment needed for secure storage and transfer of information across the other different services	• Establish, maintain, operate and manage secure communication networks (wireless or wire/fibre based) and information storage e.g. secure cloud-based services • Implement security	To be developed
Security service	Supports the security requirements of the IM service system, consisting of many integrated ICT systems with valuable and sensitive information	• Develop a security policy and framework aligned with regulations • Manage, operate and monitor implementation of policy • Issue security certificates if and when required	To be developed
Authority regulations	Not a service, but defining the regulatory framework for the integrated mobility service, which may come from national or city laws / regulations from government or transport bodies	• Develop and publish laws, regulations and guidelines • Monitor provision and compliance with above • Enforce any lack of compliance	To be developed

Source: ISO TR4447:2020

ISO TR 4445 further define the role models for ITS service applications and as an example, depict a draft roles and responsibilities model for smart cities as shown in Figure 2.33. In this example, service providers operate in a system wherein there are certification authorities as well as regulatory authorities (the jurisdictions) and the service providers access the available services (cars, trucks, buses, trains, etc. as well as transport infrastructures, road, rail, etc.) in order to meet the mobility requirements of their customers.

Figure 2.33: Roles and responsibilities in Integrated mobility services (ISO TR 4445)



3 STAKEHOLDER CONSULTATIONS

A total of ten consultations were held by a combination of face to face meetings and teleconferences during February to March 2020 as shown in Table 3-1. Each engagement took approximately 60 minutes following a series of open ended questions related to the respondent's view of the current state of the environment and of the future transport and mobility environment. Prior to the interviews, each respondent has received communications regarding the study, its scope and objectives and the study's purpose and context was also clarified to the respondent at the commencement of each engagement.

Table 3-1: Stakeholder consultations

	Respondent	Organisation	Date
1	A	National Agency 1	Feb-14
2	B	Industry	Feb-19
3	C	Industry Association President & Australian HOD to ISO TC204	Feb-24
4	C	State Agency 1	Feb-25
5	E	State Agency 2	Feb-26
6	F	State Agency 3	Mar-2
7	G	State Agency 4	Mar-2
8	H	Academic	Mar-3
9	I	National Agency 2	Mar-12
10	J	State Agency 5	Mar-12

The key areas raised in the interviews are listed in the section below together with a section that draws the comments together into several general themes.

3.1 KEY AREAS MENTIONED IN STAKEHOLDER ENGAGEMENT

The comments from respondents are referenced in parentheses.

1. Vision
    a. Defining a vision is missing (A)
    b. In transport, we are not talking the same language, the same outcomes (H)
    c. There is no unified vision, it is evolving. It will be nice to define an encompassing vision, which will be most relevant to commuter transport (E)
    d. We need to have a vision for both the urban and regional context (E)
    e. Vision for a future transport and mobility environment is more on the political side. It's about jobs creation, different industries, different transport projects (F)
    f. Need to have a National Vision, targets, objectives for the next 5 years and then you will have buy in from everyone. We need an idea and a roadmap. (F)
    g. Media is key. They are a critical player and it shapes up the vision of politicians and governments. Political parties will pick it up (F)

h. Forest used to be “Road Agencies”, now forest has changed to “Transport”. Only one member is a Road Agency, all other members are now Transport Agencies (A). This arose in discussion about not seeing the forest for the trees.
i. You need to start wearing new glasses, to see new ways through the architecture (A)
j. Need to develop a holistic view horizontally (across the silos), a view which is strengthened through the trials underway across jurisdictions (B)
k. Future mobility is quite fragmented, there is a policy vs operational gulf (D)
l. Our Agency is thinking of a virtual TMC living in the cloud. The days of dedicated facilities are coming to an end (D)
m. It’s the same everywhere in the world, unless you go to China and build a new city from scratch (H)

2. <u>Leadership</u>
   a. It needs to be led by example (A)
   b. Where do we start? We have an ITS Committee but what is needed is a whole-of-Government approach (F)
   c. Unless there is a specific agenda item in which this work can be delivered into, it will not happen. At our level in the office we are uncertain how to raise this and progress further. (F)
   d. ITS type approvals, signs, line makings all need to have ‘actions’ to be able to make further progress. When it is subjective, people keep going round and round (F)
   e. There is a lack of good resources – good people drained out of governments. Don’t have the understanding. Provide the infrastructure framework – that’s their job (H)
   f. In Singapore, the Land Transport Authority works closely with Universities. It’s the same in the US, Germany and Japan – people from government work closely with universities (H)
3. <u>Busy with day to day workloads</u>
   a. Agencies know how to deliver infrastructure. They are good at planning, design, construct and deliver (A)
   b. Solutions is to just deploy ITS applications on road management and for safety, which doesn’t affect other parts. Guys on traffic team are already busy on day to day tasks and not keen to add new work load (F)
   c. Everything in transport is incremental. Stick with what you have! Going for something new is difficult (H)
4. <u>New challenges</u>
   a. Talking about the problem is easy, coming up with the solution is the problem (C)
   b. Agencies find it difficult to understand how technologies, people, processes and data work together to deliver an outcome (A)
   c. Because they have always done it ‘that way’, it is difficult to bring change, it needs to be from the top (A), main inhibitor is the organisation (B)
   d. There is a strong dimension in multi-modal transport (A)
   e. Protocols between states, it took us over 3 years in the journey (I)
   f. MaaS raises new possibilities to control the road. We provide the infrastructure pipe, we control the pipe, we sell the bandwidth. We need new algorithms and we have missing information such as risks, UBERS and other movements on the road (D)

g. Industry and technology vendors are not mature in the transport sector. Kapsch, QFree and Siemens, CISCO, Amazon, Microsoft all sell their technology and systems. Telcos and Cubic are new entrants, toll operators buy 'things' don't have it in-house. These are the new players in Future Transport and Mobility Environment (H)

h. The 'glue' that keeps it together (i.e., ITS) is challenging. Then C-ITS is even more challenging because of the scale. (H)

i. SCATS was always thinking local instead of global, linking 2-3 sets of intersections then expand for the corridor. Now we need to think more holistically across all modes (C)

j. An interdepartmental point of view, top down driven is helpful, e.g., from a DoT, while a Road agency or a PT Agency view is usually limited (B)

k. We still have a state by state approach, eg type approvals are required for each state (line markings, ITS devices, signs, sensors, etc). When push comes to shove it isn't done. Lack of agreement by CEs, Ministers (C).

l. AIMES focusses on the foundation, like the mobile phone, not on the apps or services the mobile phone can deliver (H)

m. Tough to lobby from officer's side. Easier from public side to get approval. (F)

n. How do we bring all these initiative into one common vision? (E)

5. <u>Architecture</u>

a. Need to start from the ITS point of view – a systems engineering approach, enterprise architecture, roles and responsibilities, concept of operations (A)

b. We should use the UMTC standards based approach (as in the UK). There is a standard committee and data objects are clearly defined (D)

c. Core elements must be identified, Reference architecture (technology, people, data, processes), Business Cases clarified (A)

d. We need a layer approach to simplify (B)

e. The front ends and the back ends are different in future transport and mobility (D)

f. ISO is thinking of a sub-committee structure (to combine some Working Groups in a layer grouping) rather than have each Working Group do its own thing (C)

g. We already have a logical architecture for our data (I)

6. <u>We have the capability</u>

a. NTC AV reforms, data governance and in-vehicle safety are all happening. There are a lot of elements of work that are already occurring (G), but still a lot unknown, no fully integrated MaaS platform (G)

b. There is technical expertise, but we need to set the framework (D)

c. With the recent bushfires, there was a need to set up a standard for jurisdictions to report bushfires and it was done quickly with support by all (D)

d. We were able to plan and deliver a whole set of new guidelines and roll out the temporary traffic management guidelines and training within 2 years with the strong support of all jurisdictions (A).

e. Reforms like the National Temporary Traffic Management, training, deployment, guides, education of sub-contractors, launch of the Guides is a good example of capability. Work of Temporary Traffic management didn't go back to the department but done at a national level on an 'emergency/urgent' status. (F)

f. There is a digitisation of transport assets and customer base underway, e.g., ICMP (integrated congestion management plan), TfNSW digital platform. At the bottom layer, there are many projects seeking to digitise road assets, customer journeys, even in real time (B)

g. Only way to achieve progress is to show the value and benefit. Start with a like minded group (n.g., bus agency), then try trains etc. (B)

7. Testing sites

   a. In medical science, they are able to advance fast because there is an eco-system from laboratory to animals to humans and then product. We don't have these things in transport where we can try our own things and products (H)

   b. The key elements in AIMES are the data (fast and slow data exchanges), the operational safety and congestion management. (H)

   c. It took two years of talking to get AIMES up and running as a test site, Companies develop and come back to refine (H)

   d. Key elements are: security, digitisation of physical infrastructure, high definition maps, data needs, match the protocols (eg road works) (J)

8. Data

   a. Structure the data so that you can use it (D)

   b. What are the data you have that will give you the outcomes you want? Data exchange/data hub supporting fast and slow data is good for operations and safety (H)

   c. MaaS is based on the understanding that data needs to be shared. Otherwise no MaaS! (H)

   d. The broadcast data from the Central ITS facility could support a range of cases; probe data, signal demand requests, can be used for HVs, dynamic route information and personal mobile devices (J)

9. Supporting infrastructure

   a. We need to have supporting infrastructure in place such as the ConOps, Bluetooth, using Big data, using NIAF (National ITS Architecture Framework) (E)

   b. How does the data infrastructure support outcomes, needs to be clear (I)

   c. At some stage, we have to stop building roads so that it creates a market for the compelling case for deployment of ITS (F)

   d. We have paid a high level of attention to infrastructure, but what are we to do now? Is it going to be a free for all, how do we manage for safety and what will be the future infrastructure investment? (G)

   e. Start with the fundamentals, the things that are needed. For example, detectors technology – what is the best architecture to support it, CITS needs cellular, fibre of C-ITS. (H).

   f. Soft infrastructure is key. What data, where it comes from. A fair and equitable playground, competition law, all these factors need to be taken into account in the future environment (H)

   g. In the context of the billions of dollars spent on roads and infrastructure, support for CITS is not a MASSIVE investment but a MASSIVE mind shift! (H)

   h. You need the system to educate people, I see CISCO going to talk to Transdev and facilitate progress (H)

   i. Another key element is the need for a System Manager. The System Manager has three roles – Regulatory, operational and infrastructural (I)

j. In the future environment all organisations are actors. But the BACK END is TMR's IP. The Central ITS facility owned by TMR is for TMR's benefit in delivering safety and productivity (J)

3.2 COMMON THEMES ARISING

The main categories of the comments from the stakeholder engagements are in the areas of vision, leadership, busy with day to day work loads, new challenges, architectures, we have the capabilities, testing sites and supporting infrastructure.

It is always more powerful to engage with experienced practitioners who are able to express the challenges, issues and experiences in their own words. While the comments in the previous section obviously cover a lot of ground across the entire transport and mobility environment, it is evident to the reader that there are some common themes of importance to this paper.

1. Firstly, there is clearly a need of a fresh vision of the Future Transport and Mobility Environment (FMTE) which will enable a realignment of the goals and objectives of jurisdictions.
2. There is also a need for leadership to both develop this vision and then to develop the logical and physical layers.
3. It is recognised that most agencies are already busy with day-to-day work pressures and sufficient resources should be allocated to this task.
4. There are several challenges in the Future Transport and Mobility Environment,
    a. but we have the capabilities, having worked on similar projects in the past and already have some of the answers, structures, approaches and frameworks
    b. and we also have accumulated expertise and built our knowledge in many trials and tests both in the past and in those underway in a number of jurisdictions, so we will not need to be recreating the wheel
    c. and we have also made progress in the supporting infrastructure of the FTME, in terms of the soft infrastructure as well as the central and communications infrastructure.
5. We have a strong team in architecture and are progressed with the National ITS Architecture and have developed regulatory and operational frameworks in a number of transport domains, traffic management, freight and logistics, CAVs, MaaS, digital platforms etc. which can be further streamlined into the logical and physical layers that will support all these domains.

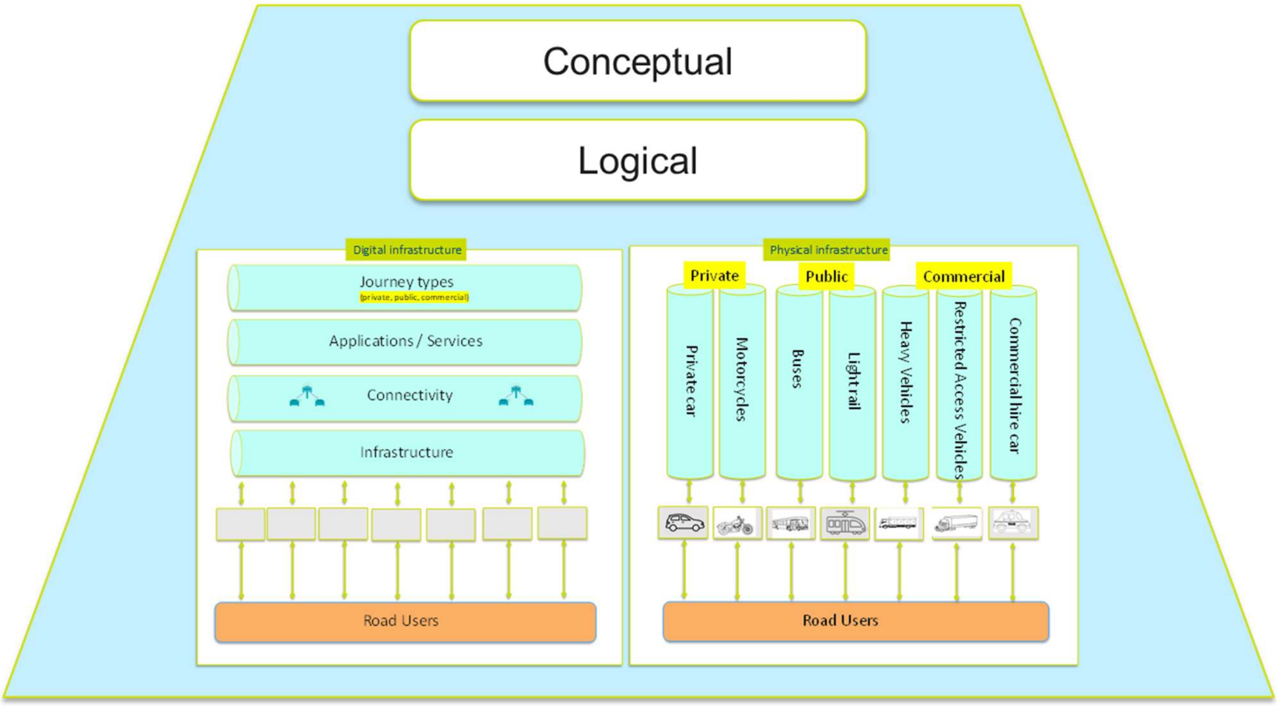
4 ARCHITECTURE

This section will describe the different depictions of a conceptual architecture for FTME and recommend a conceptual architecture for consideration.

4.1 CURRENT STATUS

In recent years, the focus of the transport community has shifted to mobility integration i.e. to create a seamless, multi-modal mobility service. For instance, the increasing trend in MaaS demonstrated the importance of this seamlessness in servicing people's journeys. The concept of mobility breaks the boundaries of the traditional transport business, which was often siloed (as illustrated in the "Physical Infrastructure" diagram in Figure 4.1). The rapid development in the IT field has disrupted this siloed approach and provided a more "horizontal" perspective (as illustrated in "Digital Infrastructure"). In order to provide the integration, there is a need for an overarching "conceptual" and "logical" architecture to ensure a holistic approach.

Figure 4.1: Hierarchy of transport management

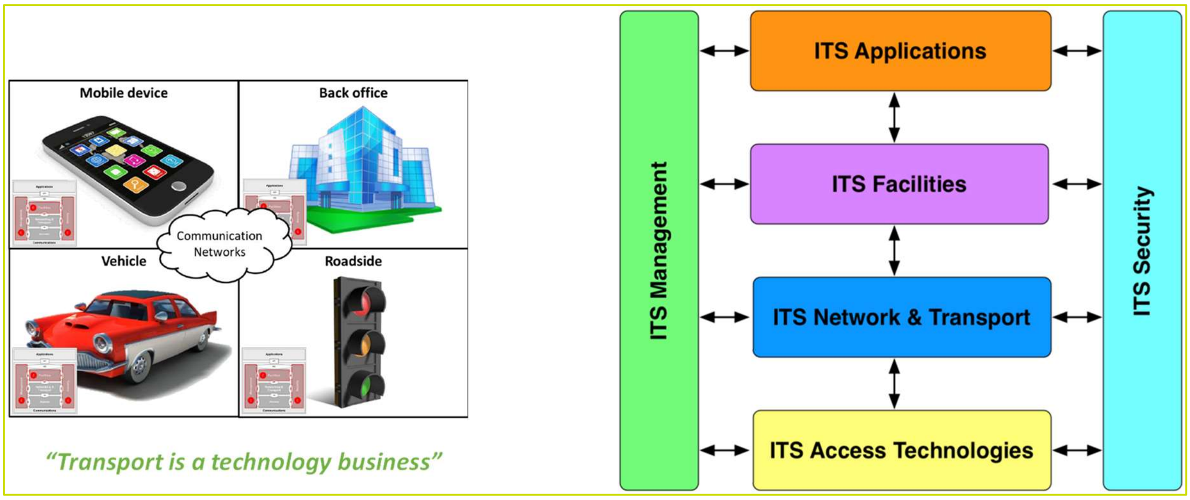


The conceptual architecture is technology-agnostic, describing the working concepts of the future transport management environment (akin to a Concept of Operations). The main challenge is to design a conceptual architecture that is intended to be based upon a future vision, rather than being shaped by current state thinking and solutions (i.e. future-proof). The future transport and mobility environment operates as a system that includes elements of technology, information, processes and infrastructure enabling the safe and secure movements of people and freight all across Australia.

Many Australian states and territories and cities around the world are actively seeking out new technology, applications, systems and capability to address the current and future transport and mobility challenges. A clear conceptual architecture will provide the catalyst for engagement, in collaboration with other willing participants from interstate transport jurisdictions, in working towards a national outcome.

In seeking a conceptual model, and as many assert that transport is a technology business, it is reasonable to draw some parallels with technology architectures, especially the ITS station architecture as shown in Figure 4.2, noting that the ITS station architecture is itself based on the earlier OSI stack developed by ISO in the 1980s for computer technologies.

Figure 4.2: Transport is a technology business



It can also be noted that similar concepts are well used in many domains in transport and mobility and the figures below provide some evidence of the similarities.

The examples provided in the following figures are from:

1. *The Internet* – Figure 4.3 shows the Internet of Things World Forum's reference model in layers beginning with the physical layers at the bottom through to the communications, data, applications and logical processes and collaboration functions.
2. *IT Hardware and Software supplier* – Figure 4.4 shows the CISCO Australian and New Zealand Transportation Stack for Transportation (CISCO 2018) which was developed though a number of projects with various jurisdictions.
3. *Freight and Logistics data* – Figure 4.5 shows the architecture for European logistics information exchange developed under the AEOLIX program (AEOLIX 2019).
4. *Automotive manufacturer* – Figure 4.6 depicts the Toyota Mobility Services Platform where Toyota plays the role of the integrated mobility service provider for its customers.
5. *Testbed* – Figure 4.7 shows the architecture for AIMES, the Australian Integrated Multimodal EcoSystem at the University of Melbourne, starting from the physical layers at the bottom and through to the data exchange and data services layers to its collaborators and customers (Sarvi 2019).
6. *Government* – Figure 4.8 and Figure 4.9 shows the NHVR's Network Architecture and Enterprise Information Management Framework. In its efforts over the last five years to deal with a greater degree of online data both from jurisdictions and industry, the NHVR has pioneered the use of a conceptual framework to build its operational and supporting physical layers for data and information (NHVR 2017). The NHVR has a clear view of the types of data and where it gets its data from and how and where it uses the data that is available to it as shown in Figure 4.10.
7. *Government* – Figure 4.11 depicts the Queensland Mobility Framework and the various business, data, applications and technology areas described earlier in this paper.

Figure 4.3: IoT World Forum Reference Model

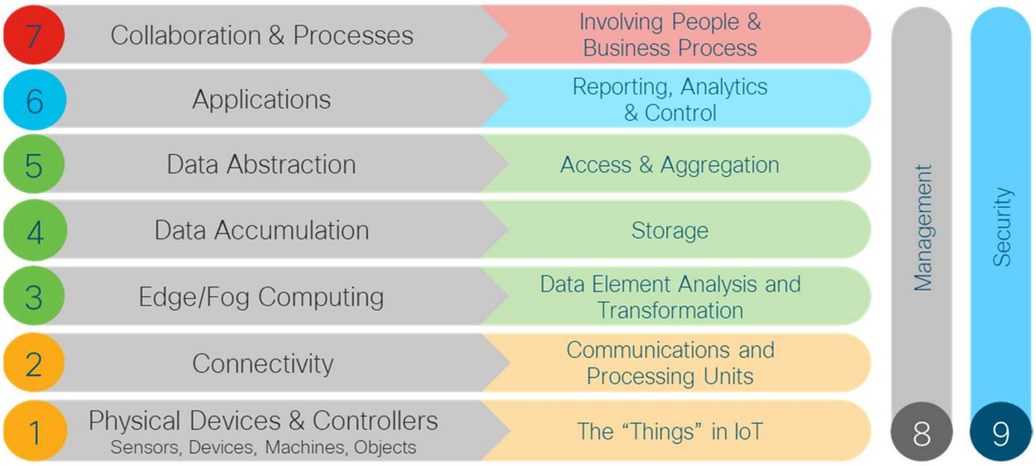


Figure 4.4: ANZ Transportation Stack (CISCO)

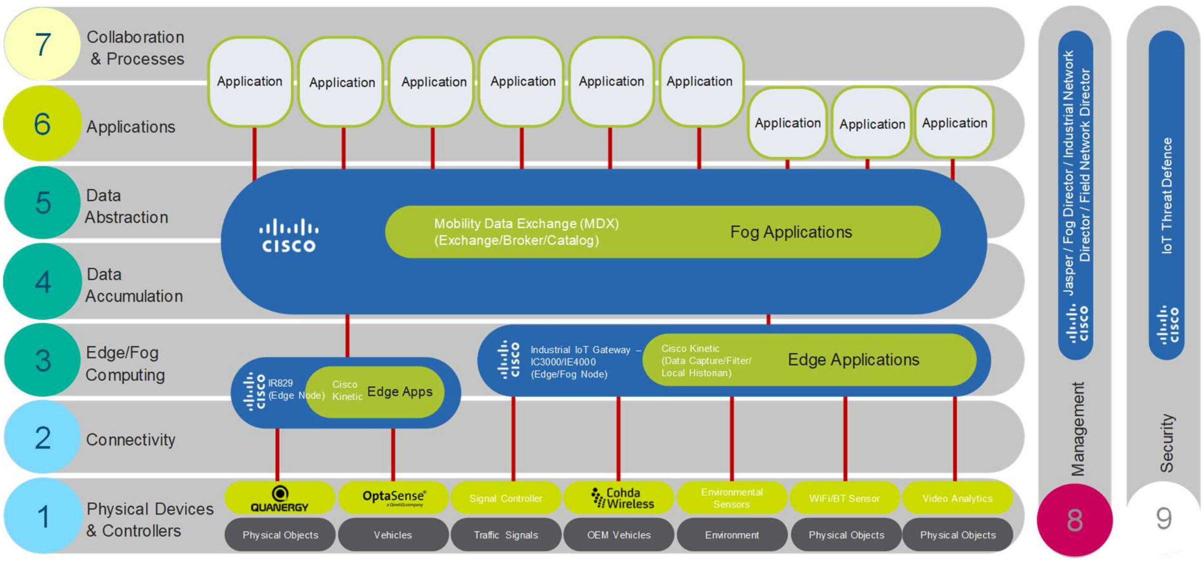


Figure 4.5: AEOLIX platform view for freight data

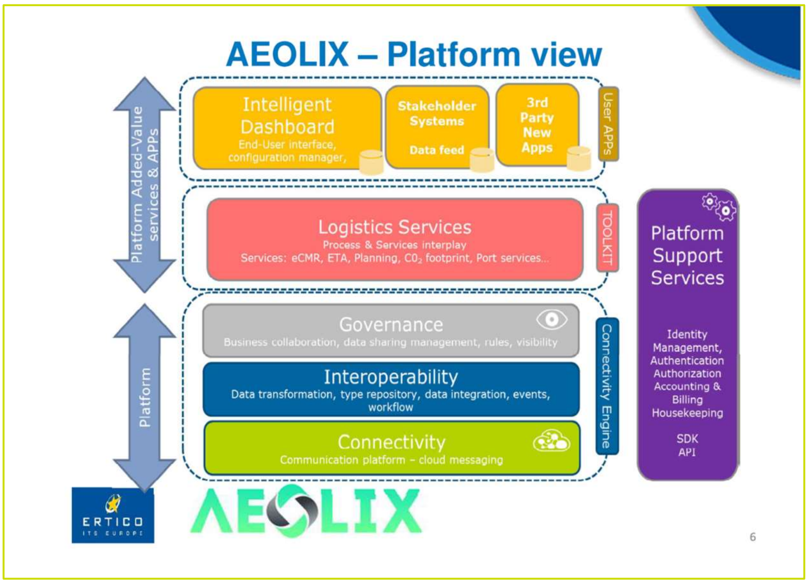


Figure 4.6: Toyota Mobility Services Platform

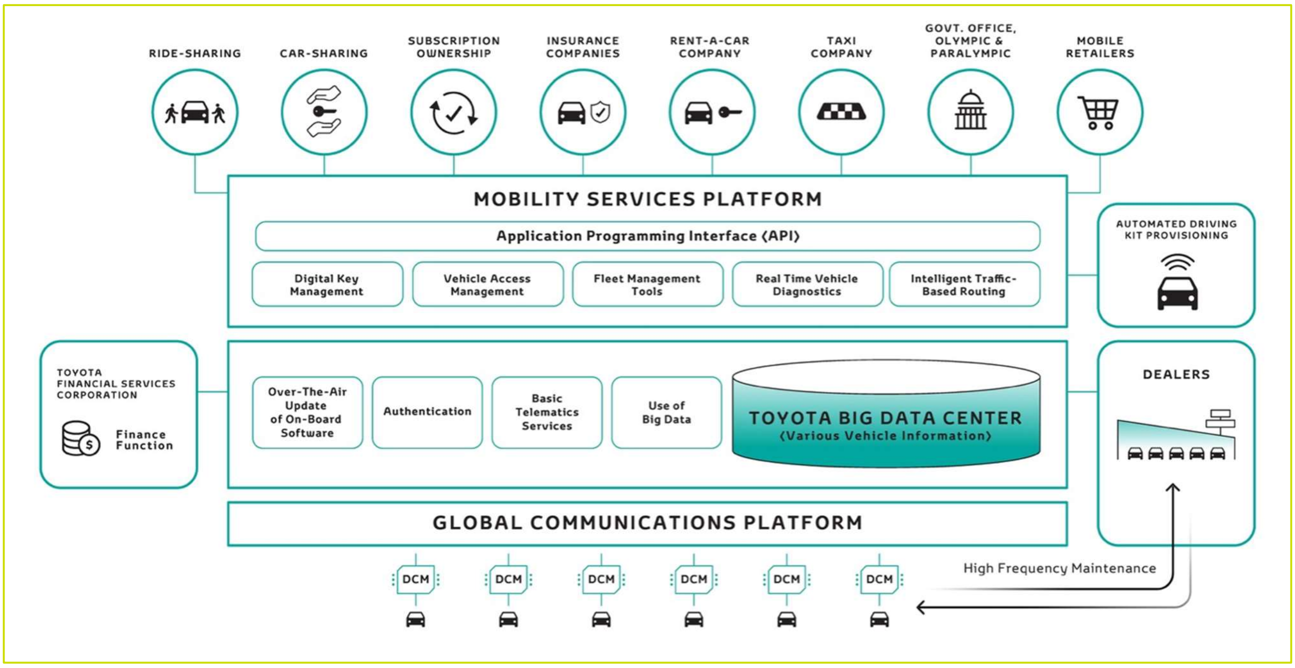


Figure 4.7: AIMES architecture

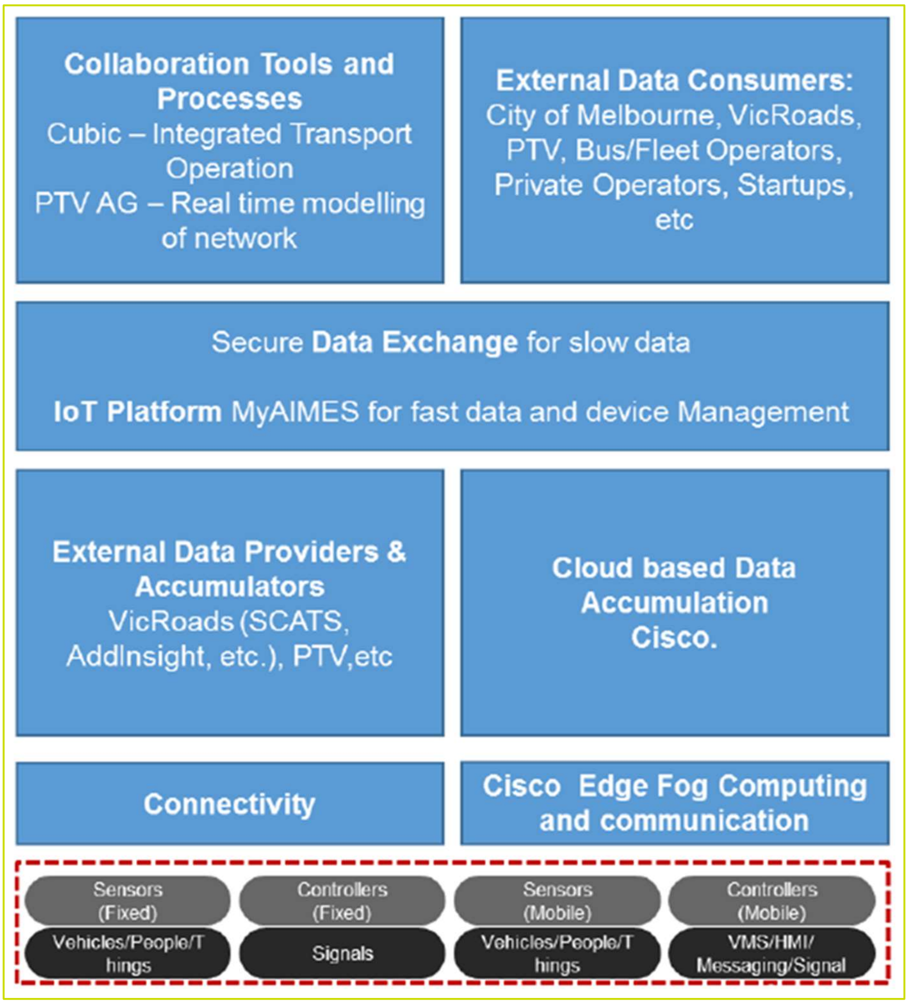


Figure 4.8: NHVR network architecture

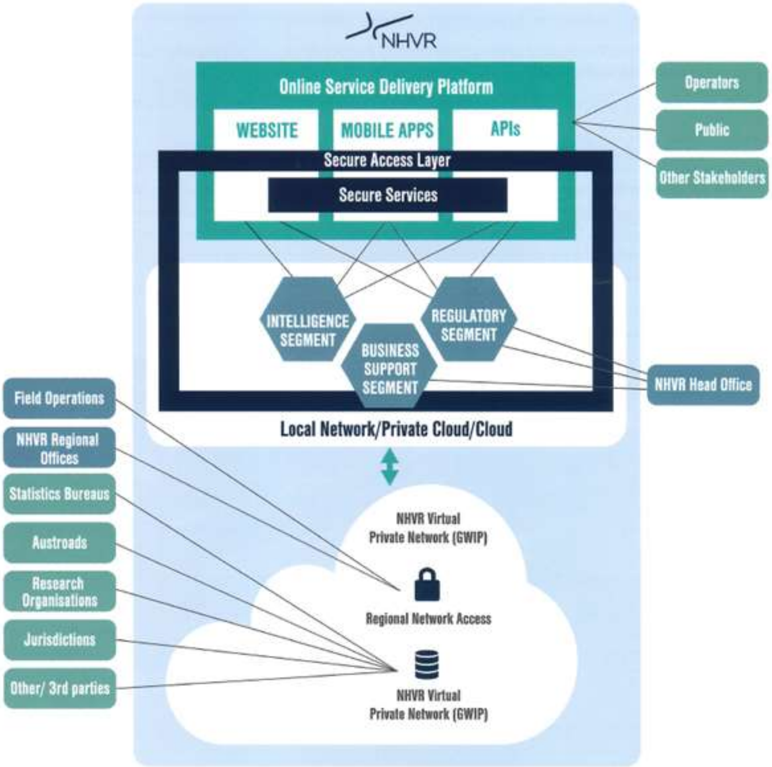


Figure 4.9: NHVR Enterprise Information Management Framework

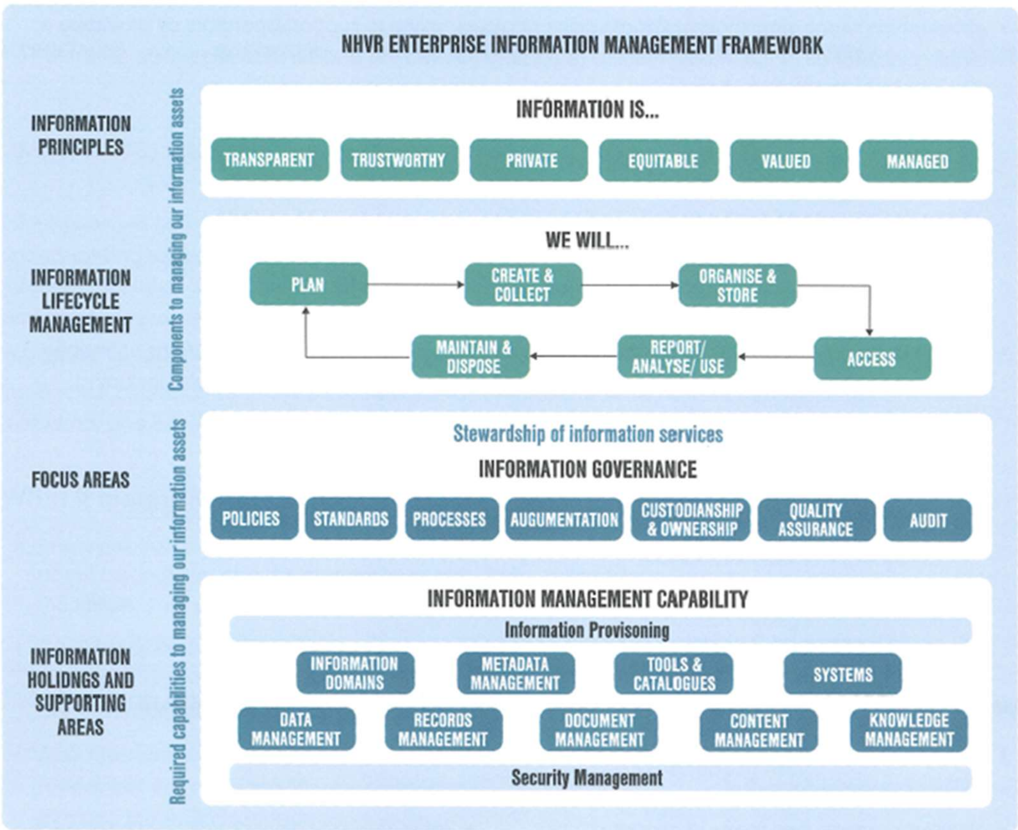


Figure 4.10: Hierarchy of key information types

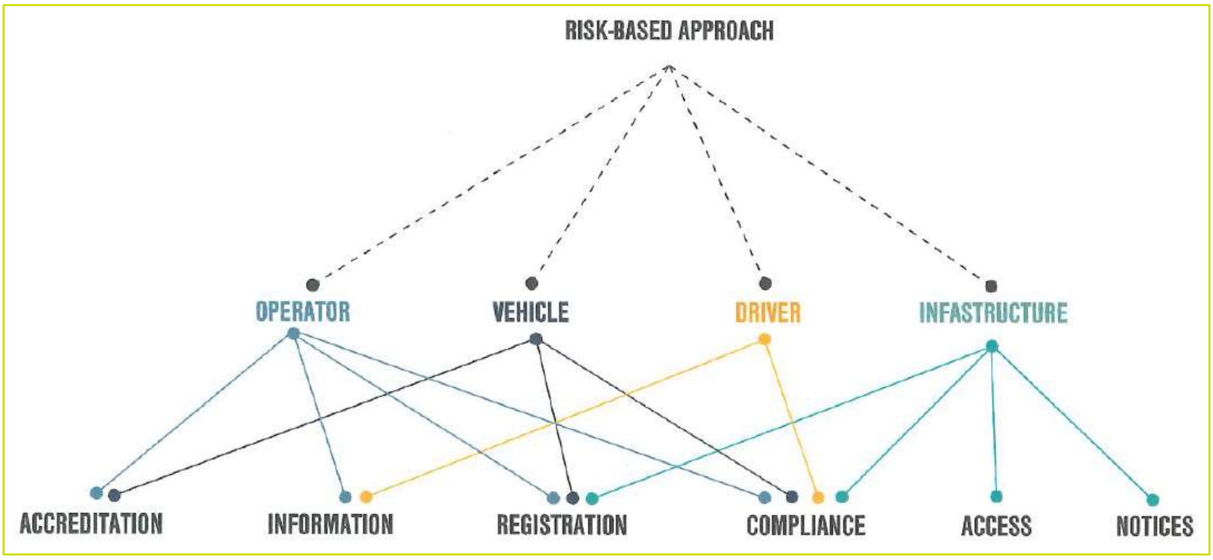
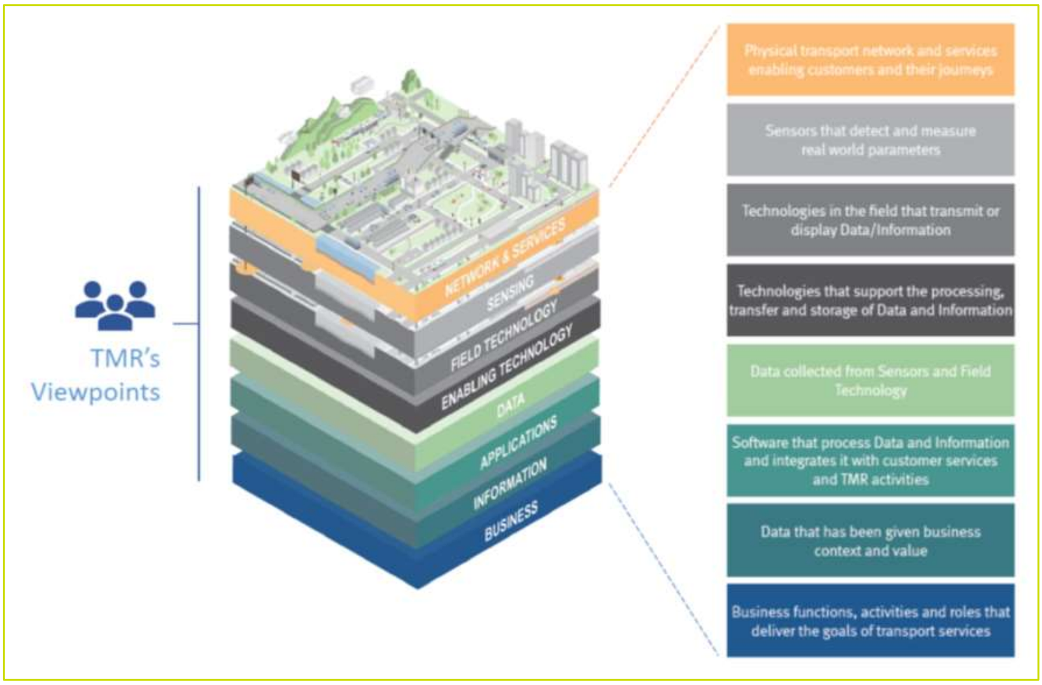


Figure 4.11: Queensland Mobility Framework



4.2 PROPOSED CONCEPT ARCHITECTURE

Following the range of architectures and concepts presented in the earlier sections and based on the recently emerging CEN/ISO TR4447 Integrated Mobility Concept and ISO TR4445 Role Models for ITS Service Application, a conceptual model is required.

A recent PIARC report on Big Data for Road Network Operations (PIARC 2019) suggested a conceptual model as shown in Figure 4.12 which was based on a US Big Data National Working Reference Architecture report (NIST 2019). The NIST conceptual model is shown in Figure 4.13.

NIST (2019) further showed the interaction between multiple actors in a larger system as shown Figure 4.14. The actors include several Data Providers, Big Data Application Providers, Big Data Framework Providers and Data Consumers.

Figure 4.12: Big Data Reference Model (p53, PIARC 2109)

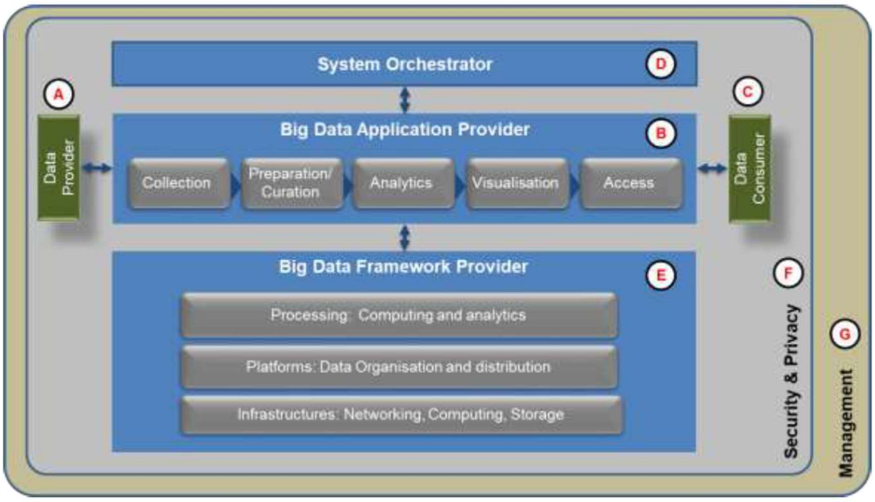


Figure 4.13: NIST Big Data Reference Architecture (p11, NIST 2019)

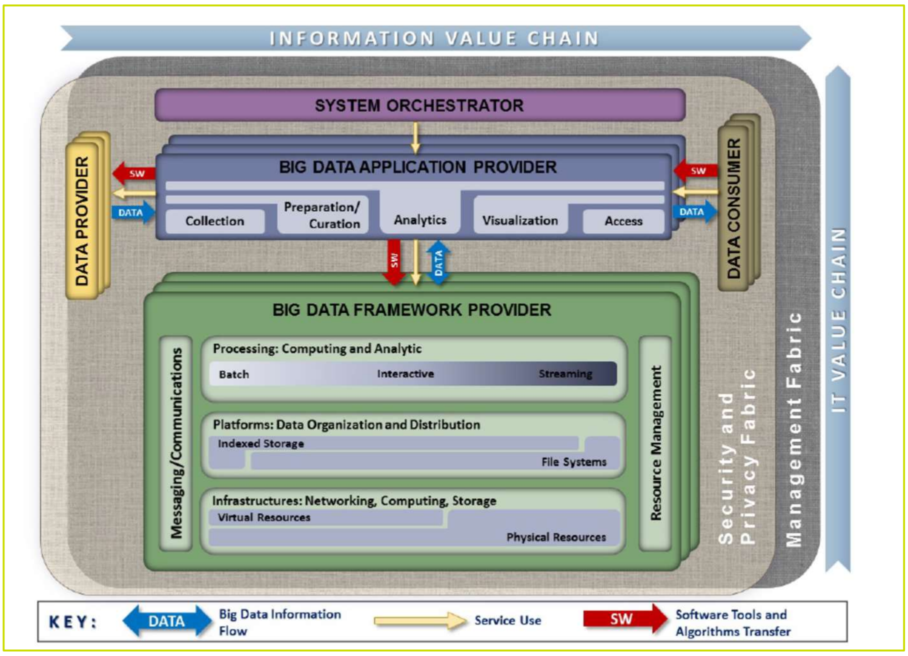
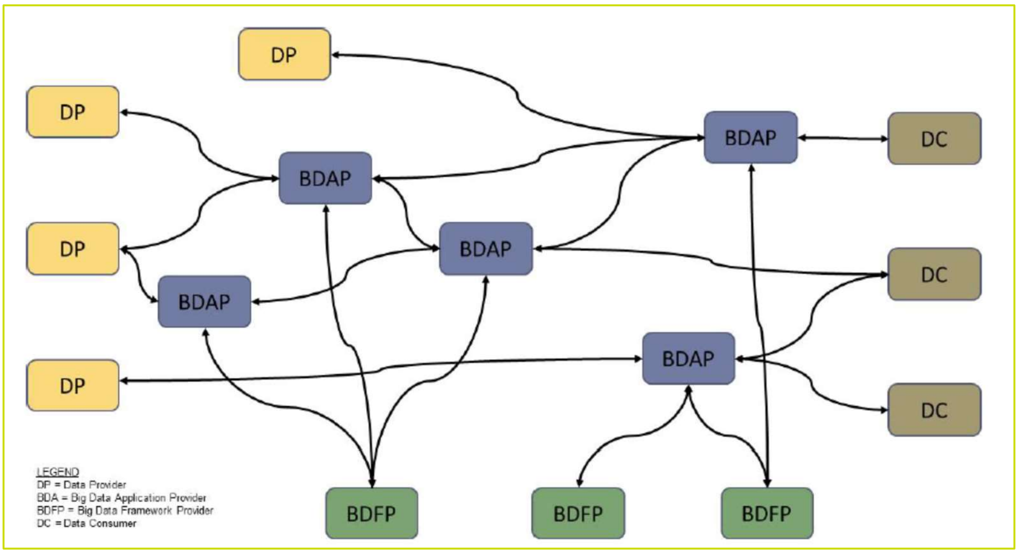
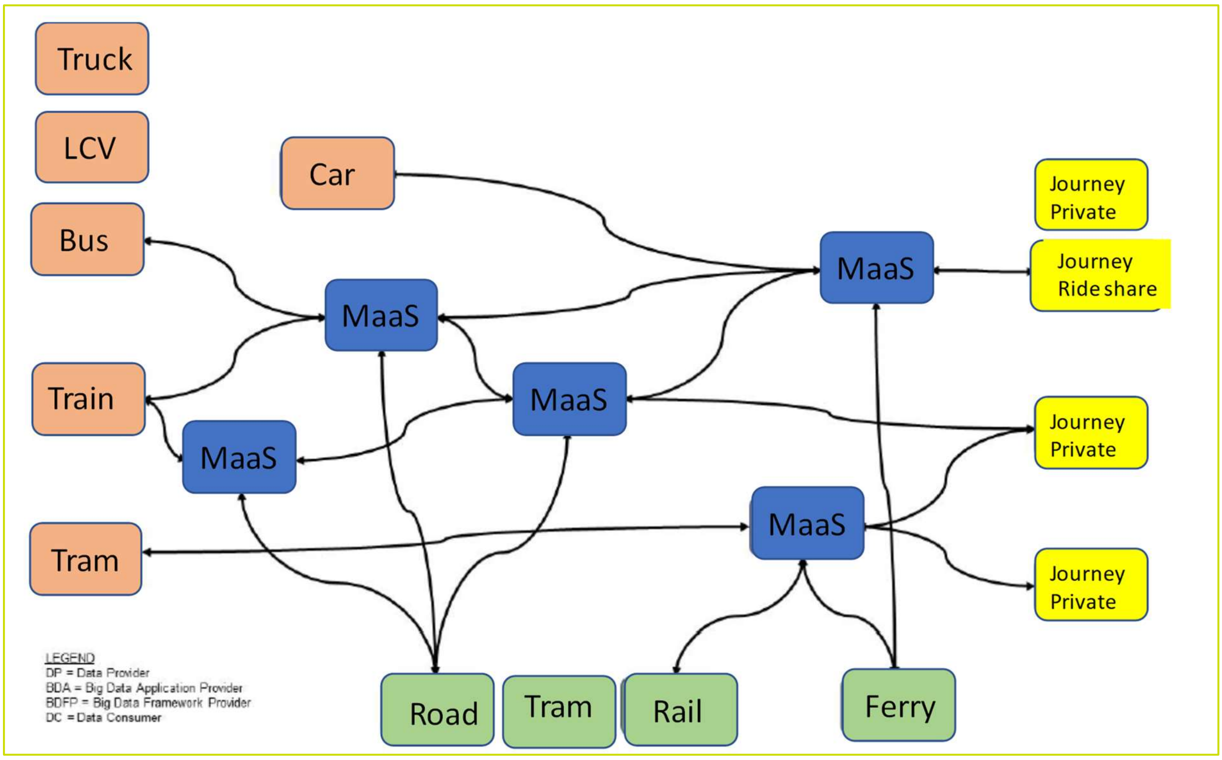


Figure 4.14: Interaction of actors within a larger system (Data Services)



Based on the integrated mobility concept (ISO TR 4447), a similar representation of the services and actors can be transposed from the NIST representation to Figure 4.15 to show the actors or assets in a future transport and mobility environment. These actors represent Transport Services, Transport Infrastructure Services, MaaS providers and Customers.

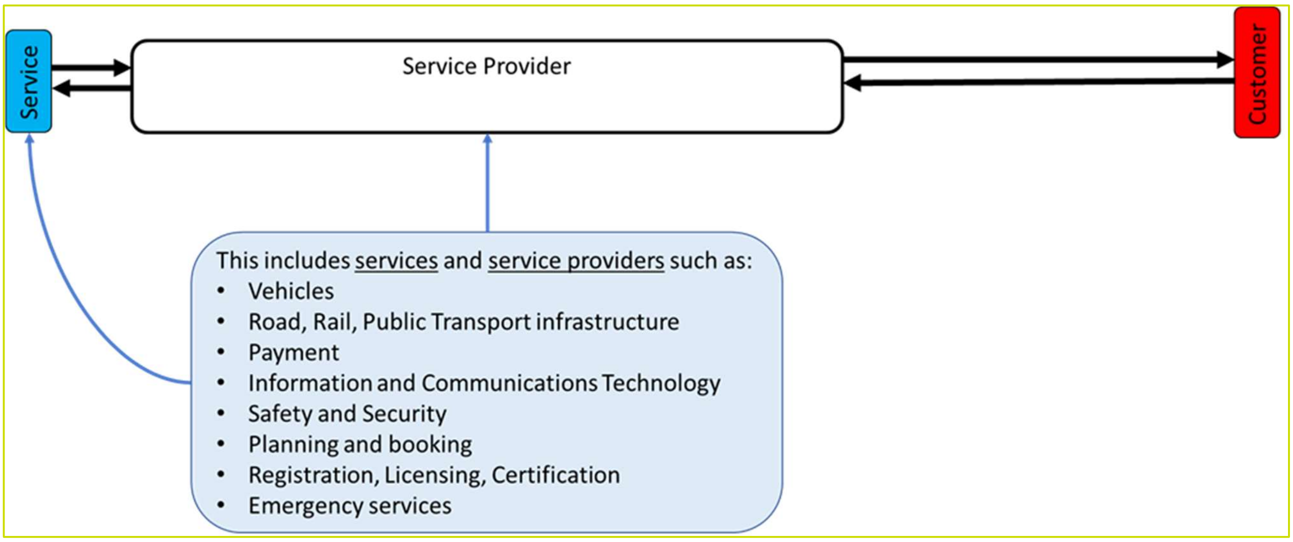
Figure 4.15: Interaction of actors within FTME (adapted by ARRB)



4.2.1 CONCEPTUAL MODEL

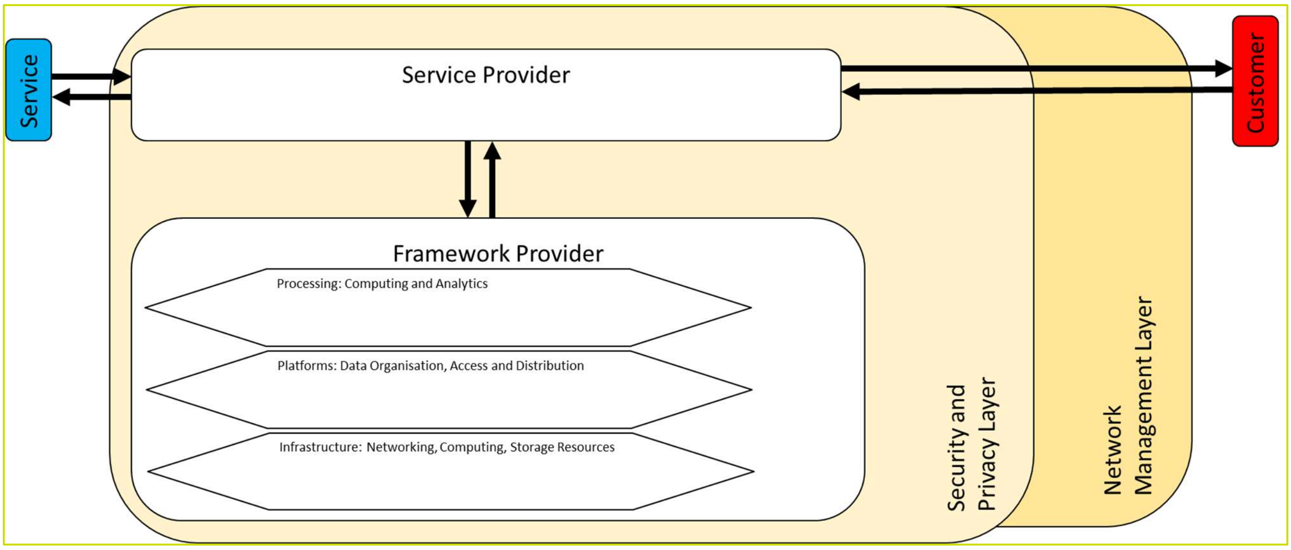
We will now commence to develop the conceptual model step by step. We commence with Figure 4.16 which represents a single service provider delivering a service to a customer. The service could involve vehicles, different transport networks (road, rail, etc.), traveller information, MaaS, and so on as shown in the figure.

Figure 4.16: Basic Service Provision



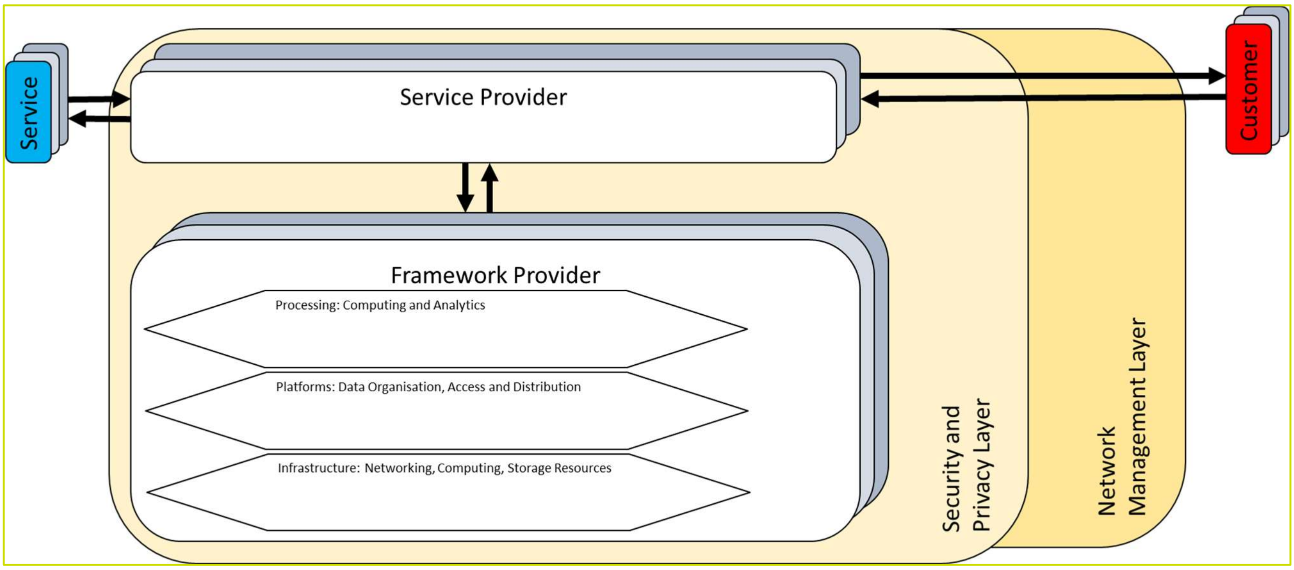
In order for the Service Provider to deliver the Service, the Service Provider needs to have a system which has infrastructure, platforms and processing capabilities, supported by security, privacy and management layers. The Service Provider could build a bespoke platform but usually will rely on technology vendors to provide hardware, software, storage, analytics and other requirements on an in-house or as a service as shown in Figure 4.17.

Figure 4.17: Basic Service Provider System



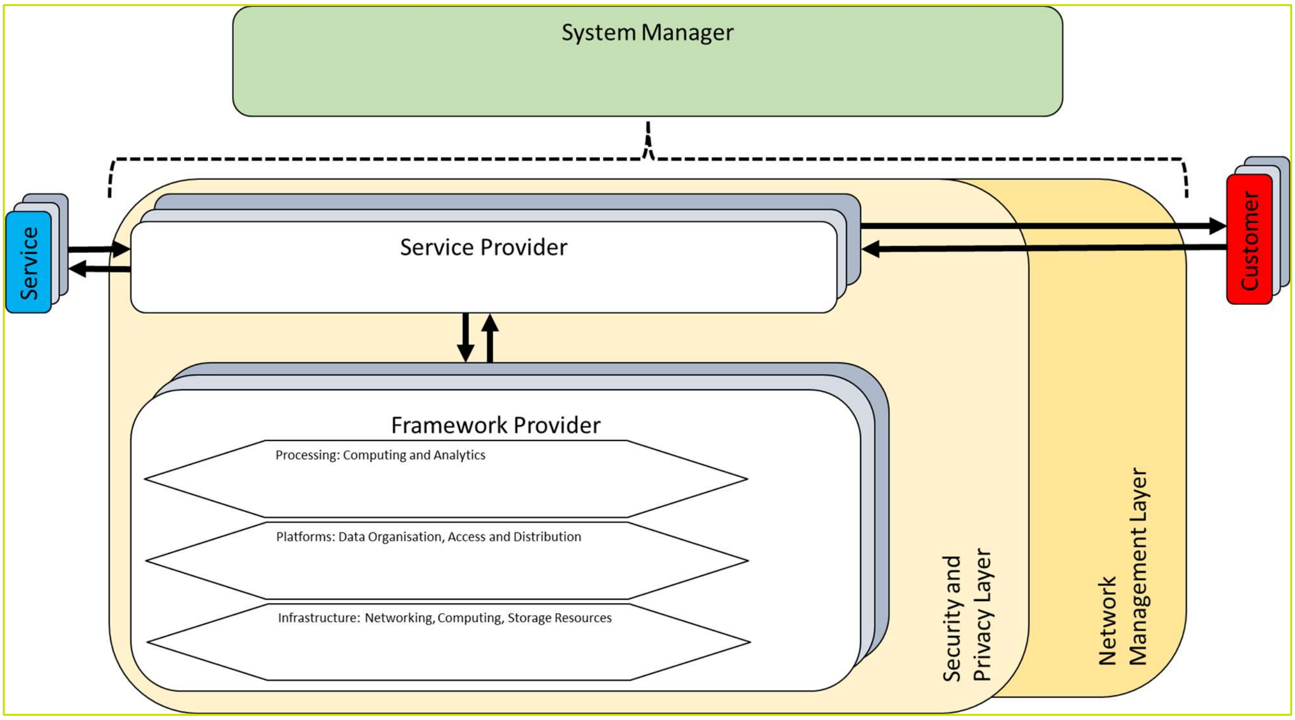
Other organisations are attracted to the new business model and more services are developed with more services providers, framework providers expand (cloud servers, data platforms, analytics suites etc.) and more customers are attracted to the benefits these new services are able to offer to them.

Figure 4.18: Basic Service Provision



As determined by the regulatory jurisdiction in which the future transport and mobility system operates, the service and framework providers may need to be certified by the regulator, and so some form of approval authority (regulatory) role may form an essential part of the architecture, but the role may and will be instantiated differently by different jurisdictions. Regulations in road transport include road rules, vehicle registration and driver licensing and traffic management to ensure smooth safe operations on the network. In this conceptual model, we use the term “System Manager” and it is added in as shown in Figure 4.19.

Figure 4.19: System Manager in Basic Service Provision

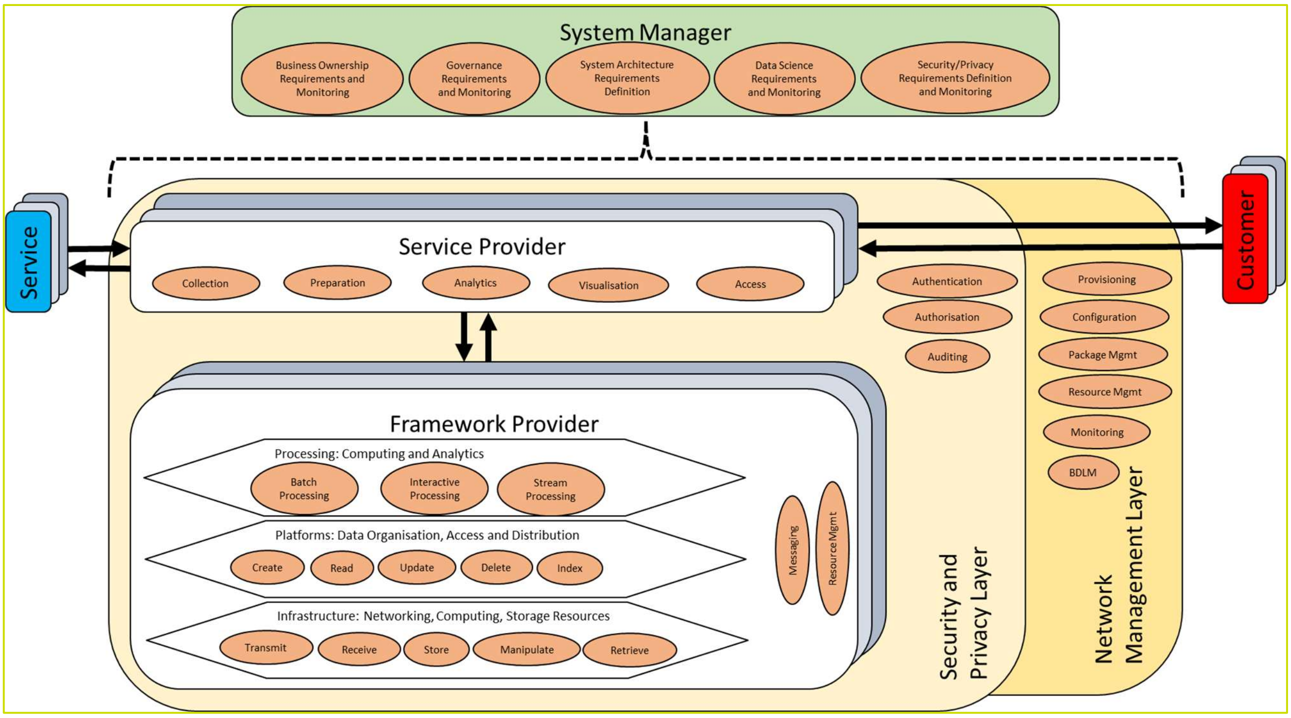


4.2.2 ROLES AND RESPONSIBILITIES

As we begin to start in identifying the activities undertaken in each of the roles identified in the conceptual model, we begin to develop a deeper understanding of the architecture and hence the necessary 'logical' components that need to be documented and in place for the whole eco-system to operate.

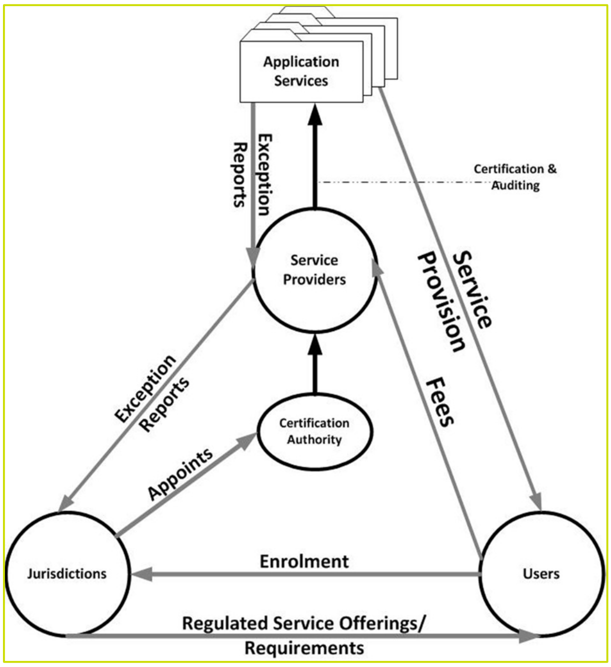
Figure 4.20 provides a view of examples of high level classes of activities that will need to be the responsibility of and performed by the roles identified in the conceptual model.

Figure 4.20: High Level classes of activities in the Conceptual Model



Typically, accompanying a conceptual model is an accompanying document identifying the roles and responsibilities within the model. As an example, Figure 4.21 details the roles and responsibilities in regulatory telematics, ISO 15638 which is the basis of the Intelligent Access Program or IAP administered by Transport Certification Australia. Another example of roles and responsibilities can be found in ISO TR 4445 mentioned earlier in Section 2.9.3.

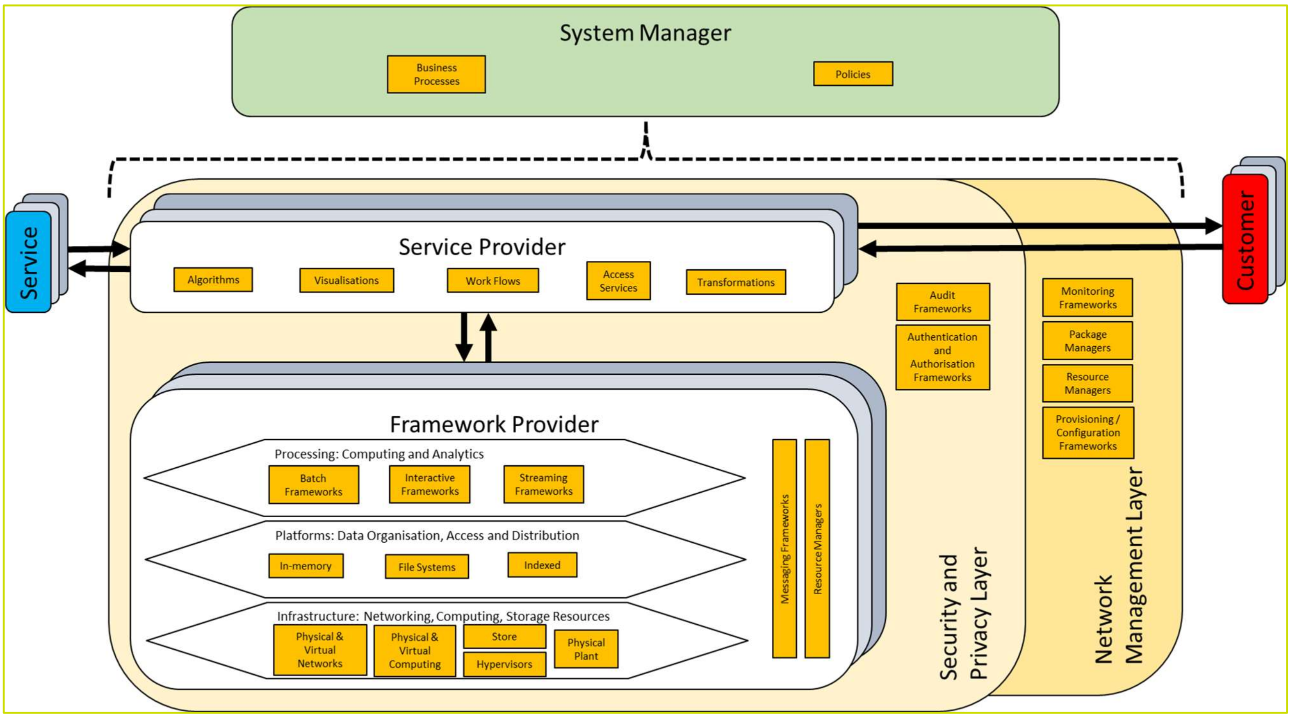
Figure 4.21: Roles and responsibilities in system



4.2.3 FUNCTIONAL COMPONENTS

The functional component view of the conceptual model should define and describe the functional components (e.g. hardware, software, people, organisations) that perform the various activities outlined in the activities view. For the conceptual model proposed, Figure 4.22 shows common classes of functional components in each of the roles identified.

Figure 4.22: Common Classes of Functional Components



4.2.4 CORE FUNCTIONS

In a future transport and mobility environment, there will be many different services as mentioned earlier, such as mobility services (ISO TR 4447), traffic management, connected and automated vehicles, big data, road pricing / electronic fee collection, and freight and logistics. If the conceptual model outlined earlier were to be developed for each specific FTME service domain, then upon examination of the roles and responsibilities (Figure 4.20, Figure 4.21) and functional components (Figure 4.22) the investigator will discover that in each and every service domain there are common elements in roles and responsibilities and functional components.

Table 4-1 provides some examples of core functions that may apply for the different actors in the Conceptual Model. Returning to the Conceptual Model again and bearing in mind the logical and physical layers, then these core functions can also be categorised into logical and physical layers.

Table 4-1: Core functions (examples)

Role in Conceptual Model	Common elements / (core)
System Manager	Regulatory policy Operational framework Certification Safety Assurance Whole of network monitoring and optimisation Compliance and enforcement Registry and credential management National interoperability and consistency
Service Provider	Applications, Processes, Analytics, Business Systems Infrastructure Assets Connectivity Positioning Safety Assurance
Framework Provider	Hardware Software Assets Storage (Cloud) Connectivity Positioning Sensors
Security and Privacy	Secure exchange of data Trust and integrity of data Assurance of privacy Facilitation of a platform for sharing Misbehaviour management
Network Management	Standards Protocols Monitoring Package management

A depiction of the core functions in logical and physical layers is given in Table 4-2.

Table 4-2: Core functions (in logical and physical layers)

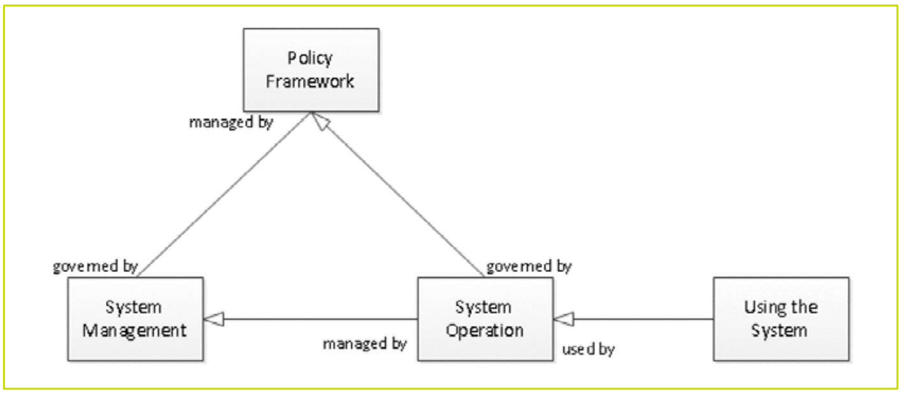
Architectural Layer	Common elements / (core)
Logical	1. Regulatory policy 2. Operational framework 3. Certification 4. Safety Assurance 5. Whole of network monitoring and optimisation 6. Compliance and enforcement 7. Registry and credential management 8. National interoperability and consistency 9. Secure exchange of data 10. Trust and integrity of data 11. Assurance of privacy 12. Facilitation of a platform for sharing 13. Misbehaviour management 14. Standards 15. Protocols 16. Monitoring 17. Package management
Physical	1. Infrastructure (e.g., signals, line markings, lighting) 2. Assets 3. Connectivity 4. Positioning 5. Hardware 6. Software 7. Storage (Cloud) 8. Connectivity 9. Positioning 10. Sensors

The following figures provide as examples, some of the core functions that should be considered in FTME and it is drawn from international and Australian developments.

LOGICAL LAYER

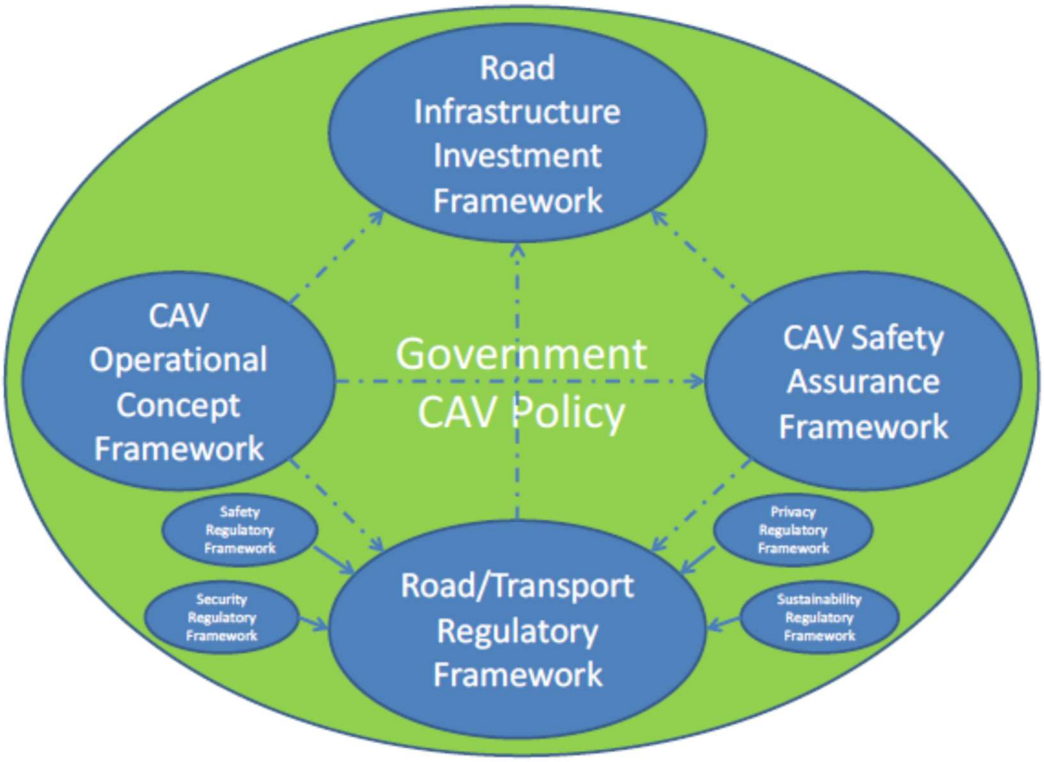
Figure 4.23 provides a clear example of a governance model within FTME and is based on a roles and responsibility model developed for co-operative ITS systems (ISO 17427).

Figure 4.23: Regulatory framework (ISO TS 17427)



In the future connected and automated vehicles domain, Australia has made progress in linking the regulatory, infrastructure investment, operational concept and safety assurance framework through the work of the National Transport Commission and Austroads as shown in Figure 4.24.

Figure 4.24: Regulatory frameworks in CAV (1)



The NTC work in CAVs especially in terms of the automated driving system entity (ADSE) has also carefully considered the need for further regulations in relation to the already existing legislation in place as shown in Figure 4.25.

Figure 4.25: Regulatory frameworks in CAV (2)

Road Vehicle Standards Act	Negligence	Work Health and Safety Law	Australian Consumer Law
Heavy Vehicle National Law	Passenger transport legislation	Corporations Law	Contract
State and territory criminal law	Road rules and human driver licensing	Vehicle registration and roadworthiness	Road management legislation
Telecommunications regulation	Road rules and human driver licensing	Dealer and repairer legislation	Fallback-ready user duties (policy only)

National efforts in a co-ordinated response in addressing certain regulatory and operational gaps for FTME were detailed in a National Land Transport Technology Action Plan which began in 2016. In the second version of the plan for 2020-2023 (TIC 2019), progress was reported, and new action items were included as shown in Table 4-3.

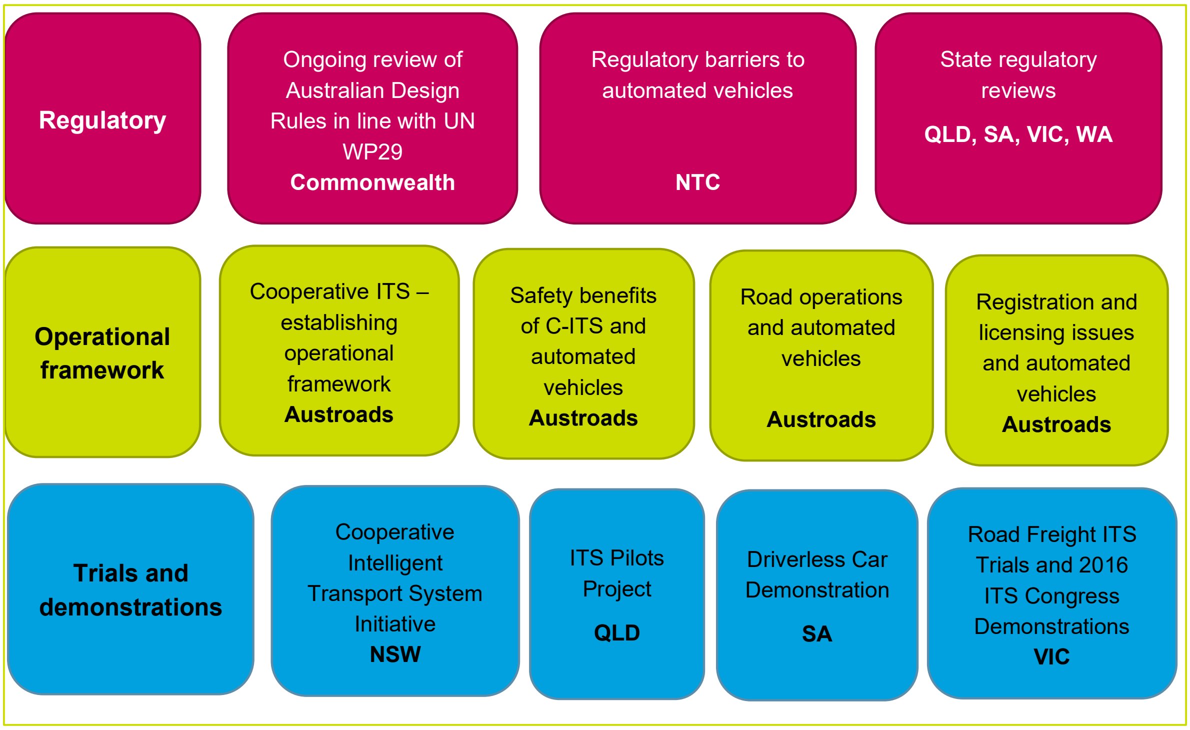
The groups (or categories) listed in the left-hand column provide yet a further example of the logical and physical layers that need to be in place to support the FTME. It should be noted that these actions were developed without the context of the conceptual model described earlier. It could be argued that the conceptual FTME model would encourage a more comprehensive coverage of actions.

Table 4-3: Actions in National Land Transport Technology Action Plan (TIC 2019)

Group	Completed Items	Ongoing Items	New Items
Safety, Security and Privacy	• Establishment of a regulatory framework for testing automated vehicles • Evaluation of low-cost technologies to improve safety at level crossings • Investigate the costs, benefits, and possible deployment models for automatic crash notification	• Development of national operational guidelines to support on-road use of automated vehicles • Development of a national deployment plan for security management of connected and automated vehicles	• 1.1 End-to-end regulation for the commercial deployment of automated vehicles • 1.2 Cooperative Intelligent Transport Systems (C-ITS) Security Credential Management System (SCMS) Pilot Project • 1.3 Guiding principles and approaches to facilitate safe and legal larger-scale trials of automated vehicles. • 1.4 Accelerate the deployment and uptake of road safety technologies and innovation.
Digital and Physical Infrastructure	• Exploration of the merits of new safety and traffic management technologies • Investigation of options to provide enhanced geo-positioning information to the land transport sector	• Priority trials and research of Intelligent Transport Systems	• 2.1 Develop guidance on how infrastructure can be future ready for CAV technology within an integrated transport and land use planning framework • 2.2 Develop program of work to address the barriers and challenges impeding the uptake of Low and Zero Emissions Vehicles (LZEVs)
Data	• Exploration of how telematics and other intelligent transport systems can be used to optimise operations and planning for port precincts and intermodal terminals	• Improve the availability of open data in the transport sector	• 3.1 Explore uses of C-ITS and AV data to improve network efficiency and investment
Standards and Interoperability		• Development of a Cooperative ITS infrastructure road map • Publish a connected vehicle (Cooperative Intelligent Transport Systems) statement of intent on standards and deployment models (	• 4.1 Evaluate deployment models and associated costs and benefits of C-ITS vehicle technologies
Disruption and Change		• Explore options to increase the uptake of telematics and other technologies for regulatory and revenue collection purposes • Investigate options for interoperable public transport ticketing	• 5.1 Identify and facilitate emerging technologies that improve freight outcomes • 5.2 investigate the role of governments in MaaS and identify priorities and enablers to support its effective development and deployment • 5.3 Research into the competition impacts of automated vehicles

Co-ordinated national and jurisdictional approaches have also been depicted as in Figure 4.26 where the regulatory efforts work together with the development of the operational framework, and are supported by real world experiences in trials and demonstrations across the jurisdictions.

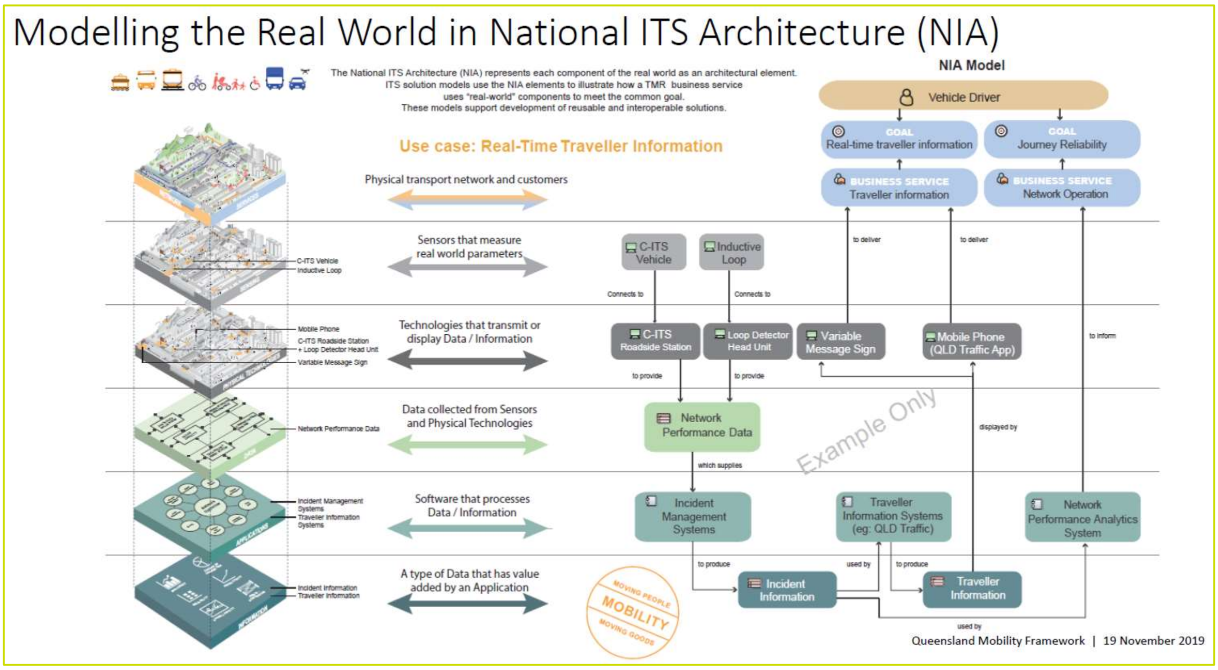
Figure 4.26: Working together



PHYSICAL LAYER

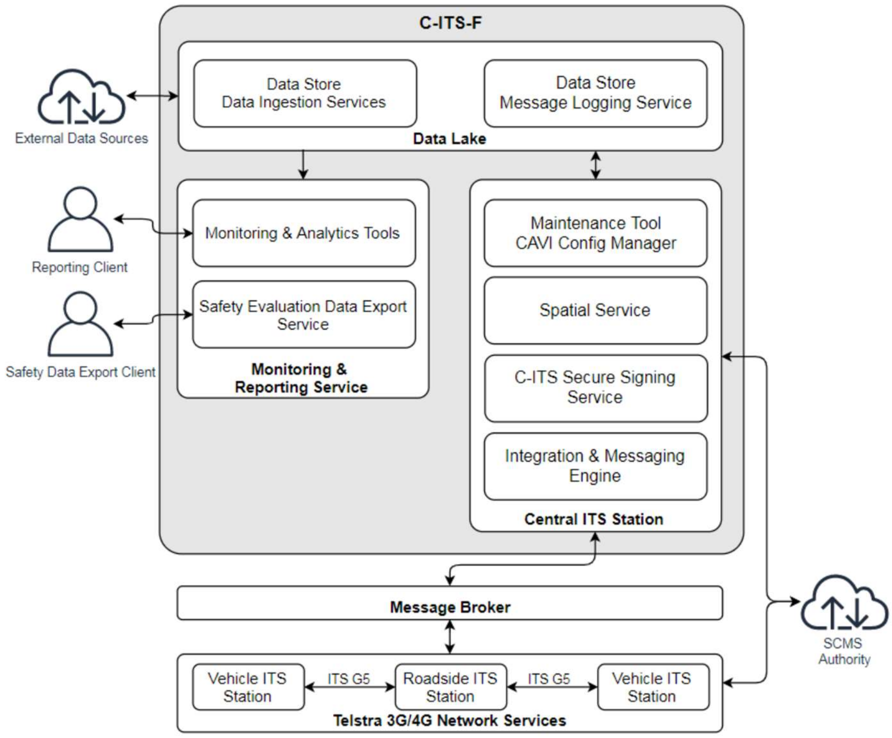
An example of how the physical layer can be mapped into the architecture can be observed in the work by Queensland in their mapping of the NIA with the Queensland Mobility Framework as shown in Figure 4.27 (TMR 2019b).

Figure 4.27: Physical layer into conceptual model



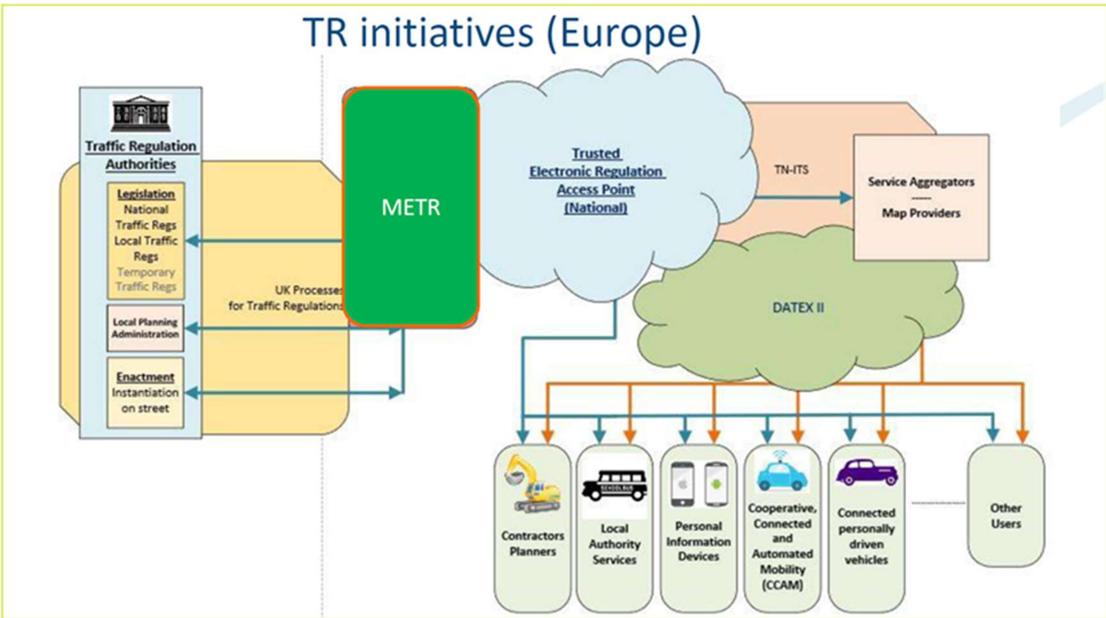
A further example of a specific core function is the central C-ITS facility developed by Queensland Transport and Main Roads for the CAVI project as shown in Figure 4.28 (Nielsen et al. 2019). This facility was designed, built and operated by TMR to support and enable secure, consistent messaging (basic safety messages) from infrastructure to vehicles for TMR's trial deployment. This included interoperability between several vendors whose technology are being deployed in vehicles and at the roadside units.

Figure 4.28: Regulatory frameworks in CAV (2)



A European example under the CEN/ISO Mobility Integration working groups is in the development of a digitised or electronic version of road rules or traffic regulations. This is necessary for highly automated systems that are being introduced in vehicles. This key logical and physical layer is another core function for FTME as shown in Figure 4.29 and Australian participation and consideration of these work items for local application are cost-effective approaches in addressing the needs for such similar core functionality locally.

Figure 4.29: Management of Electronic Traffic Regulations (METR, ISO 2019)



5 DISCUSSION

This discussion paper has presented the background to the Future Transport and Mobility Environment (FTME) and referenced the trends, challenges, existing state of the art efforts, expertise and knowledge from several different perspectives in the FTME domain.

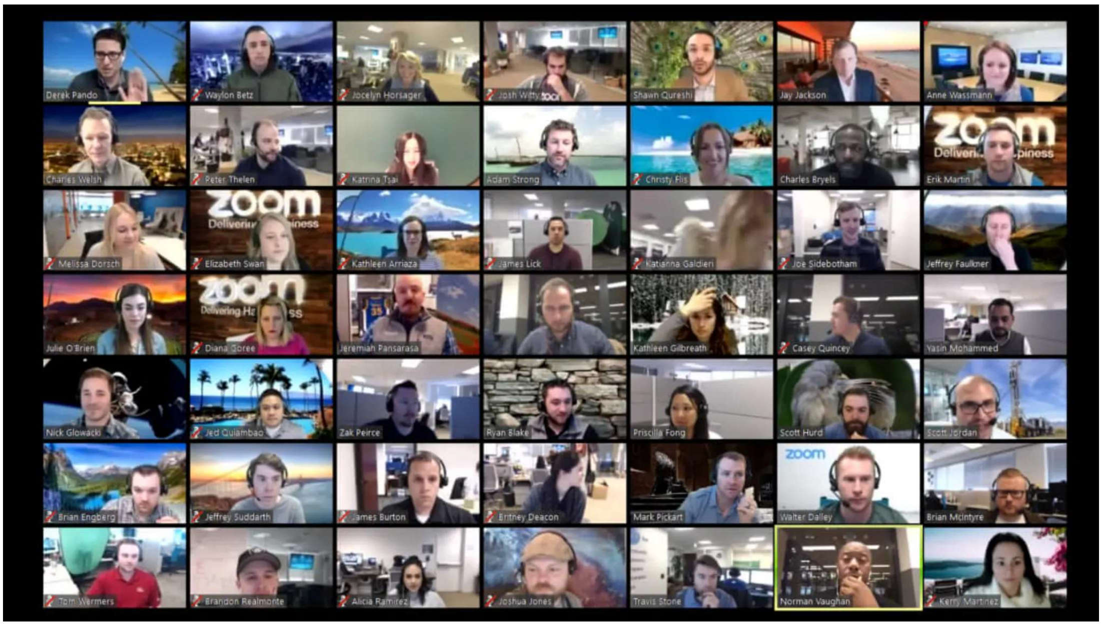
A limited but powerful stakeholder engagement was also undertaken which provides the opportunity to construct validate the thoughts, ideas and content of this paper.

The architectural section (Section 4) proposed a conceptual model grounded on ISO standards as well as many examples drawn from local and international experiences across a range of service domains. It further steps through roles and responsibilities, key activities and functional classes and identifies core elements in the future concept of operation.

5.1 IMPACTS OF COVID-19

As mentioned earlier, at the time of writing this discussion paper, the global coronavirus pandemic has brought unprecedented changes to our daily lives, including the transport environment and the way we use it to move around. An enduring image of these times that we will remember is shown below.

Figure 5.1: Image of the Coronavirus age!



Source: Zoom call between Zoom staff (Sydney Morning Herald 2020)

There has been much social commentary and opinion pieces written, and some of the views include:

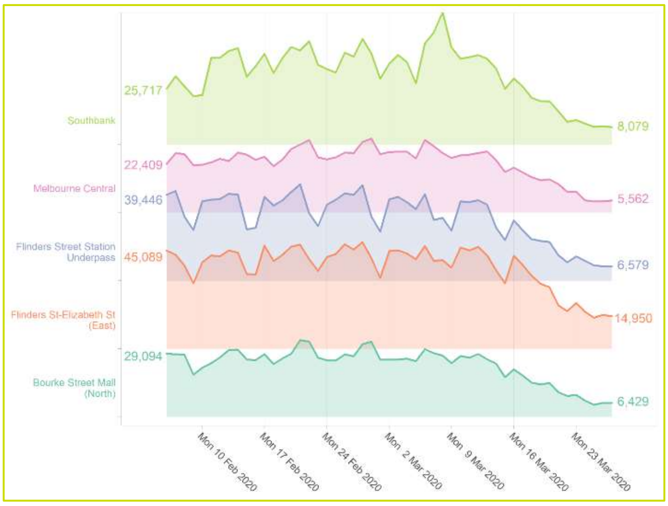
- Social distancing will be prolonged as will crowd avoidance
- There is a perception of risk of infection by transmission in all community settings e.g. public transport, workplaces, community areas, parks, conferences, sports and entertainment facilities
- The growing importance of biosecurity as the new attribute in mode choice – leading to increased private vehicle trips
- Infrastructure needs possibly need review with focus on smaller investments in improved bicycle lanes, freight distribution capacity and redesign of community spaces
- A possible increasing traffic congestion but mitigated by:
  - Social distancing at the office 'forcing' the staggering of working in the office
  - A shift towards working from home for a certain number of days each week

– Businesses opening for longer hours to reduce crowding as working hours become more flexible (Hensher 2020).

Data collected by ARRB's National Transport Performance Centre showed how congestion and pedestrian numbers have been affected in key areas of the Melbourne CBD around the time of COVID-19 restrictions. ARRB believes that these impacts would be similar in most major capital cities of Australia. It also showed heavy vehicle volume on the freeway has remained almost identical to pre-COVID-19 levels, as in Figure 5.3, and so freight movement is similar in the wake of restrictions.

In a recent US study, INRIX (2020) reported that long-haul trucks continue to make their trips at nearly the same amount preceding the crisis, but do not have to contend with the congestion around urban areas that typically stifle productivity. Despite an unprecedented 46% drop in personal VMT, INRIX found that freight movement had fallen a modest 13%, highlighting how vital commercial freight is to the country's efforts to recover from the pandemic. INRIX concluded that freight corridors should be top of mind as the public and private sectors work toward investing and ensuring that these vital arteries are preserved and maintained the recovery from COVID-19 occurs.

Figure 5.2: Pedestrian traffic at major Melbourne sites by day, February to March 2020



Source: Pedestrian Count By Day – Selected Sites (ARRB 2020)

Figure 5.3: Average weekday traffic volume on Monash Freeway (T0505/T0507)

Source: Traffic Count Volume relative to early Feb. Plot – By Week (ARRB 2020)

While there has been much reflection and although it is perhaps too early to form definitive views, it can be noted that the FTME post COVID will be quite different in a number of ways:

1. In a time of crisis and emergency, transport systems are neither publicly nor privately owned, they are used however they are needed to help the community (buses delivering equipment to hospitals, cars

donated for community outreach, passenger airliners carrying PPE to other countries); public-private partnerships ensure maximum efficiency, and we can't let this lesson go to waste (World Economic Forum 2020).

2. There will be a period of re-assessment – "It's time for a pause," "We have an opportunity on a global level to undo the wrongs of past transportation policies and practices and course-correct..."; the current situation allows us to reassess and future-proof the resilience, flexibility and efficiency of our transport system, and to experiment with things like mobility corridors (Forbes 2020).
3. We have seen in Australia, a strong central leadership with the establishment of the National Cabinet and this would also support a shared vision for future transport and mobility which is the topic of this discussion paper.
4. It is therefore timely, that a fresh focus on concepts and architectures, roles and responsibilities for a FTME can be put forward for further consideration, a vision and concept that has resilience and can withstand future challenges and is flexible enough to support a range of scenarios.

5.2 NEXT STEPS

This Final Discussion Paper presents the background to the Future Transport and Mobility Environment (FTME) and referenced the trends, challenges, existing state of the art efforts, expertise and knowledge from several different perspectives in the FTME domain. The paper includes the Discussion Paper as well as the summary of discussion points from stakeholder feedback which can be found in the Appendix H of the paper.

The next steps for this Project are to produce a Final Report which will build upon the feedback received and include further stakeholder engagement and development of the core elements of the architecture.

REFERENCES

ACMA, 2011, Broken Concepts, The Australian Communications Legislative Landscape. Australian Communications and Media Authority, Canberra, ACT. Aug.

AEOLIX 2018, AEOLIX Architecture for European Logistics Information Exchange, ERTICO – ITS Europe, Brussels, Belgium, Nov

ARRB, 2011, ITS architecture for assessment of Heavy Vehicle Pricing Options, BAS-004/ITS Architecture, COAG Road Reform Plan, 003244-1, Australian Road Research Board, Vermont South, Vic, May

ARRB 2020, 'What are the impacts of the COVID-19 Pandemic on our Transport Systems', ARRB, Port Melbourne, VIC.

Austroads, 2007, *Tools that impact Network Performance, Summary Report*, AP-R313-07, Austroads, Sydney, NSW.

Austroads, 2014a, *National ITS architecture – Context and vision*, AP-R467-14, Austroads, Sydney, NSW

Austroads, 2014b, *National ITS Architecture – ITS business architecture*, AP-R468-14, Austroads, Sydney, NSW

Austroads, 2015, *Concept of Operations for C-ITS Core Functions*, AP-R479-15, Austroads, Sydney, NSW

Austroads, 2016a, *Operationalising Austroads' Product Acceptance Process*, AP-R524-16, Austroads, Sydney, NSW.

Austroads, 201b, *National ITS Architecture Framework: Project Update*, AP-G98-16, Austroads, Sydney, NSW.

Austroads, 2017a, *National ITS Architecture Stage 2 Module 2: Mapping FRAME Content to TOGAF*, AP-456-17, Austroads, Sydney, NSW.

Austroads, 2017b, *Current Practice and Developments in Concept of Operations across Road Agencies in Australia and New Zealand,* AP-R553-17, Austroads, Sydney, NSW.

Austroads, 2019, *Opportunities in Mobility as a Service*, AP-R601-19, Austroads, Sydney, NSW.

BITRE 2014, Australian Infrastructure Statistics, Yearbook 2014, Bureau of Transport and Regional Economics, Canberra, ACT

BITRE 2017, Costs and Benefits of Emerging Road Transport Technologies, Report 146, Bureau of Regional and Transport Economics, Canberra, ATC

BITRE 2019, Australian Infrastructure Statistics, Yearbook 2019, Bureau of Transport and Regional Economics, Canberra, ACT

CISCO 2018, Towards a Multimodal Transportation Data Framework, supporting emerging transportation models and services, CISCO White Paper, Melbourne, Vic, Dec

Carter,C., Wu,H., 2019, Pricing Mobility as a Service for Success, AP-CP1779, 26th ITS World Congress Singapore, Oct.

Cisco 2018, *Enabling MaaS Through a Distributed IoT Data Fabric, Fog Computing and Network Protocols*, Cisco, U.S.

Cisco 2019, *Smart Intersections – IoT Insights using Video Analytics and Artificial Intelligence*, Cisco, U.S.

Cisco 2019, *Smart Intersections – IoT insights using Wi-Fi*, Cisco, U.S.

City of Hobart 2019, *Transport Strategy (Draft)*, City of Hobart, Hobart, TAS.

City of Melbourne 2019, *Transport Strategy 2030*, City of Melbourne, Melbourne, VIC.

City of Toronto 2019, *Automated Vehicles Tactical Plan*, City of Toronto, Toronto, Canada.

Department for Transport 2019, *Future of Mobility: Urban Strategy*, Department for Transport, London, UK.

Department of Transport 2019, *Our Strategic Plan 2019-23*, Department of Transport, Melbourne, VIC.

Department of Transport 2019, *Strategic Plan 2019-22*, Transport WA, Perth, WA.

Drive Sweden, 2018, Roadmap - Connected Mobility as a Service in Sweden, An activity in the innovation partnership program – next generation's travel and transport, , Swedish Government, Swedenhttp://fardplan.kompis.me/

Ericsson 2017, *Six ways ITS is transforming the Dutch transport system*, webpage, Ericsson, Stockholm, Sweden, <https://www.ericsson.com/en/blog/2017/10/six-ways-its-is-transforming-the-dutch-transport-system>.

Ericsson 2019, Ericsson Mobility Report, Ericsson, Stockholm, Sweden.

Forbes 2020, *Is The Coronavirus The Transportation Industry's Opportunity?*, webpage, Forbes, New Jersey, U.S., viewed 5 May 2020, <https://www.forbes.com/sites/dawnchmielewski/2020/05/05/the-cost-of-coronavirus-pandemic-park-closures-cut-disney-revenue-by-1-billion/#5c2c6eb36ff0>.

Griffith, S., Fehl, K., 2016, Better Business Outcomes through ITS, AN-TP0174, 23rd ITS World Congress, Melbourne, Vic, Oct.

Hensher, D 2020, *What Does Intelligent Mobility Add to Sustainability?: Is MaaS a Game Changer or Not? What about Post-Covid-19?*, The University of Sydney, Sydney, NSW.

iMOVE Australia 2017, *Australian Integrated Multimodal Ecosystem – a world first*, webpage, viewed 6 March 2020, <https://imoveaustralia.com/news-articles/intelligent-transport-systems/australia-national-connected-multimodal-transport-test-bed/>.

iMOVE Australia 2018, *MaaS and On-Demand Transport – Consumer Research and Report*, webpage, iMOVE, Melbourne, VIC, viewed 5 May 2020, <https://imoveaustralia.com/project/maas-on-demand-transport-consumer-research-report/>.

iMOVE Australia 2019, *MaaS business models: Lessons for operators and regulators*, webpage, iMOVE, Melbourne, VIC, viewed 5 May 2020, <https://imoveaustralia.com/project/maas-business-models/>.

iMOVE Australia 2019, *MaaS trial in Sydney*, webpage, iMOVE, Melbourne, VIC, viewed 5 May 2020, <https://imoveaustralia.com/project/maas-trial-sydney/>.

INRIX 2020, *COVID-19's Impact on Freight: An Analysis of Long-Haul Freight Movement During a Pandemic*, by B Pishue, INRIX, Kirkland, WA, U.S.

Infrastructure Victoria 2018, *Advice On Automated and Zero Emissions Vehicles Infrastructure*, Infrastructure Victoria, Melbourne, VIC.

Infrastructure Victoria 2018, *Automated and Zero Emissions Vehicles | Transport Engineering Advice*, Arup, Melbourne, VIC.

Infrastructure Victoria 2018, *ICT Infrastructure Advice for Automated and Zero Emission Vehicles*, WSP, Melbourne, VIC.

ISO 15638, 2012, Framework for collaborative telematics applications for regulated commercial vehicles (TARV) Part 1: Framework and Architecture, International Standards Organisation, Switzerland.

ISO TS 17427, 2013, Roles and Responsibilities in the context of Co-operative ITS based on architecture(s) for co-operative systems, International Standards Organisation, Switzerland.

ISO 14813-1, 2014, Intelligent transport systems — Reference model architecture(s) for the ITS sector - Part 1: ITS service domains, service groups and services, International Standards Organisation, Switzerland.

ISO 21217, 2014, Intelligent transport systems — Communications access for land mobiles (CALM) — Architecture, International Standards Organisation, Switzerland.

ISO TR 4447, 2020, Integrated Mobility Concept, International Standards Organisation, Switzerland

ISO TR 4445, 2020, Role Model for ITS Service Application, International Standards Organisation, Switzerland.

ISO 2019, Connected Rules of the Road, Management for Electronic Traffic Regulation METR, ISO TC204 WG19 & CEN TC278 WG17, Document N0179, International Standards Organisation, Switzerland.

ITF, 2015, Big Data and Transport: Understanding and Assessing Options, International Transport Forum at the OECD, Brussels, Belgium.

ITS Australia 2019, *Mobility as a Service in Australia: Customer insights and opportunities*, Intelligent Transport Systems Australia, Melbourne, VIC.

ITSWC, 2019, Post Congress Detailed Report, 26th ITS World Congress Singapore, Oct.

Karl, C., 2017, Policy, Standards and Harmonisation, Post Congress Report, 23rd ITS World Congress, Melbourne 2016, Vic.

Karl, C., & Brannigan, J., 2019, DIRDC Freight Requirements Study: Institutional Arrangements, a research Report for the Department of Infrastructure, Regional Development and Cities, ARRB Group, Melbourne, VIC.

Karl, C. & Kutadinata, R., 2019, Freight data projects in Australia, Australian Transport Research Forum, Canberra, ACT, Oct.

KPMG, 2018, Autonomous Vehicles Readiness Index, assessing countries openness and preparedness for autonomous vehicles, KMPG International, kpmg/avri

KPMG, 2019, Autonomous Vehicles Readiness Index, assessing countries openness and preparedness for autonomous vehicles, KMPG International, kpmg/avri

L.E.K. Consulting 2019, *Are We There Yet? New Mobility Readiness Scorecard*, Tourism & Transport Forum, Sydney, NSW.

Lu, J., Dabic, T., 2019, Realite: an end-to-end integrated solution for smarter transport, AP-CP2340, 26th ITS World Congress, Singapore, Oct

Manning, P., 2019, 'Connected Vehicles – application of real-life case studies', 26th ITS World Congress, Singapore, Siemens Mobility, Melbourne, VIC.

Melbourne School of Engineering n. d., *Australian Integrated Multimodal EcoSystem (AIMES): About us*, webpage, viewed 6 March 2020, <https://eng.unimelb.edu.au/industry/aimes#about>.

Mukherjee, S & Patnaik, S 2020, 'Zoom users top 300 million despite growing ban list, shares hit record', *The Sydney Morning Herald*, 24 April 2020, viewed 5 May 2020, <https://www.smh.com.au/business/companies/zoom-users-top-300-million-despite-growing-ban-list-shares-hit-record-20200424-p54mrt.html>

National Highway Traffic Safety Administration 2016, *The Road Ahead: Strategic Plan 2016-2020*, U.S. Department of Transportation, Washington, DC, U.S.

NHVR, 2017, Business and Technology Capability Strategy 2017-2021, National Heavy Vehicle Regulator, Newstead, QLD.

Neilsen, N, Blogg, M, Alderson, D, Chalmers, P, Eaton, J & McDonald, G 2019, 'Ipswich Connected Vehicle Pilot: Cloud-Hosted Central Facility', *ITS World Congress*, 26th, 2019, Singapore, ITS World Congress, Singapore, AP-TP2218, pp. 4.

NIST, 2019, NIST Big Data Interoperability Framework: Volume 6, Reference Architecture, Version 3, NIST Special Publication 1500-6r2, National Institute of standards and Technology, Gaithersburg, MD, USA, Oct.

NSW Government (TfNSW), 2018, Future Transport Strategy 2056, Transport for New South Wales, Sydney, NSW.

NSW Government (TfNSW), 2018, *Future Transport 2056: Connected and Automated Vehicles Plan*, Transport for New South Wales, Sydney, NSW.

NTC, 2018, Safety Assurance for Automated Driving Systems, Decision Regulation Impact Statement, National Transport Commission, Melbourne, VIC, Nov.

NTC, 2019a, A risk based approach to regulating Heavy Vehicles, Issues Paper, National Transport Commission, Melbourne, VIC, Mar.

NTC, 2019b, Assurance Models, Issues Paper, National Transport Commission, Melbourne, VIC, Aug.

PIARC, 2019, Big Data for Road Network Operations, Technical Committee B.1 Road Network Operations/ITS, 2109R18EN, World Road Association (PIARC), Paris, France.

Productivity Commission, 2016, Intellectual Property Arrangements, Inquiry Report No. 78, Australian Government, Canberra, ACT.

Productivity Commission, 2017, Data availability and Use, Productivity Commission Inquiry Report No 82, Australian Government, Canberra, ACT, Mar.

Productivity Commission, 2019, National Transport Regulatory Reform, Draft Report, Australian Government, Canberra, ACT, Nov

TMR, 2015, Future Network Management, Discussion Paper (*internal unpublished*), Queensland Department of Transport and Main Roads, Brisbane, QLD.

TMR, 2018, *Cooperative Intelligent Transport Systems (C-ITS) Pilot*, Queensland Department of Transport and Main Roads, Brisbane, QLD, viewed 19 March 2020, <https://www.publications.qld.gov.au/dataset/6773a591-1f61-4c6d-9543-2f8a19dabc6c/resource/b8a5ab55-21af-4ab4-9bd0-126c239ced94/fs_download/01679c-its-factsheet-updated-v21.pdf>.

TMR, 2019a, *Strategic Plan 2019-2023*, Queensland Department of Transport and Main Roads, Brisbane, QLD.

TMR, 2019b, *Queensland Mobility Framework (Queensland Land Transport Technology Framework – QLTTF): Lunch'n'Learn* (internal unpublished), Queensland Department of Transport and Main Roads, Brisbane, QLD.

TMR, 2019c, *CAVI components*, webpage, Queensland Department of Transport and Main Roads, Brisbane, QLD, viewed 19 March 2020, <https://www.qld.gov.au/transport/projects/cavi/cavi-components>.

TMR, 2020a, *Queensland Transport Strategy: Our 30-Year Plan for Transport in Queensland*, Queensland Department of Transport and Main Roads, Brisbane, QLD.

TMR, 2020b, *Cooperative and Automated Vehicle Initiative*, webpage, Queensland Department of Transport and Main Roads, Brisbane, QLD, viewed 19 March 2020, <https://www.qld.gov.au/transport/projects/cavi/cavi-project>.

Sarvi, M., 2019, 'Australian Integrated Mobility Ecosystem (AIMES)', *ITS World Congress*, 26th, 2019, Singapore.

Scales, N, 2019, Scaling up for Smart Mobility, iMOVE https://imoveaustralia.com/smart-mobility-expert/neil-scales-tmr/, iMOVE CRC, Melbourne, Vic.

Scott, D., & Bax, C. 2019, Delivering on Proactive Congestion Management, Special Interest Session 41, 26th ITS World Congress, Singapore, Oct.

Siemens, 2019, *Traffic management solutions from a global market leader*, webpage, Siemens, Munich, Germany, <https://www.mobility.siemens.com/global/en/portfolio/road/traffic-management.html>.

Telstra, 2020, Towards Zero: creating safer roads with cellular-V2X in Australia, Ericsson and Telstra, Melbourne, VIC.

TIC, 2019, National Land Transport Technology Action Plan 2020-2023, Transport and Infrastructure Council, Canberra, ACT.

TfNSW, 2018a, Challenge 1: Mobility as a Service, Transport for NSW, Sydney, NSW.

TfNSW, 2018b, Future Transport Strategy 2056, Transport for NSW, Sydney, NSW.

Traffic SA, 2020, *AddInsight*, webpage, Government of South Australia DPTI, Adelaide, SA, <https://addinsight.com.au/>.

Transport & Environment, 2018, *How to decarbonise European transport by 2050*, Transport & Environment, Brussels, Belgium.

Transport and Infrastructure Council, 2019, *National Land Transport Technology Action Plan 2020-2023*, Department of Infrastructure, Transport, Cities and Regional Development, Canberra, ACT.

Transport for New South Wales, 2019, *Cooperative Intelligent Transport Initiative (CITI)*, TfNSW, Sydney, NSW, viewed 19 March 2020, <https://roadsafety.transport.nsw.gov.au/downloads/citi-overview.pdf>.

Transport for New South Wales Centre for Road Safety 2019, *Cooperative Intelligent Transport Initiative*, webpage, TfNSW, Sydney, NSW, viewed 19 March 2020, <https://roadsafety.transport.nsw.gov.au/research/roadsafetytechnology/cits/citi/index.html>.

The University of Melbourne n. d., *AIMES*, webpage, viewed 6 March 2020, <http://aimes.com.au/>.

The University of Melbourne n. d., AIMES: *Australian Integrated Multimodal EcoSystem: Intelligent transport technology for smart cities,* The University of Melbourne, Australia.

The University of Melbourne n. d., *Australian Integrated Multimodal EcoSystem (AIMES): The Brains Behind the Future of Smart Transport,* The University of Melbourne, Australia.

Walsh, D., 2014, Information and the evolving data space, Presentation to the Networks Reliability Workshop, Roads Australia, Melbourne, VIC, Jul.

Wazirada, Q., 2018, Changing Role of ITS Infrastructure in a Connected Autonomous World' ITS Australia Summit, Sydney, NSW.

World Economic Forum, 2019, Globalization 4.0: Shaping a New Global Architecture in the Age of the Fourth Industrial Revolution, World Economic Forum, Geneva, Switzerland.

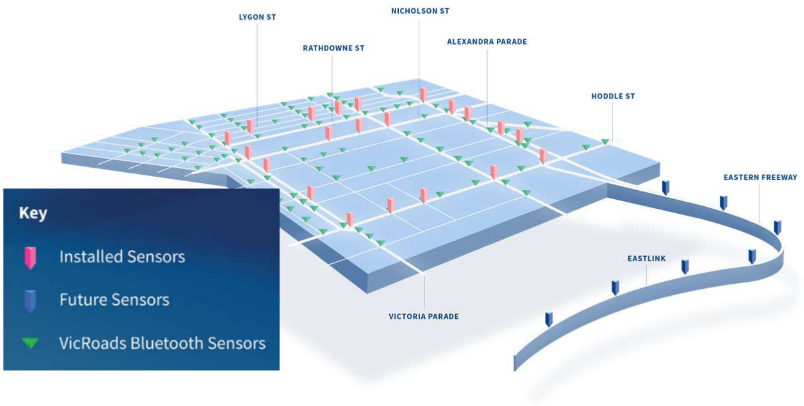
World Economic Forum, 2020, *3 ways transportation systems are adapting to the coronavirus crisis - and what we can learn*, webpage, WEC, Cologny-Geneva, Switzerland, viewed 5 May 2020, <https://www.weforum.org/agenda/2020/03/a-covid-19-transportation-adapt-lessons-learned/>.

APPENDIX A AIMES

The Australian Integrated Multimodal Ecosystem (AIMES) is a world-first test bed for integrated transport and technology, with the goal, "to link all transport infrastructure and users in cities together to deliver safer, cleaner and more sustainable urban transport (The University of Melbourne n. d.)."

Founded by Professor Majid Sarvi from The University of Melbourne in 2016, it was developed in the inner-city Carlton area of the Melbourne CBD, stretching 100 km and spanning six square kilometres. With more than 50 local and global partners, it aims to deliver multimodal transport: connected and automated vehicles, connected public transport, and connected pedestrians and cyclists with smart public transport stations and intersections (Melbourne School of Engineering n. d.). As shown in Figure A.1, there is the potential for extensive data collection, with up to 1,000 sensors of different types that could be installed (iMOVE Australia 2017).

Figure A.1: AIMES' suite of smart sensors and systems



Source: AIMES sensor suite (The University of Melbourne n. d.)

The aim is to create a connected, highly integrated transport environment, making use of Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Vehicle-to-Everything (including vulnerable road users) (V2X) communication systems (The University of Melbourne n. d.). It offers an environment for government, industry and academia to collaborate and use for in-depth testing in a variety of traffic conditions, road users and types, and infrastructure (The University of Melbourne n. d.).

AIMES used some of Cisco's (2018) technology in order to decrease CAV response times to impending events and assess threats to vulnerable road users using edge and fog computing at the infrastructure (roadside intersection) level. They found that using these devices provided the opportunity to quicken responses to life-threatening situations, without having to wait for mass CAV adoption.

AIMES also ran a trial using Wi-Fi based analytics technology at roadside infrastructure on intersections. Using Cohda Wireless Road-Side Units (RSUs), a near real-time view of road user performance and traffic flow was achieved. This solution is also future-proofed, upgradeable to DSRC or C-V2X once this technology in CAVs is widespread (Cisco 2019).

IoT, video analytics, deep learning (DL) and artificial intelligence (AL) were used for traffic flow management and insights into road user behaviour. In this case, Cisco's Intelligent Edge Video Analytics (IEVA) artificial intelligence software was used to identify different types of traffic (cars, pedestrians, trucks, buses, bikes, motorcycles) travelling through an intersection within the AIMES testbed. This achieved a 95% level of accuracy, and can be applied to more complex situations (detecting emergency vehicles, erratic and unsafe drivers) in the future (Cisco 2019).

APPENDIX B DATA PROJECTS

B.1 GROUP 1

	Data and Information Gap (Data Requirements)	Project	Objective	Lead Agency
1	Locating and understanding infrastructure datasets, Difficulties in comparing infrastructure performance and activity across infrastructure sectors and metrics	Infrastructure Performance Dashboard	Develop an Infrastructure Performance Dashboard	BITRE
2	Consistent national approach for measuring road speed performance and reliability, ability to conduct before and after assessments for road infrastructure projects	Road-Speed Performance and Reliability Dashboard	Expanding road speed performance dashboard	BITRE
3	supply chain model for agriculture	TraNSIT - Transport Network Strategic Investment Tool	Transport and logistics options for agriculture to identify potential cost savings	CSIRO
4	Measuring freight performance	Freight Performance Indicators	Develop a national freight performance framework and associated freight indicators.	BITRE
5	Information on best-practice modelling assumptions	Developing and Promoting Best Practice Modelling Assumptions	Develop best practice and consistent modelling assumptions to improve infrastructure planning and investment	BITRE
6	Measuring transport's contribution to the Australian economy	Measuring Transport's Contribution to the Economy - Transport Satellite Account	Develop a Transport Satellite Account.	ABS
7	Nationally consistent source of non-fatal road injury data.	Non-Fatal Road Injury Data Linkage Project	Providing non-fatal road injury data by linking crash data (collected by jurisdictions), hospital data and deaths data.	Austroads
8	Providing more timely and more detailed information about road freight and road freight vehicle movements, more cost effectively.	Road freight telematics data collection	Develop an enduring road freight telematics data collection and road freight telematics-based statistical outputs.	BITRE
9	Insights on transient population changes.	Insights on transient population changes – Cruise Ship Analysis.	Conduct a pilot study using telecommunications models to better understand changes in temporary populations associated with cruise ship arrivals.	BITRE
10	Data sharing guidance, methods and standards	NSW Data Sharing Taskforce	Facilitate data sharing by: providing advice on existing relevant legal frameworks; developing methods and standards for anonymising personal information; and developing methods for testing the existence of personally identifiable data in datasets.	NSW Data Analytics Centre (DAC)
11	Locating, understanding and utilising available transport and infrastructure datasets.	Tracking State and Commonwealth Open Data Developments	Improve visibility of cross jurisdictional open data and data sharing initiatives.	BITRE
12	Open data to support the implementation of Connected and Automated Vehicles.	Road Operator Data to Support Connected and Automated Driving	Identify gaps between the road operator data provided to users (developers) and what is likely to be required in future for CAV operations.	Austroads
13	Lack of formats and processes for industry data into agencies	Using industry information	investigate possible reporting formats and processes for industry data for agencies	TfNSW
14	Heavy vehicle movement surveys around ports	Port Movement Surveys	detailed various OD pair surveys	Govts and Ports
15	Link travel times	UBER movement data	link travel times in major Australian capital cities	UBER
16	Link travel times	TomTom data	link travel times in major Australian capital cities	TomTom
17	Link travel times	Google movement data	link travel times in major Australian capital cities	Google
18	Link travel times	Suna movement data	link travel times in major Australian capital cities	Intelematics
19	Route mapping with road attributes	HV Road attributes	HV network, restrictions, Hazmat, RAV networks, POIs, Distance markers, rest areas,	ARRB
20	Heavy vehicle performance and volume by type	Traffic on Rural Roads model (TRARR)	traffic on rural roads software to analyse and predict the performance of two lane highways for the implementation of overtaking lanes, principally for HVs	ARRB
21	Tools for modelling network operations based on vehicle performances	SMART Roads	planning software used for network operations planning (Movement in place)	Austroads, NZTA
22	30s data, location, time and vehicle type to develop operating speed of HVs	Design guidelines for heavy vehicles	review and enhancement of guidelines for various classes of HVs	ARRB
23	HV crash data (Victoria only) on maps with other attributes (speed limits, travel times),road assets and other information	ARRB Advanced Technology Lab and Safe Systems	HV safety analytics	ARRB

B.2 GROUP 2

	Data and Information Gap (Data Requirements)	Project	Objective	Lead Agency
1	Lack of national-level infrastructure asset management measures	Heavy Infrastructure Vehicle Asset Registers	Expand the asset registers.	DIRDC
2	Strength, roughness of the road	Road asset data	planning maintenance, monitoring deteriotation, use in hv road pricing	NTC
3	supply chain visibility	Supply chain indicator scoping report	Scoping study for future data collection	BITRE
4	Limited information on the accuracy of cost-benefit analysis (CBA) predictions and whether projects fulfil their objectives.	Post Completion Analysis for Infrastructure Projects	Conduct more independent post completion (ex-post) evaluations of CBAs for infrastructure projects and make findings publicly available.	BITRE
5	Assessing value for money for road and other infrastructure investments.	Cost Benchmarking for Infrastructure Investments	Expand and update cost-benchmarking work.	BITRE
6	Assessing value for money for road and other infrastructure investments.	Network Optimisation Framework, Reference Guide and Solution Assessment Tool	1. Provide a consistent governance framework which strongly encourages the consideration of network optimisation solution as part of any infrastructure proposal. 2. Collect and document existing network optimisation solutions and provide a growing library of ready-to-implement solutions available to TMR staff. 3. Establish a consistent and efficient method to evaluate network optimisation solutions against traditional infrastructure projects.	QTMR
7	Provision of up to date routing information for road freight	Heavy vehicle routing, Data Analysis Tool	routing informtion to drivers, agencies and telematics companies	TfNSW
8	Provision of up to date road infrastructure management information	Road Infrastructure Management (RIM) tool	aggregated telematics data at the road link level based on IAP and other data	TCA
9	Linking and merging of multiple data sources in a standardised format	Traveller information exchange (TIX)	improving journeys by providing beter information to HV drivers	TCA
10	HV telematics data (Mass, location, classification) with road asset condition data and other data sets as required	ARRB Advanced Technology Lab	Development of a research visualisation platform combining telematics data with Road agency data for research purposes	ARRB
11	National-level statistics to better understand the movement of freight to and from ports.	Customs freight data analysis project	Develop use case for the Customs freight data	BITRE
12	Standardised data	Intermodal visibility of the GS1 EPICS standard	evaluation of the GS1 Electronic Product Code Information Service standard	ALC
12	Traveller information and traffic management including signal priority for vehicles	Addinsight	provision of network wide performance indicators using bluetooth technology	DPTI, SA
14	Mobility data based on mobile phones	Telstra Location Insights	aggregates and anonymises information from proprietary network assets to provide highly relevant analytics and predictive insights, SA2 level	Telstra
15	Travel time data from 3rd party providers to support post implementation audits	Post implementation treatment network analysis (PITNA)	using travel time to analyse the before and after impacts of pinchpoint projects	RMS

B.3 GROUP 3

	Data and Information Gap (Data Requirements)	Project	Objective	Lead Agency
1	Live permit data to improve driver notificastion and compliance	Live permit data in truck	ability to access permit data while on board vehicle	TfNSW
2	On-board mass systems on HVs	OBM type approval	overcome mass breaches and meet COR duties	TCA
3	Improved reliability along 40km of freight routes in Pennant Hills, Parraamatta and King Georges Road, Sydney	Freight Signal Priority Trial (CITI)	green light progression for freight vehicles, V2I commumications with SCATS system	TfNSW
4	Real time monitoring, weighing and image acquisition	Next Gen Weigh-in-Motion Infrastructure	use of in-road scales with cameras and laser classifiers	VicRoads
5	secure industry data exchange. Facilitate linking between companies and between other golbal supply chains	Trade Community System / Port Community System	secure platform for informaton sharing	
6	industry data exchange, data dictionaries built/shared, establish platform rules, standardised data inputs, structuring data to be displayed, sharing rules	Data share platform	centrally processed data repository	TfNSW
7	APIs, natural query language, voice query, aggregated insights with artifical intelligence	Data experience	data platform to capture and share insights on roads, permits and assets, improved access to route data and key information. Secured shared access, protect vulnerable assets.	TfNSW
8	Secure access and permitting of HVs, determine suitable processes, develop specific tools	Blockchain	using blockchain to reduce time taken by councils to provide permits for access across bridges	TfNSW
9	Smart sensors connected to vehicles and infrastructure integrated to deliver smart transport services	AIMES (Australian Integrated Multimodal Ecosystem)	living laboratory for delivering integrated transport technology products and services	University of Melbourne
10	Safety applications for vehicles based on V2X communications	utilising CITS for V2X, Connected and Automated Vehicles Initiative (CAVI)	500 vehicle/ 50 intersection trial in Ipswich for day 1 CITS safety applications	QTMR
11	new data for IoT sensors	WA DOT MaaS Trial	trial of big data and IoT	WA DOT
12	new data for IoT sensors	Liverpool Smart City	trial of big data and IoT	DIRDC
13	new data for IoT sensors	Mornington Peninsular trial	trial of big data and IoT	DIRDC
14	trusted information exchange, Trade/Port Community Systems trial	TCS Blockchain Port of Brisbane	information exchange within Port Community using blockchain	Port of Brisbane

APPENDIX C ISO 15638

Framework for collaborative Telematics Applications for Regulated commercial freight Vehicles (TARV) (ISO 15638-1 to 24)

This set of standards is applied to the framework for conducting data collection/value information provisioning services assuming a system to provide users (freight operators) with regulatory and operational information through installation of vehicle sensors and GPS reception equipment in regulated commercial freight vehicles and transmission of data generated by these devices to service providers. It includes authentication for private IT providers. It is also assumed that information on violations of the regulation be provided by service providers to the regulatory authorities. In Europe and the United States, operational management of commercial vehicles is being conducted through making the adoption of digital tachographs mandatory (on June 15, 2019 use of a next-generation tachograph was mandated in Europe).

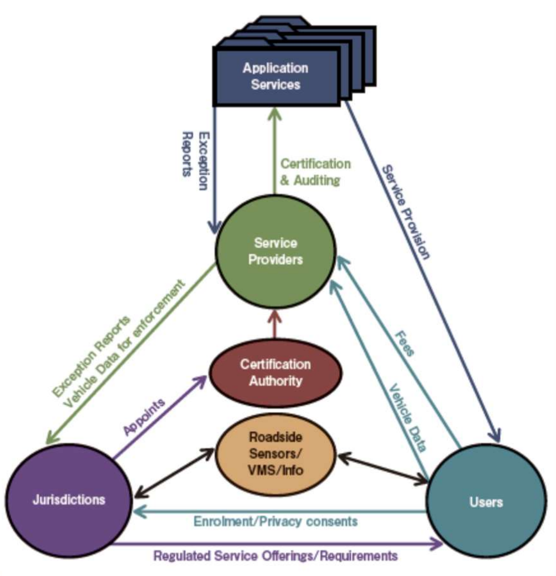
At the April 2015 Hangzhou meeting, Part 20: Weigh in motion (proposed by the EU) and Part 21: Enhancements using roadside sensors (proposed by Japan), at the October 2016 Auckland meeting, Part 22: Vehicle stability monitoring, and at the April 2019 Florida meeting, Part 24: Safety information provision were approved as new work items.

In the future, the ISO 15638 series is supposed to enable driver management, operational management and weight monitoring of heavy vehicles, and stable driving through combination of standards for each Part. The intention is to make it a valuable standard to improve efficiency of urban logistics.

Part 21 includes examples of use of on-board and roadside equipment, and focuses on worldwide deployment of the Japanese ETC 2.0 service.

Part 22 is a framework for monitoring freight balance and informing the driver of the state of freight to protect heavy vehicles from the risk of rollover accidents. Part 24 provides a variety of safety information.

Figure Framework diagram of ISO 15638



15638 series

ISO Number	Title
ISO 15638-1	Framework and architecture
ISO 15638-2	Common platform parameters using CALM
ISO 15638-3	Operating requirements, 'Approval Authority' procedures, and enforcement provisions for the providers of regulated services
CD 15638-4	System security
ISO 15638-5	Generic vehicle information
ISO 15638-6	Regulated applications
ISO 15638-7	Other applications
ISO 15638-8	Vehicle access management
FDIS 15638-9	Remote electronic tachograph monitoring (RTM)
DIS 15638-10	Emergency messaging system/eCall (EMS)
ISO 15638-11	Driver work records (work and rest hours compliance) (DWR)
ISO 15638-12	Vehicle mass monitoring (VMM)
TS 15638-13	'Mass' information for jurisdictional control and enforcement (MICE)
ISO 15638-14	Vehicle access control (VAC)
ISO 15638-15	Vehicle location monitoring (VLM)
ISO 15638-16	Vehicle speed monitoring (VSM)
ISO 15638-17	Consignment and location monitoring (CLM)
ISO 15638-18	ADR (dangerous goods) transport monitoring (ADR)
TS 15638-19	Vehicle parking facilities (VPF)
CD 15638-20	Weigh-in-motion (WIM) monitoring
ISO 15638-21	Enhancements using roadside sensors (ERS)
DIS 15638-22	Vehicle stability monitoring
PW I15638-23	Tire monitoring
PWI 15638-24	Safety information provision

Source : ISO 15638:2012

APPENDIX D CAVI

The Cooperative and Automated Vehicle Initiative (CAVI) is a project delivered by the Department of Transport and Main Roads (TMR) to prepare for and accelerate the arrival of advanced vehicle technologies with safety, mobility and environmental benefits on Queensland roads. This is with the goal, "to test cooperative and automated vehicle technologies that make roads safer, and contribute towards the Queensland Government's vision of zero deaths and serious injuries on the state's roads (TMR 2020b)."

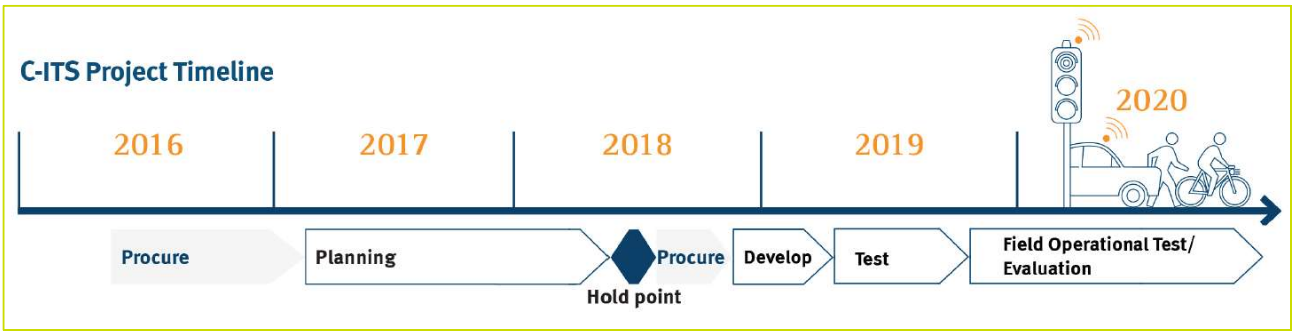
CAVI consists of four components:

- Cooperative Intelligent Transport Systems (C-ITS) Pilot – The largest component of CAVI, trialling cooperative vehicles and infrastructure on-road. Taking place on public roads in and around the City of Ipswich, the pilot will be delivered in two phases – planning and pilot deployment, starting with the C-ITS safety use-case, including V32I and V2V applications.
- Cooperative and Highly Automated Driving (CHAD) Pilot – Testing a small number of cooperative and automated vehicles on public and private roads. This will assess asset readiness, driver behaviour and vehicle performance.
- Vulnerable road user pilot – Testing new technology applications that address specific vulnerable road users' safety issues, including pedestrians, cyclists and motorcycle riders.
- Change management – A process for TMR to consider what is business practices are required to support widespread deployment of cooperative and automated vehicles on roads (TMR 2019c).

This project will focus on:

- Developing policy to support productive outcomes
- Supporting regulation, legislation, licensing, certification and testing
- Demonstrate technology while managing infrastructure, data and system integration
- Build public awareness and encourage partnerships in private and public sectors.

Figure D.1: C-ITS Pilot project timeline (TMR 2018)



APPENDIX E CITI

In 2012, Transport for New South Wales (TfNSW) established the Cooperative Intelligent Transport Initiative (CITI), Australia's first ever C-ITS testing facility. Cooperative intelligent transport systems (C-ITS) allow vehicles to communicate and connect with other C-ITS equipped vehicles and road infrastructure. With C-ITS, drivers can be alerted about hazards and traffic signal information (CITI 2019).

Situated just south of Sydney in the Illawarra region near the town of Woolongong, this environment:

- Allows research, development and testing of the road safety benefits and challenges of C-ITS in an Australian setting
- Allows hardware and software developers to test their systems
- Offers a diverse range of locations, including rural, mountainous and industrial areas, and a mixture of freeway and local roads
- Builds Knowledge and experience in the deployment and maintenance of C-ITS in Australia.

This trial has so far fitted:

- 60 trucks
- 11 public buses
- 52 light vehicles
- 1 motorcycle
- 7 traffic signal sites
- 1 roadside unit located in a rest area
- 3 roadside units elsewhere
- 1 railway level crossing (TfNSW 2019).

Examples of the safety alerts drivers receive include:

Figure E.1: Safety alert messages on AV display unit in vehicles

CITI has since been expanded to include up to 50 light passenger vehicles, allowing Illawarra drivers access to new technology to improve road safety (TfNSW 2019).

Another extension to the CITI project has seen Siemens partner with TfNSW to test a Rail2X application. In this, a level crossing status is broadcast to connected vehicles approaching the level crossing from a Road Side Unit (RSU).

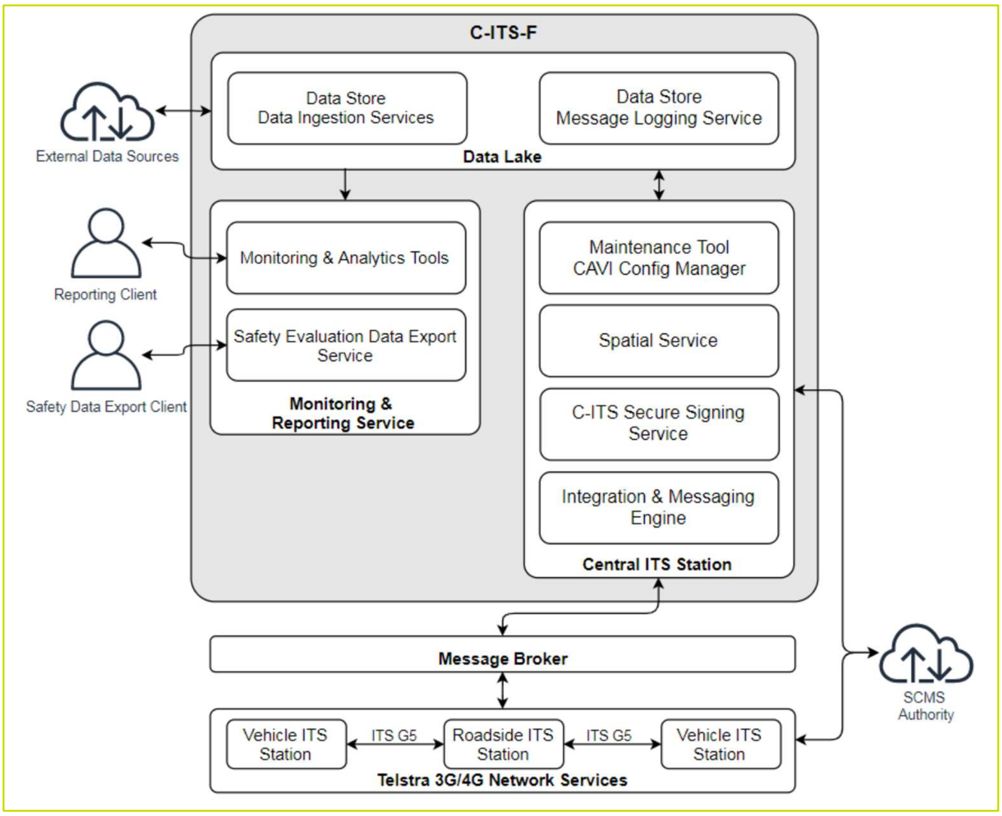
Figure E.2: Aerial view of Rail2X site

APPENDIX F CENTRAL ITS FACILITY

The department's central facility (C-ITS-F) is a cloud-hosted, serverless central facility currently under development on Amazon Web Services (AWS) and uses architecture wherever possible to support development agility, access to a range of cloud services, and lower costs ideal for both pilot and deployment.

As illustrated in Figure 3, the central facility supports several functions:

- Data lake: ingests external data sources, stores central, vehicle, and roadside station data and provides access for analysis, monitoring and maintenance.
- Central ITS Station (C-ITS-S):
  - provides dynamic spatial information based on the road network model which is required to build the compliant C-ITS messages, such as the trace, event history, and relevance zone
  - transforms and augments the data to create and manage the lifecycle of standards conforming C-ITS messages
  - signs C-ITS messages with security signatures
  - sends C-ITS messages to field stations (vehicle and roadside stations) using a message broker.
- Message broker: manages data transfer between functions in the central facility and field stations. The message broker is decoupled from the C-ITS-F to enable future protocol flexibility as the EU standards mature.
- Monitoring and reporting service: used to monitor and analyse the data collected in the data lake from all stations in the system. The analysis maintains sustainable operation and data integrity.
- Maintenance tool:
  - provides software and firmware management, executing over-the-air updates directly to field stations
  - manages configuration by disseminating up-to-date system, use case and device parameters using the message broker
  - manages the logged data returned by field stations via the message broker.



APPENDIX G IMOVE MAAS PROJECTS

MaaS business models: Lessons for operators and regulators (iMOVE Australia 2019)

This study aimed to identify key obstacles to the emergence of MaaS in Australia, and if and how they can be overcome.

1. The expected impacts and desired outcomes from MaaS

   Universities will develop a framework for determining the likely positive (i.e. reduced private car ownership) and negative (i.e. increase in congestion) impacts of MaaS, and what the desired outcomes of MaaS should be (based on public, industry and government perspectives).

2. The viability of different business models

   The role of ownership and access for MaaS providers e.g. B2C (business to customer) where the provider owns and operates transport services, or P2P (peer to peer) where the provider facilitates access to multiple independently owned transport services.

3. The role of different actors in the MaaS ecosystem

   What is the role of the public and private sector? How might the role of the public sector differ across local, state and federal government, and across urban, regional and remote contexts?

4. Data management

   What kind of data is needed to support integration between different transport services for planning, booking and payment, and how can this data be securely stored and managed.

5. The influence of the social and spatial context on the delivery of MaaS solutions
   How viable is MaaS in urban, regional and remote areas, which services of MaaS can these areas support, how will consumer and political opinion differ across different areas and demographic groups.

MaaS Trial in Sydney (iMOVE Australia 2019)

This project enrolled participants in a six-month trial, where they needed to arrange their everyday travel needs through a MaaS app (a customised version of Skedgo's TripGo). This gave them access to public transport (train, tram, ferry, and bus) and car-based transport services (taxi and car rental, Uber, Car Next Door and GoGet). The participants were able to find and compare (cost, travel time, environmental impact and health benefits) and book these services through the app, exploring the benefits of greater freedom of mobility.

MaaS and On-Demand Transport – Consumer Research and Report (iMOVE Australia 2018, ITS Australia 2019)

This project addressed the following:

Where are we at?

- Review the current status of MaaS overseas and in Australia
- What activity is happening, and the enablers for successful trialling and introduction

What do others think?

- Explore Australian and global customer preferences, expectations and perspectives on MaaS and on-demand transport

Australian opportunities

- Recommended actions for government, industry and research organisations to support the development of suitable on-demand and MaaS transport.

APPENDIX H STAKEHOLDER FEEDBACK: SUMMARY OF DISCUSSION POINTS

This Appendix captures summarised discussion points relating to the iMOVE Discussion Paper on Future Transport and Mobility Environment (FTME), which was provided to a cross-section of government and industry stakeholders in the transport and technology field across Australia in May 2020.

Discussion points were captured via phone interviews, email, and an anonymous survey.

The intent of this paper of summarised discussion points is to provide insights from government and industry representatives on the themes and ideas raised in the discussion paper. Releasing this summary is intended to complement the discussion paper through outlining common responses.

INFORMAL FEEDBACK

Following the circulation of a Draft Discussion Paper, “Future Transport and Mobility Environment” in May 2020, feedback was collected via engagement with recipients either directly, written communications or via a survey that was administered to all recipients of the draft paper.

A variety of feedback was received relating to additional related topics that could have been included and considered in the discussion paper.

1. Greater clarity of context for the paper

Several respondents sought to understand the driver for the discussion paper, given the various national work already in-train on future transport technology.

Whereas other respondents, in their feedback, highlighted the need for the discussion paper—while there is significant work underway on national consistency and understanding, there is also significant variance across jurisdictions.

Authors’ note: TMR and ARRB’s intent behind this iMOVE project needs to be clearly articulated. More context will provide a basis for understanding and appreciation of the report as well as its linkages to the other programs, projects and studies in progress.

2. Role of Incident management

The discussion paper presents an ideal world, whereas in reality, things go wrong. There is value in acknowledging that things go wrong, and in describing the future state, detail how these incidents are managed.

Authors’ note: The incident management functions are picked up under the overall network / traffic management domain.

3. Active Transport / Micromobility – Cars and other modes

The discussion paper focuses on current users, but would benefit from greater acknowledgement of growing active transport use and emerging micro-mobility modes. These are an additional demand on the network, that like all others, need to be considered and accommodated as appropriate.

There was discussion around whether the paper was too vehicle-centric, whether the future is about reducing vehicles or facilitating more vehicles, balancing needs, or instead focusing primarily on movement of people and goods.

Priorities will be influenced by many factors, and a future mobility environment needs—without focusing specifically on planes, trains, automobiles, scooters, walking, bicycles, or any other mode—to accommodate the fact that priorities can and will change.

Authors’ note: Accepted, and will be included.

4. COVID-19 Impacts

With COVID-19 impacting many at the time of the discussion paper being released, it was of course a topic of discussion. COVID-19 may result in many changes to our network, from changed demand (fewer people travelling due to restrictions, possible future increases in active transport), to changes supply (potentially less capacity of public transport network due to social distancing).

This ultimately is a supply and demand impact, like many other events that impact the transport system.

Authors' note: Accepted. This area continues to evolve as lockdowns are lifted and plans for transition and transformation of mobility are reconsidered in the medium to longer term.

5. Alignment to other work

There is much work in this space, considering the future of mobility:

- NTC Discussion Paper of Trial Guidelines mentions extension of trials to cross border, large scale and commercial trials, in itself a roadmap.
- The UK CAV Roadmap by Zenzic is a great example.
- The National Land Transport Technology Action Plan is endorsed by all Australian transport ministers and sets-out the work priorities to deliver emerging technologies in a safe, efficient, accessible, and sustainable manner.
- The National ITS Architecture (NIA)
- PIARC
- HARTS /HTG 7 work.
- Various other iMOVE projects.
- Austroads programs/projects
- ISO work on Mobility Integration (ISO TC204 WG19)

Would it be possible to link the direction of other iMOVE projects and align them with the FTME paper?

Authors' note: Accepted. The identification of core elements that exist or are in development in Australia and internationally will reduce the need to recreate the wheel and enable more efficient, scalable and integrated services and applications for FTME. Efforts will be undertaken to identify the core elements we have in the 'pantry' across all services in FTME.

6. Improving consistency, and how we communicate and share

Many of the core elements captured in the discussion paper already exist in some form—for example data standards, standards more broadly, safety assurance, security, and technology concepts such as the Central ITS Station.

Similar to other discussion on existing mobility initiatives, there is an opportunity to connect the various groups, materials, technologies and trials within Australia, through improved (and common) communication, and a centralised repository of this work.

Initiatives across Australian jurisdictions appear 'piecemeal', with a tendency to develop solutions in house. There is limited view of these individual initiatives contributing in a meaningful way to growing a larger body of knowledge.

Authors' note: Agreed. Communication and dissemination will be an area to be considered in the Final Report.

7. Terminology, and roles and Responsibilities

Transport agencies refer to themselves in a variety of different terms—mobility enablers, transport brokers, network stewards—what do these terms actually mean?

Common understanding of the meaning of words is key to communication. Are there any definitions for these terms? Are the terms unique, or do they all mean roughly the same thing?

Authors' note: Accepted. Even while MaaS is generally common in EU and elsewhere, in the US it is known as MoD (Mobility on Demand). It will be necessary to include a section on common terms and definitions for improved understanding.

8. Opportunities in Knowledge Dissemination

There is an opportunity to capture the concepts presented in the discussion paper in a central, reusable location and format. This will enable future work to build on the concepts in the paper, rather than the paper to be a one-off.

Authors' note: Accepted. Further consultation and engagement is required to scope and integrate with existing and new work programs.

SURVEY RESULTS

In addition to unstructured feedback, an anonymous online survey was provided to recipients of the discussion paper. Below is a summarised collection of feedback.

Question 1

Was the Discussion Paper helpful? In what areas was the paper useful to you? (for example; vision, concept, architecture)

The majority of recipients found the discussion paper was helpful, with the primary reason being the explanation of concepts.

Key feedback included:

- The paper could be used as a reference for future work
- There is benefit in somehow connecting the many existing initiatives and bodies of work into a common 'ecosystem' or reference
- It is positive that the discussion paper is not vehicle-centric
- There is an opportunity to distil the discussion paper into a summary of the concepts.
- Ten out of 13 people mentioned that the discussion paper was useful for them. This was for different reasons, mainly for the explanation of concepts.

Question 2

Were there any gaps missing, areas that needed further strengthening, or errors that need correction? e.g. specific areas like MaaS, CAVs or digitisation, regulatory side, human factors etc.

The overall feedback given was that there were gaps that needed addressing, mostly related to MaaS and more of a focus on the way forward, rather than background information.

Key feedback included:

- Opportunity to include a summary of the many concepts captured in the paper.
- There is a lot of discussion of 'existing' thinking, while there is a need to consider the future.
- Need more acknowledgement of all modes, including active transport and micro-mobility, and how this integrates into the future environment.
- There is an opportunity to capture a roadmap for how we progress in coming years.

Question 3

How can the final Discussion Paper better meet the needs of your jurisdiction to make an impact in government and industry? e.g. knowledge dissemination, consensus of views, provides a framework, foundation for going forward

References to key concepts are suggested, as well as general comments about the structure of the paper. Some suggestions for knowledge dissemination i.e. webinars were also given.

Key feedback included:

- Whether a draft or example roadmap could be produced, capturing the trails, trends and what is next; this could be a means to help jurisdictions to standardise.
- How this document could be linked into existing work, such as the National Land Transport Technology Action Plan.
- Opportunity for concepts and materials captured in the discussion paper to be made available in a central and reusable form, for training and awareness, and to enable others to build on top of the concepts.

Question 4

What actions are needed going forward (building awareness, prioritising, investment, facilitation)?

Engagement with leadership in government and industry, and alignment with existing policies and regulatory frameworks.

There is a need for a clear lead to progress this type of work.

There is an opportunity to present the concepts in the discussion paper in a simpler or more engaging way (such as animations or webinars) to improve accessibility of the information.

Further engagement with industry as well as government would be beneficial.

Question 5

Does the conceptual architecture, roles, functions and core elements reflect your own sense of the FTME system?

Most agreed that these aligned with their views of the FTME system, but also said that these should be more clearly laid out for others to understand. Conforming to architecture such as NIAF and PIARC was also suggested.

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