Framework for a national intelligent transport systems architecture

March 2010

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NZ Transport Agency research report 397

ISBN 978-0-478-35293-1 (print)
ISBN 978-0-478-35292-4 (electronic)
ISSN 1173-3756 (print)
ISSN 1173-3764 (electronic)

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James, R, J Date and C McBride (2010) Framework for a national intelligent transport systems architecture. *NZ Transport Agency research report 397*. 72pp.

Keywords: intelligent transport systems, ITS, ITS architecture, NZTA

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Acknowledgements

Our thanks to the steering group consisting of Transit New Zealand and Land Transport NZ staff (now NZTA) for their assistance and support in this research. Particular thanks to David Bakker (Land Transport NZ Enterprise Architect) Anna Cleary (Land Transport NZ Rail section) and Kerri Broadhurst (NZ Police) who spent additional time sharing their expertise. Thanks also to the three peer reviewers George Howells, Tony Bacon of Vodafone (NZ) and Henry Pretorius (NZTA) for their contributions. Finally, thanks to Liz Anderson for her strategic policy review.

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Executive summary

Intelligent transport systems (ITS) include systems for traffic light control, traffic management, electronic vehicle safety such as anti-lock braking systems, engine management, positioning systems, public transport, electronic surface transport and information sharing between transport modes. Together these systems hold enormous potential to increase transport efficiency, enhance safety and provide better services to the end users (or customers).

As ITS progress, new technologies are invented and adopted. The technical challenge is to harness, integrate and fully utilise the enormous potential of coordinating the view of all transportation data that can benefit the end user. More significant are the political, social, institutional and regulatory challenges to full integration of ITS. This report describes the concept of how an ITS architecture can assist stakeholders to resolve these challenges. It also briefly describes the purpose of subsequent development.

ITS architectures are intended to simplify rather than complicate the process of developing ITS applications, and in this context the term ‘architecture’ means a technology neutral map of services incorporating current systems and a future ‘big picture’. With a properly developed and fully implemented architecture, stakeholders can identify both the services required by end users and the sources of data for those services. Such an architecture will also describe how to optimise, coordinate, structure and share data sources and information services for the common benefit of end users.

Through the sharing of data, services and, where appropriate, information, the overall cost and the cost of providing each component of the system are reduced. The ability for the private sector to operate effectively is enhanced because data already available from existing systems may be shared at lower cost than that required to build new systems to collect the same data. This will not happen by chance. The potential efficiency gains are highly likely to present a value for money opportunity to all stakeholders, whereas maintaining a business as normal approach will result in further complexity and costs.

This report provides the first step in developing a national ITS architecture. It references international examples of ITS architectures and describes some ITS components (data capture and ITS services) that are currently in use or likely to be in common use during the next decade. Hence we refer to this report as a framework for a national ITS architecture. The framework is aimed at improving alignment of all stakeholders and enhancing a common understanding of what is involved in an ITS architecture.

The methodology used in preparing this framework involved consulting with a small group of subject matter experts, developing a draft set of ITS services based on international examples, a second round of consultation based on the draft set of services and further development and refinement of a core set of ITS services and sub-services tailored to the New Zealand transport environment.

The NZ Transport Agency is one of the groups that will gain significantly from an ITS architecture. It is in a sound position to promote, manage and adopt a consistent ITS architecture across the government sector, as well as facilitate collaboration with the private sector and academia. System integration, with a sound underlying architecture, will significantly reduce both capital and operating costs across the transport sector, while helping to improve the services offered to end users.

Abstract

The New Zealand intelligent transport systems (ITS) framework architecture was developed between 2007 and 2010 by Hyder Consulting Ltd for the NZ Transport Agency. It forms the basis on which to describe best practice development of a full ITS architecture for New Zealand consisting of a reference architecture, logical architecture and physical architecture. This will include a range of major national and significant regional level systems.

Intelligent transport systems (ITS) are defined by the International Standards Organisation as:

> *The application of information technology, communications technology, and sensor technology, including the Internet (both wired and wireless), to the general challenges and opportunities of surface transportation.*

This report provides the first step in developing national ITS reference, logical and physical architecture. It compares international examples of ITS architecture and describes some ITS components (data capture and ITS services) currently in use or likely to be in common use in New Zealand during the next decade. Hence we refer to this report as a framework for a national ITS architecture. The framework is aimed at improving alignment of all stakeholders and enhancing a common understanding of what is involved in an ITS architecture.

1 Introduction

The New Zealand intelligent transport systems (ITS) framework architecture was developed between 2007 and 2010 with reference to European, Canadian, US, Australian and Asian ITS architectures. This report outlines the role and function of an ITS architecture in the New Zealand context and recommends a core set of services suitable as a starting point for consultation on the development of national reference, logical and physical ITS architectures for New Zealand. The aim is to facilitate improved coordination and funding direction for the development of the first step: a national ITS reference architecture.

ITS are defined by the International Standards Organisation as:

> *The application of information technology, communications technology, and sensor technology, including the Internet (both wired and wireless), to the general challenges and opportunities of surface transportation.*

New Zealand is heavily dependent on surface transportation. With the drive for increased efficiency, productivity and economic growth, best practice solutions are required to manage increasing congestion of major urban highways and routes, fuel prices that will rise in the medium to long term, the consequences of around 400 road deaths every year[1], and increased carbon emissions.

Implementing ITS solutions conforming to an ITS architecture will identify synergies and encourage systems to work together, thereby providing opportunity for access to better quality and timely data, as well as delivery of a grater range of services than is currently possible. Reference to high-quality timely data will improve business intelligence, enhance the evidence base for decision making and result in smarter more cost-effective transportation management.

Properly architected and designed ITS provide a seamless, cost-effective and highly efficient method of reducing crashes and congestion, improving compliance, improving performance monitoring, and promoting efficient use of vehicles and the roading system. The net result is improved safety, sustainability, economic development and mobility.

Currently ITS technologies are used in rail, roading, vehicle fleets, driver assistance and monitoring systems. In New Zealand, these systems continue to advance and develop disparately and independently due to the lack of an overarching architecture. A fully implemented ITS architecture will provide significantly greater benefits for all transport users than those achieved for one user by any individual system.

A national ITS architecture will provide the opportunity to better manage existing assets across the transport sector, thereby postponing the need for capital investment in infrastructure upgrades. This will become more important, especially in the roading sector, where investment will be focused on larger projects over the next decade.

As ITS progress and new technologies are invented and adopted, major technical challenges arise in integrating, collating, evaluating and analysing the available data to realise the enormous potential of true evidence-based decision making. Perhaps more significant are the political and human challenges of

[1] Source Ministry of Transport website: *www.transport.govt.nz/research/MotorVehicleCrashesinNewZealand2007/*

aligning key government and private sector decision makers towards common goals, data sharing agreements and trust. Future development of a national ITS architecture will therefore need to form the basis of a common standard for the design of ITS.

An architecture is not a system design, nor is it a design concept. It is the framework around which multiple design approaches can be adapted and developed, each one specifically tailored to meet the individual needs of the users, while maintaining the benefits of sharing a common plan. It is often layered with higher layers describing the 'big picture' and lower layers addressing physical subsystems.

The framework architecture developed provides the first fundamental building block in the national ITS architecture. It is hoped that this will enable the public and private sectors and individual end users to commence aligning design, development and implementation of their own ITS strategies, products and services.

2 Purpose of the research

The purpose of the research was to review international ITS architectures and to develop a national framework ITS architecture with an indicative set of ITS services tailored to the New Zealand environment. The research also looked at how to involve and improve alignment of all stakeholders to enable funding for a reference architecture.

In New Zealand, as elsewhere, many ITS devices and systems are already in use; further systems are being developed and their use in the transport sector is likely to increase significantly over the next 20 years. Current ITS examples include commercial fleet and logistics management systems, the Northern Gateway Toll System, passenger and driver information facilities, real-time bus timetabling, integrated ticketing, the NZ Transport Agency's (NZTA) advanced traffic management systems, regional controller agent urban traffic control systems and Police/emergency services applications. Regulations were passed in January 2010 enabling technology-based mass-distance-location road user charging.

In New Zealand, some coordination has been achieved through consultation at a local level. The lack of a national ITS architecture and lack of political will to share project resources is already leading to increased overall costs, duplication of systems and reduced potential for interoperability.

Interoperability and information sharing between government agencies and external companies is critical to achieving maximum benefit from the information available. However interoperability cannot be achieved without policy makers understanding which systems should work together. This allows system implementers to develop both the interoperability requirements and formal interface standards.

To obtain maximum future benefit from the available information requires action to properly coordinate, simplify and integrate ITS systems (both existing and planned).

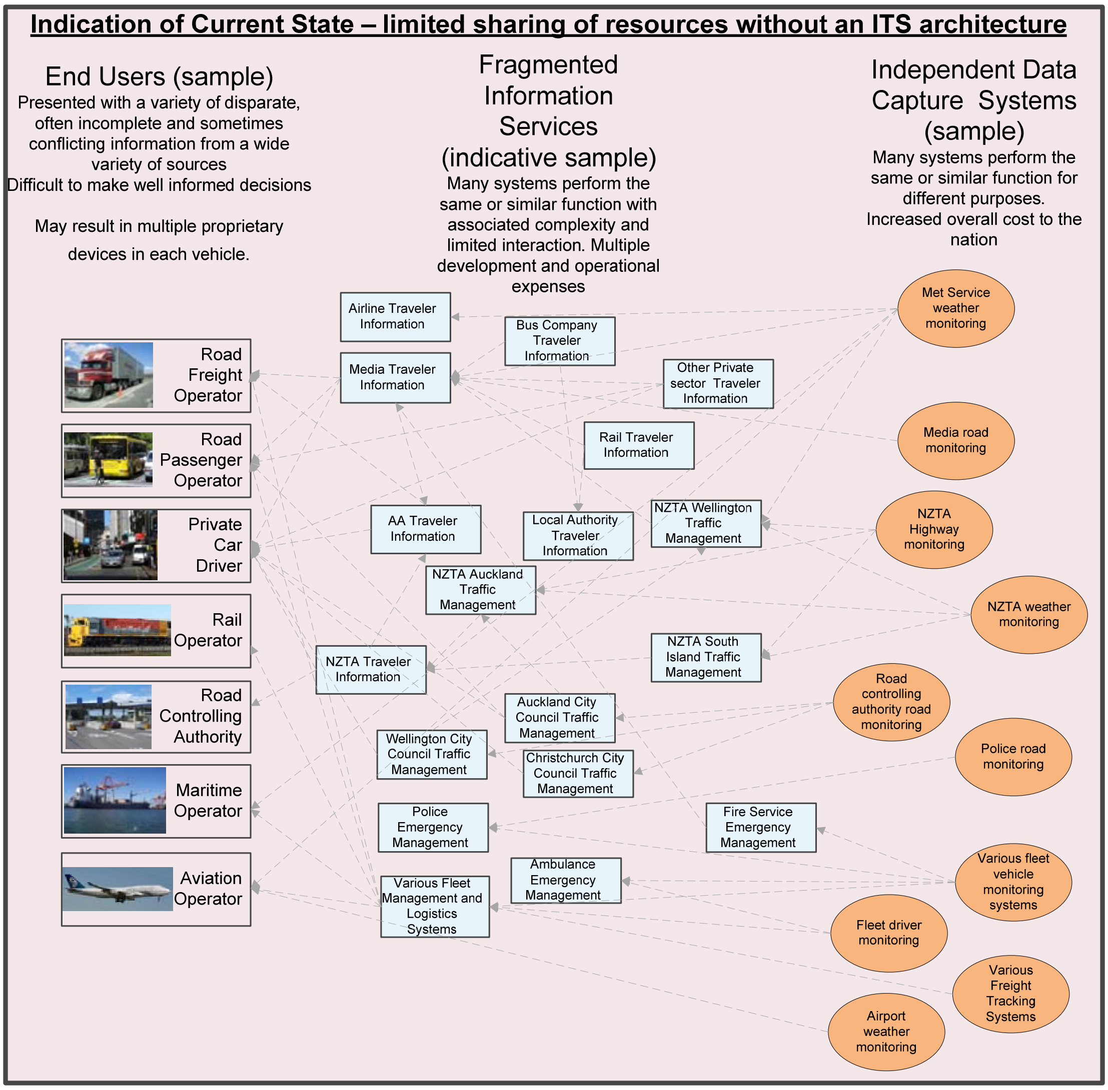
This framework for a national ITS architecture for New Zealand describes the big picture around the opportunity for different devices to work together and their potential synergies. The framework recommends best practice methodology as a basis on which to develop a full set of reference, logical and physical ITS architectures for New Zealand. These architectures will include major national and significant regional ITS systems.

The ITS domain is wider than highways, commercial vehicles or any single agency. The framework ITS architecture aims to demonstrate the need to include many agencies from the government and private sectors and from academia.

Without an architecture there is a likelihood that similar ITS (sub)systems will continue to be designed and implemented, often capturing the same data using different devices. As further systems are developed and implemented in isolation there is potentially the requirement for a range of after market devices to be fitted to each vehicle. This in turn could impact negatively on safety.

Without an architecture, data is not effectively or efficiently processed into information. At present, each user of the national 'system' needs to extract a range of sometimes conflicting information from a wide range of sources.

Figure 2.1 Without an ITS architecture multiple components perform the same task



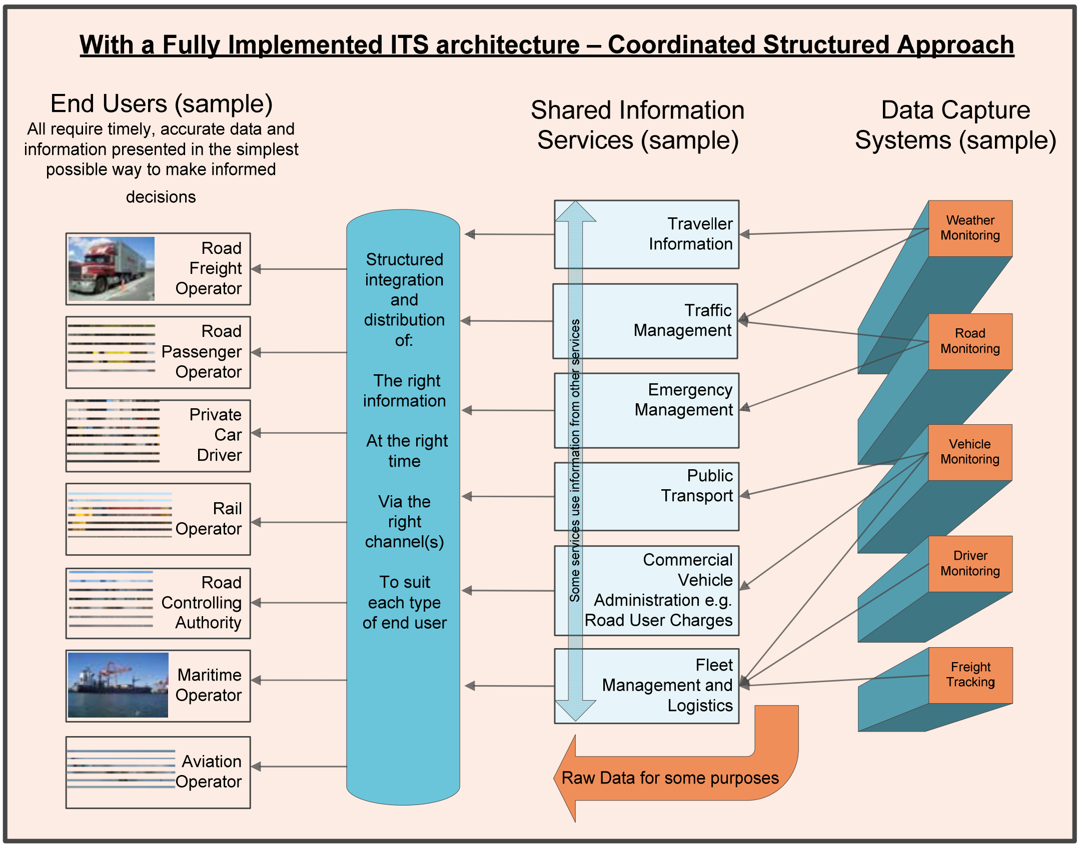
With a properly developed and fully implemented architecture, the data sources and information services required by end users are identified and optimised through sharing. This provides a coordinated and structured approach in providing information to a wide range of end users.

Through the sharing of data, services and, where appropriate, information, the overall cost is reduced and better services provided to end users.

The ability for the private sector to operate is enhanced because data already available from existing systems may be shared at a lower cost than that required to build new systems to collect the same data.

None of the above will happen by chance; maintaining a business as normal approach will result in further complexity and cost to the nation.

Figure 2.2 The ITS architecture enables a coordinated and effective information structure



The framework ITS architecture reviews international ITS architectures and applies a logical methodology to demonstrate which ITS are currently in use or may be applied in New Zealand and what might be achieved.

Ideally an ITS architecture aims to map and enable:

- data collection by sharing relevant data collection devices and the resultant data between services
  - collecting each piece of data once only and sharing collection costs
- processing standardised data sets into reliable and meaningful information from which business intelligence may be developed
  - consistent data is placed in the context of each service and developed into consistent information that is shared electronically wherever appropriate
- ITS products (services) available for delivery to a variety of end users ideally through a single device
  - consistent information chosen from a range of services.

Systems developed or integrated to meet an ITS architecture will provide comparative simplicity, clarity of information and value for money. In this sense an ITS architecture helps enable the development of an effective ITS strategy by individual agencies, allowing them to focus their development and/or investment on those areas likely to contribute most to their overall goals.

2.1 Architecture defined

Architecture may be defined as a strategic or top-down description of the structure of the system.

The framework architecture is a sound starting point for developing the scope and definition of a reference architecture, logical architecture and physical architecture (see section 4.2 for a more complete description of these).

This report outlines the role and function of an ITS architecture and recommends a core set of complementary services. A national architecture seeks to link these services, achieving national consistency in ITS, enhancing productivity and promoting economic growth.

A reference architecture is essentially a strategic business analysis, focusing on users and user services, providing a big picture plan of current and future services and facilities and the functional linkages between them.

A logical architecture identifies the actual system components (and their dependencies) that provide the functional services needed to meet the business goals of the reference architecture. A logical architecture identifies the type of linkages required between services. Together with system requirements documented in the reference architecture, the logical architecture represents a strategic national ITS deployment scenario.

The framework architecture provides a sketch of the contents of the reference and logical architectures.

A physical architecture provides cohesion in the deployment scenario. This is a significantly more detailed architecture defining layers of physical architecture in terms of physical subsystems and focusing on standardising interfaces to enable interoperability.

Implementation and integration of ITS to meet these architectures will provide a seamless, cost-effective and highly efficient means of accurately monitoring requirements and meeting government objectives.

ITS can make significant contributions to ensuring environmental sustainability; assisting economic development; assisting safety and personal security; improving access and mobility; and protecting and promoting public health. New Zealand already has a range of electronic ticketing and positioning systems independently performing the same tasks. Failure to develop a facilitated approach to New Zealand ITS in the near future is likely to result in significantly greater cost integrating systems at a later time.

2.2 Relevance to the NZTA’s key topic areas

The NZTA has a number of transport roles which will benefit from full implementation of an ITS architecture.

- ITS will assist the NZTA, in its role as the central funding organisation for roads, by providing evidence-based intelligence for well informed decisions about future planning and allocation of funding.
- The NZTA is the operator of the state highway network where ITS are already used. Improved coordination and automated data sharing with the private sector would assist operations.

- The NZTA is the regulator of network access and use including safety, various forms of licensing and road user charging. From January 2010, ITS may be used for mass-distance-location road user charging but this service is not integrated with other services.

ITS will assist the NZTA in achieving its five strategic priorities by:

- improving customer service and reducing compliance costs. This will be achieved by adopting the ITS architecture to improve coordination between related, yet currently segregated projects; enabling efficiency and value for money in funding direction
- planning and delivering roads of national significance. This will be achieved by using ITS to improve understanding of traffic flows and volumes and assisting in the construction process
- improving the road safety system through better traffic management and electronic systems to reduce risk
- improving the efficiency of freight movement. ITS will contribute through better traffic management and improved administrative process for freight operators
- improving the effectiveness of public transport.

The NZTA is one of the major organisations that will gain significantly from promoting and facilitating a more coordinated national approach to ITS development and deployment.

System integration, with a sound underlying architecture, will significantly reduce both capital and operating costs across the transport sector by:

- improving the level of benefits achieved from developing ITS facilities
- eliminating duplication and significantly reducing both capital and operating costs
- providing a sound basis for future planning and allocation of funding.

Most of the funding for public ITS systems is currently provided (at least in part) by the NZTA through the National Land Transport Fund. The most effective way to maximise the long-term benefits from this investment is to ensure systems are consistent with a sound underlying architecture, designed to deliver a thoroughly planned, integrated and interoperable environment for the future.

The NZTA is in a sound position to promote, manage and adopt a consistent ITS architecture across the government sector. Coordinating ITS in this manner could have favourable impacts on the management of assets. The Auckland ramp signalling project provides a good example of this where, together with other ITS initiatives, it has helped reduce congestion on key Auckland network segments. Continuing this trend will help defer the need to upgrade some regional networks without adversely affecting regional growth, allowing greater investment in routes of national significance.

The NZTA may also be in a sound position to facilitate collaboration with the private sector and academia. A recent example of the NZTA's influence on the private sector is the joint publication of interim guidelines for electronic road user charges (RUC) management systems.

2.3 End users of ITS

Primary end users of ITS include the travelling public, road controlling authorities, commercial freight operators, passenger operators, and maritime, aviation and rail operators.

Information is supplied by authorities who currently fund, develop and operate stand-alone ITS facilities, generally to manage traffic nationally and in the main urban centres. It is also supplied by a range of other private and public sector sources, for example the media.

Some larger transport operators already own and operate electronic vehicle (fleet) and driver monitoring systems. Other operators contract specialist ITS providers to operate the same type of system. Commercial ITS systems for freight logistics, fleet and driver intelligence enable competitive advantage through long-term cost efficiencies and superior customer service.

Around 10 commercial ITS companies currently operate in New Zealand providing real-time electronic tracking services for an estimated 30,000 vehicles (Road User Charges Review Group 2009). Tracking systems may potentially interact with other systems sharing the real-time communications capability to offer remote:

- freight dispatch and verification of delivery
- monitoring and adjustment of engine management systems including fuel usage
- monitoring and management of vehicle and driver safety systems
- monitoring and management of vehicle security systems
- monitoring and management of other ancillary systems, eg refrigeration
- real-time traffic flow and congestion information.

Limited information about commercial vehicle movements is provided to the NZTA, generally in support of RUC off-road rebate claims. From January 2010 it has become possible to use an approved electronic distance recorder for ‘on road’ road user charging. There is little doubt that many companies using this type of system will also prefer to electronically and automatically file a variety of other regulatory documents with the NZTA to save manual administration costs.

Further potential end users of an integrated system include many government agencies with an interest in the sustainability of transport. It would assist NZ Police in targeting those who are non-compliant, and vehicle service agents who may wish to run remote monitoring and diagnostics to increase safety and sustainability. All emergency services might benefit from real-time information about traffic congestion. Health and biosecurity operations will use real-time information in the event of disease outbreaks.

2.4 Challenges

Most of the major system operators (both public and private) recognise that in a fully interoperable ITS environment, sharing data will provide greater benefits for and efficiencies from each of their systems.

Interoperability means ensuring all ITS systems and devices are readily able to communicate and share data with each other. This will be achieved by following or developing standards to ensure consistent meaning and accuracy. Technical interoperability is considered a standard feature with the majority of new 'off-the-shelf' software applications; however, technical 'application' interoperability does not address data interfaces.

The remaining technical challenges are coordination and systems integration within the NZTA and between other service providers, including major authorities and other external parties. An ITS architecture will assist with this in the reference architecture by identifying where interfaces should exist; in the logical architecture by identifying the services that use the interface; and in the physical architecture by defining the data interface specifications.

The major political, social, institutional and regulatory challenge is in gaining consensus and authority to share data. Building trust between all stakeholders is critical to gaining this consensus. ITS architecture aims to involve a range of public and private sector parties, and build trust and cooperation by providing a common vision.

The private sector already operates ITS systems such as vehicle tracking and associated RUC refund applications. Integration of RUC data with government administration potentially offers a significant reduction in the operator's cost of compliance. It will also benefit operators who use a single data capture device for charging and logistics purposes.

This level of involvement is critical to ensure that the future reference ITS architecture meets all user needs, enhances information requirements and increases cost benefit. ITS are about collaboration rather than focusing on the needs of one organisation, agency, industry group or transport operator.

This framework ITS architecture is designed to raise awareness of the issues, recommend the way forward, improve the scope and definition of the reference, logical and physical architectures and so improve coordination and the allocation of funding.

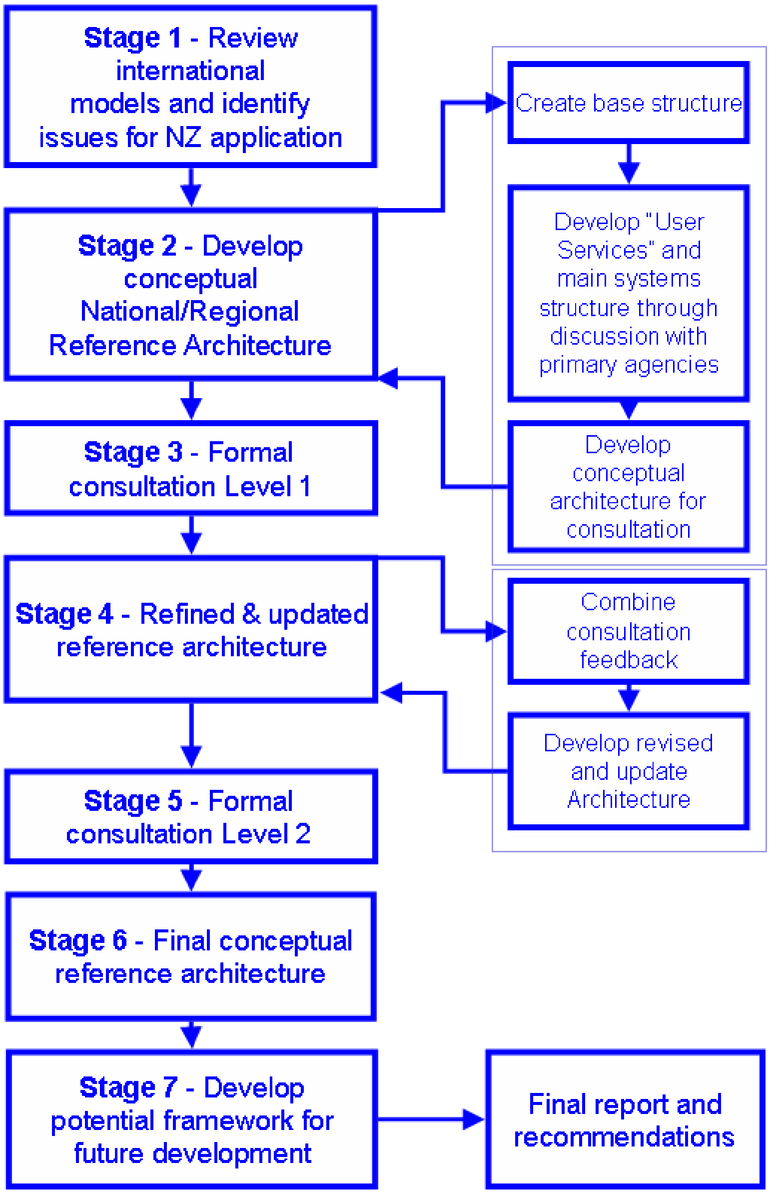
Developing a national ITS reference architecture in the future will provide a common big picture view. This will make the critical communication tasks much easier, informing strategy for the development of the logical and physical architectures, and enabling design and deployment of shared ITS services.

The national ITS architecture will provide a framework for the exchange of data and information and identify linkages between ITS strategies and system developments and deployments in the public and private sectors.

3 Research methodology

The methodology defined for this research is summarised in the following figure:

Figure 3.1 Research methodology



This methodology was based on a number of defined stages and sub-elements designed to develop a framework architecture through a process of close consultation with system operators. These stages are described below.

3.1 Stage 1 – Review of international models

The first stage of the research involved a review of overseas ITS architecture models and the key aspects of their underlying structure. The models examined included the US national and regional architecture model that has been in use for around 10 years; the Canadian model; the European Keystone Architecture Required for European Networks (KAREN) model; and the Australian reference architecture and data registry model.

Through this review New Zealand-specific issues were identified, and the research then focused on simplifying and tailoring a model better suited to the New Zealand situation. Considerations included the extent and complexity of existing and planned ITS facilities, levels of potential integration and coordination with external systems. The main objective of this stage was to identify the most appropriate base structure from which to develop the framework architecture.

3.2 Stage 2 – Develop draft framework architecture

Stage 2 involved the development of a draft framework architecture for New Zealand. This was compiled through discussions with representatives from the central agencies and organisations involved in current and planned ITS facilities and included developing a recommended ‘user services’ section and main systems structure.

3.3 Stage 3 – Formal consultation level 1

Following the development of a draft framework architecture, a formal consultation process sought feedback from the main stakeholders on its form and content. Stage 3 included a structured process of meetings to assess issues of feasibility, benefits and constraints of the ‘first cut’ architecture.

This stage also included discussions on the process that could be used to develop a full architecture in the future. A full architecture will most likely include a reference architecture, logical architecture and physical architecture.

3.4 Stage 4 – Refined and update draft framework architecture

Stage 4 involved modifying and updating the initial architecture based on the consultation feedback and developing a more detailed and refined model for further consultation.

3.5 Stage 5 – Formal consultation level 2

Following the development of the refined framework architecture, a second formal consultation process was used to consolidate feedback from the main stakeholders on its form and content. This included a survey to assess issues of feasibility, benefits and constraints at a more detailed level.

This stage included further discussions on the processes necessary to develop a full architecture in the future.

3.6 Stage 6 – Final framework ITS architecture

This stage involved finalising the framework architecture to form the basis for developing a full ITS architecture.

3.7 Stage 7 – Develop potential framework for future

This final stage established a recommended framework of services and processes fully tailored to New Zealand requirements describing and enabling development of a full ITS architecture. The framework architecture listed in chapter 7 'Concept for the future' indicates the type of services preliminary consultation indicated as a sound starting point for developing a formal New Zealand ITS reference architecture. This involves discussion and consultation with a much wider group of stakeholders representing over 100 organisations. Chapter 7 includes high-level descriptions of existing ITS systems, planned ITS systems, present and future services supporting each of these systems and a range of other possibilities. The key to ITS is recognising the value of organisational collaboration and system interoperability; each component service can add value to many other services, ideally eliminating duplication of infrastructure requirements.

3.8 Final reporting

This final report was developed and issued to the peer reviewers in draft form before final submission to the NZTA.

3.9 Steering group review

At an early stage in the project a steering group was established including the identified peer reviewers and a selection of key people involved in the industry. It included representation from ITS New Zealand as the main industry body with an interest in promoting an interoperable ITS environment in New Zealand.

The steering group's role involved considering the direction of the study from a New Zealand perspective, including consideration of potential costs/benefits and the relevance in terms of the Land Transport Management Act 2003 (LTMA) and New Zealand Transport Strategy (NZTS) objectives.

4 ITS architecture background

In order to provide an appreciation of the purpose of this project, the following section sets out what a national or regional ITS architecture comprises, and how high-level architecture is used in other countries and regions to coordinate the development of ITS solutions.

The International Standards Organisation describes ITS as:

> *The application of information technology, communications technology, and sensor technology, including the Internet (both wired and wireless), to the general challenges and opportunities of surface transportation.*

Throughout the world ITS assist in managing increasing demand for transportation by applying technological advancements to the transportation system, and improving the quality, safety and effective capacity of existing infrastructure.

As New Zealand grows, it is becoming increasingly difficult to build new capacity to meet transport demand in our major urban centres. ITS can help address this challenge by maximising the use of existing infrastructure while minimising costs and reducing the adverse impacts of transport and transport infrastructure. ITS examples which New Zealand is working towards include:

- integrated traffic management and motorway management systems
- traveller information facilities
- integrated demand management systems
- congestion charging and tolling systems
- roadside and vehicle-based safety systems
- emergency management and recovery systems
- public transport and integrated ticketing systems.

As the use of stand-alone ITS technologies and facilities continues to advance and develop in New Zealand the number of systems, standards and potential interfaces are becoming increasingly complex. In addition, the expectations of users (including stakeholders) rise, particularly in terms of accessibility to real-time information, system functionality, reliability and the perceived ease with which changes and enhancements can be made.

A fully integrated ITS environment provides greater benefits for all participants than those achieved by any of its individual component parts. But in order to achieve this integration, it is necessary to have a range of organisations (including private and public sector) cooperating and sharing information in a manner that will enable them to achieve their aims. This requires effective communication and collaboration between as many stakeholders as possible.

A defined high-level and technology neutral ITS architecture can make this critical communication task much easier. It enables complex ideas to be specified in a manner that is easy to understand. This enables identification of technical solutions and highlights critical requirements. ITS architecture can also assist in identifying business opportunities, system deployments to be planned, and risks to be identified; all in a manner that is simple to understand.

ITS architectures are intended to simplify rather than complicate the process of developing ITS applications, and in this context the term 'architecture' means a technology neutral map of services incorporating current systems and a future big picture.

4.1 Benefits

The benefits of establishing a sound ITS architecture are typically value-for-money benefits attributed to systems engineering and integration.

Further development of the architecture at logical and functional levels will involve an analysis of the data underlying each service, comprehensive identification of commonalities and a technical approach to data flows, data sharing, integration and interface standards so that the private sector, and national and local agencies can be assured that ITS products and services are compatible and interoperable with other ITS products and services.

This level of specification means that system integrators can leverage the ITS architecture to create efficient system designs in which the services avoid redundancy and are inherently compatible. Compatible systems enable each technology to serve multiple functions as a common resource, providing significant cost savings.

These architecture characteristics are likely to result in lower system development, and operational, maintenance, upgrade and expansion costs for product providers with improved information benefits for the end users.

In these ways a national architecture may provide significant long-term benefits for ITS strategies, system designs and implementation.

An ITS architecture encompassing national and regional levels provides benefits for a variety of ITS stakeholders. For example, an ITS architecture:

- establishes, manages and aligns a common understanding of assumptions across all components
- permits technology to change and evolve without wholesale component replacement
- facilitates consistency of information across all components
- facilitates interoperability of hardware, software and data components
- facilitates a more open and stable market with many participating suppliers and collaborative partnerships
- permits economies of scale from component re-use
- promotes and encourages investment by developers and users through a greater certainty in the future
- provides for improved future operational resource planning
- reduces development time and cost
- reduces duplication of systems

- reduces capital and operating costs
- enables application software components to be built by separate developers
- enables information sharing between subsystems therefore enabling multi-modal transport management systems.

Without an ITS architecture there is:

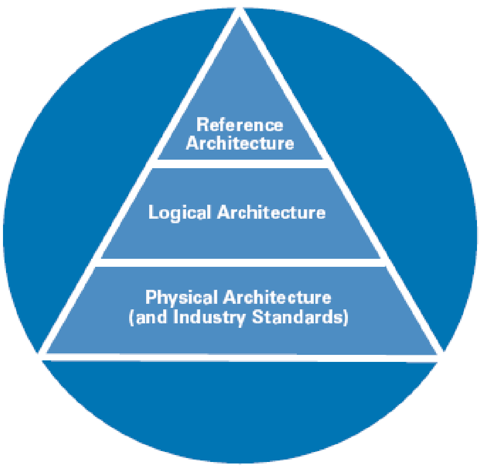
- a lack of coherent component integration
- limited appreciation of the risks to deployment and operation
- difficulty in extending the services provided
- difficulty in adapting to new technologies
- higher costs for component ownership and operation
- potential failure to develop the full potential of system deployment.

If we develop a properly defined architecture and comply with it going forward, there is an opportunity to achieve all the benefits listed above.

4.2 Architecture levels

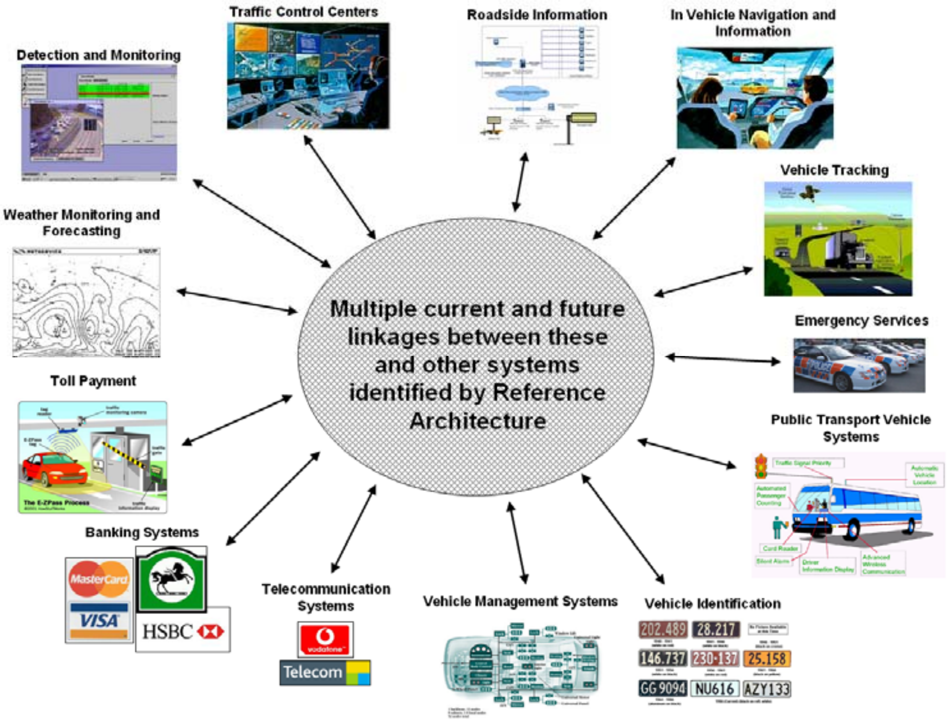
Most ITS architectures comprise three levels (or views).

Figure 4.1 Architecture levels



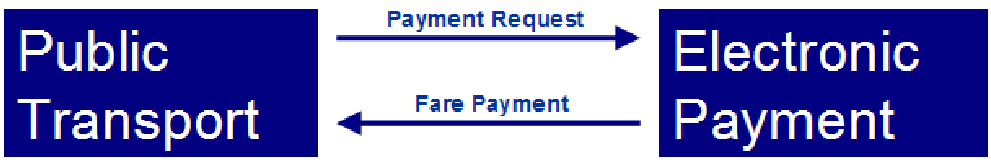
Reference architecture focuses on users and user services, providing a big picture plan of current and future services and facilities, and the primary functional linkages between them. An example of this is shown in figure 4.2.

Figure 4.2 Reference architecture example



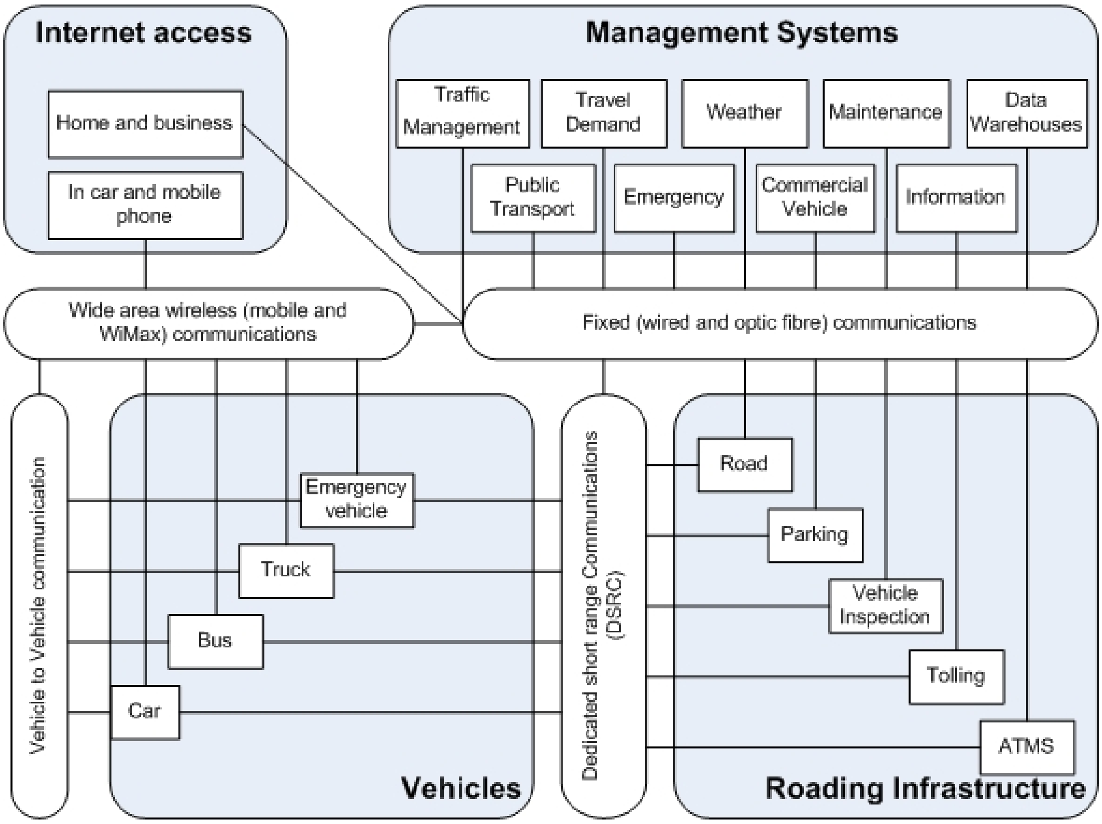
Logical (or functional) architecture focuses on user services broken down into functions and indicating the nature of data and information exchange required to perform the functions. Figure 4.3 sets out an example of a simplified logical architecture.

Figure 4.3 Logical architecture example



Physical architecture defines the more detailed layers of the architecture in terms of setting out physical subsystems. An example is shown in figure 4.4.

Figure 4.4 Physical architecture example



5 International examples

Overseas examples of well developed ITS architectures exist worldwide in four main places:

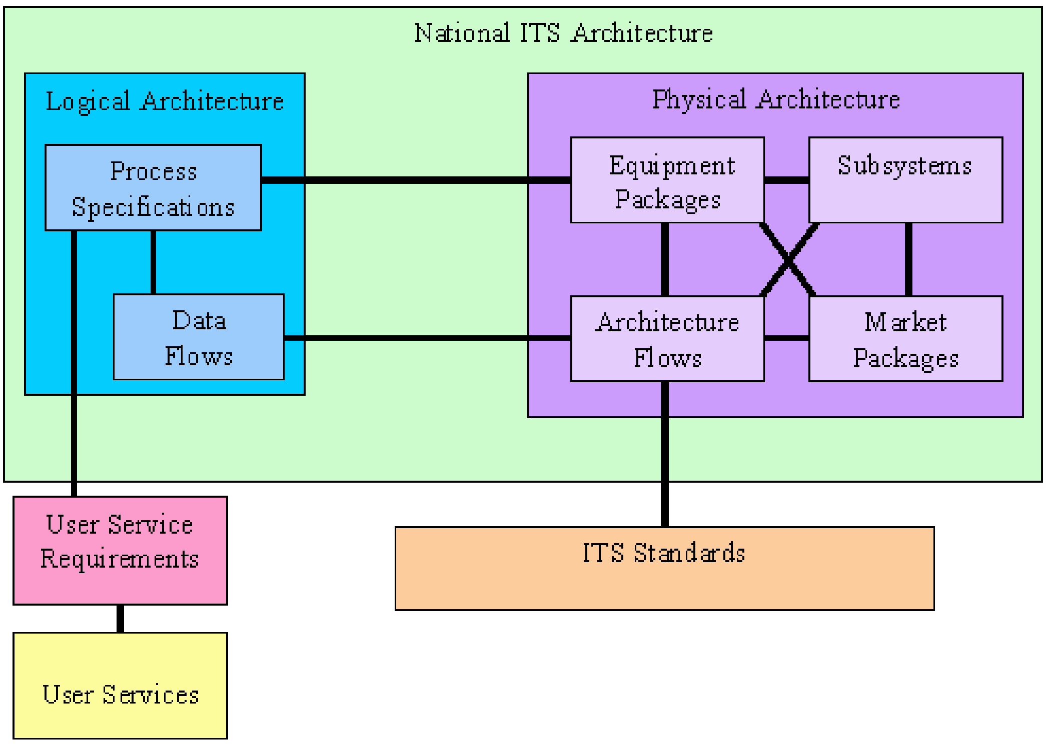
- USA
- Canada
- Europe
- Australia

ITS architecture is a major driver of ITS development and deployment in the US and Europe, and has a growing application in Australia.

5.1 United States

In recent years US$30M has been invested in the development of the US national ITS architecture. This provides a top-level framework, setting direction for ITS implementation, funded by the US Federal Government, and including a major commitment to training.

Figure 5.1 USA national ITS architecture



5.1.1 Role

The role of the national ITS architecture in the US is to provide a common framework for planning, defining and integrating ITS. It is made up from the input of transportation practitioners, systems engineers, system developers, technology specialists, consultants and other key members of transportation groups across the US.

The deployment of ITS across the US is driven by a number of factors that stem from the mobility that Americans take for granted as part of everyday life. The factors that drove the investment in a national ITS architecture were:

- **Congestion** in inner city and urban areas has a major impact on quality of life and the environment.
- **National security** is an important issue for the US and particularly for its transportation systems following the terrorist events of 2001. Potential targets include major transport hubs, structures and major events.
- **Road safety** is a concern with 2.7 million people injured in traffic accidents in the US in 2005 (Bureau of National Statistics 2009).
- **Inefficiency** of transport systems can range from parking issues to compliance issues for commercial operations.
- **Loss of productivity** can be suffered as a result of one or a combination of all the above and can on a large scale directly effect national productivity.

The US recognised that ITS technologies could be deployed to address the main issues faced by the country and that implementing ITS in a structured manner would bring the most significant benefits. Therefore the US national ITS architecture was created and continually developed using technology changes over the years. The architecture has provided a common structure for the design and implementation of ITS and is the framework around which multiple design approaches can be developed

In 2004, the ITS Management Council reorganised the functions of the ITS programme to focus on nine areas that would lead to particularly significant benefits. The aims of each of these initiatives were to improve safety, mobility and/or productivity. The major initiatives were:

- **Vehicle infrastructure integration:** advanced vehicle-vehicle and vehicle-infrastructure communications to keep vehicles from leaving the road and improve the safety of movements through intersections
- **Next generation 9-1-1: to** establish the foundation for public emergency services in a wireless environment and develop an emergency call system compatible with any communications device
- **Cooperative intersection collision avoidance systems:** combined autonomous-vehicle, autonomous-infrastructure and cooperative communication systems to improve safety for manoeuvres through intersections
- **Integrated vehicle-based safety systems:** to demonstrate the technologies necessary to equip all new vehicles with advanced driver assistance systems that will help drivers avoid the most common types of fatal crashes

- **ITS Operational Testing Program to Mitigate Congestion:** to facilitate the operational testing and evaluation of innovative and aggressive congestion reduction strategies
- **Integrated corridor management systems:** to assist agencies in implementing integrated corridor operations, creating supporting analysis tools, approaches and technical standards
- **Clarus (National Surface Transportation Weather Observing and Forecasting System):** to establish a partnership between state and federal agencies to develop and demonstrate an integrated surface transportation weather observing, forecasting and data management system
- **Emergency transportation operations:** to develop the tools, techniques, demonstrated benefits, technical guidance, and standards necessary for state and local agencies to effectively manage 'no notice' evacuations
- **Mobility services for all Americans:** to increase mobility and accessibility for the transport disadvantaged and the general public, and achieve more efficient use of federal transportation funding resources through technology integration and service coordination
- **Electronic freight management: to** enable improvements in speed, accuracy and visibility of information transfer in a freight exchange.

5.1.2 Stage of development

The national ITS architecture in the US is a very mature product that has been through significant development since work began on the architecture in the early 1990s. The first suite of documents was published in 1996.

Version 6.0 was released in April 2007 and contains the following updates:

- Architecture support for additional dedicated short-range communications (DSRC) applications. This supports the wireless communications channel used for close-proximity communications between vehicles and the immediate infrastructure. It also supports location-specific communications for ITS capabilities such as toll collection, public transport vehicle management, driver information and automated commercial vehicle operations. Features added were safety messages between vehicles and vehicle warning systems enhancements.
- The vehicle infrastructure integration initiative (VII) improves integration between intelligent vehicles and intelligent infrastructure using short-range communications by adding several new packages including traveller information, environmental probe surveillance and infrastructure monitoring.
- Enhanced commercial vehicle information systems and networks (CVISN) were updated to include driver identification cards and data flows to track repair status, fleet maintenance management, driver records and driver credentials.
- Border inspection – administration, border inspection systems and border information flow architecture.
- Clarus initiative. The weather and surface conditions reporting initiative was updated to emphasise the collection of quality checked environmental sensor data.
- Electrical lighting and management systems manage roadside electrical and lighting systems based on monitoring of operational status, timing plans, sensors and commands related to traffic incidents.

- Emergency management operations (EMO) initiative disseminates traveller information stemming from EMO and biohazards with no prior notice.
- Integrated justice information systems (IJIS) incident management standards efforts. The IJIS data flow with the emergency management and traffic management subsystems was updated.
- Public transport area was modified to support maintenance, fleet activities and provide a count of the number of passengers through electronic ticketing.

5.1.3 Model

The national ITS architecture is made up from three components:

- reference architecture
- logical architecture
- physical architecture.

The architecture defines the functions that must be performed to implement a service and the systems where these services belong. It also defines the information flows between systems and the communication requirements for those information flows.

It is within the logical architecture that the structure of the model is defined. This presents a functional view of ITS services. It defines the functions or process specifications that are required to perform ITS user services, and the data flows that need to be exchanged between these functions.

The US architectures are delivered in three views: a hypertext (browser) view, a document view and a database view.

5.2 Canada

The Canadian ITS architecture was developed from the US model, largely due to the benefits of having closely connected transport systems that complement each other. However there are a number of differences because of the Canadian environment.

The logical architecture of the Canadian ITS architecture was developed in parallel with the physical architecture, unlike the US where the development of the physical architecture was based on the logical architecture.

Points of difference from the US architecture and issues of particular relevance in the Canadian context include:

- level of population dispersion
- bilingual language considerations
- extreme climate
- use of the metric system of measurement
- legislative issues

- existing system infrastructure
- communications industry and regulatory considerations.

The following is a list of services that were identified as applicable to Canada but absent from the US architecture:

- maintenance activities
- automated enforcement
- non-vehicular traffic
- intermodal transportation
- road weather conditions.

Figures 5.2 and 5.3 show the differences between the two systems.

Figure 5.2 Canadian ITS architecture

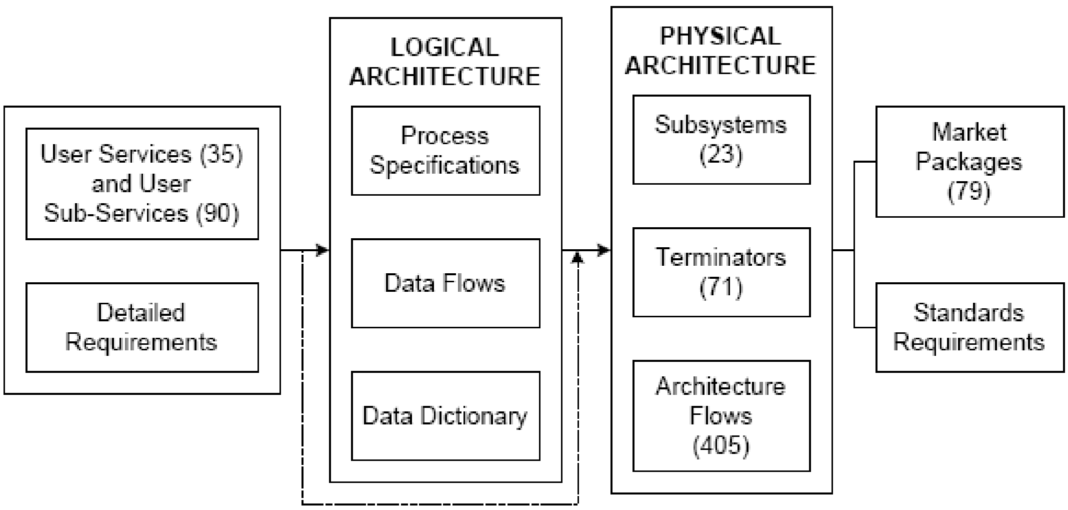
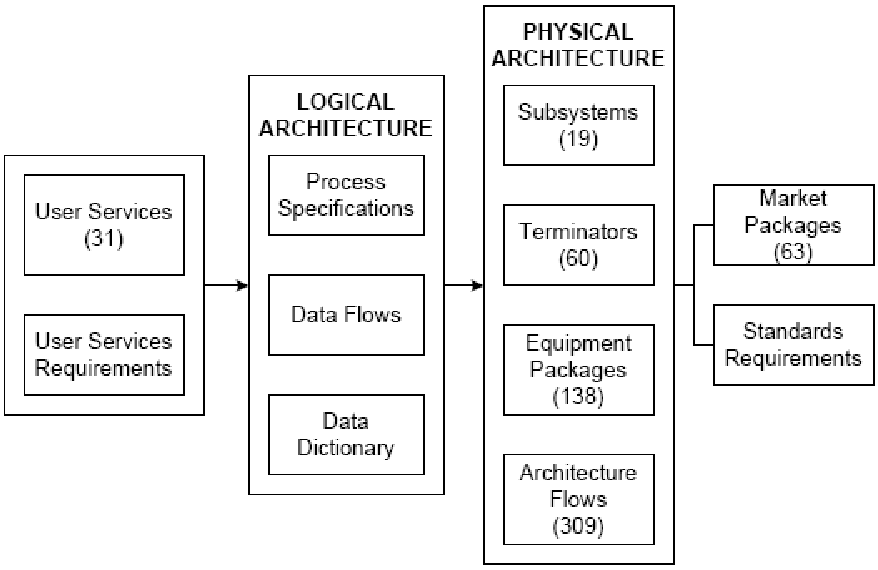


Figure 5.3 US ITS architecture



The Canadian ITS architecture includes 35 user services. Of these, six user services were developed specifically for the Canadian ITS architecture, including:

- **operations and maintenance** to provide government agencies, as well as contractors with the resources to manage the operations and maintenance of vehicle fleet and equipment assets, and monitor and manage traffic flow around work zone areas
- **automated dynamic warning and enforcement** to provide systems that warn vehicles or motorists of imminent danger, and provide electronic enforcement of traffic control and regulations
- **non-vehicular road user safety** to provide warning systems primarily focused on pedestrian and bicyclist safety
- **intermodal freight management** to provide systems to monitor the status of freight in transit and at freight terminals
- **disaster response and management** to coordinate disaster response strategies from a virtual control centre, and disseminate information to agencies and individuals on traffic conditions, diversion routes etc
- **weather and environmental data management** to provide system-wide gathering, fusion and dissemination of information on roadway weather conditions and forecasts.

The integration of the Canadian and US architectures is facilitated by a border information flow architecture (BIFA). Completed in 2005, BIFA does this by identifying agencies at or near the border and mapping information flows between them. A key feature of BIFA is that its definition of ITS projects includes technologies used by non-transportation stakeholders such as Canadian and US customs agencies.

5.2.1 Role

The Canadian ITS architecture provides a unified framework for integration to guide the coordinated deployment of ITS programmes within the public and private sectors. It offers a starting point from which stakeholders can work together to achieve compatibility among ITS elements to ensure unified ITS deployment for a given region.

The architecture describes interaction among physical components of the transportation systems including travellers, vehicles, roadside devices and control centres. It also describes the information and communications system requirements, how data should be shared and used, and the standards required to facilitate information sharing. Overall, the Canadian ITS architecture defines the functionality of ITS components and the information flows among ITS elements to achieve total system goals.

5.2.2 Stage of development

Canada began developing an ITS architecture in 1999 and has had a working architecture in place since the end of 2000. In 2006 Transport Canada began the process of updating the Canadian architecture, and it was decided that the Canadian architecture should remain aligned with the US architecture. Therefore the key focus of the update was to address the differences that had developed between the US and Canadian systems since 2000. In relation to aligning with the US architecture, three principles for this update were identified:

- All functionality that was added to create the Canadian architecture in 2000 and had not been since added to the US should be kept in the updated version.
- Where the US had subsequently added functionality that was similar to functionality added to the Canadian architecture in 2000, any additional enhancements implemented in the US should be incorporated.
- Where the US had added functionality that did not exist in the Canadian architecture, it should be integrated in the update.

5.2.3 Model

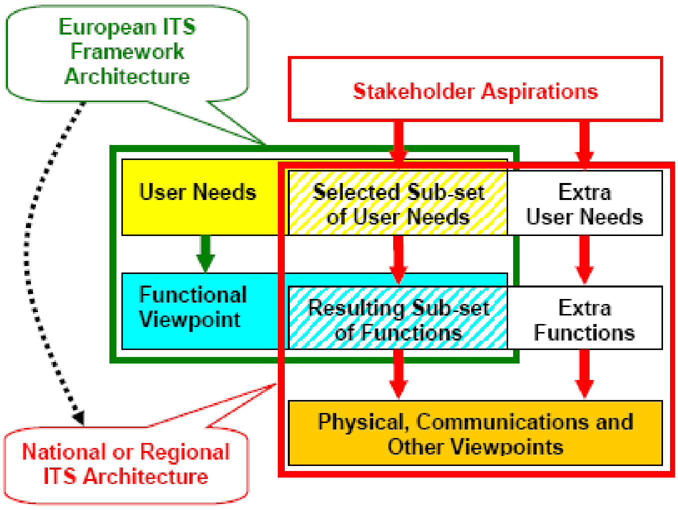
As with the US national ITS architecture, the Canadian architecture consists of three components:

- reference architecture
- logical architecture
- physical architecture.

5.3 Europe

Compared with the US, fewer resources have so far been committed to developing a common architecture among European states. Many ITS applications have already been deployed across different states and the challenge in Europe is therefore to integrate these building blocks to provide consistency. A series of European Commission (EC) funded projects have been undertaken, among the most significant being the KAREN project completed in 2000, and the more recent project Framework Architecture Made for Europe (FRAME).

Figure 5.4 European ITS architecture



5.3.1 Role

The European ITS framework architecture was created in order to provide guidelines and a common approach to the planning, development and implementation of ITS throughout Europe.

It provides a framework for the development of:

- national, regional or local ITS architectures
- systems for ITS deployments at national, regional or local level.

The following functional areas are covered by the European architecture:

- electronic payment facilities
- safety and emergency facilities
- passenger transport operations
- traffic management
- advanced driver assistance systems
- journey assistance
- law enforcement
- freight and fleet operations.

The European ITS framework architecture provides structure and guidance from which other regional or national ITS architectures and system specifications can be developed.

The European architecture recognises the growing use of advanced telematics technologies in modern transport systems, their increasing complexity and the importance of ensuring integration and interoperability between systems. It delivers a high-level framework or system architecture that provides strategic guidelines, and covers the technical elements and organisational, legal and business aspects.

5.3.2 Stages of development

The European ITS architecture started its development in the mid-to-late 1990s following on from the development of the system in the US.

The first version was created by the KAREN project and issued in October 2000. It was the result of an effort to create a minimum stable framework necessary for the deployment of working and workable ITS within the European Union until at least 2010. The architecture focused mainly on road-based applications.

Version 1.1 was issued in March 2002 by the FRAME projects. It consisted of an update of the previous version and corrected a number of inconsistencies found in the initial version developed by the KAREN project.

The second version was issued in August 2004 by the FRAME projects. It was an upgrade of the previous version and took into account the use of the selection tool.

Version 3.0 was issued in November 2004 and incorporated further improvements based on the update requests and problem reports submitted by users of the ITS framework architecture.

5.3.3 Model

The model consists of the following parts:

- user needs
- functional viewpoint
- physical viewpoint
- communications viewpoint
- deployment
- cost benefit
- organisational viewpoint
- risk analysis.

User needs provide the formal definition of what the stakeholders want an ITS deployment to supply in terms of services to be delivered and any constraints they wish to place on the delivery of these services.

Functional viewpoint defines the functionality needed by the ITS system to fulfil the user needs and interface with the outside world. It also includes a definition of the data used by the system as input or output. It is divided into functional areas, which are further divided into functions. All areas are provided with diagrams (called data flow diagrams) which show how the functions relate to each other, to data stores and to the outside world through the data flows.

Physical viewpoint describes the various ways the functional architecture can be used by defining how the functionalities can be grouped into physical locations to form systems that can be implemented, taking account of any user needs that have physical (as opposed to functional) requirements. It consists of a series of ‘example systems’ and also provides a description of the methodology for deployment and implementation.

Communications viewpoint was developed from the physical architecture and describes the kind of communications links needed in a system to support its physical data flows. It may include some requirements from the user needs where they relate to specific communication requirements. It consists of an analysis of the communications requirements for several of the example systems defined in the physical architecture. It also describes the best current communication technologies and standards.

Deployment shows how the systems derived from the architecture can be deployed and describes some of the ways in which existing systems can be migrated to conform with the European framework architectures.

Cost benefit provides a prediction of the likely costs and benefits that can be expected to accrue from the deployment of the architecture.

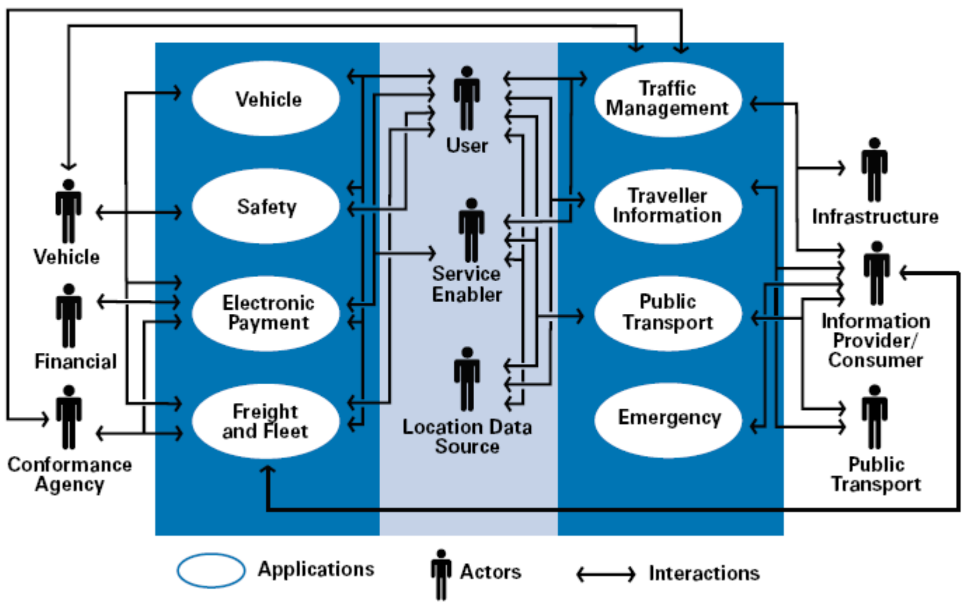
Organisational viewpoint looks at how the organisations responsible for owning, managing or operating systems can work together in order to deliver the ITS services being developed.

Risk analysis describes the risks to ITS deployment and categorises them according to the seriousness of their impact. Mitigation strategies are provided for some of the most severe risks.

5.4 Australia

In Australia, architecture work has been done in some states and a national ITS reference architecture developed in the form of a multi-modal ITS future big picture. This aims to improve the future development and deployment of ITS services within Australia by providing a framework for the development of standards, promoting integration of systems and providing a basis for education.

Figure 5.5 Australian ITS architecture



5.4.1 Role

The ITS architecture in Australia was developed under the guidance of ITS Australia, which is an organisation of individuals and companies with a vested interest in the application of ITS technologies.

The mission statement of the Australian ITS architecture is:

> *To develop a multi-modal national ITS reference architecture, summarising ITS uses, systems, communication linkages and actors that will improve the future development and deployment of ITS services within Australia by providing a framework for the development of standards, acting as an educational tool, promoting the integration of systems and increasing the competitiveness of the ITS industry.*

The Australian ITS architecture was developed solely as a reference architecture which is the top level of the three levels of architecture mentioned earlier. It does not deal specifically with the more detailed levels of logical and physical architectures but defines the 'reference' structure of how the different ITS facilities integrate with each other.

It provides a concise, comprehensive and systematic statement of a system's fundamental principles and aims that serves as both an educational tool and a framework for guiding the development of the more detailed logical and physical architectures and hence the standard development process.

The Australian project identified the objectives of a reference architecture as:

- to build consensus
- to clarify system components and to foster system interoperability
- to inform stakeholders and increase awareness of ITS development
- to act as a forerunner to system architecture and identify the need for standards.

5.4.2 Stage of development

The Australian ITS architecture was developed in the late 1990s and followed on from the report *Intelligent transport solutions for Australia: summary report* (Booz Allen & Hamilton 1998).

The first release of documentation was in 1999. Further development of the reference architecture is ongoing due to the complex nature of the multi-modal approach to the Australian architecture.

In the meantime, the Australian national reference architecture is intended to serve as an important reference document for those companies and agencies involved in the development, procurement, implementation and use of ITS systems.

5.4.3 Model

The model is delivered in the form of computer-aided software engineering (CASE). CASE is a widely used electronic business tool which delivered the reference architecture in an electronic format.

The project defined the attributes required of the model to be:

- simple and concise

- comprehensive
- flexible
- useable
- internationally compatible
- understandable
- economical in development and deployment.

The model in Australia took note of the fact that there had been few efforts internationally to produce a truly multi-modal system architecture that could address the needs of all potential ITS stakeholders. As the project progressed it became more obvious that the task of producing a comprehensive and truly multi-modal national reference architecture, as was identified within the project mission statement, was going to be an ongoing task beyond the scope of the initial project. However, introductory phases were completed so that the proposed reference architecture truly represented opportunities for the deployment of ITS in all transport modes.

Air, rail and water transport already used significant deployments of ITS technology. The interfaces between road and these modes constituted the most important multi-modal ITS architecture issues to be addressed. Therefore, the scope of the national reference architecture for ITS was restricted in having to take this into account.

5.5 Japan and South Korea

The ITS architecture in Japan was developed in the mid-1990s with the following aims:

- to build an integrated system efficiently
- to secure expandability of the system
- to promote national and international standardisation.

The Japanese architecture focuses more on the physical architecture which describes in detail the system specifications, so is not as relevant to the current situation in New Zealand.

Although not as relevant as the other examples described in this section, Japan and South Korea appear to be leading the way in ITS solutions and it will be useful to keep track of what is going on in this fast-moving environment as the full architecture is developed.

Japan and South Korea are currently leading the world in ITS, and national government agendas are among the most significant drivers for the development of ITS these countries. This leadership role leverages an already positive market climate for ITS services and consumer demand for telematics and applications for vehicles.

The Japanese and South Korean governments, having assessed the environmental issues and social costs produced by transportation systems, have identified their primary ITS goals: lower accident rates, increased pedestrian safety, and reduced traffic congestion with its benefits of lower fuel consumption. Cooperating with manufacturers, they are starting to launch ambitious field tests and pilot services.

In South Korea, the government will invest a total of US$3.2 billion from 2007 to 2020 in the National ITS 21 Plan. Its aim is to install vehicle operation management systems and traffic information data terminals in all public buses. Installation of electronic payment systems on buses is expected to be completed by the end of 2011.

Meanwhile Japan launched an ambitious ITS programme called ‘Smartway 2007’ on the Tokyo Metropolitan Expressway in October 2007. A full-scale deployment throughout Japan started in 2008. Japan is currently entering a more mature stage. The Japanese traffic information service scheme aims to implement advanced technologies progressively in conjunction with ITS projects. These include the Advanced Cruise-Assist Highway System to eliminate the potential causes of accidents in high-speed environments, and the advanced safety vehicle to offer safer ‘smart driving’ via vehicle-to-vehicle communications.

Electronic toll collection is another part of the overall picture in both countries. There is expected to be a 26% compound annual growth rate in South Korea to the end of the current forecast period in 2012. Japan is attempting to expand this by using in-vehicle electronic toll collection (ETC) units for cashless service at parking lots and petrol stations.

5.6 Summary of international examples

Although each of the international examples has been developed using a different base and methodology, designed to suit their own objectives, the underlying purpose of each is the same: to provide a sound basis for the future development of ITS in the region.

6 Developing a New Zealand ITS architecture

The international examples studied were implemented for slightly different reasons and with different objectives in mind. The purpose of this research project was to gather the key points and lessons learned from the architectures developed overseas, and see how these concepts could best be applied to the New Zealand context.

New Zealand is a much smaller nation than the other examples and does not have any state borders or separate legal jurisdictions to complicate the architecture. New Zealand has relatively few well established ITS systems and comparatively limited funding. A standardised national ITS architecture defined prior to mainstream use of ITS systems will simplify the system design and adaption process limiting costs and providing significant benefits. New Zealand can also learn from international successes and failures.

New Zealand ITS capability relies to some extent on vehicle and equipment manufacturers. In international terms, the New Zealand market for vehicles and electronic devices is relatively insignificant; New Zealand will effectively largely receive what manufacturers offer (provided it complies with New Zealand legal and other requirements). It follows that the New Zealand ITS architecture should account for and align with European, US and Asian ITS architectures so that the ITS devices developed for those markets are compatible with ITS systems and services developed for New Zealand.

6.1 Framework architecture

The framework architecture contained in this document (see section 6.2) presents a high-level strategic view of what an ITS architecture might look like.

After researching ITS architectures already developed and in development in Europe, US, Canada and South-East Asia, a relatively simple framework architecture listing possible services was developed as a starting point for discussion on a reference architecture for New Zealand.

New Zealand has a significant number of advantages that reduce requirements for the national ITS architecture when compared with most international examples.

Almost all of the international architectures need to deal with transnational or interstate border crossings (or both). This immediately means those architectures need to allow for foreign or interstate vehicles in addition to vehicles from within their own jurisdiction.

The majority of international architectures also need to deal with the added complexity of gaining consensus in purpose between differing states and nations. This needs to be followed up by consensus in technical interoperability standards already established in each.

In contrast, New Zealand is a single nation with (albeit limited) current interoperability and therefore the framework need not deal with the complexities of interregional differences in standards, policy and legislation to the extent of other international examples.

6.2 Framework architecture fundamentals

When dealing with highly complex IT architectures it is standard practice to develop a framework. The framework accounts for the fact that individual users are generally only interested in the part of the system relevant to their own needs and do not need (or want) to understand the complexities of other parts of the information process.

The framework highlights a wide range of services in the New Zealand environment, and raises awareness of the many types of transport-related information. These are clustered in groups of similar services.

A framework architecture therefore translates the complexity of a large uncoordinated information system, the national architecture, into more readily understandable views. These views describe essentially the same information for different audiences.

The framework may be considered as a ‘service’ view rather than a ‘technical’ view. It describes a set of ITS tasks, activities and elements that are used or are likely to be used in New Zealand. This view enables discussion, raises awareness and informs more technical views, particularly reference and logical architectures.

The architectural views, which are discussed in section 4.2, analyse the underlying data for commonalities among the products required to deliver each service and describe functional linkages. The technical views are reference, logical and physical architectures. Significant further work is required to develop each of these.

6.2.1 User services

User services are a high-level description of user requirements stating what an ITS system does, or might be expected to deliver from a user perspective. It also delivers a description of which other services might be required to share information. A full collection of user services will form the basis for describing technical requirements from which a technical (logical) architecture can be formed. This describes the processes that are needed to work together to provide the required user services. It is expected that as time progresses there will be further requirements for services, therefore description of user services is an open-ended process.

6.2.2 User sub-services

User sub-services are those user requirements that are generally functionally related to each other and share most or all of the same underlying technical services. The user services from each sub-service will have different outcomes or meet different perspectives.

6.2.3 Who might be involved/recommended approach

It is recognised internationally that obtaining a broad view requires the involvement of representatives from government, industry and academia. The recommended approach is to develop reference, logical and physical architectures driven by champions from these areas.

7 Concept for the future – framework ITS architecture for New Zealand

The following is a framework national ITS architecture. It is a list of user services and sub-services with brief explanations of each. It is based on international architectures, available technology and the feedback received from the NZTA and NZ Police during consultation involving overseas ITS architectures.

This framework is tailored for the New Zealand environment and includes references to initiatives currently planned or undertaken by the NZTA and NZ Police. Other ITS initiatives listed are technically feasible and might readily be applied, but may not currently be planned.

This framework indicates relatively accurately what a future New Zealand reference ITS architecture might look like. The framework will be used as a starting point for discussion with a much wider range of stakeholders to integrate, validate, share data, fine tune and add services for the benefit of all groups in the transport sector.

7.1 Traffic management systems

'Optimising the movement of people and goods'.

7.1.1 Traffic network flow monitoring and management

Separate traffic management systems (TMS) are operated by the NZTA and many larger local authorities.

These systems include traffic detectors, road condition and environmental sensors, digital cameras, the supporting field equipment, and communications to transmit the collected data back to existing traffic operations centres (TOC).

Derived data can be used locally (eg traffic detectors connected directly to a signal control system) or remotely (eg CCTV system sends data back to the TMS). The data generated enables the TOC operators to monitor traffic, environmental and road conditions, to detect, identify and verify incidents and also to detect faults in sensors.

Future enhancements will include near real-time information obtained from the traveller information service (TIS), dynamic route guidance information, weather information, predictive modelling based on historical data, probe vehicles providing traffic, road condition and environmental information. This will permit continuously optimised traffic control strategy and optimised traffic light timings. The same data can be used for maintenance management, and archived data can be used to support development of traffic models used in strategic and long-range planning.

Figure 7.1 Variable message sign providing traveller feedback

7.1.2 Vehicle-based sensing supporting traffic management systems

New data capture technologies provide an additional approach for real-time data surveillance of the road network. Probe vehicles provide position information which combined with time differences can be used to derive traffic speed. Probe vehicles will include those fitted with GPS to use dynamic route guidance and the real-time monitoring system (RTMS). This type of service is already available in New Zealand.

Road and weather conditions may be collected by specially equipped probe vehicles when agreement is reached with operators of roading contractor fleets, truck fleets, etc. Probe information is transmitted real time wirelessly to the TOC and analysed in conjunction with other information to indicate average travel time, speed, traffic density trends and road conditions. This type of probe vehicle is already in use in the US.

Bluetooth devices may be identified and tracked along particular stretches of road to derive traffic speed. Every operational Bluetooth device emits a unique electronic signature, providing an inexpensive and readily available method of traffic probing in congestion prone areas. Bluetooth data is anonymous and cannot be readily linked to any individual vehicle. This technology has already been successfully applied in the Ipswich motorway upgrade in Queensland, Australia.

It is also possible to obtain position information from mobile phone data. Cellular floating vehicle data (CFVD) consists of anonymised information about the movement of cell phones based on 'handover' between cell sites. With the use of algorithms CFVD may be used to generate traffic flow and density information. CFVD technology is already in use in several countries including the UK.

7.1.3 Parking management

Sensors detect the occupancy status of parking spaces on the street and in off-street car parks. The TIS advises motorists who are looking for a parking space where the nearest available spaces are, and if required, directions to drive there. Automatic number plate recognition (ANPR) can also be used in private car parks to record time in and time out as a charging mechanism and to detect unlawfully taken vehicles. This type of service is widely used internationally.

7.1.4 Pedestrian and cycle management

The NZTS 2008 seeks to encourage cyclists and pedestrians. Consideration should be given to gathering statistics and encouraging management of foot and cycle traffic in urban areas. Recognition of pedestrians and cyclists for statistical purposes is attainable using camera-based shape recognition software.

7.1.5 Traffic control

7.1.5.1 Traffic light control

This provides the central control and monitoring equipment, communication links, and the signal control equipment that support local, regional and/or arterial traffic management. A range of traffic signal control systems are included, ranging from static pre-timed control systems to fully responsive traffic systems that dynamically adjust control plans and strategies, based on current traffic conditions and priority requests.

Coordination between highways and territorial local authorities is an area that should be developed in New Zealand. This may be achieved with a common time base or other strategies, ideally involving real-time coordination. The NZTS 2008 seeks to encourage cyclists and pedestrians. Consideration should be given to traffic lights being configured to prioritise foot and cycle traffic in urban areas. This is particularly so when no vehicular traffic is approaching the crossing point. Recognition of pedestrians and cyclists may be made by a push button at lights or using more advanced camera-based shape recognition software to detect the approach of pedestrians and cyclists.

7.1.5.2 State highway control

This provides the communications and roadside equipment to support ramp metering controls, lane controls, variable message signs and intersection control for state highways and motorways. This service incorporates the data obtained from traffic network flow monitoring to support highway monitoring and adaptive strategies as an option. It should also interface with local TMS so that highway control systems do not cause local road disruptions (eg ramp meters may cause traffic delays on city roads and these can be mitigated by integrated and coordinated traffic management).

7.1.5.3 Regional or national traffic control

This integrates the traffic light control and state highway control mechanisms by adding the required communications links and integrated control strategies. This user sub-service provides for the sharing of traffic information and control among local traffic operations centres to support a regional or national control strategy. New Zealand is geographically and electronically small enough to enable a centralised integrated national TOC ideally with a second backup TOC.

7.1.5.4 Incident management and coordination

This manages both scheduled and unscheduled incidents so that the impact on the transportation network and traveller safety is minimised. Unplanned incident detection capabilities are already included in the traffic network flow monitoring sub-service in the Wellington and Auckland advanced traffic management systems (ATMS). Regional coordination with other traffic management and emergency management centres, MetService, road works contractors and event promoters is supported by this service.

7.1.5.5 Travel demand management (TDM)

TDM is achieved through reducing the need to travel, reducing travel distances, promoting more efficient travel, travel routes and mode of travel, and changing the time people travel. ITS focus particularly on promoting more efficient travel and encouraging changes to the time people travel.

7.1.5.6 High occupancy vehicle (HOV)

HOV lane management coordinates motorway ramp meters and connector signals with HOV lane usage signals. HOV lanes ideally offer special bypasses and exclusive rights of way that may vary by time of day. Automated vehicle occupancy detectors may be installed to verify HOV compliance and to digitally photograph and notify the electronic offence system (NZ Police) of non-compliance. (A law change would be required to implement this.)

7.1.5.7 Reversible lane management

This provides for the management of reversible lane facilities. In addition to standard surveillance capabilities, it includes sensory functions that detect wrong-way vehicles and other special surveillance capabilities that mitigate safety hazards associated with reversible lanes. The user sub-service includes the field equipment, physical lane access controls, and associated control electronics that manage and control these special lanes. This user sub-service also includes the equipment used to electronically reconfigure intersections and manage rights of way to address dynamic demand changes and special events. An example is the Auckland Harbour Bridge.

7.1.5.8 Predictive lane management

This includes advanced algorithms and processing capabilities that support historical evaluation; real-time assessment; forecast of the roadway network performance; dynamic route guidance schedules; RTMS; weather conditions; and the prediction of travel demand patterns to support better linked travel time forecasts. The source data will come from the traffic management subsystem itself as well as from other traffic operations centres and forecasted traffic loads derived from route plans supplied by the information service provider subsystem.

7.1.5.9 Congestion charging

This imposes a toll for using arterial routes and motorways during peak periods to encourage road users to use public transport or travel at another time. The NZTS 2008 indicates that the use of electric vehicles is to be encouraged and these vehicles may be exempted from a congestion charging.

7.1.6 Environmental conditions management

7.1.6.1 Road/highway weather information system

This monitors current road and weather conditions using a combination of MetService (weather) information, data collected from fixed environmental sensors deployed on and about the roadway and in probe vehicles. The collected road weather information is monitored and analysed in conjunction with the TMS to detect and forecast environmental hazards such as icy road conditions, dense fog and approaching severe weather fronts. Basic weather information systems are already in use in New Zealand.

7.1.6.2 Emissions management

This monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data. The collected information is transmitted to the emissions management subsystem for processing.

Individual vehicle emissions monitoring involves measuring tail pipe emissions either at static test sites or testing emissions in motion sites (including ANPR) on motorway off-ramps etc. Vehicles that exceed emissions standards are identified and can be processed through the electronic offence subsystem. (A law change would be required to implement this).

General air quality monitoring measures air quality, identifies sectors that are non-compliant with air quality standards, and collects, stores and reports supporting statistical data. The gathered information can be used to implement environmentally sensitive traffic management programmes and policies, and to enforce regulations and rules with targeted enforcement. Although New Zealand has a range of general sites, fixed individual vehicle monitoring sites are a recent development and may not be used in New Zealand for some time.

7.1.7 Operations and maintenance

7.1.7.1 Infrastructure maintenance management

This supports automated alerts for the deployment of roading contractors' vehicles including construction, maintenance, road burner trucks and snow ploughs. Information from the TIS, TMS and historic data can be analysed with advanced algorithms to create micro-predictions of roadway conditions, supporting improved maintenance planning and dispatch. The infrastructure systems can be automated to perform vehicle dispatch and asset management, advise issues requiring attention, and record the response times and time spent. This information may be useful for predictive analysis and contract refinement. Roading contractors' vehicles should be fitted as environmental probe vehicles to provide valuable weather and environmental information. Thermal mapping is already used in the Desert Rd to enable predictive analysis and early intervention. A national system might be readily implemented.

7.1.7.2 Smart work zones

Smart work-zone systems gather, store and disseminate information relating to road-work zones. The roadside elements of the user sub-service can monitor and control traffic in the vicinity of the work zone. The centre element of this user sub-service, ie the human operator or pre-programmed machine, can:

- participate in incident management by initiating incident notification, or by participating in incident response
- advise drivers of road-work zone status (either directly at the roadside or through an interface with the TIS or TMS)
- manage and track construction and maintenance activities, coordinating with other subsystems (such as traffic management)
- schedule and manage the location and usage of maintenance assets (such as portable dynamic message signs).

Roadway maintenance and construction personnel, and other work crew assigned to the road works, use information systems to rapidly correct deficiencies that have been noted through the centre element's advanced surveillance and overview capabilities. This improves the quality and accuracy of information available to travellers regarding closures and other roadway construction and maintenance activities. Some technology elements are currently used for longer-term major works in New Zealand.

7.1.8 Automated dynamic warning and enforcement

7.1.8.1 Dynamic highway warning

This system dynamically presents warning information to drivers. Warnings may be generated in response to roadway weather conditions, road surface conditions, traffic conditions, obstacles or animals in the roadway, and any other transient events that can be sensed. Warnings may also be generated that recognise the limitations of a given vehicle for the geometry of the roadway (eg rollover risk for tall vehicles).

This user sub-service differs from 'traffic information dissemination' in that it is possible for all processing to occur at the roadside, making this suitable for remote application. A simple example of this is the lahar warning system on the Desert Rd.

7.1.8.2 Variable speed limit and enforcement

This provides dynamic variance of speed limits in response to roadway conditions. It may include lowering speed limits due to weather or traffic conditions to reduce the risk of accidents. This user sub-service may also relate to portable systems for smart work zones around road work areas. A key capability of this user sub-service is the ability to provide automated speed limit enforcement by detecting and conveying offence information to the electronic offence system. New Zealand currently operates a range of variable speed limits; however, enforcement is not yet enabled.

Figure 7.2 Variable speed limit sign indicating 80km/h speed limit applicable at the time

7.1.8.3 Traffic signal and sign enforcement

This is detection of offending vehicles and enforcement of traffic control signals. Existing capability is in the form of red light cameras. The technology exists to detect vehicles accelerating through orange lights and failing to comply with other types of signals and signs for example the Police 'accident' sign which imposes a 20km/h speed limit. Digital evidence of a vehicle disobeying sign enforcement is a logical predecessor to 'intersection safety warning' and 'intersection collision avoidance', where offence detection is also used to reduce the likelihood of a crash.

7.1.8.4 Cyclist and pedestrian safety

This supports close-proximity sensing and warning systems used to interact with pedestrians, pedestrians with disabilities, cyclists and other vehicles that operate on highways, or on pathways which intersect with highways. This includes advanced imaging sensors with recognition capabilities, which will allow automated warning or active protection systems for this class of users.

7.1.8.5 Railway crossing safety and control

This manages highway traffic at level crossings (LX) using passive and active warning systems. Traditional warning systems may be augmented with other standard traffic management devices, eg variable message signs and traffic lights. The warning systems are activated by approaching trains. Activation should also connect to adjacent intersection traffic lights so that local control can be adapted to highway and rail crossing activities. Additional capabilities might:

- transmit information about the arriving train to approaching vehicles including the train's direction of travel, its estimated time of arrival, and the estimated duration of road closure
- enable detection of a stationary vehicle or object within the LX or equipment faults and provide an immediate automated notification to traffic and railways management systems, and directly to approaching trains.

7.1.8.6 Coordination of rail operations

This provides an additional level of strategic coordination between rail operations and traffic management centres. Rail operations provide train schedules, maintenance schedules and any other forecast events, which will result in LX closures. This information is used to develop forecast LX closure times and durations which may be used in advanced traffic control strategies or to enhance the quality of traveller information.

7.2 Driver monitoring systems

7.2.1 Fatigue monitoring system

Fatigue monitoring can be conducted in a variety of ways including analysis of braking and acceleration patterns, camera monitoring of the driver and eye scanning. Each of these systems can alert the driver and remote management if an exception is detected.

7.2.2 Driver behaviour monitoring

Camera-based systems linked to engine management systems can record acceleration, braking, gear changes, steering and digital video of the vehicle's movements. This information is generally stored on a drive in the vehicle but can be remotely uploaded by management (or parents) or retrieved directly from the vehicle following a crash or other incident. This technology is already used internationally and in New Zealand.

7.2.3 Electronic driving hours logbook system

An approved alternative logbook scheme will require a two-factor driver identification consisting of the driver licence and one other form of verification. Driver work time can be recorded via an internet login linked to employee check-in systems at depots, or from a device such as a digital tachygraph in the vehicle. By sharing data and communications with the RTMS, enforcement officers and operators can access a driver's work-time data via their respective computer networks (including a roadside inspections system). This system will have a number of advantages over the paper logbook system making it significantly more difficult to falsify entries to cover up breaches of driving hours. It will enable enforcement activity to be focused on those operators who choose to continue using the paper logbook system. This system could also be used to ensure that only authorised drivers are able to drive a vehicle. There are currently no approved alternative logbook schemes in New Zealand.

7.3 Vehicle monitoring systems

7.3.1 Real-time monitoring system (RTMS)

The RTMS tracks the route of vehicles (trucks and trailers) operated voluntarily under the RTMS scheme. Tracking is in real time using a positioning device; heavy vehicle weight information may be included by adding on-board electronic load cells, and driver information may be added using selected driver monitoring systems. Other systems that may integrate with the RTMS are vehicle safety, distance recording and remote power down when a vehicle is unlawfully taken. Freight or hazardous materials may be electronically associated with a vehicle or depot and tracked in real time. RTMS information will be transmitted via the wireless data network and the vehicle owner or operator may choose to share selected information with the NZTA and enforcement agencies, benefiting all parties. Advantages may be obtained through dynamic route guidance, overall traffic management, logistics and automated regulatory compliance. It is important in the current political environment that RTMS is a voluntary scheme; this is to overcome vocal minority concerns about the perceived threat to privacy. Private systems are already in use in New Zealand; however, the government does not currently access these.

Freight may be tagged with radio frequency identifiers (RFIDs) or similar proximity devices to enhance logistics tracking. All this information is collected on board and transmitted wirelessly, generally via the data network. These devices are in widespread use.

For commercial operators who have elected to share information with the NZTA and NZ Police a contracted external data collator might collect all standardised data and advise the electronic offence system when exceptions are detected. Exceptions might include deviation from a specified route, deviation from a permitted excess weight limit or exceeding weight or speed limits over older bridges that have restrictions for safety reasons. A number of benefits are likely to be available to operators who elect to share information with the NZTA. These might initially be in the form of administrative cost savings for RUC off-road rebates, electronic logbooks as opposed to the paper booklets, and electronic overdimension and overweight permit applications. Longer term, the same technology might be used to pay tolls and congestion charges possibly with discount rates for specific times of day.

The New Zealand Standard series P6910 'vehicle data systems' sponsored by the NZTA was scoped in July 2008 and is intended to specify minimum performance for RTMS components. The electronic clearance system will be able to compare RTMS information with physical data collected on approach to a roadside check facility and alert enforcement officers when calibration changes have recently been made to on-board equipment.

7.3.2 Engine management:

Emissions and fuel use monitoring is an optional add-on to the RTMS and emissions can be derived relatively accurately from fuel usage. Other engine management information such as braking, acceleration and gear changes can be optionally collected by the operator to enhance driver training and fleet management. Most modern vehicles use electronic engine management systems; however, the data generated is not generally collected externally at this point.

7.4 Vehicle safety and control systems

7.4.1 Vehicle-based collision avoidance

7.4.1.1 Lateral warning systems

These allow for lateral (side) collision warning using on-board sensors to monitor the areas to the sides of the vehicle and collision sensors. These systems present warnings to the driver about potential hazards. Lane departure warning systems are available in some current car models.

7.4.1.2 Lateral collision avoidance

This automatically controls the steering when lateral warning systems present high-risk alerts. The alert information is combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor to control the vehicle steering. This technology is being trialled internationally.

7.4.1.3 Longitudinal warning systems

This allows for longitudinal (front-rear) collision warning using safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front and behind the vehicle. These systems present warnings to the driver about potential hazards. Basic short-range systems are widely fitted to many modern vehicles as parking assistance devices.

7.4.1.4 Longitudinal collision avoidance

This automates the speed and headway (following distance) control functions on board the vehicle. This occurs when longitudinal warning systems present high-risk alerts. The alert information is combined with vehicle dynamics processing to control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor to control the vehicle speed.

7.4.2 Infrastructure-based collision avoidance

7.4.2.1 Intersection-based collision warning

This determines the probability of a collision in an equipped intersection (either highway-highway or highway-rail) and provides timely warnings to drivers in response to high-risk conditions. Sensors and cameras in the roadway infrastructure assess vehicle locations and speeds near an intersection. Using this information, a warning is determined and communicated to each approaching vehicle using a short-range communications system.

7.4.2.2 Intersection collision avoidance

This sub-service builds on the intersection collision warning system and in-vehicle equipment. Equipment installed in the vehicle responds to high-risk alert information and can take control of the vehicle in emergency situations. The vehicle uses the information to develop control actions which alter the vehicle's speed and steering control and potentially activate its pre-collision safety system.

7.4.2.3 Sensor-based driving safety enhancement

This enhances the driver's visibility using an enhanced vision system. On-board sensing and display hardware is needed to provide detection and imaging of obstacles under low-visibility driving conditions. Enhanced vision might take the form of a heads-up display projected on the windscreen. This is already available in some high-end cars.

7.4.2.4 Safety readiness

diagnoses critical components of the vehicle and warns the driver of a potentially dangerous vehicle condition. On-board sensors will determine the vehicle's condition and performance, determine on-board safety data and display information. Basic forms of these systems are currently fitted in most vehicles. It is feasible to transmit vehicle fault information to fleet management and enforcement systems.

7.4.2.5 Pre-collision restraint deployment

This provides in-vehicle sensors to monitor the vehicle's local environment, determine collision probability and deploy a pre-collision safety system. It will include on-board sensors to measure lateral and longitudinal gaps, together with weather and roadway conditions to determine lateral and longitudinal collision probability. It will have a processor and mechanism to deploy a pre-collision safety system. This type of system is already fitted to many vehicles.

7.4.2.6 Automated vehicle operation

This enables 'hands-off' operation of the vehicle on the automated portion of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control, and automated highway system check-in and check-out. This user sub-service currently supports a balance in intelligence allocation between infrastructure and the vehicle, and is being trialled internationally.

7.4.2.7 Autonomous vehicle operation

The US Defense Advanced Research Projects Agency (DARPA) defines an 'autonomous ground vehicle as a vehicle that navigates and drives entirely on its own with no human driver and no remote control. Through the use of various sensors and positioning systems, the vehicle determines all the characteristics of its environment required to enable it to carry out the task it has been assigned'. Autonomous vehicle technology has already been successfully developed to the level where autonomous vehicles can avoid moving and static obstacles, obey all traffic laws and navigate successfully to the required end position. Autonomous systems are likely to be available in private vehicles by 2020.

Notes:

- A processing complexity arises when only one of two vehicles is fitted with automated or autonomous collision avoidance systems.
- Some emerging standards for V2V and V2I communications are IEEE 802.11p and CALM M5 standard.
- A legal complexity arises from each of these systems as current New Zealand law deems the driver to be in control of the vehicle. These systems partially or fully remove control from the driver.

7.5 Commercial transport operator and fleet services

7.5.1 Commercial vehicle administrative processes (CVAP)

These provide for electronic application, processing, fee collection, issuing, maintenance and distribution of licensed operator, driver and vehicle information, RUC, licensing charges and other charges.

Through CVAP, operators, drivers and vehicles may be enrolled in the electronic clearance programme (provided by a separate user sub-service which allows an approved operator's commercial vehicles to be screened and authorised to travel through roadside check facilities. Current profile databases will be held and maintained in the CVAP subsystem for all vehicles and drivers in an operator's fleet.

When combined with RTMS, RUC off-road rebate claims could be automated and longer term it is possible that payment for on-road travel (e-RUC) might be automated for those operators that elect to join the scheme. (A law change would be required for this.)

A verified real-time weight/distance report will facilitate automated charging at actual weights rather than the present nominal weight system for RUC. This will minimise the cost of compliance and eliminate the risk of fines for those operators who elect to join the scheme and do not tamper with the equipment. The same system could be used to automate payment of annual vehicle licensing fees and to alert operators when driver licences and certificates of fitness are due or no longer valid for the class of vehicle to be driven. The NZTA TORO database system already offers the driver alerts while private systems are soon to offer real-time road user charging. .

7.5.2 Electronic road user charging

From January 2010, the law permits RUC to be collected electronically using an approved electronic distance recorder (EDR) including a combination of sensors with the primary distance sensor being derived from wheel revolutions and validation through global navigation satellite and other sensors. The EDR will communicate with a private sector electronic service provider acting as an intermediary between transport operators and the NZTA.

7.5.3 Automated overdimension and overweight permit system

The NZTA currently accepts applications, issues overdimension permits and uses a different application and issue process for overweight permits. Both systems are manual, supported by electronic recordkeeping. There is the opportunity to draw together both processes in an integrated and automated online application facility that queries a proposed route with mass and dimensions and immediately advises the applicant if there are obvious issues. This may use the NZTA geospatial viewer to provide a visual (map) interpretation and permit entry by drawing or listing a proposed route, or requesting the system to suggest a proposed route. Real-time monitoring would ensure compliance with the permits. This type of system is in use internationally and is available in New Zealand.

7.5.4 Online hazardous materials register

Transporters of hazardous goods are required to carry inside the driver's door of the vehicle, documentation detailing the type and quantity of hazardous goods. An electronic system could readily print out the required document and electronically integrate with commercial freight management systems for logistical purposes.

The vehicle transporting the hazardous materials will be manually entered in the system or derived from RFIDs or similar freight tracking systems. An integrated electronic system will store all operational hazardous goods information linked to the carrying (and towing) vehicle. In the event of an automated emergency notification or a roadside inspection (including an electronic crash report entry) involving a vehicle carrying hazardous materials, an alert will be triggered to emergency services, to the roadside inspections system (including the electronic crash reporting system), and where appropriate, to the TMS, TIS and the rail information system (RIS). The full alert will provide full details of the location, type, quantity and risk of all hazardous goods. The TIS, TMS and RIS alert will only advise of the incident and its effect on the road or rail system. This will significantly enhance detection, management and public safety at incidents involving hazardous materials.

7.5.5 Operator rating system

The operator rating system (ORS) is currently being developed to publicly rate management systems of licensed transport operators through analysis of safety-related driver and vehicle data. This includes certificate of fitness faults, crashes, offences and roadside inspections. The system also stores unpublished rankings and detailed data analysis for each operator. Detailed data is only available to the operators, the NZTA and NZ Police. Operator and vehicle data may also be queried by the electronic clearance system.

7.5.6 Weigh in motion (WIM)

WIM provides for high-speed weigh-in-motion sites that are either fixed or removable. This equipment is readily integrated with overdimension detectors, ANPR, and digital camera systems to act as an automated screening device for electronic roadside inspections and electronic clearance. It may also be used to gather statistical information. The physical checkpoint acts as confirmation that the real-time tracking system is providing accurate information.

7.5.7 Electronic clearance

This provides for automated clearance at roadside check facilities. The electronic clearance facility potentially communicates with the operator rating system, the weigh-in-motion system, the driver licence and motor vehicle registers, the hazardous materials register and RTMS information to retrieve, check and compare critical operator, vehicle and driver data. This is used to authorise well operated, apparently compliant vehicles to continue through an operational weigh station using a traffic light system.

Enforcement staff must have access to the same information and have the ability to override the automated system to stop any vehicle using the same traffic lights.

7.5.8 Roadside check facility (weigh station)

The weigh station may be equipped with integrated ANPR, evidential electronic weighing sensors, height sensors, and a wireless secure computer network enabling the roadside inspections system and connected to the police network. Technology currently under development may also check tyre tread depth using in-ground sensors. All the information collected by the electronic clearance system must be available to enforcement staff and the system should list any defects and send these to the roadside inspections system.

7.5.9 Roadside inspections system

The roadside inspections system is currently under development. This will provide an evidential standard electronic record of a roadside inspection. This system operates by querying key information fields such as registration number, and driver and transport licence numbers with the source databases. Each key field may be electronically entered by scanning bar codes on the relevant documents. The enforcement officer only has to check the details entered and then enter other required information. The system returns all associated information and recognises any exceptions as offences (and lists them). Upon submission of a roadside inspection record, the operator is emailed all details and the electronic offence system could be advised to issue offence notices. The record is also a source of information for the operator rating system and other interested NZTA groups. Copies can be printed for use in court as evidence in a prosecution. Handheld devices connected to a wireless local area network will ensure that all checks are recorded and entered directly in the system contemporaneously (at the time they are made) as evidential best practice.

7.5.10 Commercial freight management

7.5.10.1 Freight tracking:

Freight tracking covers the ability to track and monitor containers and freight shipments anywhere in the transportation system. The information may be available to customers, fleet managers and logistics service providers. The service monitors movements against trip plans with guaranteed delivery times, and alerts any emerging deviations from schedule. Selected information, for example hazardous materials, may also be available to emergency services when queried in the event of an incident or roadside enforcement check. This user sub-service supports the monitoring of the container/shipment location, contents and specialist requirements such as refrigeration temperature, unauthorised door openings, changes in load weight, and excessive shocks during the entire pickup-transport-drop-off period regardless of mode (road, rail, shipping or air). It may also be used to provide estimated time of arrival information and to schedule the next ‘leg’ with dispatch instructions. This system is enabled by RFIDs fitted to freight containers and recognised by freight terminal and vehicle systems. Recognition by these systems enables associations with the vehicle or location. Specialist RFIDs are also capable of functions for example container temperature monitoring and reporting.

7.5.10.2 Intermodal terminal management

This user sub-service supports the operation of the roading aspects of an intermodal terminal. It has the ability to identify and control vehicle traffic entering and departing the facility, guide vehicles to loading and unloading points, maintain site security, monitor container integrity, provide an interface with Customs as appropriate and record container pickup and drop-off. It also allows data exchange with all authorised systems.

7.6 Public transport services

Note: Public transport vehicles are a specialised subset of commercial vehicles.

7.6.1 Near real-time timetabling

Passenger vehicles operating the RTMS update the public transport system's timetable information in real time. Fixed bus routes may also make real-time timetable information available to the information service provider subsystem and to passenger displays at bus stops. If services are sufficiently frequent, near real-time timetabling may replace fixed timetables.

7.6.2 Fixed route passenger operations

These operations include automated driver assignment and monitoring, as well as vehicle scheduling and route designation for fixed-route services.

7.6.3 Integrated ticketing

Integrated ticketing allows for the management of passenger loading and fare payments on-board buses, trains, ferries and potentially aircraft using a single electronic method ('ticket') for the entire journey. The payment instrument may be either a stored value or credit card specific to the application, a card supported by a broader banking network, or a mobile phone. Mobile phones have the advantage of being able to store and display proof of payment, saving the requirement for a printed ticket verifying the electronic payment. Readers located on-board the vehicle or possibly at terminals such as bus stops and railway stations allow fare payment. Sensors mounted on the vehicle permit the driver and remote management to determine vehicle loads. Data is processed, stored and displayed in the vehicle and communicated as required to remote management. The NZTA has already recognised the value of integrating and centralising a New Zealand integrated ticketing system.

7.6.4 Multi-modal coordination

Multi-modal coordination establishes two-way communications between multiple remote management systems and the TMS to improve passenger service coordination.

Multi-modal coordination between public transport agencies can increase traveller convenience at transfer points and also improve operating efficiency.

Coordination between TMS and public transport management is intended to improve on-time performance of the public transport system to the extent that this can be accommodated without degrading overall performance of the traffic network. This system may also provide a second priority tier in the emergency vehicle priority system giving buses priority at traffic lights. It is noted that a bus priority solution has already been implemented in Auckland by the Auckland Regional Transport Authority.

7.6.5 Multi-modal connection protection

This enables coordination of multi-modal services to optimise the travel time of travellers as they move from one transport mode to another (or to different routes within a single mode). The most advanced long-term form will be when passengers purchase multi-modal journeys and store route plans enabling any delays in one service to be accounted for by the provider of the next service on the journey (enabling brief delay services to ensure traveller connections).

7.6.6 Demand responsive passenger transport (taxis etc)

Existing taxi dispatch systems perform automatic vehicle assignment, monitoring and scheduling. Multi-modal coordination may be enabled to enhance this service. Potential exists to interact with the TMS to provide automated route information and to use taxis as traffic probe vehicles, automatically feeding traffic and environmental information to the TMS. Such a system will need to account for travel time reductions when taxis use priority or transit lanes.

7.7 Emergency management and enforcement services

7.7.1 Personal and public transport security

This allows the user (driver, passenger or pedestrian) to initiate a request for emergency assistance and enables the emergency management subsystem to locate the user and determine the appropriate response. The request from the traveller needing assistance may be manually initiated or automated and linked to vehicle sensors. The data is sent to the emergency management subsystem. Providing user location implies either a location technology within the user device or location determination within the communications infrastructure. Many mobile phone models are already fitted with GPS and it is likely that this will become a standard feature over the next five to 10 years. Mobile phone coverage is highly desirable for personal security but is not yet available at all New Zealand railway stations. This subsystem includes cameras, fixed phones, mobile phones and other devices.

7.7.2 Public security

This will provide for the physical security of public transport passengers. An on-board security system is deployed to perform surveillance and warn of potential risk situations. Public areas (eg bus stops, parking areas and railway stations) are also monitored by the system. Monitoring may be conducted by a TMS, transport service provider or contracted agency. Incident-related information is also transmitted to the emergency management subsystem when an incident requiring an external response is identified. Emergency services should also have direct access to camera and sensor information when required. Incident information may also be communicated to the information service provider.

7.7.3 Automated emergency notification

Systems such as the European E-call are designed to automatically notify emergency services (wirelessly) in the event of crash systems deployment (airbags etc). The notification includes electronic location coordinates and vehicle identification information. Linkages may be made to hazardous goods and driver monitoring systems. Emergency notification systems also permit manual operation to alert emergency services of an incident and include a voice link. Emergency officials can then contact the vehicle and its occupants directly, to check on their condition and dispatch appropriate rescue services. It is intended to make E-call standard equipment for all new cars in Europe by 2010 for full implementation by 2014.

7.7.4 Remote power down:

This system enables locating and powering down unlawfully taken vehicles fitted with appropriate devices. Powering down is the preferred option rather than an engine kill function because it restricts the driver's ability to evade Police while permitting the driver to abandon the vehicle in a safe place when it stops. These systems are already available commercially in New Zealand but ideally will be linked directly to the Police emergency management subsystem. It is essential that such a system is highly secure to prevent misuse.

7.7.5 Emergency response management

This provides the computer-aided dispatch systems and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. These currently consist of the Police/Fire Service computer-assisted dispatch system and separate ambulance systems. These systems may be configured to make selected information such as location, situation and whether delays are expected or being experienced available to the TIS by way of a tick box or button on the existing entry screen. Information derived from automated emergency notification systems can also be electronically fed into the electronic crash reporting system to prepopulate vehicle information.

7.7.6 Emergency vehicle priority

This enables emergency vehicles to create a 'green wave' of traffic lights in the direction (or route) they are travelling. The location and intended route of the emergency vehicle is ideally achieved by route planning (a subset of dynamic route guidance) with other possibilities and combinations including RTMS/GPS, ANPR or DSRC. Precise positioning enables instructing the TMS to create a green wave to clear traffic in advance of the emergency vehicle. This enhances rapid and safe progress. A second priority level for emergency vehicles can be applied for buses and possibly other public transport vehicles.

7.7.7 Emergency response chain

This provides automated advance warning of details to TMS, hospitals, railway operators and other secondary agencies in the event of a serious incident. It also provides additional time for secondary agencies to prepare for major incidents. Relevant predetermined details may be passed electronically once a simple selection is made such as a tick box in emergency management systems, the electronic crash reporting system and, where relevant, the online hazardous materials register.

7.7.8 Hazardous material planning and incident response

This integrates incident management capabilities with commercial vehicle tracking, automated emergency notification and the online hazardous materials register to advise emergency services of a hazardous materials component in any incident. Early advice will mitigate safety risks and enable effective treatment of incidents involving hazardous materials. The response is tailored based on information provided as part of the original incident notification including the vehicle and associated online hazardous materials register information, or according to supplementary information provided by the RTMS, or visual identification of the vehicle involved.

7.7.9 CIMS emergency support system

This provides electronic support for the coordinated incident management system (CIMS) response to major incidents involving more than one agency. Examples can include natural disasters such as earthquakes, landslides and floods or man-made disasters such as chemical spills, terrorism or air crashes. The service supports coordination of the local, regional or national TMS with the lead agency in the incident response. The lead agency in a CIMS response may be the Fire Service, NZ Police or Ministry of Health. Other agencies may include ambulance, private sector experts, roading contractors, welfare agencies and many other allied agencies. Traffic system assets such as variable message signs and probe vehicles monitoring traffic conditions may be used to support evacuation and assist incoming emergency vehicles. Coordination between emergency management subsystems belonging to each agency will support emergency notification and coordinated response between agencies. Communications between the emergency response management subsystems and emergency command vehicles enable CIMS support at the incident command zone.

7.8 Electronic offence detection systems

7.8.1 Digital speed cameras:

NZ Police currently operates static and mobile wet film cameras that photograph vehicles detected exceeding the speed limit. Wet film requires manual collection, manual processing and development and manual reading of number plates. The entire process is costly and time consuming.

Digital cameras have recently been introduced in some New Zealand mobile units. Digital cameras offer technical feasibility to transmit offending vehicle images directly from static sites via a dedicated wire line or from mobile sites via a mobile data link.

The images can then be processed by the back office ANPR system and data is available near real time for processing by the electronic offence subsystem. ANPR squads may also be alerted to vehicles of interest. This system works best using ANPR software at the camera site to process images of all passing vehicles and automatically checking registration numbers against the Police computer systems.

7.8.2 Intersection cameras

Intersection crashes are a serious issue in New Zealand. Digital intersection cameras offer the same advantages as digital speed cameras. Modern intersection detection systems offer integrated speed detection systems to capture those who accelerate through orange lights or are speeding, in addition to those who fail to comply with red lights. Processing of offences can be performed automatically and remotely by the electronic offence subsystem.

7.8.3 Automatic number plate recognition (ANPR)

ANPR is either a local function (contained within detection devices or situated nearby) or a remote function (for example at the Police Infringement Bureau or Transport Registry Centre). ANPR effectively reads a digital photograph. Modern ANPR systems accurately recognise around 98% of number plates through a variety of methods and refer those that cannot be recognised to human operators. The advantage of using a variety of digital cameras connected to ANPR is the ability to process the information as it occurs. ANPR is used successfully overseas and should be used in New Zealand to assist with:

- detecting and recovering unlawfully taken vehicles (UK)
- driving offences, eg speeding, red light running, failing to pay tolls, no warrant/certificate of fitness, unpaid vehicle licence fees
- apprehending drivers for whom arrest warrants have been issued (UK)
- commercial vehicle movement monitoring (Australia)
- national security requirements such as counter terrorism (UK)
- stopping petrol delivery at petrol stations for stolen vehicles and those that have previously driven off failing to pay (UK).

There is potential to automate offence detection for expired warrant/certificate of fitness and vehicle licence fee evasion by checking every number plate of vehicles passing enforcement cameras.

It is obvious that sharing camera data from all these systems will provide significant cost advantages and prevent duplication of systems in line with the NZTS and government policy statements. Sharing camera data (without offence information) with TMS will also increase the amount of information available to make better informed traffic management decisions and promote sustainability and reduction in greenhouse gases. It is acknowledged that there may be some political and legal issues to address in this area.

Petrol stations: The private sector is able to use digital cameras and ANPR technology to prevent recurring drive offs (without paying for petrol). A high correlation might be expected between vehicles involved in drive offs and other types of crime including unlawfully taken vehicles. There is scope to share a list of unlawfully taken vehicles with service stations to prevent refuelling and simultaneously electronically advise Police when an unlawfully taken vehicle is at the service station.

Crime fighting ANPR: The NZ Police have an ANPR project of this nature. Dedicated ANPR Police squads in the UK have demonstrated an arrest rate around 10 times that of the national arrest rate, publicly announcing the intention to 'deny criminals the use of the roads'. A very recent technological development is a 'Poliscan' system with ANPR fitted facing the front and rear of a Police car, enabling mobile number plate scanning and checking. It is acknowledged that crime fighting systems and a limited number of other systems may restrict data sharing in order to comply with legal and national security classification requirements.

7.8.4 Roadside inspections

The roadside inspection system for commercial vehicles (under development) could readily be adapted to include checks and reporting on all other vehicles. This is dependent on Police rolling out vehicle-based computers with barcode imaging facilities in all enforcement vehicles. Offence notices could be generated on-site or by the electronic offence system. Accurate management and statistical reporting of offences and warnings will become a simple function of this system.

7.8.5 Electronic crash reporting

Crash reporting is currently carried out on a five-page triplicate form that is time consuming to complete. Properly implemented, an electronic crash reporting system will use the same technology as the roadside inspections system with the added advantage of being able to distribute highly accurate, timely, electronic information to the two databases and to one predominantly manual system currently in use.

These databases include Police prosecutions, the Ministry of Transport crash analysis system (CAS) and the various Police crash reporting offices.

Automating the crash reporting process will significantly improve the timeliness and accuracy of reporting and decrease time spent at the scene (with positive implications for other highway users), eliminate duplication of data entry and enable information transfer through the emergency chain, for example to assist hospitals in patient identification, improved diagnosis of injuries and requests for hospital blood samples. (A law change would be required.) This system might also be used to order, direct, authorise and record towing contractors.

7.8.6 Electronic offence subsystem:

The Police Infringement Bureau can receive electronic information (most pre-processed by ANPR) and automatically generate and post offence notices. The types of offence notices that can be generated include speed camera, intersection camera, HOV lane offences, excessive emissions detection, expired warrant/certificate of fitness or licence label, roadside inspections (commercial vehicles and cars) and electronic crash reporting. Law changes would be required to generate notices for HOV lane offences, excessive emissions detection and expired warrant/certificate of fitness or licence labels. The benefit of automating detection of these types of offences is that Police resources will be freed to perform more enforcement checks and focus on serious offending. In the cases of roadside inspections and crash reporting, members of the public will generally not be held up as long as they are now and this will decrease traffic delays, particularly on highways during the peak traffic flow.

7.9 Electronic payment services

Electronic payment services are essentially an interface with the banking system enabling direct transfer of funds (payment) where this is requested by an electronic system and authorised by the payer. Alternative forms of electronic payment include smart cards (stored value cards) with embedded value. These cards operate by storing pre-purchased ‘value’ from a specific supplier on an electronic circuit in the card. As the card is used for transactions the ‘value’ diminishes. In fact the supplier has the use of the entire value of the money and can collect interest from the time the pre-purchase is made.

7.9.1 Electronic toll collection:

This provides toll operators with the ability to locally or centrally collect tolls electronically and detect and process offenders using the electronic offence subsystem. Variations in the fees collected enable implementation of demand management strategies. Most toll System rely on two vehicle identification systems. (1) DSRC with vehicles that are ‘on account’ and have transponders fitted enabling direct bank transfer of the toll. (2) ANPR which records images of all passing vehicles. The system recognises which vehicles have paid tolls within a defined time period through any of a variety of channels (including DSRC) and forwards details of the remaining plates to the electronic offence system. The NZTA has already realised the benefits of an integrated national tolling system. New Zealand does not have the traffic volumes required to sustain many tolling systems and the Northern Toll Road currently operates on a purely ANPR system.

7.9.2 Electronic parking payment

This provides for electronic collection of parking fees by a variety of methods:

- mobile phone-based credit card payment to generate a parking receipt (currently used in some areas of New Zealand)
- automatic fee collection in some New Zealand car parking buildings, using short-range communications with the same in-vehicle equipment utilised for electronic toll collection
- ANPR.

The City of Westminster (UK) has eliminated parking meters and pay and display machines altogether and uses mobile phone technology combined with a real-time database payment system. Parking payment is a service that might readily be provided at national level in New Zealand utilising the tolling system back office (ie the NZTA computer system to recognise vehicles and generate payment checks).

7.9.3 Electronic fuel payment

This provides for electronic payment of petrol purchases by an automatic fee collection using short-range communications with the same in-vehicle equipment utilised for electronic toll collection and/or ANPR. It is a service that might readily be provided at a national level in New Zealand sharing the tolling system back office. The concept has not been accepted or adopted overseas but provides a strong customer focus with potential benefits when integrated with other ANPR systems.

7.9.4 Passenger transport services payment

Electronic fare payments can be made using readers located on-board the vehicle. An alternative used overseas is to have readers in the infrastructure; however, New Zealand probably does not have the population to justify this alternative. Data is processed, stored and displayed on the vehicle and communicated as needed to the public TMS.

7.10 Traveller information service

This is an information collation and distribution service. The objective is near real-time coordinated information and incident notification, and traffic forecasting for the following 10 to 15 minutes using a traffic prediction tool. It provides a full set of information layers collected in live data feeds from various systems. Live data feeds ensure that the information is continually as good as the source information and does not require additional information management by the service provider. The user can select and de-select any services to meet system, route or user requirements. Core layers will include:

- traffic conditions (TMS)
- weather conditions (TMS and MetService)
- special advisory information (TMS and emergency management)

- public transport information
- incident information (TOC and emergency management).

Optional information layers will include:

- business directories
- public transport
- rideshare
- air quality
- parking
- toll information,
- traffic camera views
- booking and payment services
- dynamic route guidance.

The near real-time dissemination of current information and forecasted information is ideally made through the internet, mobile phones and in-vehicle devices. Commercial radio stations can readily select the desired information layers, for example incident and traffic information, from an internet-based service. The NZTA geospatial viewer already operates this type of live information service in a browser environment and the additional layers might readily be added. This will significantly enhance the capabilities of each system. The current NZTA road event information system (TREIS) and the planned Infoconnect systems are both browser-based information systems operating on a much narrower focus and delayed response. The NZTA i-Pond project is a further example of a tool to query multiple external and internal databases.

7.10.1 Real-time ridesharing information

This matches travellers with vehicles travelling on the same route to the same destination. This service can include pre-planned and dynamic information. Ideally information from a dynamic route guidance system will be used if a vehicle user requesting route guidance indicates they can ride share. Regular journeys may also be set up via an internet browser interface. It is best applied via the internet and optimised for web-enabled mobile phones with messaging facilities to the provider vehicle.

7.10.2 Traveller business directory

This provides an optional information layer to the dynamic route guidance service by making a location-based business directory available to the user. It will also make reservations, purchases and payment possible via the internet.

7.10.3 Parking facility management

This provides enhanced monitoring and management of parking facilities. ANPR systems support electronic collection of parking fees and enable determination of current parking availability. Sharing the data with TIS and TMS will assist with optimising traffic flows and advising motorists which car parks have spaces available. This also supports coordination between parking facilities to enable regional parking management strategies and may be integrated with enforcement systems.

7.10.4 Autonomous route guidance

This enables route planning and detailed route guidance based on static, stored information collected through in-vehicle sensory, location determination, computational, map database and interactive driver interface equipment. Communication with the infrastructure is not assumed or required. This is the type of service provided by current in-vehicle GPS navigation devices.

7.10.5 Dynamic route guidance

This provides advanced route planning and guidance which is responsive to current conditions and position. Autonomous route guidance combines real-time information sourced from the broadcast traffic information service (and optional layers) which is processed in relation to a vehicle position and pre-determined destination to enhance route guidance information with left/right style directions to optimise the journey. This system also enables use of connected vehicles as traffic probes. Processing could be performed locally (by the device in the vehicle) but ideally with internet-enabled cars (these have been in production since 2008) and cell phones. Dynamic route guidance processing will be performed more efficiently by a centralised server with the route guidance instructions transmitted via the internet.

7.11 Information storage and retrieval

7.11.1 Data warehousing

Traditionally all data collected by a government agency has been archived or warehoused by that agency for future retrieval. In the interoperable environment it is feasible and even preferable to virtualise data warehousing in a federated architecture. This means that each of the source systems will operate an accessible and interoperable data warehouse. The ITS business requirement is to set up standardised data quality, data privacy, data format and meta-data management and to provide general query and report access to authorised users. Data only needs to be warehoused by the TIS if the source provider does not operate a suitable data warehouse. An example of a modern reporting system retrieving information from multiple sources is the NZTA i-Pond development. I-Pond will gather key reporting data at set intervals from the motor vehicle and driver licence registers, CAS, Statistics NZ household travel survey and the privately owned CJD Technologies roading assessment and maintenance management (RAMM) databases.

8 Consultation

The suggested framework for the architecture outlined in section 7 was developed from the consultation input to the draft created from international models and adapted to the New Zealand situation. The consultation process outlined in the methodology consisted of two parts:

- a workshop/seminar with transport sector leaders
- a second consultation round involving an interactive spreadsheet.

The group consisted of key NZTA (Transit and Land Transport NZ) staff as a starting point with the initial thoughts of this group being extended to a wider audience during the second consultation round. People from different areas of expertise were chosen as a cross-section of the industry.

The workshop consisted of a presentation to explain the fundamentals and ensure consistent understanding of the concepts behind a framework for a national ITS architecture. Once the clear platform and objectives were set, input from the group was recorded on a skeleton or 'straw man' framework. Following this workshop the initial draft architecture was refined to a point where it could be sent out for the second consultation round in the form of an interactive spreadsheet.

The objectives of the second consultation round were conveyed to those involved by asking some key questions of them as they completed their responses.

- Is the user service relevant to New Zealand?
- What other service is each user service related to?
- What is the priority of such an application to New Zealand?
- Who are the key stakeholders?
- Any other comments from a specific area of expertise?

9 Discussion and conclusions

New Zealand has a wide range of ITS already in use. Many of these systems use older stand-alone applications that perform the function they were designed for but are not readily interoperable. Many other systems are interoperable but have not been integrated for commercial sensitivity, political and cost reasons.

ITS architectures aim at enabling and improving fuel efficiency, fuel consumption, decreasing carbon emissions, reducing delays and congestion, enhancing safety and providing traveller information and security. ITS architecture involves a strategic and integrated approach to optimise performance of existing and future infrastructure, services and vehicles. Optimum performance of the New Zealand transport sector will only properly be achieved through collaborative architecture, design and implementation of multi-modal, intermodal, cross-sector and cross-regional systems and services.

Information sharing does not and will not readily occur in a tactical, operational or low-level strategic 'business as usual' environment. Business as usual will dictate the design of each system focusing solely on the requirements of the system owner. Optimised performance of the transport network will require collection of all relevant and timely data. However this level of optimisation requires significant collaboration.

Collaboration will include collecting and sharing raw data from a variety of input devices; sharing data communications channels; analysing and processing that data; transforming data into information for use by various national agencies, regional and local authorities, commercial transport operators, emergency services and other potential users.

Planning and implementing any new business process involving ITS requires a relatively new way of thinking in transportation planning. Current government policy supports economic growth. ITS can assist if a collaborative, outcome-driven approach is taken for the benefit of all users. This approach focuses on the function of ITS input devices rather than ownership or original purpose. For example, agreement to share data output from high-resolution digital traffic cameras, reducing the traditional focus on ownership will decrease duplication and triplication of cameras installed for different purposes at the same or nearby sites.

Technology continues to advance. Significantly greater amounts of traffic data will become available to all collaborating parties if planned properly. A corresponding reduction in installation and maintenance costs, power usage and telecommunications traffic will reduce the total cost of ownership for the government, taxpayers and ratepayers. Similarly, failure to develop a facilitated approach to New Zealand ITS in the near future is likely to result in significantly greater costs integrating systems at a later time.

New Zealand has over 10 different commercial fleet tracking systems; these perform similar tasks utilising differing methodologies and technologies, with limited or no interoperability and provide different outputs. Yet the NZTA relies on data from each to support RUC claims.

Electronic ticketing is rapidly disappearing down the same path with many different electronic ticketing systems already implemented company by company, even within the same cities. There will be significant political and financial cost involved in converging the application of these examples (of ITS technology) in New Zealand. This project is already underway.

The key issue is to identify which ITS services will work together. The recommended approach is the development of standard technical architectures: reference, logical and physical.

ITS architecture provides a technical big picture of the feasible, logical and practical linkages. The related political, economic, social, legal and organisational issues to enable technical success are challenging and should be the subject of separate strategy development.

10 Recommendations

One of the key objectives of this research project was to establish a recommended way forward, defining the scope and definition of a national ITS architecture as the basis for collaboration and alignment of all stakeholders. A full architecture will include plans for the integration of major national and significant regional systems, requiring consultation and collaboration with a very large number of stakeholders. Developing a national ITS architecture may therefore be achieved in a step-by-step approach.

- **STEP 1a**: **Governance group:** Establish a governance structure to guide further work. Identify champions from the NZTA, the Ministry of Economic Development and the Ministry of Research, Science & Technology, and from the private sector. It is apparent there are no clear or stand-out single champions. ITS have wider application than highways or commercial vehicles. As a road controlling authority the NZTA is also an end user. The structure should therefore allow for input from key stakeholders and the industry.
- **STEP 1b: National ITS strategy:** Identify New Zealand's particular needs and objectives. The NZTS, combined with the work done in Australia, might provide a good basis from which to start. Develop an ITS strategy addressing these needs.
- **STEP 1c: Reference architecture:** Establish the process. Engage with all end-user groups to raise awareness and encourage participation. Consult with subject matter experts.
- **STEP 2: Logical architecture:** Develop process in consultation with subject matter experts.
- **STEP 3: Physical architecture:** This also requires champions and development of a process.

The framework architecture presented in this research project is designed to relatively quickly raise awareness, facilitate improved coordination and funding direction for the logical next step, the development of a national ITS reference architecture. The framework will enable the NZTA to direct the:

- delivery of a business proposal seeking funding for full consultation and development of a national reference architecture (based on the services outlined in chapter 5) with a much wider range of stakeholders as soon as possible
- development of a national logical architecture in conjunction with the reference architecture, the proposed New Zealand Standard series around data collection from moving vehicles and current New Zealand standard P6906 'Electronic fee collection using DSRC'
- specification of open and modular systems in federated architectures, enabling longer system life cycles, greater interoperability and reduced dependency on 'hard-coded' proprietary applications
- delivery of a seamless, integrated and modular customer facing set of services through the development of standard interface specifications
- development of incentives and accountability measures for local government and the private sector to share data and progress toward meeting the ITS architectures.

The information and core set of services produced in this framework provide a sound basic starting point from which to develop a full New Zealand ITS architecture at reference, logical and physical levels. Following completion of the project the results will be provided to all of major ITS operators in New Zealand through the IPENZ Transportation Group and ITS New Zealand.

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12 Glossary

ANPR (automatic number plate recognition) also known as: automatic licence plate recognition (ALPR), automatic vehicle identification (AVI), car plate recognition (CPR), licence plate recognition (LPR) and lecture automatique de plaques d'immatriculation (LAPI)

ATMS Advanced traffic management system. In New Zealand this consists primarily of systems in Auckland and Wellington that monitor traffic flows, traffic speeds and weather using a combination of CCTVs, radar and variable message signs to advise motorists of conditions and impose lower speed limits as required. There are other specialist systems in place to deal with avalanche control, lahar warning and remote variable message signs.

BIFA Border information flow architecture

CARD Computer assisted dispatch system shared by NZ Police and the NZ Fire Service

CAS Crash analysis system. The database recording all reported road crashes in New Zealand, and associated data

CCTV Closed circuit television. A camera connected wirelessly or wired to a monitoring system as used in many traffic and security situations

CFVD Cellular floating vehicle data: using anonymised cell phone data to derive traffic flow information

CIMS Coordinated incident management system. New Zealand management system for multi-agency responses. Adapted from and aligned with international models

CVAP Commercial vehicle administrative processes

DARPA Defense Advanced Research Projects Agency. US Department of Defense research agency. Responsible for the autonomous vehicle programme

DSRC Dedicated short-range communications. Allows communication between vehicles and on-road infrastructure

EC European Commission

EDR Electronic distance recorder

EMO Emergency management operations (US)

EVP Emergency vehicle priority at traffic lights

Federated architecture A system architecture that includes a number of distributed computer systems with different business purposes, each functioning interoperably and to common standards

FRAME project (Framework Architecture Made for Europe). The FRAME projects built on and enhanced the framework architecture developed in the KAREN project. Ran from 2001 to 2004

GIS Geographic information system. Any system that manages geospatially referenced information to determine position as an attribute of other information. This generally involves a description of latitude and longitude. It may also involve a related description of elevation

GNSS Global navigation satellite system. Collective term for all satellite supported global navigation systems. These provide timed radio signals to permit devices on earth to cross reference and determine longitude, latitude and elevation. Current commercially available devices are accurate to within 5–7m. More expensive surveyor grade equipment can be accurate to within 30cm. GNSS includes NAVSTAR – GPS (US), Glonass (Russia), Galileo (Europe), Beidou (China) and IRNSS (India). The only fully operational system is GPS

GPS Global positioning system. US system using satellites to provide reference points to determine position. Part of the wider GNSS

GPS *Government policy statement on land transport funding*. A statement of the NZ Government funding priorities

HOV High-occupancy vehicle (lanes) are lanes set aside for vehicles that have a minimum number of passengers

IJIS Integrated justice information systems (US)

ITS Intelligent transport systems: The application of information technology, communications technology and sensor technology, including the internet (both wired and wireless), to the general challenges and opportunities of surface transportation

iPond New NZTA reporting system that queries a variety of databases to gain a view of available information (queries CAS, driver licence register, motor vehicle register, RAMM and the household travel survey)

KAREN model (Keystone Architecture Required for European Networks). An EU project to develop a framework for a European ITS architecture. Ran from 1998 to 2000

Logical architecture Logical (or functional) architecture focuses on 'user services' broken down into functions, and indicating the nature of information exchange needed to perform the functions

LTMA Land Transport Management Act 2003

LX Level crossing(s)

National ITS 21 plan South Korea's ITS plan

NZTA NZ Transport Agency. The agency formed from 1 July 2008 merging Land Transport NZ and Transit NZ

NZTS 2008 NZ Transport Strategy. Government strategy document for land transport, updated in 2008 to supersede the 2002 NZTS

Operator rating system Currently being developed to publicly rate all licensed commercial transport operators in New Zealand from July 2009

Police Infringement Bureau The centralised Police office that processes all speed camera offence notices and all infringement notices (option to pay fine imposed by offence type and not requiring a court hearing)

Physical architecture Physical architecture defines the more detailed layers of physical architecture in terms of physical subsystems, for example traffic management systems

RAMM Road assessment and maintenance management. A geospatially referenced New Zealand database owned by CJN technologies used to store data about roading assets

Regional controller agent A traffic light management system that synchronises and adjusts cycles over a wide area to optimise traffic flows

Reference architecture A plan of current and future services and facilities, and the primary functional linkages between them

RFIDs Radio frequency identification is a system that uses transponders to identify specialised electronic chips and read information stored on them. Linked with GPS tracking and mobile data technologies these systems permit real-time tracking of goods and other items, generally for logistics purposes in the transport industry. RFIDs are becoming common in other applications such as tracking high value clothing, timing sports events and baggage handling.

RIS Rail information system

RTMS Real-time monitoring system

RUC Road user charges: The system in place in New Zealand for over 30 years to collect taxation from vehicles with a gross vehicle mass over 3500kg and vehicles powered by fuels that are not taxed at source. Petrol and LPG are taxed at source

Smartway 2007 ITS system in the Tokyo metropolitan expressway

Stored value card Carries embedded value purchased from the card issuer

TIS Traveller information service

TOC Traffic operations centre (may also be known as TMC or traffic management centre)

TMS Traffic management system

Traffic prediction tool Already developed by IBM and Singapore Land Transport Authority to accurately (85%) forecast traffic conditions 10 minutes in advance. The forecast is based on real-time information inputs from existing Singaporean intelligent transport systems such as the EMAS (Expressway Monitoring and Advisory System), GLIDE (Green Link Determining System), J-Eyes (Junction Electronic Eyes) and Traffic Scan

Variable message signs Electronic signs where the message can be changed remotely to advise motorists of changes in travel conditions. May also include variable speed signs

WIM Weigh in motion. A system that can measure the weight of moving vehicles

Wireless local area network Provides access to a computer network through a wireless router (range maximum around 300m). May be secured to mitigate the risk of unauthorised access