NACOE
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FINAL REPORT

R5_Vehicle to Infrastructure Technology Applications in Queensland

Project No: 007146

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Queensland Government Australia

SUMMARY

The Queensland Department of Transport and Main Roads engaged ARRB Group, under the National Asset Centre of Excellence Research Program, to undertake a preliminary investigation into cooperative applications using mobile phone access technology and in-vehicle telematics in generating productivity benefits for the road freight industry.

This report contains a detailed review of current connected vehicle environment including:

- overview of architectures of heavy vehicle telematics
- travel applications, requirements and possibility to leverage on existing fleet management services
- provision of location based services and the overseas examples of C-ITS applications accessing Space Based Augmentation Services (unavailable in Australia)
- in-vehicle services and insurance plans using emerging telematics devices
- traffic and traveller information providers and the range of services provided by original equipment manufacturers
- intelligent access program and vehicle telematics in Australia and the potential for leveraging existing equipment for telematics applications for regulated commercial freight vehicles
- regulatory guidelines, the roles of industry and government in the area of vehicle telematics and C-ITS
- the concept of C-ITS/connected vehicle open platform is not business as usual and interoperability options are not fully defined
- the concept of ITS station and access technologies
- freight related C-ITS projects undertaken in Europe and USA.

The use cases in Europe were referenced when a list of projects were developed for Queensland. The deployment of traffic signals pre-emption for heavy vehicles in Queensland is considered to be one of the most promising projects. Conceptually, two architectures can be used.

Firstly, this can be done by establishing a geo-fence in the vicinity of the intersection. When a heavy vehicle goes through that geo-fence, the on-board telemetry device sends a signal to the data provider’s server, i.e. a form of polling, advising the heavy vehicle’s presence. The information can then transmitted to an external system, e.g. STREAMS, via an application programmable interface (API).

Alternatively, the service can be provided without involving telematics. However, it will require a number of systems to be developed and would require TMR to take on additional responsibilities, such as access control.

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1 INTRODUCTION

The Queensland Department of Transport and Main Roads engaged ARRB Group, under the National Asset Centre of Excellence Research Program, to undertake a preliminary investigation into cooperative applications using mobile phone access technology and in-vehicle telematics in generating productivity benefits for the road freight industry.

The past 20 years has seen the unprecedented growth in the number of heavy vehicles on Australian roads accompanied by an increasing focus on how this impacts road safety, congestion, pavement wear, funding and productivity. The growth is expected to increase with a predicted doubling of the freight task between 2000 and 2020 (National Transport Commission, 2006).

The freight task, in Queensland alone, is forecast to increase to 1,550 million tonnes in 2020-21 from 881 million tonnes in 2009-10 (Department of Transport and Main Roads, 2013). In response to this forecast, the Department of Transport and Main Roads in Queensland have drafted the Move Freight document outlining the priorities for facilitating this growth whilst improving efficiency. Among the list of priorities is the need for better freight policy and information including better management of freight vehicles using technology as well as the development of information systems to better utilise freight-related data.

In order to meet these increasing freight demands, the implementation of information technology through Cooperative-intelligent transport systems (C-ITS), in particularly 5.9 DSRC, 3G/4G and in-vehicle telematics, has many advantages over building additional roads and bridges as the latter is constrained by funding, availability of land, and likely community and environmental issues.

C-ITS is a relatively low cost and versatile solution and does not require a great deal of infrastructure. Various field trials and studies, particular overseas, has suggested that the implementation of C-ITS is effective in alleviating traffic congestion, reduce accidents and in the context of heavy vehicles, has the potential to deliver higher network efficiency, safety and productivity.

The scope of this project is to produce a literature review on the current state of 5.9 DSRC, 3G/4G freight applications and ability of the IAP architecture to deliver applications using the current 3G/4G access technology, along with any applicable domestic or international research. From this review, a list of possible applications and projects are recommended that could be implemented in Queensland in 2014/15.

This report consists of:

- a scan of practices, covering:
  - current connected vehicle environment
  - current Australian freight environment
  - C-ITS/ connected vehicle open platform
  - use cases
- a list of potential projects.

2 TERMINOLOGY

BSMD: Bounded Secured Managed Domain

ITS Station: A platform designed for various roles (vehicle, roadside, central, etc.) and applications (infotainment, traffic control, road safety, etc.)

ITS Reference Architecture: An architecture follows the principles of the OSI model for layered communication protocols which is extended for inclusion of ITS applications

CALM: Communications Access for Land Mobiles, a set of communication standards for C-ITS, the standards are communication-centric, but they go beyond communications

CAN-bus: Controller Area Network bus is an automotive bus designed to allow communication of micro-controllers, sensors and devices within a vehicle

C-ITS: Cooperative Intelligent Transport System

CVIS: Cooperative Vehicle-Infrastructure System

DARC: Data Radio Channel (DARC) is a high-rate (16 kbit/s) standard for encoding data in a subcarrier over radio station broadcasts, DARC was approved as the All-European standard ETS 300 751 in 1997

DSRC: Dedicated Short Range Communication; specific to 5.9 GHz

GNSS: Global Navigation Satellite System

GPS: Global Positioning System is a satellite navigation system used for determining time and location information system

IEEE: Institute of Electrical and Electronics Engineers

ITS: Intelligent Transport System

ISO: International Organization for Standardization

In-vehicle telematics: In-vehicle telematics is a subset of C-ITS or connected vehicles and encompasses computer, electronic and communications technology within the vehicle.

ITSSv6: IPv6 Stack for Cooperative ITS, i.e. a generic communication stack design conforming to ITS reference architecture using state of the art protocols (IPv6 based) and adaptable to all usages

OBE: On Board Equipment, this may include host or router with networking, management, security and other facilities for running applications

OSI: Open System Interconnection model, i.e. a conceptual model that characterises and standardises the internal functions of a communication system by partitioning it into abstraction layers

RDS: Radio Data System (RDS) is a communications protocol standard for embedding small amounts of digital information in conventional FM radio broadcasts. RDS standardizes several types of information transmitted, including time, station identification and programme information.

RSU: Road Side Unit, this may contain ITS stations

Suna: Suna Traffic Channel, a digital traffic information service, broadcasts detailed information about traffic congestion and other road conditions directly to compatible devices

TARV: Telematics Applications for Regulated commercial freight Vehicles

Telematics: The integrated use of telecommunications and informatics, for application in vehicles and with control of vehicles on the move

Connected vehicles: Vehicles that have the ability to communicate with other devices using the mobile network

WAVE: Wireless Access for the Vehicular Environment

3 CURRENT CONNECTED VEHICLE ENVIRONMENT

3.1 Background

A connected vehicle is the term used to describe vehicles that have wireless connectivity with other vehicles, and infrastructure (e.g. signal controllers). The connection is achieved through cellular communications technology such as 3G, 4G, LTE, or through dedicated short range communication. This connectivity enables the exchange of vehicle or traffic data for a range of travel, safety and productivity application and is a key element of the cooperative intelligence transport system (C-ITS).

The technology involved in creating such systems is extensive. There are infrastructure-based and vehicle based devices that collect information and perform operations to produce a desirable outcome. The majority of devices used to collect information about heavy vehicles and traffic conditions are road based, and can be used to ascertain the traffic volume, direction of travel, type of vehicle, axle masses and license plate.

In-vehicle devices, such as telematics devices, are often connected to the vehicle's CAN-bus (controller area network) and can be used in conjunction with other sensors and satellites to collect data related to individual vehicles themselves such as the speed, direction, route, mass and other mechanical properties. In order for intelligent interaction between the vehicle and infrastructure to take place, they require a media over which to communicate information. This will also be briefly outlined.

The automotive industry, in conjunction with application developers or in-vehicle telematics companies, has been driving technological innovation in the connected vehicles field by integrating cellular communication technology into their latest vehicle models. This capability enables vehicles to connect with other vehicles, the internet and with elements of the road infrastructure.

3.2 Overview of Architectures

Current connected vehicle environment generally consist of an in-vehicle device (which could be a smart phone), with connection to engine information via ODB II port (Figure 3.1) or without taking into consideration engine data (Figure 3.2). The applications are generally hosted on servers with database back-ends, providing information to road users. It should be noted that virtually all web services and applications have database components to support their functionalities.

In the area of heavy vehicles, regulatory telematics in-vehicle unit (IVU) generally consists of the following components:

- data storage
- communications (3G/4G)
- internal power supply
- GPS and movement sensor
- linkage with vehicle management system
- in-vehicle display.

Applications for heavy vehicles largely work in the same way as applications for light vehicles; the key difference is the standardisation of regulatory telematics devices may enable applications to be used by devices developed by multiple vendors in the longer term. However, the current regulatory frameworks in most jurisdictions only specify the functional requirements in relation to access management or road user charging, i.e. tamper proof waypoint and timestamp data. Any application development would require the participation of individual vendors.

Figure 3.1: Example architecture (RACV connected vehicle)

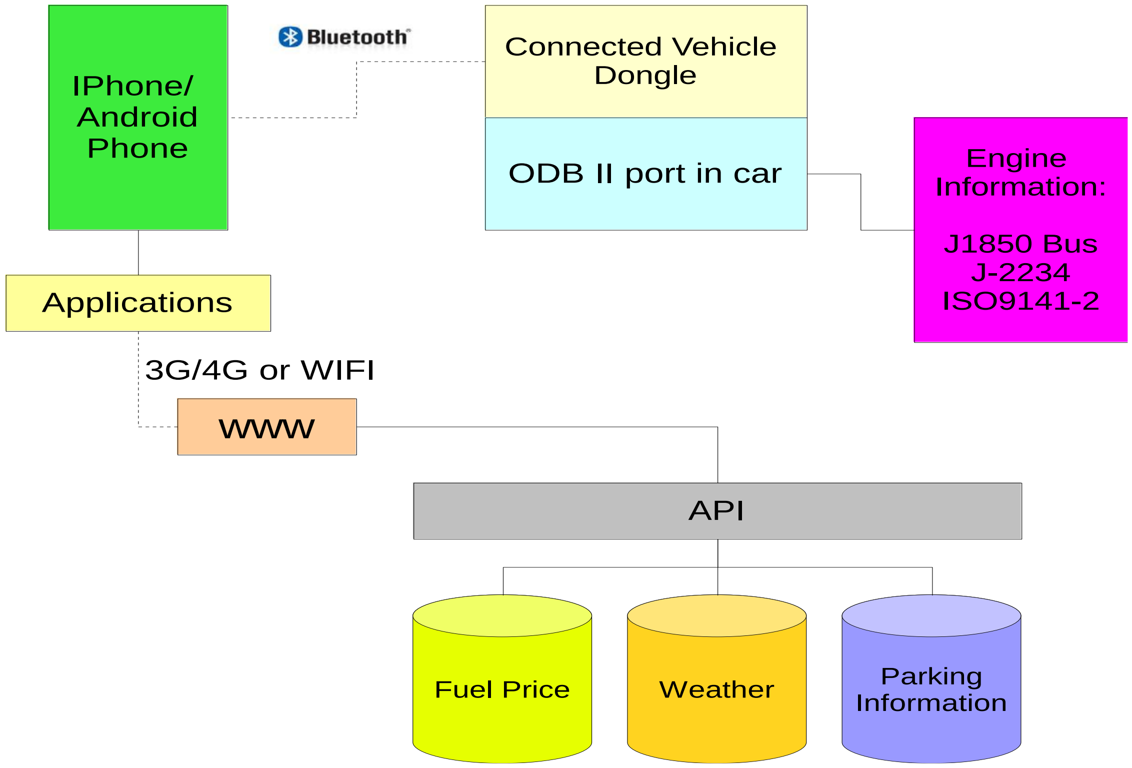
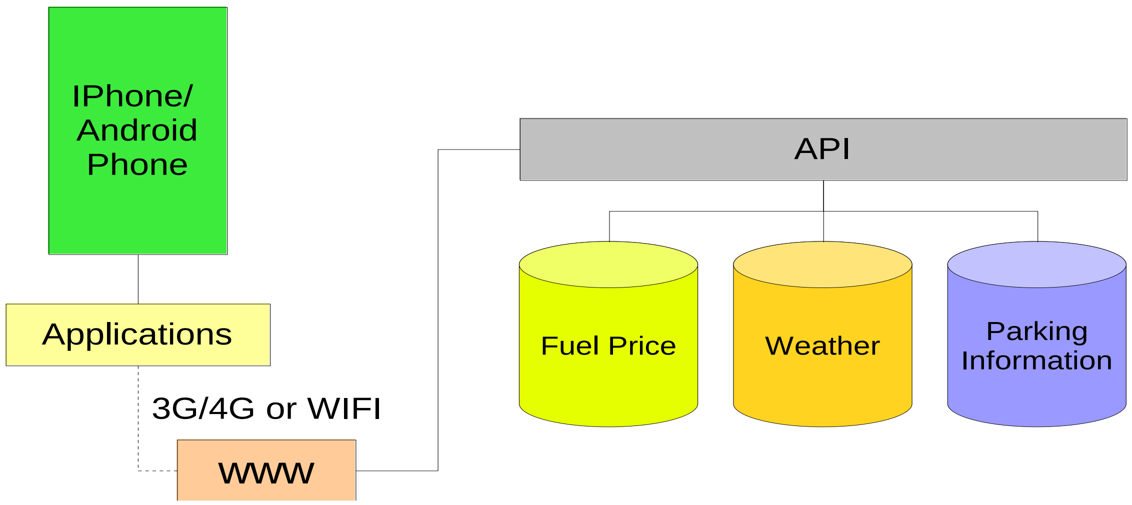


Figure 3.2: Example architecture (using smart phones as in-vehicle device)



3.3 Travel Applications

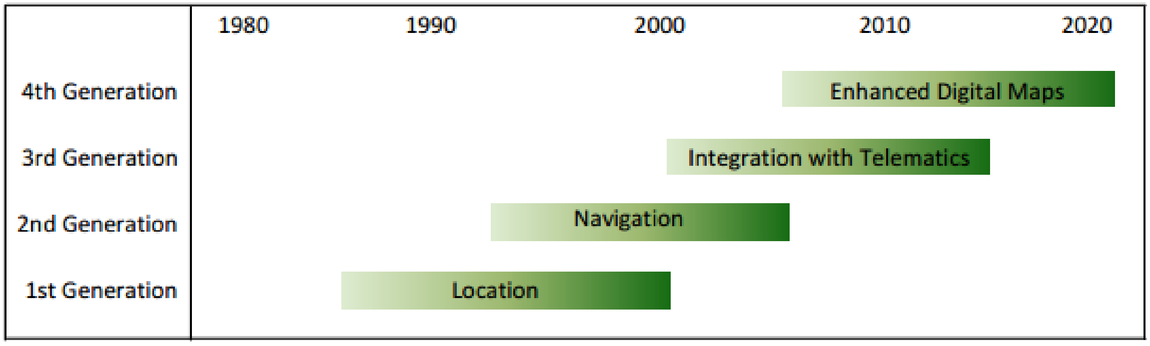
Connected vehicles can enable a variety of travel applications such as:

- Dynamic route planning to:
  - reduce travel time
  - avoid congested areas in real time
  - reduce fuel consumption
  - reduce CO2 emissions
- locating available parking
- e-call for traffic accident emergencies
- hazardous weather warning
- road work and road closure warnings.

Travel applications generally require the following components to function:

- digital mapping (the evolution of mapping digital road map shown in Figure 3.3)
- vehicle positioning using GPS or motion sensor independent of GPS
- in-vehicle display unit (which could be a standard smart phone)
- communications (3G/4G/FM/DSRC).

Figure 3.3: The generations within the evolution of digital road maps



Source: Austroads 2013

These technical requirements coincide with most telematics or fleet management services. Therefore, there are opportunities to develop vehicle to infrastructure or infrastructure to vehicle applications by leveraging existing in-vehicle devices.

3.4 Location Based Services

Location based services in the context of heavy vehicle can be provided if an application knows the presence of a heavy vehicle. Currently, presence of a heavy vehicle can be detected using on-road sensor or virtual sensor (e.g. a geofence). A connected vehicle environment may potentially share position, direction, speed, traffic conditions and potential hazards more effectively. The accuracy, integrity, continuity, availability, interoperability and timeliness of the positioning data are likely to improve over time, especially with the likely introduction of in-vehicle devices using the Australian Continuously Operating Reference Station (CORS) network in the future.

Some C-ITS systems in Europe, Japan and the United Sates have access to Space Based Augmentation Services that can fulfil the positioning requirement of those systems. However, Australia does not have such positioning augmentation levels. Therefore, a more coordinated approach to infrastructure and communication development, including improving access to a wide area augmented Global Navigation Satellite System (GNSS), may enable deployment of safety critical C-ITS applications via 3G/4G.

3.5 In-Vehicle Services

In-vehicle services are generally provided using an in-vehicle display, which can be a core part of a dispatch/ telematics system or one of the emerging trends is to use standard smart phones/ tablets as in-vehicle display for ITS applications (refer to Section 5.5.2).

3.6 Insurance

Vehicle insurance is generally considered a fixed cost of owning a vehicle. Motorists do not usually obtain insurance cost savings when mileage is reduced. Distance-based (also called Pay-As-You-Drive or Pay-How-You-Drive or per-kilometre) insurance pricing converts insurance to a variable cost, so premiums are directly related to annual mileage. Distance-based pricing makes vehicle insurance more accurate (premiums better reflect the claim costs of each vehicle) and gives motorists a new opportunity to save money when they reduce their mileage. It can help achieve several public policy objectives including but not limited to:

- equity
- road safety
- consumer savings and choice
- congestion reduction
- facility cost savings
- energy savings
- environmental protection.

Most current pay as you drive insurance policies in Australia do not require the use of connected vehicles or mileage aggregated from GPS data. Most coverage is based on odometer reading of the vehicle. Insurance companies overseas have developed devices that plug into the OBD II port, which records how much, how fast and when the vehicle is driven. This information is used to calculate discounts the customer may receive when they renew their policy. The device reports driving information by wireless communication.

A report produced by the Department of Transportation to the US Congress on potential transportation emission reduction strategies, the report ranked distance-based insurance as one of the most effective and cost effective way to reduce energy consumption and pollution emissions.

This is an area that has potential for further development into distance based and time based road user charging.

3.7 Traffic and Traveller Information

3.7.1 Intelematics – SUNA Traffic Channel

Intelematics operates SUNA traffic channel in Australia. SUNA uses data collected from road sensors and speed from probe vehicles to determine traffic conditions. The traffic information is then broadcasts to compatible navigation system or application via FM radio or 3G/4G. Most compatible navigation system uses FM (Radio Data System-Traffic Message Channel RDS-TMC) digital broadcast due to the lower cost of transmission and there is no ongoing charges for the device owner to obtain traffic update.

The compatible navigation system that uses FM cannot be used as probe vehicle. Therefore, there are opportunities for collaboration where data from connected vehicles can potentially be shared.

3.7.2 Traveller Information Services Association (TISA)

TISA is a worldwide association consists of members from the commercial RDS-TMC technology vendors and other public and private organisations that have an interest in Traffic and Traveller information. TISA maintains and develops standardised technologies, including RDS-TMC and Transport Protocol Experts Group (TPEG).

3.7.3 Transport Protocol Experts Group (TPEG)

TPEG originated in 1997, specifications were developed for transmission of language independent multi-modal Traffic and Travel Information. TPEG binary data can be transmitted over Digital Audio Broadcasting (DAB) or Digital Multimedia Broadcasting (DMB) and TPEG XML implementation, tpegML can be delivered via the internet.

TPEG’s location referencing system is considered to be robust and can be used to describe locations in complex networks. It has also been adopted by Open Travel Data Access Protocol (OTAP), i.e. a protocol that allows service providers to easily and cost effectively exchange real time traffic data stored in databases.

3.8 Original Equipment Manufacturers (OEMs)

Automotive companies such as Ford, General Motors (GM), Toyota and Audi have started offering services requiring GPS, 3G, 4G/LTE, bluetooth and wifi in their premium vehicle models in response to the increasing demand by consumers for connectivity. Some of the functionalities enable vehicles to act as an extension of the user’s smart phone, allowing phone calls to be made through the vehicle, or applications to be downloaded that enables the user to monitor vehicle information data, such as fuel consumption, or for entertainment purposes, such as streaming music from the internet.

The majority of OEMs offer the following services that require connectivity:

- remote engine diagnostics and roadside assistance
- automatic crash response or e-call
- security monitoring and theft prevention.

3.8.1 GM Onstar

The following table illustrates the capability of the GM Onstar telematics and connected vehicles system. The majority of these functionalities are provided by most major auto companies.

Table 3.1: Functionalities

Function	Sub-category
Emergency	Automatic crash response
	Emergency services

<table>
<tr><th>Function</th><th>Sub-category</th></tr>
<tr><td></td><td>Crises Assist</td></tr>
<tr><td rowspan="4">Security</td><td>Stolen vehicle: Uses GPS technology to track your vehicle. Remotely block your ignition making it impossible to restart vehicle when it's turned off. Advisor can work with police to send signal to vehicle, forcing it gradually and safely slow down.</td></tr>
<tr><td>Roadside assistance: A flat tire. An empty gas tank. If you find yourself stranded, you're never alone: with one push of the OnStar button, Roadside Assistance4 can be on the way. This incredible service is automatically included in our monthly and yearly plans as well as trial subscriptions.

Roadside Assistance features include:

▪ lock-out Service
▪ emergency tow from a public road or highway
▪ flat tire change
▪ battery jump start
▪ emergency fuel delivery</td></tr>
<tr><td>Remote services: Remote Door Unlock5 to the rescue. With OnStar, you'll soon learn what over a thousand subscribers learn every day: locking your keys in the car can happen to anyone-but OnStar can get you back in your vehicle in minutes. Just call us. An Advisor confirms your account information and security verification, and can send a signal to unlock your doors. No locksmith. No hassle.</td></tr>
<tr><td>Family link: Vehicle Locate
Find out where your loved one is at any time with Vehicle Locate.4 Just access Family Link online to view a map with the vehicle's exact location.
▪ If you've got a new driver in the house, Vehicle Locate gives you peace of mind as he takes to the road.
▪ If your family member is driving across the state to visit a friend, use the Vehicle Locate feature to check on her progress.
▪ If your spouse is unreachable and driving in inclement weather, the Vehicle Locate feature can help you determine when he might be home safe and sound.

Vehicle Location Alert
Set up email or text message notifications and the Vehicle Location Alert4 feature will let you know the location of your loved one's vehicle. You can choose the day, time and frequency of the alerts.
▪ If your teen driver is supposed to arrive at school every day at 8:00 a.m., use a Vehicle Location Alert and get a text every day regarding the vehicle's location—without you or your teen picking up the phone.</td></tr>
<tr><td rowspan="2">Navigation</td><td>Turn by turn navigation: connects you to your destination effortlessly. Just push a button for directions you saved with eNav[2] or for an Advisor to help you get anywhere. And, with OnStar, you'll have the most up-to-date routes right at your fingertips.</td></tr>
<tr><td>e-Nav: Harness the power of MapQuest to make travel planning even simpler. Just plan your route ahead of time and send it to your vehicle with one click.[1] You can store multiple destinations—and retrieve them from your vehicle whenever you want, and get up-to-the-minute Turn-by-Turn directions.
Enables sharing of favourite drives and destinations over social media.</td></tr>
<tr><td rowspan="2">Connections</td><td>Hands free calling: using the car as a giant mobile phone. You can purchase minutes to use for your calls.</td></tr>
<tr><td>RemoteLink mobile app: Connect to your vehicle remotely with OnStar RemoteLink mobile app. RemoteLink gives you remote control of certain features of your vehicle, lets you view real-time diagnostic information, and more. The app is available for select iOS®[2], Windows®[11], Android™[3], and BlackBerry®[4] devices. An active OnStar subscription and compatible vehicle are also required.</td></tr>
</table>

Function	Sub-category
	Third Party apps/services: OnStar has connected with select third party providers of apps and services. By leveraging the unique connection between OnStar and your vehicle, these services offer you innovative and personalized features.
Diagnostics	OnStar vehicle diagnostics: Monthly diagnostics of engine and transmission system, the stability control system, air bag system, emissions system, ABS and OnStar system. Also provides maintenance recommendations and tire pressure reading. All information can be accessed using a mobile phone device.

3.8.2 Toyota EnTune

Toyota Entune is offered in the United States as an integrated multimedia navigation and telematics system, providing satellite-based information on traffic, weather, sports scores, stocks, and fuel prices via subscription through SiriusXM. When connected to a compatible cellular phone running the Entune app, via bluetooth or USB cable, the system provides a browser and other applications (mainly of an entertainment nature, e.g. paid music service and radio station). The Toyota mobile phone app has iOS, Android, and Blackberry versions; to use this feature, a mobile phone data plan is required. The system can be controlled with voice recognition, and includes the “Safety Connect” personalisation system.

3.8.3 Vehicle Information and Communication System (VICS)

Vehicle Information and Communication System (VICS) is a technology used in Japan for delivering traffic and travel information to road vehicle drivers (Figure 3.4).

The VICS information can be displayed on a car navigation unit in three ways:

- simple text data (Figure 3.5)
- simple diagrams
- data superimposed on the map displayed on navigation unit (e.g. traffic congestion data).

Information transmitted can include traffic congestion data, data on availability of service areas and parking areas, information on road works and crashes. Some advanced navigation units, e.g. Honda Internavi, can utilise this data for route calculation or the driver might use his own discretion while using this information.

Figure 3.4: VICS in-vehicle unit, icons from left to right are (route guidance, traffic conditions (text feed), compass and road tolling history)

Source: Sage Professional Solutions 2014

Figure 3.5: Traffic conditions (text feed) via FM, selection of stations (multiple traffic FM stations available in Japan)

Figure 3.6: Compass based on GPS satellites

VICS can be compared with the European TMC technology and can be transmitted using:

- infrared
- microwaves in the ISM band
- FM, similar to Radio Data System (RDS) or Data Radio Channel (DARC).

3.8.4 Honda Internavi

Internavi is a vehicle telematics service offered by the Honda Motor Company to drivers in Japan. The service incorporated VICS in 2003. It is a subscription based service, maps are sent through internet connection established via the drivers' mobile phone (with data plan).

The service is available without having to purchase a Honda vehicle installed with the technology; The Internavi LINC is available at both the Apple App Store and Android Market and can be installed on compatible mobile devices.

There is the ability to overlay weather information on the in-vehicle unit, more recent versions of the route guidance application can take both VICS and weather information, e.g. snow storm or typhoon, into account when providing route guidance, allowing drivers to use alternative routes.

One notable feature of Internavi is its ability to share individual vehicle's waypoint information to the Internavi Centre Information Server (ICIS), i.e. a large waypoint and timestamp database. The information is then shared with other users, notifying other users of road congestion levels using speed as an indicator (colour coded as red, orange or blue). These Internavi vehicles are effectively floating cars that can contribute to a congestion prediction system, which provides additional and more specific road and traffic conditions than information provided by VICS. In situations where data connection is lost, the information is recorded onto the vehicles' Internavi on-board memory, the recorded data is transmitted when data connection is resumed.

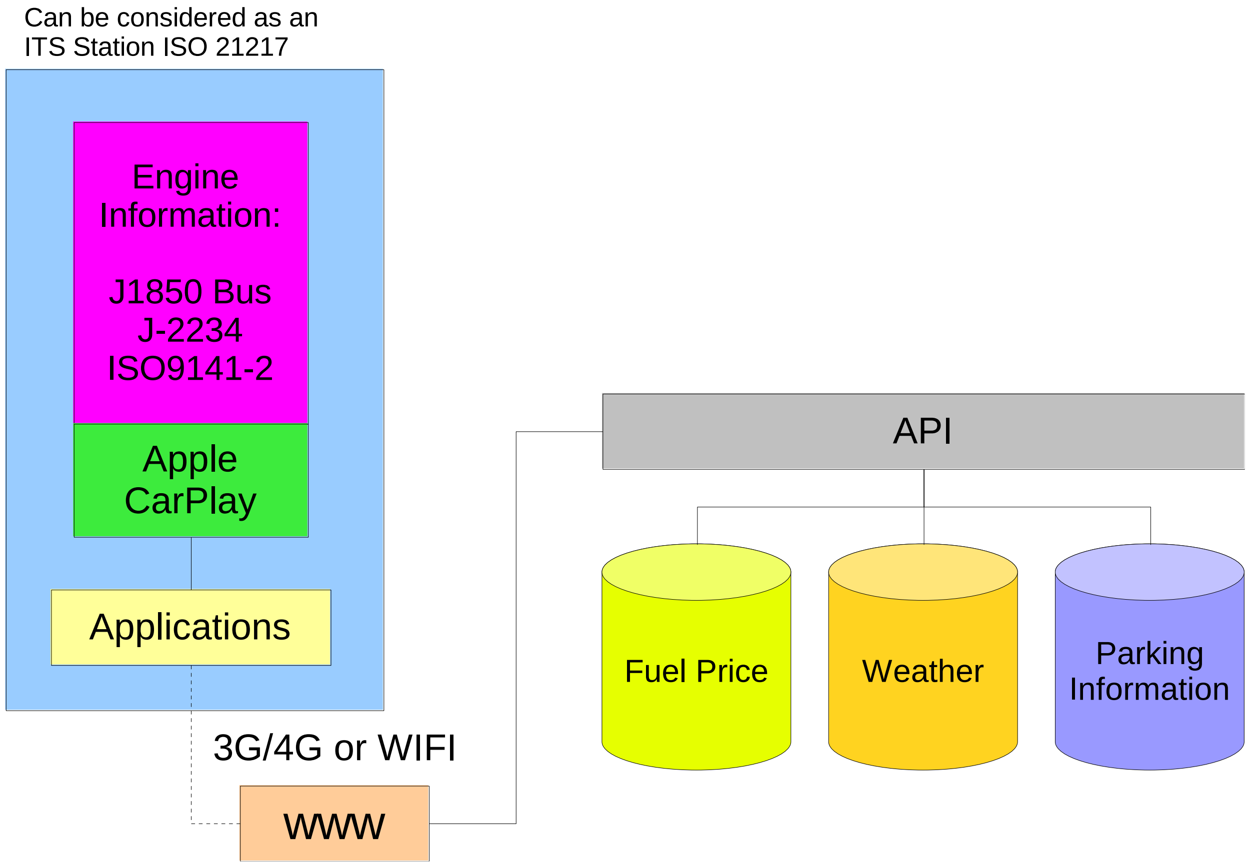
Vehicle owners can choose to disable data transmission to the ICIS service, if there are privacy concerns.

3.9 Application developers

Apple iOS and Google Android platforms are considered to be the two main platforms for development of applications. Other emerging platforms including Microsoft Windows Phone, BlackBerry 10 (previously BlackBerry BBX), Firefox OS may attract application develops to start porting their iOS or Android applications to these platforms subject to their market share.

Apple and Google are working with car manufacturers to develop technologies to run iOS and Android applications in a connected environment. Although most of the applications developed appear to be entertainment in nature, such as internet radio, music services, this is an area that should be monitored for further development. This is because the in-vehicle display can potentially be used as an "ITS station[1]" to access traveller information and other data feeds via applications and API's (Figure 3.7).

Figure 3.7: Possible architecture of in-vehicle unit made by Apple (application architecture of Apple iPhone



[1] Noting that ITS Station is an European concept, the US has a different concept.

4 CURRENT AUSTRALIAN FREIGHT ENVIRONMENT

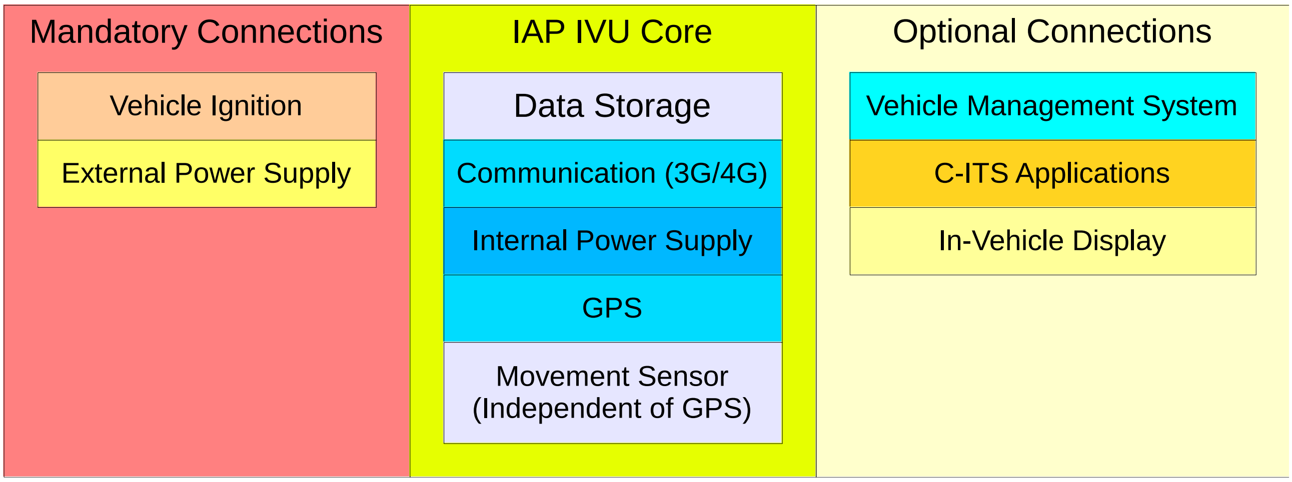
4.1 Intelligent Access Program

The Intelligent Access Program (IAP) enables participating vehicles to have greater access to the road network in exchange for monitoring. The vehicles participating are not necessarily prescriptive and may be innovative vehicles. These may include Performance Based Standards (PBS) vehicles, vehicles with a quad axle group which enables them to carry a greater payload, mobile cranes and special purpose vehicles. IAP is a national program but the operating conditions and requirements are set by each of the jurisdictions, however, participating vehicles and transport operators must only use service providers and devices that have been certified and approved by Transport Certification Australia (TCA) to operate.

As a potential platform for Vehicle to Infrastructure C-ITS, IAP has some potential, as the specified IAP IVU Core has the components required to provide some of the C-ITS applications (Figure 4.1), including:

- GPS receiver and movement sensor
- data storage (waypoint, timestamp)
- communications (3G/ 4G).

Figure 4.1: IAP in-vehicle unit specification, showing mandatory and optional connections



The main functionality of IAP is to generate compliance reports to State Roads Authorities (SRA) (Figure 4.2). It is understood that SRA's regulation activities will be transferred to the National Heavy Vehicle Regulator some time in the future.

If an in-vehicle unit with ability to run a web browser or applications is available, the GPS and communications enable a range of applications to be deployed (subject to availability of real time information), for example:

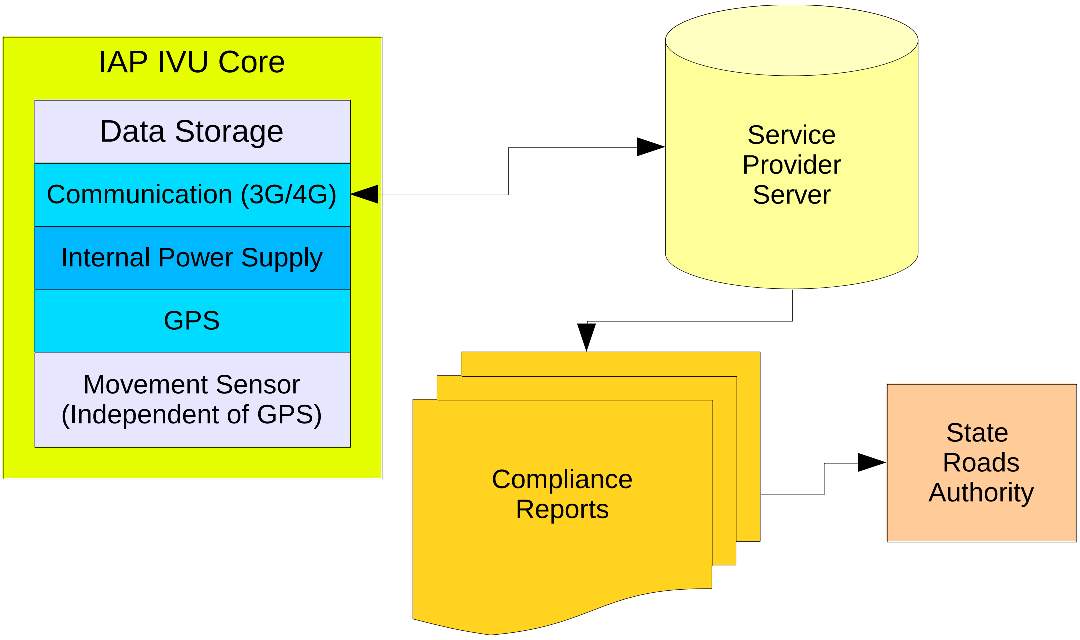
- real time travel information (in text form or overlaid on a map)
- real time hazard warning (in text/ audio form or overlaid on a map)
- fleet management
- route planning

- acting as a floating car to provide information to other road users (which will increase communication costs).

It should be noted that the current IAP specification does not cover the hardware or applications developed by telematics provider in addition to the IAP IVU core, these applications currently include, but are not limited to:

- can-bus ECM interface
- dispatch systems (including back office interfaces, customer portals etc.)
- fleet management systems
- route management
- driver logon
- fatigue management
- accident reports
- fleet maintenance systems
- g-force sensors (monitoring of drivers' behaviour)
- temperature tracking (e.g. refrigerated trailer monitoring)
- time critical freight route planning (e.g. concrete).

Figure 4.2: Current regulatory telematics reporting data flow



4.2 Telematics services

Currently, telematics service providers, including IAP telematics providers, have proprietary API's and databases. Since the IAP only represents a relatively small segment of the telematics fleet management market. The current commercial model involves IAP providers utilising systems of other telematics providers, such as MTData, which also provides telematics and fleet management services for taxi companies, couriers and other time critical delivery operators, e.g. concrete and refrigerated goods. These telematics providers would require non-disclosure agreement(s) (NDA) to be signed if a road agency is required to utilise their data or connect to their system API(s).

4.3 Platform: Telematics applications for regulated commercial freight vehicles (TARV)[2]

The NTC (2013) released a discussion paper for the purpose of identifying ways to improve heavy vehicle productivity, vehicle safety and regulatory compliance through the development of a compliance framework for telematics.

The objective of the proposed framework is to provide national policy certainty surrounding the use of telematics data for compliance purposes. It is hoped that this will encourage industry to adopt telematics and hence provide for improved road safety, productivity and environmental outcomes that contribute to higher standards of living.

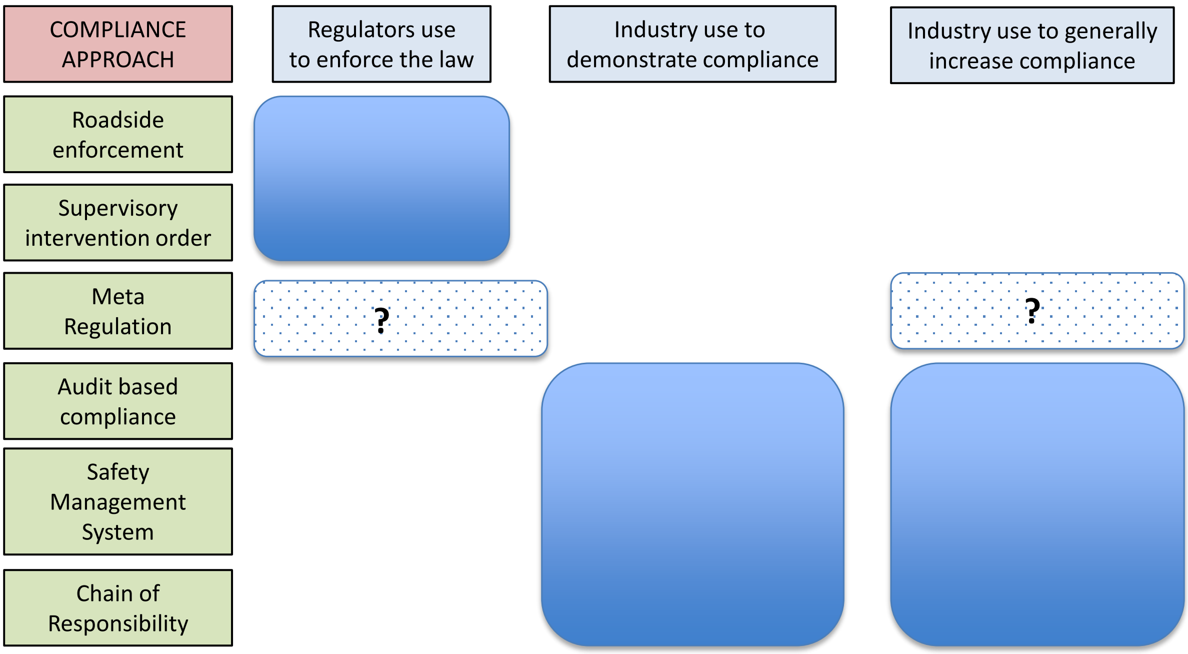
The paper proposed that the framework will:

- identify common telematics data set based on international standards, capable of facilitating multiple commercial and compliance-related applications
- establish policy principles in relation to:
  - exposure of small breaches
  - certainty of when telematics data will be access for enforcement purposes
  - protection of personal information
  - equity of treatment before the law
- The level of assurance required of telematics systems based on the intended compliance approach (Figure 4.3), the ultimate goal should be towards co-regulation or meta-regulation.

Identify opportunities for telematics to improve roadside enforcement, responsive regulation, audit-based schemes, and safety management systems, chain of responsibility and meta-regulation approaches. It is considered that a meta-regulation (or co-regulation) approach through sharing of operational information is the most desirable outcome for most state roads authorities because it is the most cost effective and enables collaboration between government and industry.

[2] ISO 15638

Figure 4.3: Determining level of assurance requires of telematics systems proposed methodology



Adapted from NTC 2013

Figure 4.4: Heavy vehicle ITS application dependency diagram

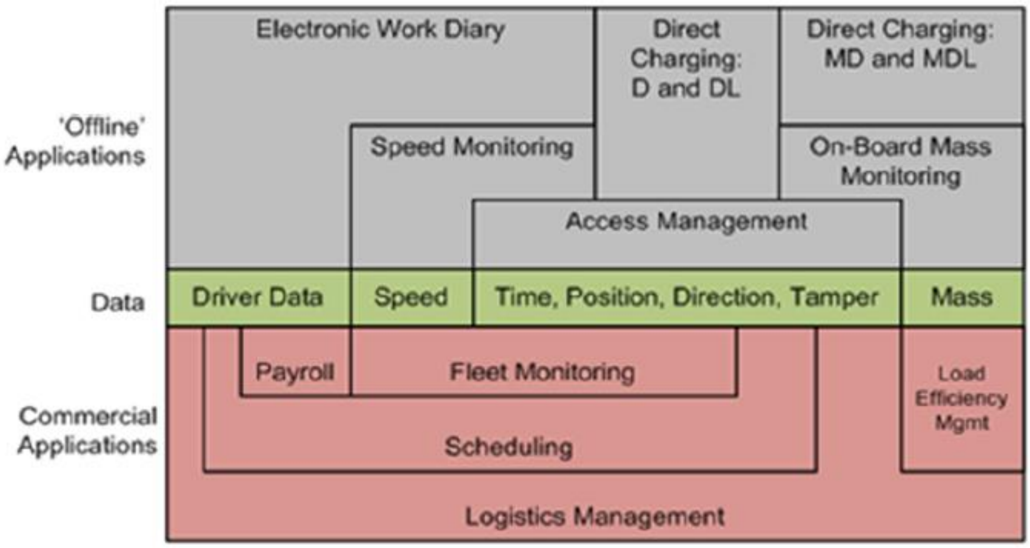
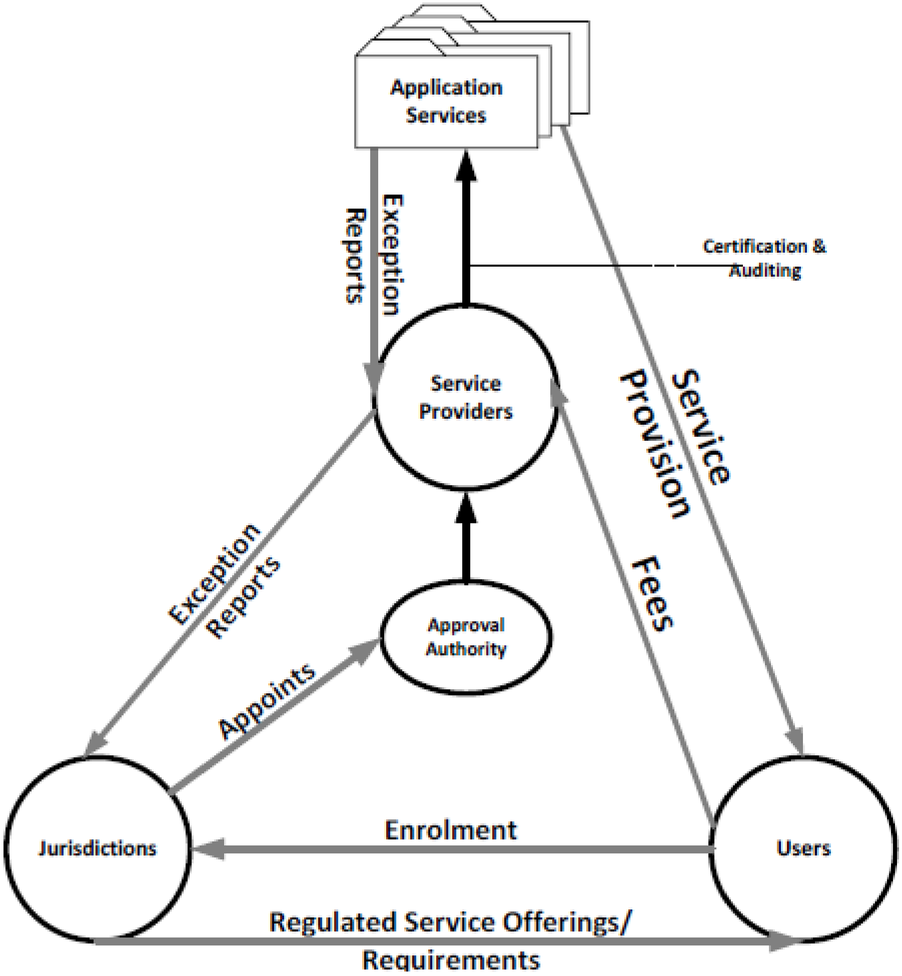
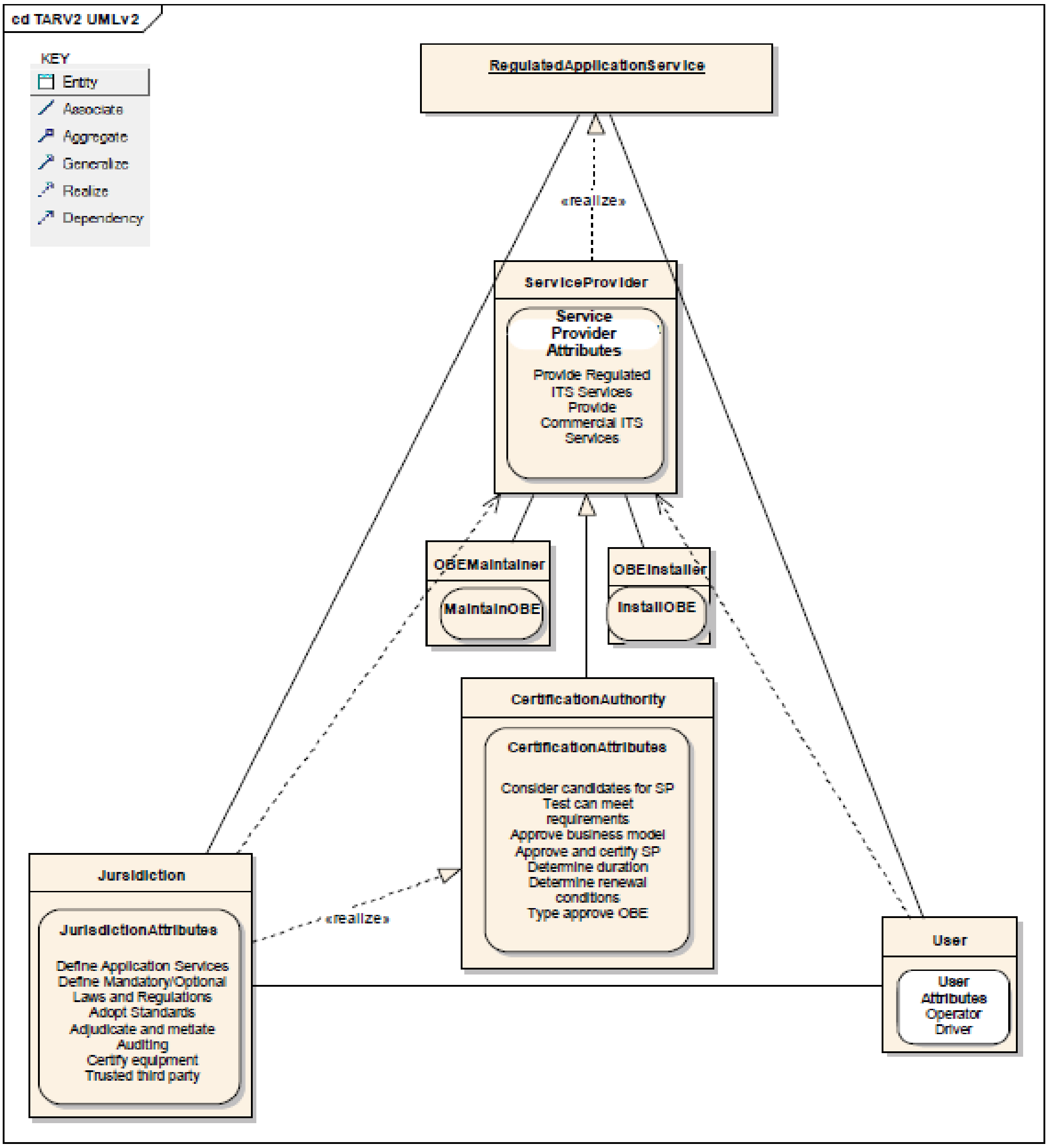


Figure 4.5: Role model conceptual architecture for TARV



Source: ISO 15638-1 TARV Framework and architecture publication

Figure 4.6: Use case model of classes and key attributes of the Unified Modelling Language (UML)



Source: ISO 15638-1 TARV Framework and architecture publication

4.4 Regulatory guidelines

4.4.1 Role of Industry

The term ‘industry’ is used to encompass the in-vehicle telematics suppliers and service providers as well as the freight industry. This section outlines the role of industry in the C-ITS discussion, particularly relating to in-vehicle telematics.

Some operators are using in-vehicle technology for the following applications:

- vehicle performance and driver monitoring

- scheduling improvements
- route optimisation
- vehicle and load tracking
- safety management analysis.

The uptake of in-vehicle technology, or other innovative technologies relating to the freight industry for that matter, has been found to be variable (NTC, 2011) with larger fleet operators being considerably more well equipped than smaller fleets that do not have the benefit cost ratio to justify the purchase of in-vehicle telematics. As such, regulatory and policy certainty are important for encouraging uptake of new technologies by smaller fleets.

Industry can assist government efforts through cooperative action to develop standards and share information along the supply chain, ensuring that the benefits of technological investments for all parties are clearly identified. (NTC, 2011).

4.4.2 Role of government

As of 2006, there were 695 telematics companies listed on the Telematics Update Business Directory (Telematics Update, n.d). It is uncertain how many of these companies service Australian businesses, however, it is clear that in order to obtain wider benefits in terms of productivity and safety, using in-vehicle telematics, especially with regards to interoperability of individual units and infrastructure system, regulatory framework would be require.

The role of government in providing policy certainty for emerging technologies is not negligible. Regulation frameworks and policies could lend certainty to operators, especially small operators, by clearly identifying the regulatory compliance benefits to be gained from investing in in-vehicle telematics (NTC 2011).

The NTC report identified that although telematics has been addressed in specific areas of regulation such as access, fatigue, and speed and mass compliance, the approach to dealing with these and new responses lack consistency, due mainly to the absence of a central policy. Government and industry would need to collaborate in order to devise a regulatory policy that would facilitate the take up of in-vehicle telematics.

How much the wider community will benefit from in-vehicle telematics (in an economic, environmental and societal sense), relies on in-vehicle telematics being widely implemented. Another aspect where regulation is crucial is the information sharing in the supply chain which involves sharing vehicle or inventory data between operators.

Smaller operators may view the idea of data transparency to be less beneficial to them than to the big operators. Government policy can help to inform industry by developing information technology standards and platforms to enhance the transfer of information along the supply chain.

The following responses required of the partnership between industry and government were suggested by the NTC (2011):

1. Remove barriers and any form of market or policy failure necessary to assist users of telematics applications to obtain benefits from uptake of new services and products, and providers of telematics to achieve adequate return on their investment.
2. Promote standards development and interoperability protocols through a government industry partnership, with a focus on removing barriers and market and policy failures, as well as promoting second-order benefits.

3. Identify large and multi-user applications which can be brought-to-market by major stakeholder(s) to grow scale and scope in the telematics market, as a contribution to an industry and market development plan.
4. Ensure that any application which has a regulatory function, whether mandated or otherwise, is subject to normal COAG regulatory assessment principals.
5. Encourage the pursuit of telematics services, standards and protocols that deliver additional benefits to industry and the community.

Progress being made in this area will be monitored and considered during the development of future projects.

5 C-ITS/CONNECTED VEHICLE OPEN PLATFORM

There are a number of known issues with Cooperative ITS (C-ITS).

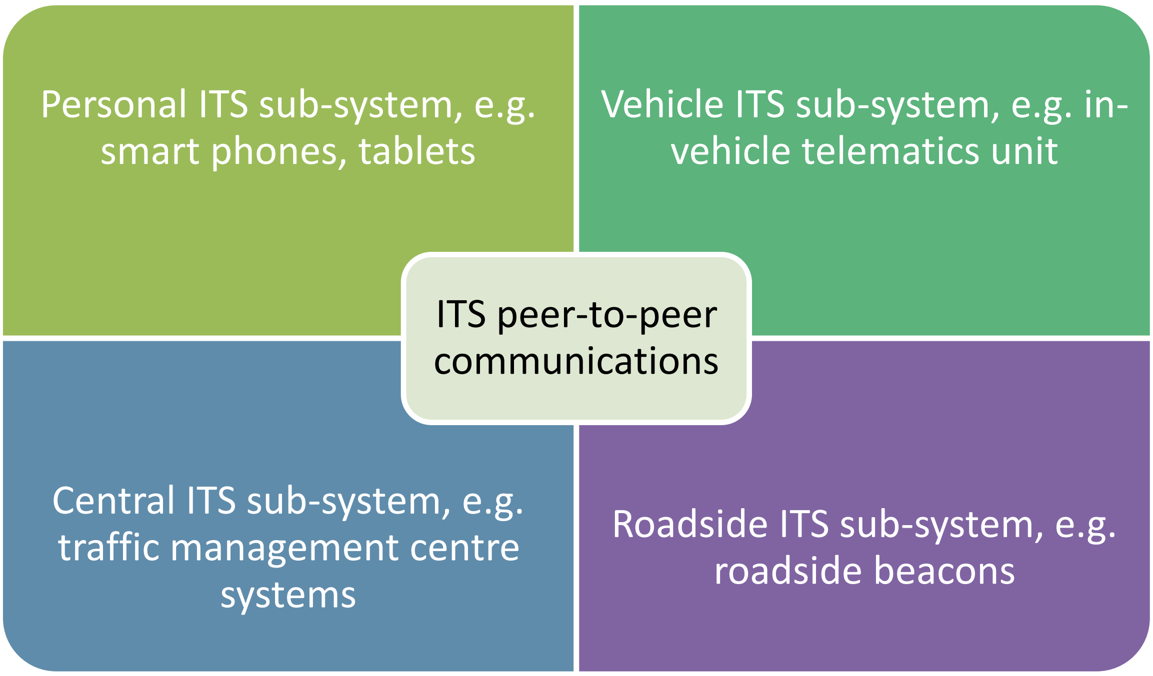
- C-ITS is not business as usual
- C-ITS requires cross-agency and industry coordination
- the standards to ensure interoperability are emerging, agreement on options, profiles are not fully defined.

There have been studies or trials undertaken in Europe and the US to implement C-ITS aiming to address these known issues. ITS peer-to-peer communications aims to link the four main objects in intelligent transport systems (ITS):

- infrastructure (i.e. road environment)
- infrastructure equipment (e.g. variable message signs, vehicle detectors, traffic signals)
- information and Communication Technology (ICT) infrastructure and ITS services
- road users (i.e. vehicles with people or goods).

At the moment, these objects do not communicate to each other. An ITS station reference model can link the four main objects together (Figure 5.1).

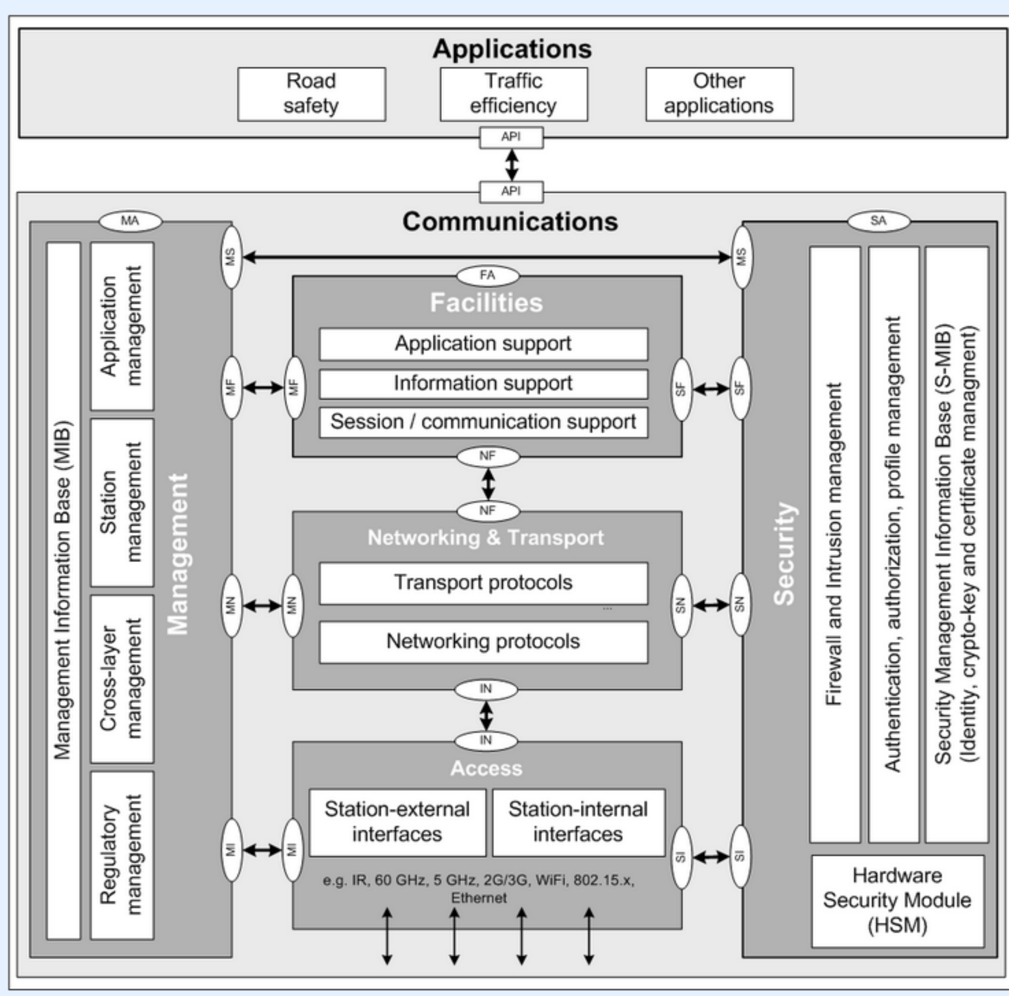
Figure 5.1: ITS station reference model – 4 ITS sub-systems



5.1 ITS Station

ITS Station is the emerging architecture standards for C-ITS. This is a European concept; the US has a different take on architecture.

Figure 5.2: CALM ITS Station reference architecture



Source: http://calm.its-standards.info/Public/CALMintroduction.html

ITS Station Architecture, based on the COMeSafety Architecture, involves various ITS layers as summarised in Table 5.1

Table 5.1: ITS station reference architecture

Layer	Function
Horizontal layers	
'I' – ITS access technologies	▪ communication infrastructure ▪ combination of the media access control (MAC) and physical (PHY) layers of the seven layer open systems interconnection model (OSI)
'N' – ITS network and transport layer	▪ runtime layer on which applications operate
'F' – ITS facilities layer	▪ provides functions to support applications for tasks. ▪ tasks include access to data inputs from other systems (such as vehicles and roadside sensors) ▪ provides communications and access to information such as maps
'A' – ITS application layer	▪ provides applications of end-user services

Vertical layers	
'M' – ITS management layer	▪ responsible for configuration and exchange of information between layers
'S' – ITS security layer	▪ provides security and privacy for users

Source: Unpublished Austroads report NS1785

Internal interfaces between the layers are categorised into:

- ITS station management interfaces: enables interaction between M and the I, N, F, S and A layers.
- ITS station security interfaces: enables interaction between S with and the I, N, F and A layers.
- ITS station communication interfaces: enables interaction between N and I, F and N, and F and A.
- ITS station application programing interfaces: implementation of MA, FA and SA intersections. Connects ITS station applications to the ITS station facilities layer sand the ITS station security and management entities.

5.2 Access technologies

Access technologies enable the interaction between vehicles and infrastructure. Communication between vehicles can be cellular or wifi based.

The two main types of access technologies explored in this report that enable communication between vehicles and the infrastructure are the 5.9 GHz Dedicated Short Range Communication technology and Cellular communications technologies.

5.3 Overview of Projects

Current C-ITS projects in Europe and United States are summarised in Table 5.2. These projects may provide guidance for applications in Queensland.

Table 5.2: C-ITS projects in Europe and United States

Project	Details	Benefits to users	Cost	Communication platform and standards
Compass 4D Start date: January 2013 Duration: 3 years Compass4D consortium consists of 31 partners from 10 countries. Coordinated by ERTICO ITS Europe The project will prove the benefits of cooperative systems and deploy services for road users to increase road safety and energy efficiency, while reducing the level of congestion in road transport. Some of the services include 'Red Light Violation Warning' (RLVW) which will send message to increase drivers' alertness at signalised intersections in order to reduce the number of collisions, or severity of collisions. Also address situations such as alerting other vehicles that an emergency vehicle is approaching or violating a red light. 'Road hazard warning' (RHW) sends messages to drivers approaching a hazard, e.g. obstacles or queuing traffic. 'Energy Efficient Intersections' (EEI) will reduce energy use and vehicle emissions at signalised intersections. Heavy vehicles, emergency vehicles and public transport will be granted green light when approaching intersection, thus avoiding stops and delays. Service provide information to drivers to anticipate current and upcoming traffic light phases and adapt speed accordingly.	▪ Type of messages sent over the Short range channel ▪ Cooperative awareness messages (CAM) ▪ Decentralized Environmental Notification Messages (DENM): ▪ Topology message (TOPO) ▪ Signal Phase and Timing (SPAT):	**Government:** Wider implementation of public transport priority services across cities Lower costs from breaking proprietary systems approach as EEIS and other cooperative services are based on open standards. Reduced air pollution and traffic Better public image Creation of ecosystem of ITS companies and new jobs Priority of some public specific vehicle **Private users:** EEI: Save time and reduce fuel consumption. RLVW: **Fleet operators** The EEI may save fleet operators 13% in fuel consumed by trucks on roads with cooperative intersections. Better safety due to priority management. Less wear of vehicle engine	€10 million	▪ Technologies built on previous projects, Cosmo and FREILOT, as well as incorporating pre-commercial equipment. ▪ DSRC (ETSI G5) and cellular network (3G/LTE) will be used. ▪ Follows ETSI ITS Station Architecture. ▪ The platform for Compass 4D is different for each pilot site, as such, on-board unit (OBU) types, hardware, operating system and programming language is up to the platform providers. ▪ OBU (in-vehicle or personal devices or smart phones) and roadside units (RSU) are used ▪ Communications between the roadside and vehicle is over Short range and long range communication. Short range uses ETSI ITS G4 (IEEE 802.11p) ▪ For communication between the vehicle and the back office or traffic management centre, UMTS/LTE is used over the cellular network. Between the roadside and the back office, a physical link, UMT or LTE is used.

Project	Details	Benefits to users	Cost	Communication platform and standards
COSMO Start date: November 2010 – June 2013 Duration: 32 months Both COSMO and Compass4D demonstrate the benefits of cooperative mobility services in realistic conditions and quantify their impact on increasing energy efficiency in transport. While the Cosmo project comes to a close, Compass4D is starting up and can directly benefit from Cosmo's best practises and lessons learnt in order to advance the sustainable deployment of Cooperative Intelligent Transport Systems in Smart Cities. The aim of the project is to demonstrate in realistic conditions the benefits of cooperative mobility services and to quantify their impact on increasing the energy efficiency of transport.	COSMO will set up three pilot sites in which a range of cooperative applications will be installed and tested: Salerno (Italy), Vienna (Austria) and Gothenburg (Sweden). All sites will implement leading-edge cooperative systems technologies developed in the recent EC-funded research projects COOPERS, CVIS and SAFESPOT. The Italian and Swedish pilot sites consist of urban scenarios, involving public transport, while the Austrian pilot is testing an inter-urban use case on a motorway. The cooperative applications tested in Salerno were: ▪ Eco traffic management and control ▪ Eco-transit and dynamic parking management ▪ Eco-driving and driver behaviour change ▪ Eco dynamic access management The Vienna test site tests traffic monitoring system on a highway with temporary construction sites. The cooperative system provides advance warning and speed indication to vehicles depending on the real time traffic situation. The Gothenburg test site demonstrated the impact on energy and fuel efficiency of combined cooperative applications involving the public transport fleet.	**Government** ▪ Smoother traffic flow ▪ Reduced congestion ▪ Positive influence on driving style ▪ Increased efficiency of bus fleet operations	Total cost €3.88 million EU funding €1.94 million	▪ Non specified in deliverables. The platforms and reference architecture is assumed to be similar to that used in Compass4D.
Freilot Start date:April 2009 Duration: 2.5 years Pilots Type B are specific funding instruments which focus is the validation at real scale or deployment of service. The FREILOT services aim to increase energy efficiency in road goods transport in urban areas: 1. Energy efficiency optimised intersection control 2. Adaptive acceleration and speed limiters 3. Enhanced "green driving" support 4. Real-time loading/delivery space booking The general idea is that cities will implement priority for trucks at certain intersections (on certain roads and/or certain times of day) and provide this priority as incentive to the truck fleets which implement acceleration, speed limiters and provide eco-driving support to their drivers. In addition, cities will also provide possibilities to dynamically book and re-schedule delivery spaces. The services will be piloted in four European implementations: Lyon-France, Helmond-Netherlands, Krakow-Poland and Bilbao-Spain, to demonstrate up to 25% reduction of fuel consumption.	Systems in this project actively interfered with the vehicle's system.	**Freight and logistics industry** ▪ 8-13% fuel reduction for energy efficient intersection control ▪ Acceleration limiter showed fuel consumption reduction between -2% and 2% ▪ Speed limiter showed no significant reduction in fuel consumption measured ▪ EcoDriving Support showed a maximum fuel reduction measured between 5.5% in the 0-100 km/h and 15.4% in 0-50 km/h range.	Total cost €3.99 million EU funding €2 million	**Could** not be found.

Project	Details	Benefits to users	Cost	Communication platform and standards
CityLog Started January 2010 Duration: The CITYLOG main objective is to increase the sustainability and the efficiency of urban delivery of goods through an adaptive and integrated mission management and innovative vehicle and transport solutions. CITYLOG is coordinated by FIAT Research Centre, it involves 18 partners in 6 different European countries, including industries, research institutes, associations and local authorities.		Optimised routing for commercial vehicles, increased safety for vulnerable road users Reduction of unsuccessful deliveries	Total cost €6 million EU funding €3.6 million	
eCoMove eCoMove is a three-year integrated project (April 2010 - March 2013), involving a consortium comprised of 32 partners and funded by the European Commission under the 7th Framework Programme of Research and Technological Development. The main aim is to minimise energy wastage in transportation by targeting three main causes: ▪ inefficient route choice ▪ inefficient driving performance ▪ inefficient traffic management & control.	The core technology components consist of the following: ▪ **Eco messages**, protocols and interfaces for communication between eco-floating vehicle data about the progress, destination, fuel consumption vehicle data which can be disseminated to other vehicles and traffic control centre. Eco Traffic Situational Data- traffic conditions sent to vehicles from infrastructure ▪ **ecoMap** – static and dynamic attributes for eco driving support: slope, historical speed profile, energy consumption data, traffic data and information from other vehicles ▪ **ecoSituational model**: vehicles driving behaviour + dynamics of nearby traffic + current driving and traffic situation + fuel consumption = optimal driving strategy ▪ **eCoStrategic model:** high fuel consumption factors in the situation level is translated to entire road network for traffic management and control strategies	**Government** ▪ reduce CO_2 emissions ▪ decrease congestion on the networks and improve productivity **Users:** ▪ Save fuel ▪ Save time **Freight and logistics industry** ▪ Save fuel and vehicle operating cost ▪ Save travel time ▪ Save on vehicle operating cost	**Total cost:** €22.5 million **EC funding:** €13.7 million	▪ V2V, V2I using wifi, GPS and cellular communication ▪ Comply with EU, national and industry standards ▪ ITS communications architecture: ETSI EN 302 665 ▪ Standardised message for exchanging data between vehicles (Cooperative awareness message CAM): ETSI TS 102 637-2 ▪ Standardised short-range event message (Decentralised environmental notification message DENM): ETSI TS 102 637-3 ▪ Results will be promoted towards standardisation by CEN, ETSI and ISO
ecoDriver Start date 1 October 2011 To be completed by 30 September 2015 To reduce CO_2 emissions and fuel consumption by 20% in road transport by influencing driver behaviour. Outputs include: ▪ Full ecoDriver System' (FeDS), a built in after-market application for passenger cars, with sepeate versions for commercial vehicles. ▪ Support via nomadic devices (smart phone app, etc) with adapted human-machine interface to allow safe use when driving ▪ Feedback and information strategies, tailored to different types of drivers, vehicles and situations. ▪ Eco-driving back office analysis software for commercial fleets.	▪ Powertrain model validation ▪ State of art review of users' expectations ▪ Report on test scenarios for validation of on-line vehicle algorithms ▪ Individual use cases and test scenarios definition ▪ Performance indicators and ecoDriver test design ▪ Dissemination and communication plan ▪ List of vehicles and participants ▪ Data and framework for scaling up ▪ Plan for using and disseminating knowledge ▪ Multi-modal in-vehicle and nomadic device eco-driving support for car drivers ▪ Evaluation plan and scenario definition ▪ Simulation and analysis document for on-line vehicle algorithms ▪ Data acquisition system ▪ Data processing chain ▪ Data Analysis tools ▪ Results of HMI and feedback solutions evaluations	**Government** ▪ reduce CO_2 emissions and fuel consumption by 20% ▪ influence driver behaviour **Users:** ▪ Save fuel ▪ Save time **Freight and logistics industry** ▪ Save fuel and vehicle operating cost ▪ Save travel time ▪ Save on vehicle operating cost **Community** ▪ Fuel efficiency standards could create up to 443,000 new jobs by 2030. Add €16 billion per year to Europe's GDP	**Total cost** €14.5 million **EU funding** €10.7 million	▪ Two communications air interfaces are defined: 3G for long range communications and ETSI G5 for medium range communications. ▪ 3G mobile networks provide global coverage for long range communications. ▪ The use of IPv4 is discouraged and should only be used for legacy applications. IPv6 ▪ should be used by applications and/or facilities for communications between vehicle, roadside, and central infrastructure. ▪ ETSI G5 (harmonised with ISO CALM M5, WAVE, and IEEE802.11p) is a medium range communication technology. ▪ ETSI definitions will be used as far as possible. ▪ The primary network layer trans ▪ port protocol is GeoNetworking (Single hop broadcast).

Project	Details	Benefits to users	Cost	Communication platform and standards
Euridice The Euridice project aimed to build an information services platform centred on the intelligent cargo concept which connects the cargo to logistics service providers, industrial users and authorities to exchange transport related information. This intelligence also allows for the exchange of transport related information whenever required along the transport chain. The project was co-founded by the European Commission under the 7th Framework Programme ICT for the Transport Area to the total cost of 14.1M€ for a duration of 36 months starting on 01 February 2008.	The Euridice project had the following objectives: ▪ supporting the interaction of individual cargo items with the surrounding environment and users on the field. ▪ Improving logistic performances through application of the intelligent cargo concept and technologies in the working practices of operators and industrial users. ▪ Developing collaborative business models to sustain promote and develop an intelligent cargo infrastructure. ▪ Realizing more secure and environment friendly transport chains through the adoption of intelligent cargo to support modal shift and door-to-door inter-modal services.	**Logistics industry** ▪ Increase efficiency of transportation networks by improving synchronisation between logistic users, operators and control authorities. **Government** ▪ Reduce CO2 emission produced by freight industry **Community** ▪ Reduce traffic congestion and pollution	**Total cost** €14.38 million **EU funding** €8.25 million	▪ Integrated platform ORPHEUS (Object Recognition and Position Hosted European Service) ▪ Fixed and mobile web service infrastructure ▪ Global and local intelligence ▪ Oracle Java responsible for providing user interface and processing administration data ▪ Oracle MapViewer integrated into application.
Logistics for LIFE (L4L) Start date: 01/01/2010 Duration: 30 months Project to build a reference framework linking stakeholders' efficiency requirements to sustainability strategic objectives and to relevant ICT solutions. Looking towards environmental sustainability, financial sustainability and societal sustainability. Objectives and outputs include: ▪ Forming a multi-disciplinary network ▪ Creating reference framework ▪ Developing strategic roadmap ▪ Promote the logistics for LIFE vision and findings ▪ Provide common working platform for the community	▪ Focused initiatives on greener mode shifts for freight and reduce empty haulage. ▪ Focus on business interoperability between actors in a supply chain to boost efficiency and improve customer service. ▪ Focus on vehicle and traffic management that assesses the impact of logistics on the environment and encourage logistic companies to be more transparent with data and processes. ▪ L4Life Framework must capture different stakeholders' perspectives in terms of efficiency and related ICT requirements and relate them to long term sustainability strategic goals.	**Logistics Industry** ▪ Reduce empty haulage rates in EU which currently range from 40% to 60%. Also address useless trips, unwanted stops, lack of synchronisation between transport modes and lengthy admin processes. ▪ Transfer freight to environmentally friend transport modes **Government** ▪ Reduce CO2 emission produced by freight industry **Community** ▪ Reduce traffic congestion and pollution ▪ Reduce fuel prices for citizens, as trucks absorb 35% of total road-fuel production.	**Total cost** €1.96 million **EC funding** €1.42 million	The platform is not technological in nature. This project is attempting to outline a framework and consequently a platform that will enable many business and stakeholders in the logistics industry to interoperate and communicate in order to facilitate more efficient logistics using ICT. Solutions required: ▪ Data infrastructure for logistic efficiency ▪ Collaborative and interoperable freight management ▪ Cargo mobility information services ▪ Freight monitoring and enforcement ▪ Green navigation ▪ Logistic brokers
SARTRE Start: September 2009 Finalised in 2012. Safe Road Trains for the Environment; developing strategies and technologies to allow vehicle platoons to operate on normal public highways with significant environmental, safety and comfort benefits. SARTRE, funded by the European Commission under the Framework 7 programme, aims to encourage a step change in personal transport usage through the development of safe environmental road trains (platoons). Systems will be developed in prototype form that will facilitate the safe adoption of road trains on un-modified public highways with full interaction with non-platoon vehicles.		**Freight Industry and community** ▪ Decrease in fuel consumption amounting to roughly 20% depending on the number of vehicles in a platoon and spacing between vehicles. ▪ **Government** ▪	**Total cost** €6.4 million	▪ 5.9 GHz DSRC for the V2V coordination. 40–Hz update of the vehicle data based on the control update cycles of the other elements of the system ▪ Hardware architecture consists of GPS receiver, the vehicle computer, Can-bus interface, HMI touchscreen. GSM/UMTS antennae. Back office server ▪ Back office architecture consists of an Office administrator, V2I interface, Back office GUI, Global data manager, map manager and a digital map. <http://www.sartre-project.eu/en/publications/Documents/SARTRE_Final-Report.pdf>

Project	Details	Benefits to users	Cost	Communication platform and standards
Smartfreight The objective of the SMARTFREIGHT project is to address the negative impact of freight in urban areas. ▪ Specify, implement and evaluate information and communication technology (ICT) that integrate urban traffic management systems with management of freight and logistics in urban areas ▪ Actual transport operations carried out by freight distribution vehicles will be controlled and supported by means of wireless communication infrastructure, on-board and on-cargo equipment	▪ Develop new traffic management measures towards individual freight vehicles through open ICT services, on-board equipment and integrated wireless communication infrastructure ▪ Improve the interoperability between traffic management and freight distribution systems ▪ Coordinate all freight distribution operations within a city by means of open ICT services, on-board equipment, wireless communication infrastructure and CALM MAIL implementation in on-board and on-cargo units, for all freight vehicles ▪ Assign different service levels to freight vehicles, depending on their environmental profile, type of goods transport and destination ▪ Grant priorities and access rights depending on the service level and traffic situation ▪ Allocate routes and times slots to freight vehicles to minimise conflicts and congestion ▪ Track and monitor vehicles carrying dangerous cargo ▪ Collect information for statistics ▪ Support control that enables enforcement ▪ Improve awareness in case of incidents ▪ Provide information that improves route planning for transport companies, such as more accurate transport network information, traffic and travel time information, through open ICT services ▪ Routing and re-routing for scheduled freight and service vehicles ▪ Provide information that improves the efficiency of these fleets ▪ Manage the use of loading and unloading areas ▪ Track freight vehicles ▪ Track cargo ▪ Monitor the status of cargo	**Freight industry** ▪ Improved efficient ▪ **Government** ▪ **User** ▪ Freight transport would be more environmentally friendly	**Total cost** €3 million EC funding €2.2 million	▪ Components: FDMS and UTMS can communicate with the in-vehicle systems through service interfaces over CALM. ▪ On-Goods Equipment: software and hardware for the OGE were developed during the lifetime of Smartfreight. Implementation is single-board platform, designed with sensors, a DSRC transponder and processing unit. External power supply (battery) needed. ▪ On-board Equipment: based on CVIS results: mobile host computer, display, mobile router, antenna for different air interfaces. Added DSRC reason for communication with cargo. CVIS software provided an effective application development platform for smartfreight with set of common services: facilities among other the CALM connection manager handles communication over CALm for different bearers. ▪ On board equipment communicates with Freight distribution management system using CALM 2G/3G. ▪ On board equipment communicates with Urban traffic management system using CALM 2G/3G. ▪ On board equipment communicates with Roadside equipment using CALM M5/IPv6 ▪ Roadside Equipment communicates with Urban Traffic Management system using IPv6/IPv4 tunnelling, ▪ Freight Distribution management system communicates with Urban Traffic management system using TCP/IP ▪ Diagram shown in appendix
Applications for the Environment: Real-Time Information Synthesis (AERIS) The objective of the AERIS research program is to generate and acquire environmentally-relevant real-time transportation data, and use these data to create actionable information that support and facilitate "green" transportation choices by transportation system users and operators. Employing a multi-modal approach, the AERIS program will work in partnership with the vehicle-to-vehicle (V2V) communications research effort to better define how connected vehicle data and applications might contribute to mitigating some of the negative environmental impacts of surface transportation.		Mainly environmental benefits		
FRATIS FRATIS is a small scale prototype project in Dallas – Fort Worth, Texas. The project uses Bluetooth and Wi-Fi sensors for collection and calculation of freight terminal wait time, the information is transmitted to a database which has a web service API and linkage to the FRATIS Portal to enable sharing with other parties, including terminal operator, dispatcher, drivers and public sector. The in-vehicle unit used are standard off-the-shelf products manufactured by TomTom, with truck routing, navigation, traffic and weather information provided by a smart phone application. Databases are used by various parts of the system to enable analysis of data and optimisation to take place.		**Freight Operators** ▪ Improved truck utilisation ▪ Decreased average travel time ▪ Decreased fuel consumption ▪ Reduced emissions ▪ Reduced terminal queue time		

5.4 European Projects

5.4.1 Compass 4D

Volvo, Siemens and Vialis are heavily involved with Compass 4D, an ERTICO – ITS Europe project, which has trials and installations in the following locations:

- region of Central Macedonia
- city of Copenhagen
- Newcastle City Council

It has three components:

- Energy Efficient Intersection
- Red Light Violation Warning
- Road Hazard Warning

The reference architecture (Figure 5.3) utilises both short range and 3G/4G communications among on-board unit, roadside unit and the back office (including traffic management centre and operation management system).

Parties/ stakeholders identified in the business model for Compass4D are:

Policy Makers and regulation – role is to define policies, monitor compliance with regulation and legislation related to the services. This includes:

- Local/national/European Public Administration: define policies and monitor compliance. In some cases they provide grants and funding to increase use of ITS and to get indirect benefits.
- Traffic manager – supervises the traffic management of an areas and is responsible for optimisation.
- Enforcement – monitoring authority and certification of violations.
- Certification bodies – certifies the adherence and compliance of products and services with standards and technical guidelines.

Service provider – role is to contractually provide services directly or indirectly through the producers to the consumers. Usually the technological company will be doing it. It could be a difference stakeholder such as a public company owned by a consortium of cities of a region.

Technology supplier – role is to supply the producers of the functionality of the service(s) or the service provider with the necessary technology and devices. Would include:

- RSU provider – provide complete RSUs and in some cases, install and maintain in road infrastructure
- Road sensor provider – provides any type of sensor (eg. Camera, speed sensor) to be connected or integrated in RSU in order to capture real data and information
- OBU provider – provides OBUs to the Car/Truck maker, or retrofit installers in aftermarket scenario
- Car/Truck maker – role is to represent markers of every kind of vehicles (cars, trucks, buses, ambulances, fire fighters, etc)
- IT provider – provides hardware, software, components and consultancy services.

Service enabler – role is to support the producers of the functionality of the service(s) or the service provider with necessary services and contents.

- Content provider – works to find and create contents (data, information, basic services) to build useful services to end users (POI on maps)
- Connectivity provider – provides the SIM card/module to be inserted itno the OBU and RSU, connectivity services to users and other actors (such as service provider or RSU providers), other value-added services like location or identity management.
- RSU infrastructure manager – provides and manage infrastructure to allow other actors to deploy cooperative services
- Retrofit installer – installs OBUs in vehicle after user has bought it.

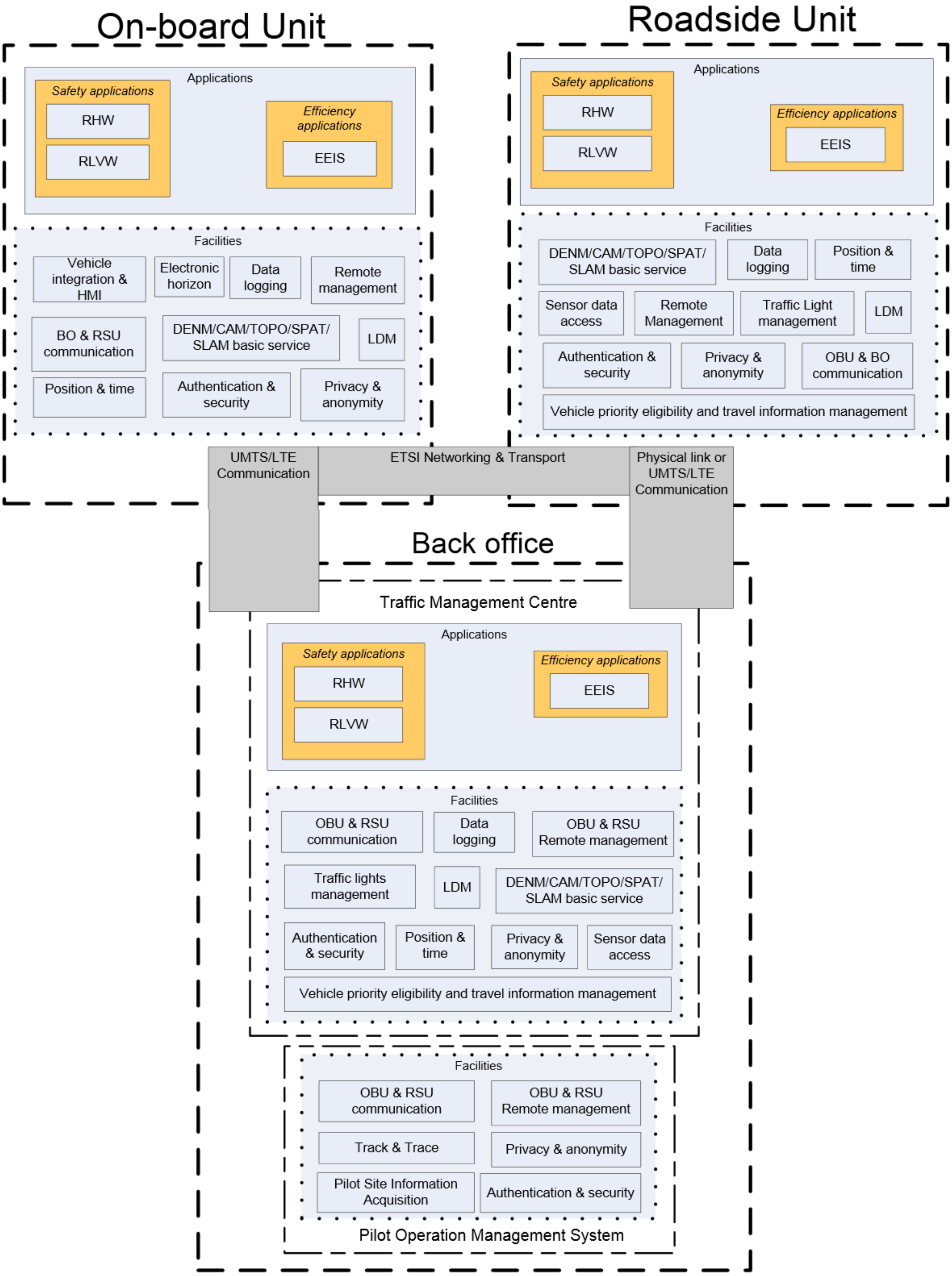
Finance – role is to support the financial transactions within the business model and the assurances related to the services.

- Payment provider – deals with transaction management (i.e. micropayments) and any monetary compensation among actors.
- Insurance companies – allows the equitable transfer of the risk of a loss or a damage in exchange for payment.

Consumption – are consumers who are willing to pay the service provider for the service(s)

- (End) Users – real, final users of the services. Can be private or commercial users.
- Fleet manager – actors that manage a number of vehicles, such as buses, emergency vehicles, trucks, taxi drivers. Compass4D Consortium will test at least 334 cooperative vehicles with more than 550 users.

Figure 5.3: Compass 4D reference architecture



5.4.2 Compass 4D – Energy Efficient Intersection Service

The Energy Efficient Intersection Service (EEIS) aims to reduce energy use and vehicle emissions at signalised intersections. The major advantage of a cooperative EEIS using infrastructure-to-vehicle communication is the availability of 'signal phase and timing information' (SPaT) in the vehicle.

Presenting this information to drivers enables them to anticipate the current and upcoming traffic light phase.

There are four service functions under EEIS:

- Green Light Optimal Speed Advisory (GLOSA): drivers receive traffic light phase information, and advice on the best deceleration strategy to approach the intersection at the most energy efficient speed. On arterial roads with multiple intersections this implies platoon progression.
- Idling stop support: 'time-to-green' information is used by the in-vehicle application for engine control and engine turn off.
- Start delay prevention support: 'time-to-green' information is used by the in-vehicle application to minimise time loss at the start of a green light phase due to reaction time etc.
- Green priority: heavy goods vehicles (HGV's), public transport vehicles, and emergency vehicles receive green priority at traffic lights.

Different levels of green priority can be distinguished by the system. The two outer limits are extension of the current phase and termination of the current phase to change to the required phase. The service also determines the level of green priority that is appropriate, depending on the vehicle type (e.g. HGV or emergency vehicle) and status (e.g. public transport vehicle on-time or behind schedule).

The communication to the road side unit can be via 802.11p or 3G/4G, depending on system needs.

5.4.3 Compass 4D – Red Light Violation Warning

The Red Light Violation Warning (RLVW) service aims to increase drivers' alertness at signalised intersections in order to reduce the number and severity of collisions. Although the focus of the service is on red light violations, the service also addresses situations involving emergency vehicles as well as the various right of way rules.

The advantage of a cooperative RLVW service using infrastructure-to-vehicle communication over conventional repressive solutions is that it can react before, instead of after, an event occurs.

There are five service functions under RLVW:

- Red light violation warning: drivers are warned when they are in danger of violating a red light.
- Red light violator warning: drivers are warned when it is probable that another vehicle is going to make a red light violation.
- Emergency vehicle warning: drivers are warned to make way for an approaching emergency vehicle that will run a red light.
- Turning warning – oncoming traffic: drivers are warned while turning, to give way to possible traffic that are also acting on a green light but are coming from the opposite direction.

- Turning warning – crossing vulnerable road users: drivers are warned while turning, to give way to crossing pedestrians and/or bicycles that are also acting on a green light.

Three system designs with different level of complexity has been identified and trialled in the project.

- Informative: the service simply presents traffic light phase information to the driver (e.g. its presence, colour and time to change)
- Rule-based: focusses on the dilemma zone and monitors spatial-temporal variables (e.g. vehicle speed and time to stop line) subject to the traffic light phase and warns the driver if pre-set thresholds are reached
- Predictive: most complex and predicts the trajectory of the vehicle to estimate the likelihood of red light violation.

The communication to the road side unit can be via 802.11p or 3G/4G, depending on system needs.

5.4.4 Compass 4D – Road Hazard Warning

The Road Hazard Warning (RHW) service aims to reduce road collisions by sending drivers warning messages which would raise their attention level, and can also inform drivers of what the most appropriate behaviour would be in relation to the hazards they faced.

The advantage of a cooperative RHW service using infrastructure-to-vehicle communication is twofold. The replacement of expensive vehicle-sensors by cooperative technology enables vehicles without such sensors to be aware of road hazards. Also, the service would only need a low amount of market penetration to have a positive impact, as the hazards would be detected and announced by the infrastructure. Both static and dynamic hazards can be identified and communicated to road users.

Warning could be presented to road users via 802.11p or 3G/4G to their in-vehicle units.

5.4.5 FREILOT

FREILOT is an EC-funded Pilot that started in April 2009 for 2 ½ years. The FREILOT services aim to increase energy efficiency in road goods transport in urban areas:

1. Energy efficiency optimised intersection control
2. Adaptive acceleration and speed limiters
3. Enhanced “green driving” support
4. Real-time loading/delivery space booking

The general idea is that cities will implement priority for trucks at certain intersections (on certain roads and/or certain times of day) and provide this priority as incentive to the truck fleets which implement acceleration, speed limiters and provide eco-driving support to their drivers. In addition, cities will also provide possibilities to dynamically book and re-schedule delivery spaces.

The services will be piloted in four European implementations: Lyon-France, Helmond-Netherlands, Krakow-Poland and Bilbao-Spain, aiming to demonstrate up to 25% reduction of fuel consumption.

There have been limited reports on the outcomes of this project.

5.4.6 Citylog

The CITYLOG European project, started on January 1st 2010, is a focused research collaborative project co-funded by the European Commission.

The main objective of the project is to increase the sustainability and the efficiency of urban delivery of goods by commercial vehicles. The project also involves changing the design of the vehicle and load unit, i.e. smaller units that build up to standard containers, to achieve a full interoperability between large freight vehicles and small distribution vans. The ITS architecture of this project is relatively simple (Figure 5.4).

Figure 5.4: ITS architecture of CITYLOG

5.4.7 Co-Cities

Co-Cities is a pilot project to introduce and validate cooperative mobility services in cities and urban areas. It will develop a dynamic 'feedback loop' from mobile users and travellers to the cities' traffic management centres, and add elements of cooperative mobility to traffic information services. Software extensions developed and trialled are based on the In-Time Commonly Agreed Interface (CAI), and the pilots will be run in the cities of Bilbao, Florence, Munich, Prague, Reading, and Vienna.

The result of this validation of cooperative mobility services will be an increased exchange of experience between public authorities and TISPs in Europe and a faster take-up of best practices.

The objectives of Co-Cities are:

- Extend the number of cities which install the In-Time Commonly Agreed Interface and connect it to the traffic management centre for a regular feed of data and information.
- Develop a fast and reliable validation process for cooperative traffic information services by using a "reference platform".

- Make transport information services more attractive and appealing to users in urban areas.

The two transport information services deployed are:

- Interoperable and multimodal RTTI services to end-users, offered by Traffic Information Service Providers (TISPs), will use different hardware and software platforms such as personal navigation devices, smart phones and web services and develop Europe–wide services based on regional traffic and travel data.
- Business-to-business services will enable Europe-wide Traffic Information Service Providers (TISPs) to cooperate with regional and urban authorities in fields such as strategy-based routing and adaptive mobility services

5.4.8 Cosmo

COSMO was a 32-month (2010-2013) pilot project aiming to demonstrate in realistic conditions the benefits of cooperative mobility services and to quantify their impact on increasing the energy efficiency of transport.

COSMO adopted a system-wide approach to the assessment of energy efficiency, measured the effect of a range of innovative traffic management systems on fuel consumption and traffic emissions, the impact of the energy used by the equipment itself. Experimentation will be carried out in the following application areas:

- Eco-traffic management & control
- Eco-driving for private cars and public transport
- Multimodal real-time travel information systems
- Dynamic Access Management strategy
- Eco-navigation

5.4.9 ecoDriver

ecoDriver is a project currently underway in Eurpoe, the aim of the project is to CO2 emissions and fuel consumption by 20% in road transport by influencing driver behaviour. The project scope includes:

- provide drivers with ‘green driving’ advice and feedback
- Adapting the eco-driving human-machine interfaces to maximise effectiveness of system (HMI – graphical interfaces, haptics, voice (messages) to the driving style (e.g. relaxed vs sportive), traffic conditions (fluid vs heavy traffic), powertrain (conventional, hybrid, electrical), and vehicle type (passenger cars, vans, trucks, buses, etc).
- test and compare effectiveness of nomadic and built-in navigation devices in encouraging green driving behaviour
- maintain or enhance driver safety while providing eco-driving support
- assess the economic feasibility of a potential market deployment of the ecoDriver system by undertaking a social cost-benefit analysis for Europe using results (scaled up for Europe)
- explore how eco-driving related CO2 reductions might be affected by different future technological, political and lifestyle scenarios.
- powertrain model validation
- state of art review of users’ expectations

- report on test scenarios for validation of on-line vehicle algorithms
- individual use cases and test scenarios definition
- performance indicators and ecoDriver test design
- dissemination and communication plan
- list of vehicles and participants
- data and framework for scaling up
- plan for using and disseminating knowledge
- multi-modal in-vehicle and nomadic device eco-driving support for car drivers
- evaluation plan and scenario definition
- simulation and analysis document for on-line vehicle algorithms
- data acquisition system
- data processing chain
- data Analysis tools
- results of HMI and feedback solutions evaluations.

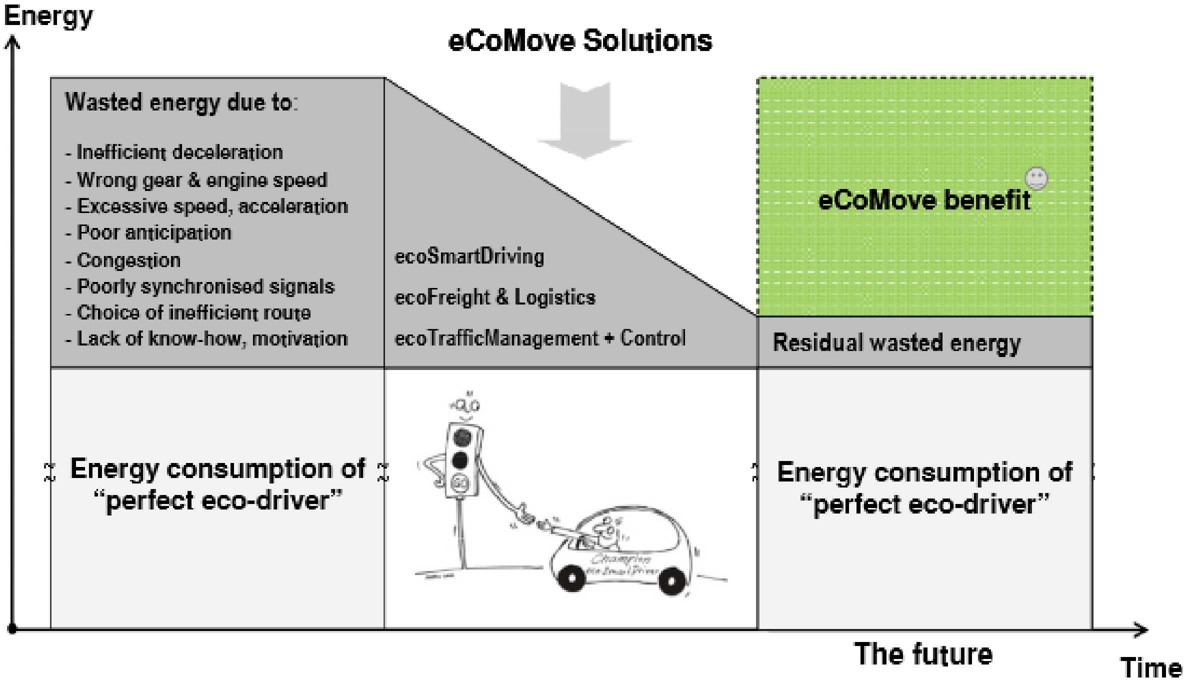
The communications interfaces utilised include ETSI G5 (medium range communications) and 3G mobile networks (long range communications).

5.4.10 ecoMove

eCoMove is a three-year integrated project (April 2010 - March 2013), involving a consortium comprised of 32 partners and funded by the European Commission under the 7th Framework Programme of Research and Technological Development. The main aim is to minimise energy wastage in transportation by targeting three main causes (Figure 5.5):

- inefficient route choice
- inefficient driving performance
- inefficient traffic management & control.

Figure 5.5: Reducing energy wastage by addressing driving inefficiencies

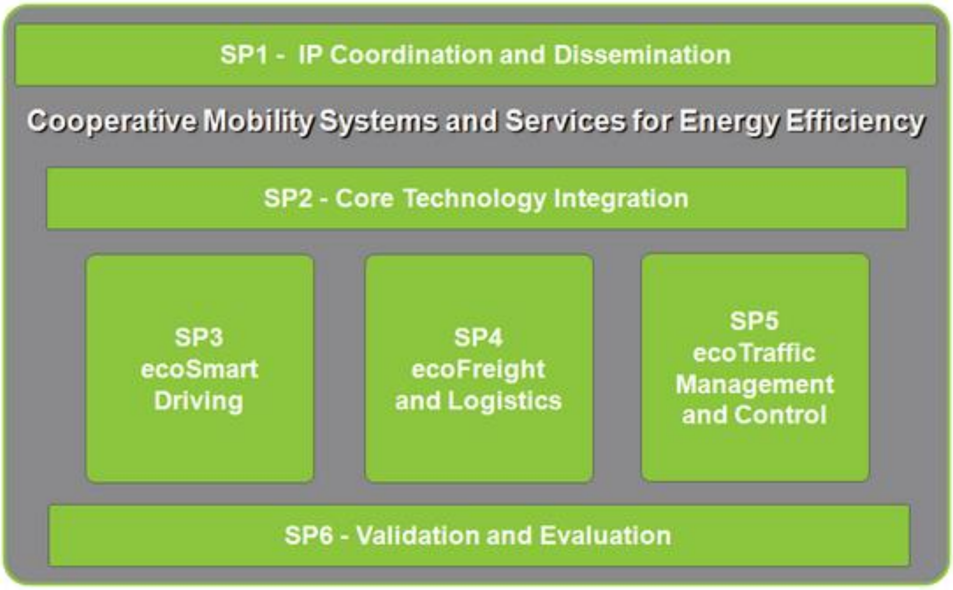


Tackling these inefficiencies means finding solutions to support the:

- **Driver** to apply the appropriate driving strategy in order to use the least possible fuel by finding the "greenest" route, the most economical use of vehicle functions, the best path through surrounding traffic and how to negotiate the next traffic signals with least chance of stopping;
- **Fleet manager** to adopt a self-learning "driver coaching system" based on incentives for energy efficiency gains, and a cooperative planning/routing system that selects the most economical route for deliveries;
- **Traffic manager** to optimise traffic lights phases and apply other traffic control measures so that the ensemble of vehicles in the network consumes the least possible energy, e.g. by granting priority to energy-greedy vehicles to avoid unnecessary stops.

The project is broken down into sub projects as illustrated in Figure 5.6.

Figure 5.6: Subprojects of eCoMove



- **SP1** involves the coordination of all the subprojects and the dissemination of information pertaining to the projects and the outcomes.
- **SP2** is the Core Technology Integration sub-project which aimed to provide:
  - **Communication platform** for vehicle-to-vehicle and vehicle-to-infrastructure communication that is compliant with the latest EU, national and industry standards.
  - **Eco messages**, protocols and interfaces for communication between eco-floating vehicle data about the progress, destination, fuel consumption vehicle data which can be disseminated to other vehicles and traffic control centre. Eco Traffic Situational Data- traffic conditions sent to vehicles from infrastructure
  - **ecoMap** – static and dynamic attributes for eco driving support: slope, historical speed profile, energy consumption data, traffic data and information from other vehicles
  - **ecoSituational model**: vehicles driving behaviour + dynamics of nearby traffic + current driving and traffic situation + fuel consumption = optimal driving strategy
  - **eCoStrategic model:** high fuel consumption factors in the situation level is translated to entire road network for traffic management and control strategies
- **SP3: ecoSmart Driving** – develop and validate system and feedback to drivers
  - Makes drivers perceive benefits from own perspective
  - Gives drivers contextualised information and instructions to adopt and maintain eco driving behaviour
  - Drivers assessed before and after
  - Applications include: eco-pre-trip planning
  - ecoSmart driving green routing, driving assist, information,
  - ecopost trip feedback anonymously to traffic control centres
- SP 4 ecoFreight and Logistics (See ecoDriver)

  - **ecoDriver coaching** pre-trip training and simulator, on-trip real-time instructions. Post trip driving records sent to fleet managers to analyse trends, provides feedback to drivers
  - **ecoTour planning** find most fuel efficient combination of vehicle, trailer, route, river and system configuration based on mission information, traffic management data, truck and driver models and routing system
  - **Truck ecoNavigation** calculates most fuel efficient route based on truck specific attributes, traffic patterns, eco maps and real-time traffic information

- SP5 ecoTraffic Management and Control
  - **Definition of set of representative use cases:** interactions of various actors (drivers, fleet management operators and authorities), main factors influencing fuel economy (e.g. smooth control and driving, efficient routes and congestion avoidance).
  - **Definition of interface** between central and local (or area) level of traffic management applications
  - **Design and development** of functional components and applications
  - **ecoAdaptive Balancing and Control** balancing traffic demand and network capacity by distributing traffic over road network: using traffic light coordination, V2I interaction, advise drivers of optimal route choice and traffic light status
  - **ecoMotorway Management** energy optimised traffic management on the interurban network, eco support of individual vehicles through ramp metering and lane change maneuvers advice

- SP6 Validation and evaluation
  - Validate: technologies, applications and services.
  - Demonstrate: validity of framework
  - Show technologies, applications and services meet high-level objectives
  - **Evaluation and validation of framework:** private and commercial drivers, suppliers and operators, have their requirements been satisfied? Do this through questionnaire study, expert interviews, workshops, Key question ‘how different driver types can be motivated to behave according to eco-driving strategies and how motivators can be generated’. Technical validation checks functionality and reliability of components of cooperative system.
  - Test sites: The project will verify and validate the developed technologies and applications at field trials in Berlin, Düsseldorf, Helmond, Munich and on French motorways. A simulation environment will also be set up as full evaluation of cooperative traffic management strategies requires a high penetration of equipped vehicles, which cannot be achieved in eCoMove.
  - Impact assessment: The developed eCoMove services will be evaluated with regards to their impact on: reduction of fuel consumption and achievement of the 20% target; driver's behaviour; traffic networks efficiency.

The conclusion of the eCoMove project on 20 November 2013 has shown that a CO_2 reduction between 4-25% can be achieved and varies according to use case, urban versus rural situations and applications. This result was attained using field trials, traffic network simulation and through driving simulator studies.

- ‘eCoMove allows vehicles to know about downstream events and take action, for example, to change route or adapt speed. Traffic control systems have more possibilities to sense approaching traffic and optimise their strategies based on this information. Infrastructure-to-vehicle communications offer more flexibility to control traffic’ – Jean-Charles Pandazis
- Guillaume Vernet, Project Manager ITS at Volvo Group Trucks Technology, said that: "in the commercial vehicle business, fuel consumption represents about a third of a transport company operational costs. By looking at goods distribution tour optimisation, fuel efficient navigation and eco-driving with a cooperative electronic horizon,
- Level of CO2 reduction depends on the traffic situation, road network and driver. Drivers receive early corrective advice to slow down ahead of situations where otherwise they would have come to a stop. Prototype haptic feedback accelerators coaches more fuel efficient driving style. Function reduces fuel consumption by up to 15%.

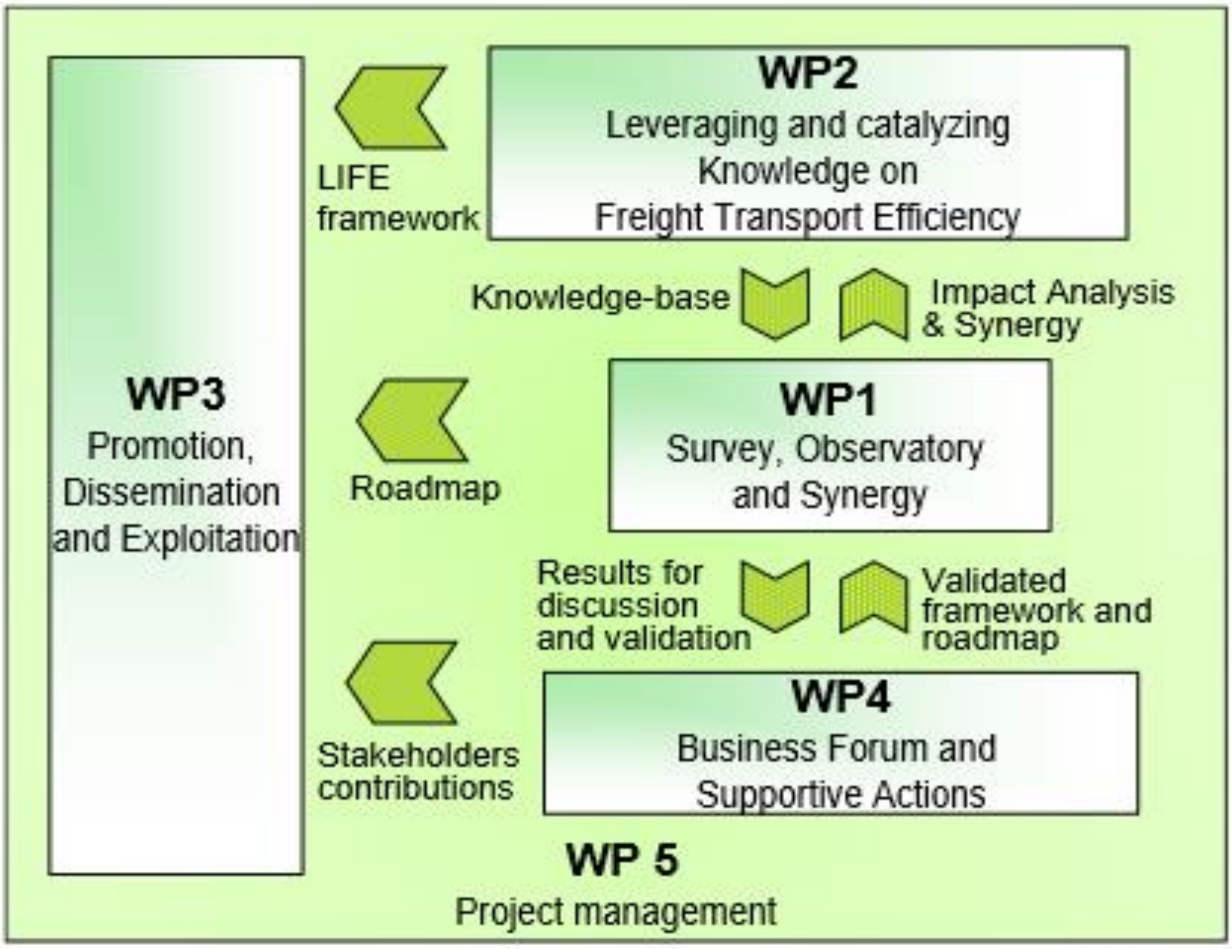
Figure 5.7: eCoMove Cooperative Technologies

Reduction of over 10% is considered feasible in urban networks. Reduction realised by network and routing schemes depends on traffic load and network. If load is low or moderate, reduction rate is around 4$, but when heavily loaded, reduction can be around 12%. Largest impact on CO2 achieved in case of severe incidents, where concerned road users need to be informed as quickly as possible about the incident and possible alternative routes.

5.4.11 Logistics for Life

Logistics for LIFE has the general goal of driving European ICT for transport research in the direction of making logistic operations more efficient, and thus more environmentally friendly, financially and socially sustainable on the long term.

Figure 5.8: LIFE project components



The Logistics for LIFE Coalition members will cooperatively work to achieve the following objectives:

- To create a multi-disciplinary network of logistic companies, technology providers and researchers actively pursuing efficiency-related initiatives within EU, national or industrial programs. The Logistics for LIFE Coalition will be structured and organized to grow its membership, by attracting key stakeholders from outside the Consortium, and to continue operating after the end of the project.
- To establish a reference framework where logistic efficiency requirements from different stakeholders are related to sustainability strategic objectives, on the one side, and, on the other side, to existing and looked-for ICT solutions.
- To develop a strategic roadmap including concrete actions and strategies that will guide and facilitate the effective implementation of ICT solutions identified in the reference framework for energy efficiency in logistics. Both the framework and the related roadmap will be periodically updated with stakeholders input, collected through the Logistics for LIFE Coalition activities, and aligned with Commission programs development as well as with input from other forums and EU projects.

- To promote the Logistics for LIFE vision and findings, as well as relevant results from the Coalition members related projects, through a coordinated plan of dissemination activities targeted primarily to the transport logistic industry community. To this purpose, the Coalition plans to participate in the major conferences and expositions on transport logistics and to coordinate the organization of joint workshops between member projects, to maximize dissemination output.
- To establish a common working platform for the community of users and researchers working on logistic long-term efficiency including: public and private web sites, on-line forums, document repositories and other web-based collaboration tools. The platform shall be used for several purposes: on-line discussion on stakeholder issues, collaborative work on the framework and roadmap documents, networking and dissemination material publication, and it shall be open to both Coalition members and external participants, who will be able join through a controlled membership request and registration process.

5.4.12 Smartfreight

The objective of the SMARTFREIGHT project is to:

- Develop new traffic management measures towards individual freight vehicles through open ICT services, on-board equipment and integrated wireless communication infrastructure
  - Assign different service levels to freight vehicles, depending on their environmental profile, type of goods transport and destination
  - Grant priorities and access rights depending on the service level and traffic situation
  - Allocate routes and times slots to freight vehicles to minimise conflicts and congestion
  - Track and monitor vehicles carrying dangerous cargo
  - Collect information for statistics
  - Support control that enables enforcement
  - Improve awareness in case of incidents
- Improve the interoperability between traffic management and freight distribution systems
  - Provide information that improves route planning for transport companies, such as more accurate transport network information, traffic and travel time information, through open ICT services
- Coordinate all freight distribution operations within a city by means of open ICT services, on-board equipment, wireless communication infrastructure and CALM MAIL implementation in on-board and on-cargo units, for all freight vehicles
  - Routing and re-routing for scheduled freight and service vehicles
  - Provide information that improves the efficiency of these fleets
  - Manage the use of loading and unloading areas
  - Track freight vehicles
  - Track cargo
  - Monitor the status of cargo

5.4.13 SARTRE (Safe Road Trains for the Environment)

Safe Road Trains for the Environment; developing strategies and technologies to allow vehicle platoons to operate on normal public highways with significant environmental, safety and comfort benefits (Dávila, A & Nombela, M 2010).

SARTRE, funded by the European Commission under the Framework 7 programme, aims to encourage a step change in personal transport usage through the development of safe environmental road trains (platoons). Systems will be developed in prototype form that will facilitate the safe adoption of road trains on un-modified public highways with full interaction with non-platoon vehicles.

The programme will address the 3 cornerstones of transportation issues, environment, safety and congestion while at the same time encouraging driver acceptance through the increased “driver comfort”.
The programme is addressing a concept that as a whole will facilitate a step change in the use of private transportation. The consideration of how platoons interact with other non-platoon users is a critical facet of the programme. This programme has a significant element of research that is looking into this aspect and this will provide clear strategies that will be implemented in the prototype system.

A further unique element of the programme is the interaction between the lead vehicle and the following vehicles and how this can lead to a new business model for road use. I.e. following vehicles may be charged to join a platoon. The introduction of platooning on normal roads with private vehicles will achieve environmental benefits (with an estimated 20% emissions reduction), safety benefits (reduction of accidents caused by driver action) and a reduction on congestion (smoother traffic flow with potential consequential increase in throughput).

It should be noted that Volvo Car Corporation is the only participating car manufacturer in SARTRE. The project road train includes a manually driven lead truck, which is followed by one truck and three Volvo cars (S60, V60 and XC60).

- All the following vehicles are driven autonomously at speeds of up to 90 km/h – in some cases with no more than a four-metre gap between the vehicles – using a blend of present and new technology.
- The basic principle is that the following vehicles repeat the motion of the lead vehicle using camera, radar and laser technology and support systems such as Adaptive Cruise Control, City Safety, Lane Keeping Aid, Blind Sport Information System and Park Assist Pilot
- The most important new features that have been added to the vehicles are:
    - A prototype Human-Machine Interface including a touch screen for displaying vital information and carrying out requests, such as joining and leaving the road train.
    - A prototype vehicle-to-vehicle communication unit that allows all vehicles within the platoon to communicate with each other.

5.5 US Projects

5.5.1 Applications for the Environment: Real-Time Information Synthesis (AERIS)

The objective of the AERIS research program is to generate and acquire environmentally-relevant real-time transportation data, and use these data to create actionable information that support and facilitate “green” transportation choices by transportation system users and operators. Employing a multi-modal approach, the AERIS program will work in partnership with the vehicle-to-vehicle

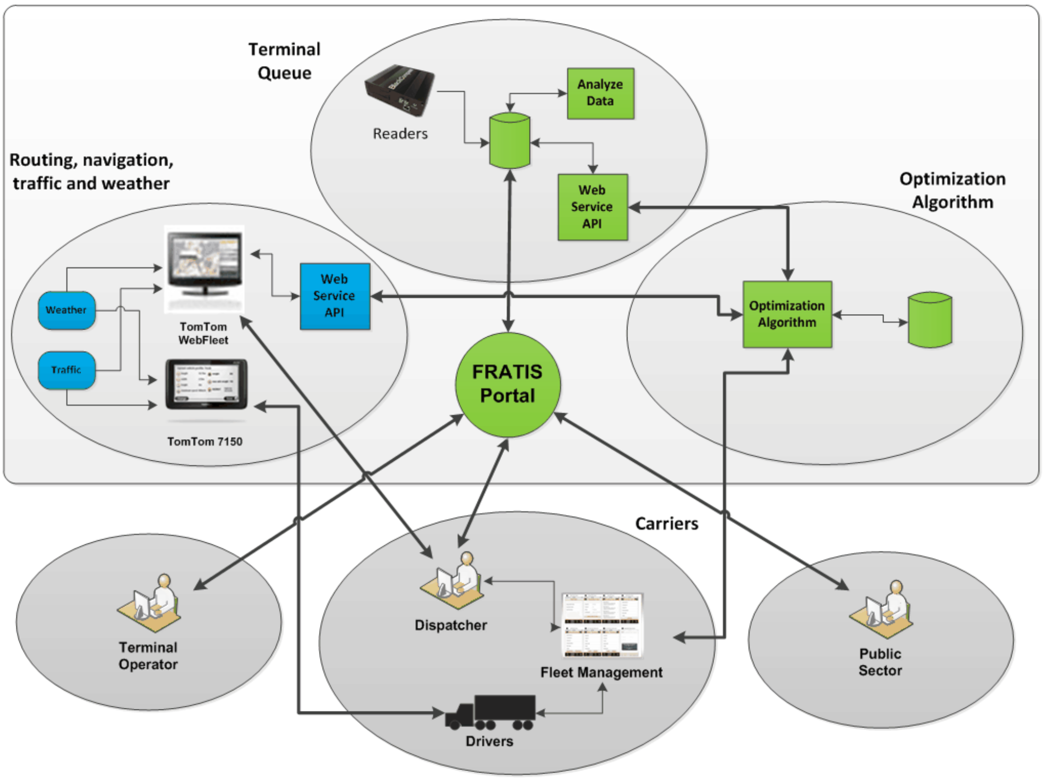
(V2V) communications research effort to better define how connected vehicle data and applications might contribute to mitigating some of the negative environmental impacts of surface transportation.

5.5.2 Freight Advanced Traveller Information System (FRATIS)

FRATIS is a small scale prototype project in Dallas – Fort Worth, Texas. The project uses Bluetooth and Wi-Fi sensors for collection and calculation of freight terminal wait time, the information is transmitted to a database which has a web service API and linkage to the FRATIS Portal to enable sharing with other parties , including terminal operator, dispatcher, drivers and public sector.

The in-vehicle unit used are standard off-the-shelf products manufactured by TomTom, with truck routing, navigation, traffic and weather information provided by a smart phone application. Databases are used by various parts of the system to enable analysis of data and optimisation to take place.

Figure 5.9: FRATIS architecture, information sharing via portal and



The benefits of the project include:

- improved truck utilisation
- decreased average travel time
- decreased fuel consumption
- reduced emissions
- reduced terminal queue time

6 USE CASES AND FUTURE PROJECTS IN QUEENSLAND

This section will explore the use cases put forward by the EU FP7 programme, ecoMove, which aims to reduce the energy wastage in the transport industry by addressing inefficient route choice, driving and traffic management. The use cases that are isolated for examination have relevance to improving heavy vehicle productivity by reducing fuel consumption and vehicle operating cost as well as reducing travel times (Figure 6.1).

6.1 ecoGreen

Green wave: Traditionally green waves are created by establishing a fixed timing relationship between successive intersections such that vehicles, travelling at a predetermined speed, can pass through the green indications at successive signals. This explicit timing relation however limits the flexibility of the system. Ideally green waves emerge and dissolve on demand with elastic coordination speed in reaction to current or expected traffic conditions.

Unlike existing control procedures, the ecoGreen Wave will not only synchronize subsequent signalized intersections but also seeks to influence the spatial-temporal structure of the traffic flows as it forms platoon shapes depending on traffic volume and vehicle characteristics. Moreover, these control measures shall be accompanied by direct driver assistance (e.g. speed advice). The cooperative features of the procedure are crucial for maximal reduction of fuel consumption. By using cooperative technologies ecoGreen Wave will have more information about the spatial-temporal state of moving platoons and their composition (vehicle types) and, as a consequence, it will even incorporate this platoon data in the control mechanisms.

The behaviour of an ecoGreen Wave system therefore depends on the traffic volumes, the smoothness of the traffic flows and the ways in which platoons can be formed, assisted by co-operative technology.

6.2 ecoTruck Parking

The objective of the ecoTruck Parking application is to reduce fuel consumption and CO2 emissions wasted by truck drivers when searching for a place to rest on motorway corridors. Truck parks along motorways improve goods security but most of the time drivers are not informed of the availability of places or are not planning and anticipating their stops which lead to unproductive kilometres driven. Some truck drivers do not stop and rest in an efficient way because they do not stop at the right available space or because they spend too much time to find an available place.

From a more global point of view, there is a growing deficit of suitable truck parking areas along major European transport corridors, while in the meantime the volume of HGV traffic increases. Intelligent Truck Parking applications may have notable benefits for energy efficiency by: achieving the optimum use of existing capacities, optimising parking spaces and managing their occupancy more efficiently. The application will inform in real-time truck drivers about availability of parking slots along their route.

6.3 ecoNetwork State

Based on various static network attributes, dynamic capacity related information, road side sensor data and - above all - vehicle generated data (positions, speed, routes), the current, future and desired traffic state for the road network is estimated by this ecoNetwork State component. The estimation of current and future states is being carried out for urban as well as motorway networks by taking into account user optimal objective functions. In the case of the desired traffic states, the optimisation follows a system optimum strategy that reflects the system operator's view by minimising the overall fuel consumption/CO2 emission.

The results are provided in form of travel/waiting times, average speed and volumes per link (in the case of current and future states). The result of the desired states is expressed through travel times and source-destination route distributions. The fuel-efficient route distribution reflects ideal traffic states from the system operator's point of view with respect to fuel consumption.

Figure 6.1: V-diagram – engineering model for use cases, functionalities and requirements

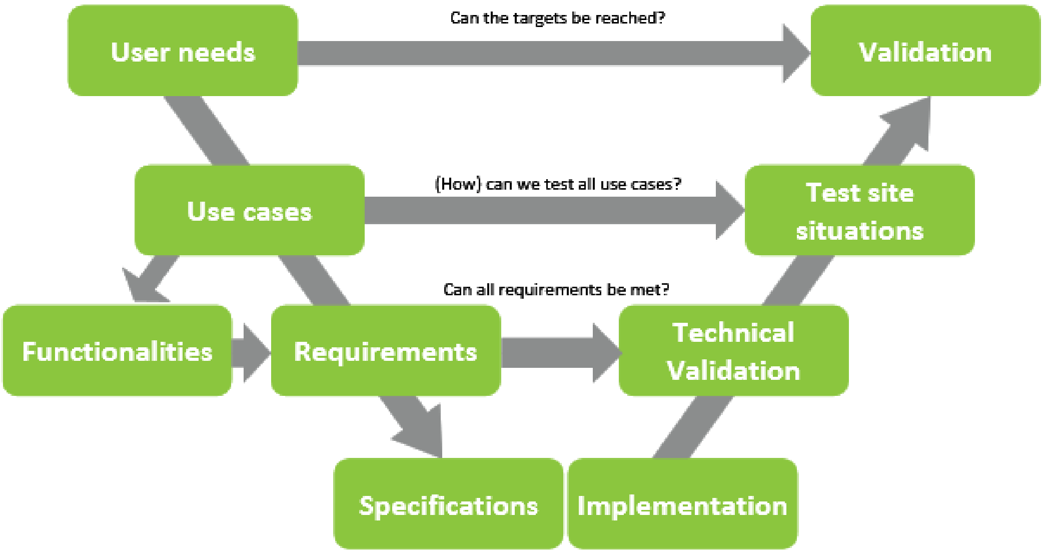
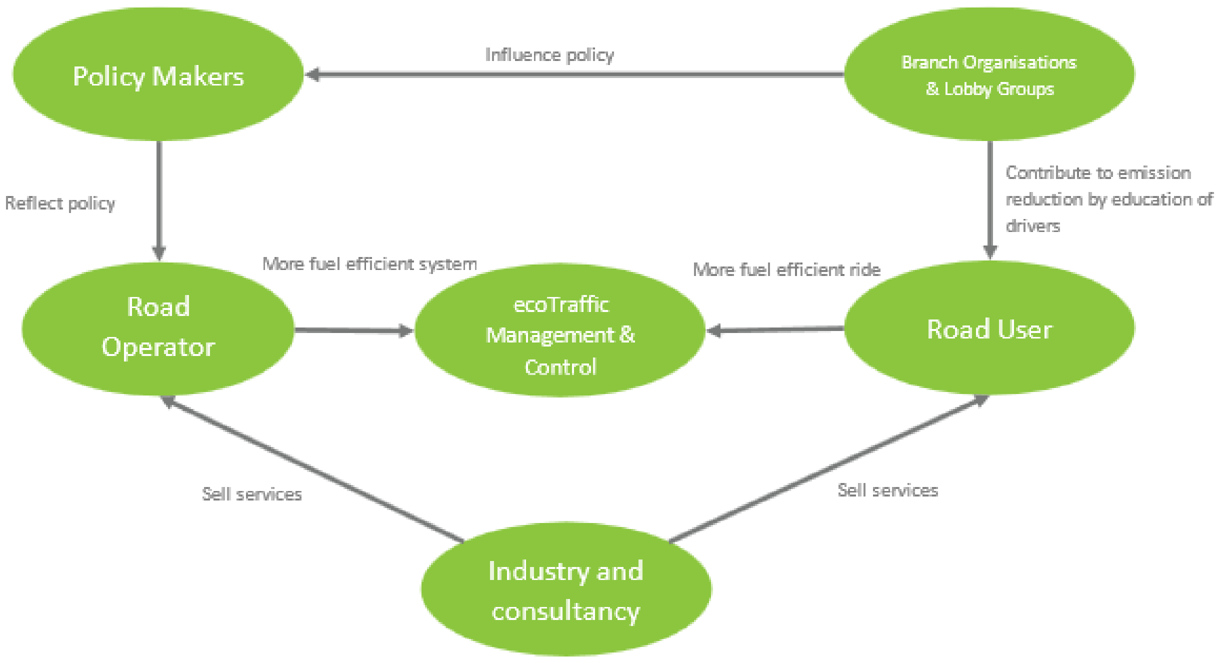


Figure 6.2: Relationships and drivers among road user, operator, policy makers, etc.



6.4 Future projects

The review summarised the state of C-ITS, the technology that is available and their applications in road safety and productive. This section will predominantly discuss the considerations of DSRC and in-vehicle telematics for applications that benefit the road freight industry and productivity. It must be emphasised that the review identified an absence of heavy vehicle applications using DSRC in improving freight productivity and network efficiency. The focus of the DSRC studies that are currently in progress all focus on the technical capabilities of DSRC in preventing collisions at intersections or raising situational awareness. Currently no studies have been published showing crash reductions in these studies. The low latency and level of architecture surrounding DSRC makes it ideal for these applications, and could therefore produce the desired road safety outcomes for all road vehicles.

One aspect of this technology that the review was unable to ascertain, due mainly to a lack of information, was the cost of implementing DSRCs. The cost of the roadside units and on board units are likely to be less expensive now than they were around 2000, due mainly in parts to the improvements in technology and increasing competition among suppliers, however, in order to be effective, the majority of vehicles that travel through the treated site would need to be equipped with an on-board unit. There may also be difficulties in obtaining enough participants to affect any meaningful change in the crash statistics. Although the benefits of DSRC, relating to safety for heavy vehicles, do seem promising, it is uncertain how the technology could assist in productivity and network efficiency.

Low latency which is a feature of DSRC that enables real time safety applications is not required for a lot of applications relating to heavy vehicle productivity. As such, government investment in DSRC for the sole purpose of aiding network efficiency for heavy vehicles may be costly as roadside units may need to be located at regular intervals on key freight routes. As such, in-vehicle telematics, which requires minimal government infrastructure investment while providing operators with numerous operational and safety benefits.

In-vehicle telematics is relatively new technology and as such, very little research has been conducted on the applications of in-vehicle telematics for productivity and network efficiency applications. In-vehicle telematics has the potential to improve productivity in a multitude of ways, such as providing accurate traffic information and travel times, monitoring compliance and safety for heavy vehicles, and signal pre-emption to reduce travel times.

The following table establishes a list of treatments and pilot studies that can be undertaken using in-vehicle telematics for commercial vehicles such as:

- signal pre-emption, extended green time, green wave or priority for heavy vehicles
- real time hazard and extreme weather warnings for freight vehicles
- road hazard pre-emption via vehicle telematics
- congestion alleviation for heavy vehicles
- smart phones as telematics devices

The objectives, considerations, possible benefits, disadvantages and rough cost estimates are given in Table 6.1.

Table 6.1: Future projects – in-vehicle telematics for commercial vehicles

Item	Treatment	Details	Rough order cost estimates		Rough order assessment of benefits		Preliminary benefit-cost ratio	Considerations
			TMR	Operators and wider economy	TMR	Operators and wider economy		
1	Signal pre-emption, extended green time, green wave or priority for heavy vehicles	Objective: to enable extended green time for heavy vehicles and signal pre-emptions to save on travel time and the need to stop and start vehicles at the lights. Especially useful if a fully laden heavy vehicle is required to start from a complete stop at an intersection on an upgrade. To optimise efficiency for the freight and non-freight vehicles, priority can be given to fully laden vehicles but not necessarily during peak times. It is anticipated that this form of signal prioritisation would be implemented in areas with relatively high volumes of heavy vehicle movement such as near ports, along strategic freight routes and key distribution points such as: ▪ inner city or urban regions where general access or PBS Level 1 vehicles operate ▪ PBS Level 2, Road train routes or B-double routes ▪ Routes with multiple key distribution points locate along them ▪ Regional towns along the Bruce hwy. The types of heavy vehicle most likely to access these areas are: ▪ Semi-trailers (general access, PBS or trailer with a quad group) ▪ B-doubles (general access, guideline or PBS) ▪ Truck and dogs (3 axle general access through to 6 axles restricted access) ▪ PBS vehicles ▪ High productivity vehicles (AB and B triples, quad axles, so on) Each heavy vehicle will need a telematics device that will transmit real time information relating to its: ▪ position ▪ speed ▪ direction ▪ route ▪ vehicle parameter (B-doubles, semis, length, how many axles, etc) ▪ mass (laden or unladen) Currently, information is received by the service provider and if requested by the customer, the SP could forward that information to the relevant party in whatever format is required. The SP could provide that information to Transmax. A module will be required to receive the data from the service provider. The module will know where the vehicle is, in which direction they are heading, if given, the route that they are taking. Using this information, the module should know which sets of lights are up ahead and can calculate, from the speed information, how long it would take the vehicle to reach the lights and calculate when to activate or extend the green time, enabling the vehicle to travel through without stopping. **Methodology** ▪ Identify signals along major freight routes and areas of high HV traffic. TMR HV sections have that information. Initial consultations with Russell Ingham (TMR) identified possible candidate sites in Mackay, Rockhampton and along Gympie Road in Brisbane. ▪ Consultations with Transmax to enact signal pre emption: modules, algorithm, programming ▪ Engagement with the Australian Trucking Association (ATA) to find members willing to participate in trial. Initial discussions have revealed that the ATA are interested and would be willing to assist with the project either by distributing surveys and feedback to members, or by opening lines of communication. ▪ Discuss with Roadtek and TMR maintenance contractors the possibility of using their vehicles in a pilot study. Must ascertain if their vehicles have some form of in vehicle telematics. ▪ Collect pre-treatment data: i.e. travel time and fuel consumption for around 3 or 4 weeks for freight vehicles, but also for vehicles on adjoining roads. ▪ Record and analyse data post treatment. ▪ If results are promising, approach industry for next stage of the study. May require workshops to convince transport operators to share data.	Project cost: $100,000 – 150,000 Ongoing maintenance cost: negligible	Data cost: negligible	Intangible benefits: • TMR's image will be enhanced	Total savings per year: $1.3m, which is made up of: A. Travel time cost savings: $857,141 per year Assuming $46.45/hr, on a route with 2,000 heavy vehicles benefiting per day on average, each vehicle saving one minute of waiting time and speed change cost savings (travel time component) of $0.40 per speed change saved B. Vehicle operating cost savings: $438,000 per year Assuming speed change cost is $0.60 per speed change cycle	BCR using just one year of benefits is around 10.	

Item	Treatment	Details	Rough order cost estimates		Rough order assessment of benefits		Preliminary benefit-cost ratio	Considerations
			TMR	Operators and wider economy	TMR	Operators and wider economy		
2	Real time hazard and extreme weather warnings for freight	Objective: To identify and warn road users of hazards on the route network such as bush fires or accidents within an optimum distance ahead of the vehicle. This information could be made available to freight vehicles in real time, enabling them to quickly recalculate their route. This may require an interface with 13 19 40 which relies on reporting by people on the ground, therefore if an accident occurs and no one is there to report it, it will not show up. Extreme weather events such as flooding or cyclone could also be detected and used to notify freight vehicles. Real time information from the Bureau of Meteorology, satellite, radar and other ground based systems used for verification and other sources could be transmitted to Transmax which then warns vehicles via the use of dynamic signage in the vicinity to take alternative routes or not proceed on their current route.	A review of warning systems and how it can interface with transmax and in vehicle telematics may be needed Investments in ground based sensors, video cameras or other pieces of infrastructure for real time verification and reporting may be required May need consultations with various stakeholders and services providers, e.g. Transmax, BOM, emergency services, police	Transport operators would require in vehicle telematics to benefit Concerns that TMR will use telemetry for enforcement purposes Industry may be required to pay for some infrastructure upgrades	Early warning of hazard or extreme weather events may improve response time and notification to other road users Risks of further accidents may be reduced	Can avoid areas severely affected by extreme weather through rescheduling or rerouting Driver safety improvements Delays can be managed in advanced		
3	Road hazard pre-emption via vehicle telematics	Objective: An alternative to item 2 above is to have vehicles that have telematics devices on them to report the conditions. For example, several vehicles losing traction on the same section of road at a particular time when it is not normally the case could suggest ice on the road. That information could be sent to Transmax where the module will store the data and increment the incidents. If the event occurs frequently (be determined by an algorithm) it will transmit a warning to all vehicles within a certain radius and are heading towards the area, that there may be a hazard on the road and to suggest caution/alternate route. Car crashes, vehicle rollovers can also be picked up by telematics devices that can be reported to Transmax. An event such as this may be picked up in real time and verification could be requested. If verification is received the information could be used to despatch emergency services (if it hasn't already been called in) and warnings sent out to other drivers with predicted delay times	-	-	-	-	-	-

Item	Treatment	Details	Rough order cost estimates		Rough order assessment of benefits		Preliminary benefit-cost ratio	Considerations
			TMR	Operators and wider economy	TMR	Operators and wider economy		
4	Congestion alleviation for heavy vehicles	Objective: Congestion can be detected using vehicle telemetry and floating car data. If a great deal of vehicles in a particular area (freight or passenger) are stopped for long periods on the road, or has an average speed of around 30km/h, transmax can send instructions to variable speed limiters upstream of traffic warning them to sleep down and place an estimated travel time. This will mitigate the need for traffic sensors that is able to count the vehicles. Best implemented on a heavily congested highway with no traffic lights, i.e. Bruce Hwy	Will require module for Transmax to analyse the data Investment in VSL placed along heavily congested roads	Will only benefit industry if there is already a significant number of vehicles (passenger and freight) on the road with telematics Operators will be required to share information	May reduce the stop start effect and keep a continuous stream of motion resulting in higher average speed during peak hours Benefits for all road users	Reduced travelling time for freight. Less stopping and starting, will save on fuel consumption		
5	Smart phones as telematics devices	Objective: with smart phones becoming ever more sophisticated, could this be used in the place of traditional in vehicle telematics devices? This project would explore the capabilities of smart phones in vehicle and speed tracking, as well as signal pre-emption. Smart phones are fitted with radio receivers and transmitters and GPS. An app could potentially be developed that will enable them to be used as on board units for accident collision, hazard warnings and congestion warning. Perhaps even signal pre-emption.	TMR may need to invest in infrastructure to communicate with smart phones when it comes to collision avoidance and signal pre-emption	Fears that smart phones will be opened to hackers and security issues		No need to purchase expensive telematics devices or the need for a service provider.		Telematics service providers may perceive this as a threat
6	Fatigue management and incident detection through a combination of log book applications and detection of abnormal driving behaviour through telematics using algorithms	Objective: the detection of abnormal driving behaviour using algorithms may enable early detection of incident and identification of fatigue drivers on the road preventing crash.						

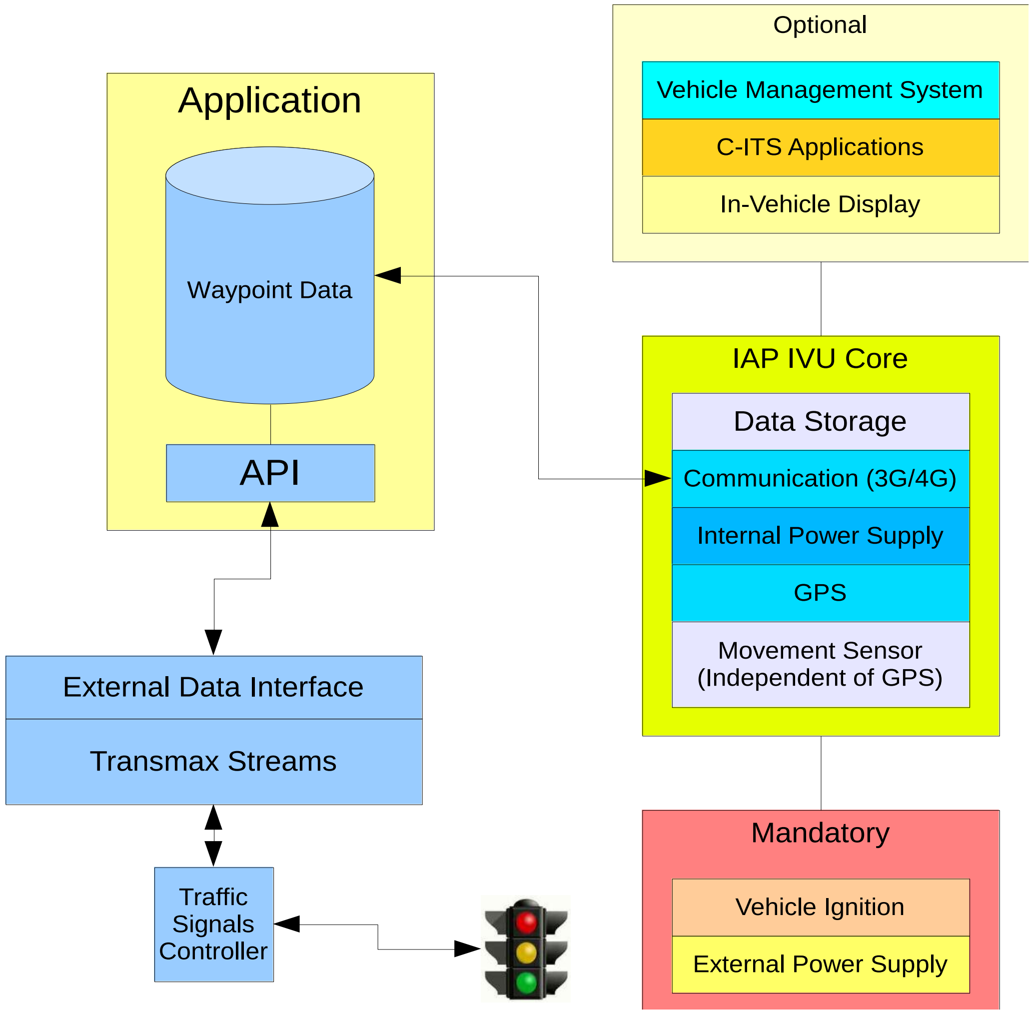
6.5 Traffic signals pre-emption for heavy vehicles in Queensland

Pre-emption using in-vehicle telematics is a relatively novel concept; therefore the technical details are not readily available. Verbal correspondents with telematics service providers, such as MTData, revealed that it is possible to accomplish this on the telemetry data provider side (Figure 6.3).

Conceptually, this can be done by establishing a geo-fence in the vicinity of the intersection. When a heavy vehicle goes through that geo-fence, the on-board telemetry device sends a signal to the data provider's server, i.e. a form of polling, advising the heavy vehicle's presence. The information can then transmitted to an external system, e.g. STREAMS, via an application programmable interface (API). It is understood that STREAMS can accept data/ triggers from external sources and thus it is conceptually feasible to implement signal pre-emption using in-vehicle telematics devices with system modifications and application development. Although using geo-fence is a "current" mindset for delivery of a project, it is not inconsistent with the way applications/ infrastructure deployed internationally.

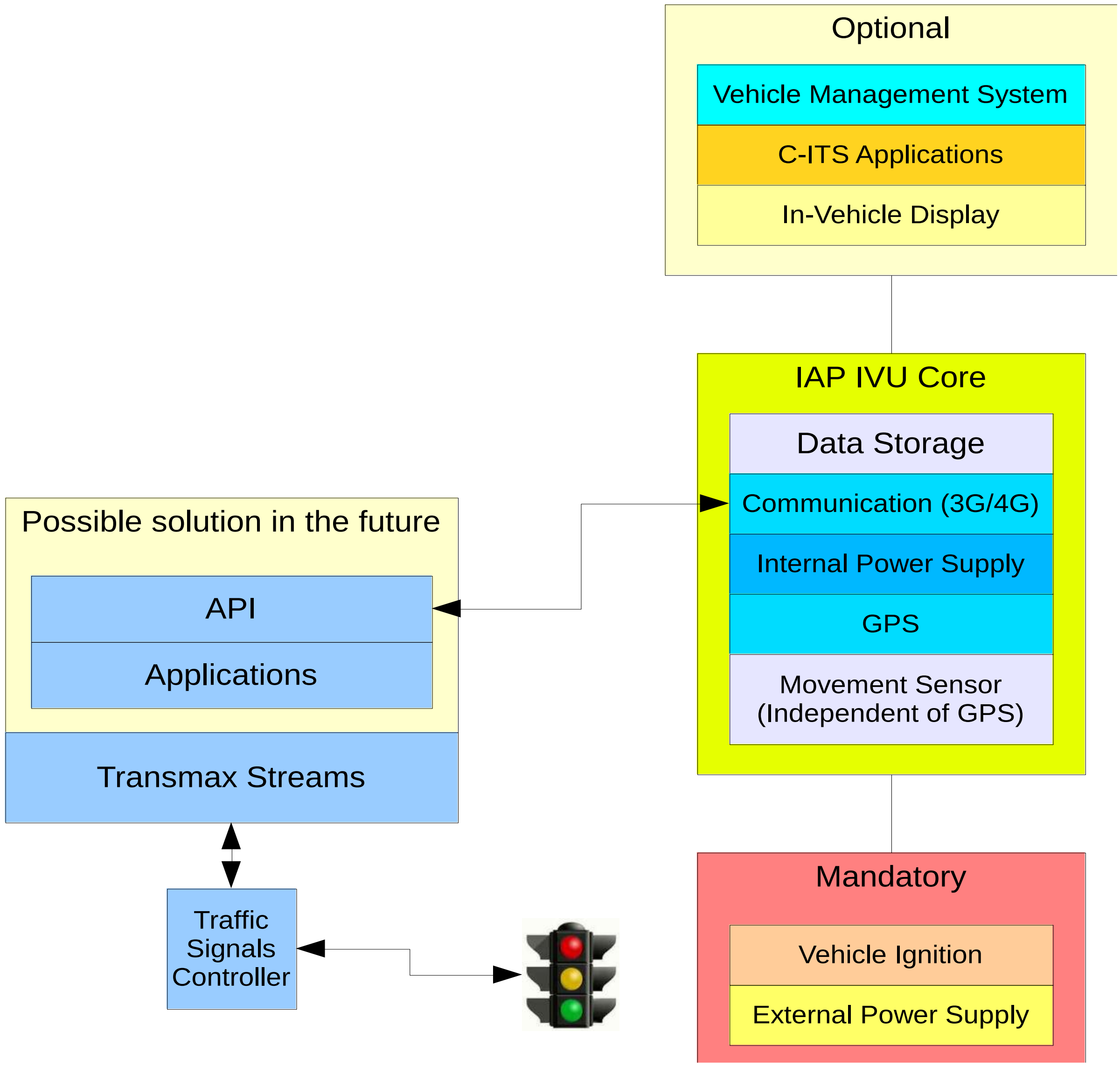
The latency of 3G/ 4G systems is not considered an issue in this type of applications as 3G systems normally have latency of less than 200 ms and 4G networks normally have latency of less than 100 ms, but that is subject to the quality of coverage at the intersection. This will have to be verified with the telecommunications supplier prior to site selection.

Figure 6.3: Architecture of signals pre-emption that can be implemented in the immediate future (short to medium term)



There is also an alternative way of delivering this service without involving telematics provider (Figure 6.4). However, it will require a number of systems to be developed and would require the TMR to take on additional responsibilities, such as access control.

Figure 6.4: Architecture of signals pre-emption that can be implemented in the longer term



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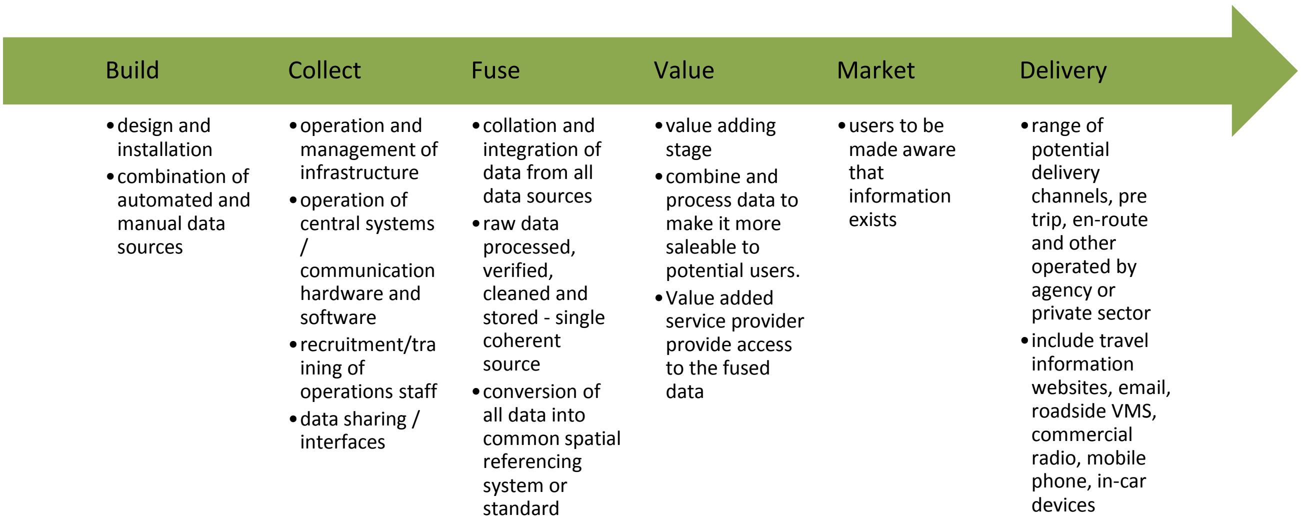
APPENDIX A TECHNOLOGY REVIEW

A.1 Data and Information Systems

A report prepared for Transit New Zealand mentioned the information supply chain whereby information about the road network is obtained, processed into meaningful information (e.g. estimated journey time or incidents), and then disseminated to the road users. The phases in the supply chain are shown in Figure A 1 with final delivery of that information to the user.

Figure A 1: Information supply chain phases for delivering travel information to road users



The part of the supply chain which needs considerable attention in order to achieve an effective C-ITS system is the 'collection' phase. Detector technologies are necessary for collecting raw traffic data to ascertain the volume and rate of traffic flow as well as the composition of traffic. Table A 1 outlines the various systems, advantages and disadvantages of each system/technology and applications (Table A 2). This list is by no means exhaustive.

Table A 1: Summary of detector technologies

Item	Detector technologies	Description
1	Inductive loop detector	Inductive loop detectors have the advantage of being low cost per unit and reasonably well established. Installation is disruptive to normal traffic flow and the detectors themselves are susceptible to damage from heavy vehicles and road works.
2	Microwave (radar)	Microwave (radar) can directly measure speed while being compact and easy to install and repair without much affecting traffic.
3	Infrared	Infra-red can be used day or night without disruption to traffic. It is compact and effective in the fog. Sensors are susceptible to atmospheric obscurants and weather, can only be used for one lane, and have unstable detection zones.
4	Laser	Lasers can provide data on a vehicle's presence, length and speed and be installed by the side of the road with a twin detector. Heavy precipitation and poor visibility can affect its performance and they are relatively expensive.
5	Ultrasonic	Ultrasonic detectors are used for measuring volume, speed, lane occupancy, presence and queue length but are subject to attenuation and distortion from environmental factors.
6	Magnetometer	Magnetometers are used instead of inductive loops in bridge desk and heavily reinforced concrete. Have limited application an medium cost.

Item	Detector technologies	Description
7	Automatic Vehicle Identification (AVI)	Automatic vehicle identification (AVI): can provide section speed data and compute travel time directly. Does not disrupt traffic. Performance is variable and depends on market penetration of tagged vehicles. Technology lacks industry standards. Public privacy is an issue.
8	Video Imaging (VIP)	Video Imaging (VIP) is used for rapid incident management and can observe multiple lanes. Does not interrupt traffic for installation and repair and can be used to track vehicles. Require different algorithms for day and night use and susceptible to atmospheric obscurants and bad weather.

Table A 2: Summary of applications for detector technologies

2	Traffic Counts	Real time traffic count information is required for measuring traffic flow. This information can then be used to provide current traffic flow information such as travel time.	Traffic count would depend on any number of the above detector technologies to determine traffic speed, and presence.
3	Journey time	Provide pre-trip and en-route journey time estimates using real-time data.	▪ Using the vehicle speed detected at various monitoring points, the speed can be extrapolated for the whole segment of road and the journey time estimated. Can be accurate given that the detector spacings are between 500-1000 m. ▪ Automatic number plate recognition can be used to track a vehicle between two points in order to estimate travel time. It is less accurate for network travel times. ▪ Floating vehicle data (FVD) is the use of GPS or short range transponders to communicate a vehicle's position to a central system in order to determine the journey time. GPS based FVD systems are the most common but mobile phone based FVD are also becoming more common (though less accurate).
4	CCTV	CCTV can monitor situations, detect incidents and respond to them.	CCTV visually assesses the level of congestion and operating speed.
5	Weather	Monitoring to provide useful data on weather conditions at key locations on the road network.	The meteorological factors that can cause a crash can include high winds, heavy rain and poor visibility. Forewarning could potentially reduce crash rates. The focus of this system should be on weather warnings that disrupt traffic flow.
6	Automated Incident detector	Respond and manage incidents. Reduce detection time of an incident.	Using detectors mentioned above to continuously monitor traffic conditions and characteristics. Use of detection algorithms to process generated data and signal incidents. ITS infrastructure would be required to enable meaningful management of traffic incidents i

For the applications targeting heavy vehicles, the information collected from the detectors will then need to be stored and processed. The processing phase can be done a number of ways either manually; which involves the intervention and monitoring by trained staff in a call centre, traffic control centre or by police officers. The automated method requires computers to process the data using algorithms.

The data could also be transmitted from the detectors to the central processing centre and then transmitted to the users, or transmitted directly to users and then processed. Often times the information is transmitted over wireless media which utilise any one of the following:

- UHF and VHF frequencies for short and long range communication
- Wireless Access in Vehicular Environment (WAVE) or dedicated short range communication (IEEE 1609 series of standards)

- Long range communication (IEEE protocol 802.16) GSM, 3G, 4G
- Wifi and WLAN (IEEE protocol 802.11)
- GPS, GNSS, satellite.

The transmission channels have various properties and are used for different applications. Transmission over long range will differ from short range communications. Certain channels are reserved for specific purposes and are controlled by the government.

A.1.1 Floating car data

Floating car data is information that can be used to determine the condition of traffic on the road network at any time. The data is collected from a number of sources, most commonly, mobile phones, toll collection devices (such as the e-Tag) and GPS systems. The location of any mobile phone (that is switched on) can be determined using triangulation or data stored by the mobile network service provider. Using advanced algorithms, the location information, can then be used to:

- infer whether the device is located within a vehicle
- if so, how fast the vehicle is travelling
- direction of travel.

From the above information, the traffic speed on a particular road network can be calculated and used to provide journey time predictions; also it can be used to show the level of congestion on the road network. Floating car data has the advantage of not requiring any additional infrastructure to obtain it.

A.1.2 Data sharing portal

The road and traffic information collected can be used solely by the road managers to inform road users, or it may be shared with third parties to develop their own applications for delivering the information to users. In the latter case, the sharing of information can be facilitated via an online data sharing portal.

The InfoConnect portal was established by New Zealand Transport Agency (NZ Transport Agency, 2010) to provide free access to traffic information to developers. The intention is that third parties would provide ‘innovative travel informative services’ to road users in New Zealand. Anyone can sign up to access the application programming interfaces (APIs) but developers who want their projects to be published in the Gallery of the InfoConnect website must submit their project to NZTA for review.

The following sections give examples of some of the projects that resulted from the sharing of traffic information.

AA Maps

AA Maps uses the information from InfoConnect to provide the real time journey times (Figure A 2) for particular routes, and compare them to the ‘normal time’ and ‘ideal time’.

Roadwatch (Figure A 3) shows traffic flow information, road works, incidents and closed roads. In addition to the free information provided by the website, users can subscribe to the ‘Traffic Alerts’ that can be sent to their phones or email for periodic fee. The alerts cover routes as well as areas.

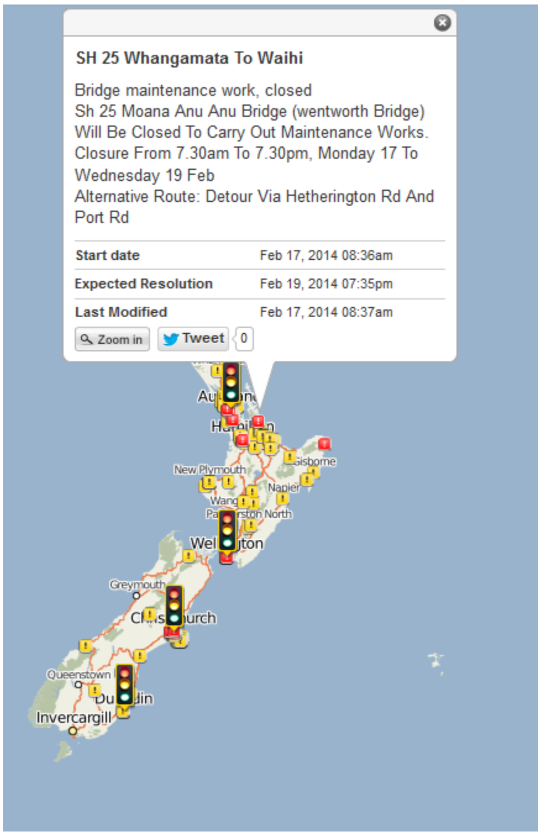
Figure A 2: AA Maps: Journey times

JOURNEY	SH #	DIRECTION	LIVE TIME	NORMAL TIME	IDEAL TIME
Shotover St (Duke St to Brunswick St)			1m 49s	53s	31s
Onewa Road from Northern Motorway to Birkenhead		WB	9m 54s	3m 36s	3m 20s
Frankton Rd (Suburb St to Stanley St)			1m 2s	25s	22s
Stanley St (Frankton Rd to Shotover St)			2m 1s	1m 3s	50s
Ohiro Road to Willeston St, via Willeston St (NB)		NB	8m 47s	6m 17s	3m 50s
Dairy Flat Highway Albany to Silverdale	17	NB	27m 55s	15m 27s	13m 12s
Hall St / Mein St to Wakefield St (via John, Wallace & Taranaki St) (NB)		NB	7m 23s	6m 37s	3m 38s

Return to the Main Roadwatch Page

Source: http://maps.aa.co.nz/traffic/roadwatch

Figure A 3: AA Roadwatch road work and road closure information



Source: http://maps.aa.co.nz/traffic/roadwatch

Traffic Cams and Road Conditions

This project provides traffic camera footage of state highways to road users in Auckland, Wellington and Christchurch. It enables road users to visually monitor the road conditions in real time to help better inform their travel decisions. Figure A 4 is a screen shot captured from one of the cameras in real time.

Figure A 4: Yahoo traffic cam and news

Source: http://nz.promotions.yahoo.com/news/traffic/auckland/southern/

A.2 Dedicated short range communication

Dedicated short range communication (DSRC) enables short range, one way or two way wireless communication between vehicles and infrastructure over 5.9 GHz radio frequency spectrum. DSRC utilises both static road side units (RSU) and dynamic on-board units (OBU) to communicate information about vehicle speed, position and more between infrastructure and vehicle (I2V), vehicles to vehicle (V2V) and vehicle to infrastructure (V2I). The low latency of communication and reliability of DSRC is highly advantageous in a range of active safety applications.

There are numerous safety applications for DSRC. Austroads AP-R375/11 (2011) reported the following potential applications that require the V2I / I2V component of DSRC:

- blind merge warning
- curve speed warning
- emergency vehicle signal pre-emption
- highway/Rail Collision warning
- in-vehicle amber alert
- in-vehicle signage
- just in time repair notification
- left/Right turn assistance

- low bridge/tunnel warning
- low parking structure warning
- pedestrian crossing information at intersection
- road condition warning
- safety recall notice
- SOS services
- stop sign movement assistance
- stop sign violation warning
- work zone warning

The following is a list of potential applications for the vehicle to vehicle component of DSRC:

- approaching emergency vehicle warning
- blind spot warning
- cooperative adaptive cruise control
- cooperative collision warning
- cooperative forward collision warning
- emergency electronic brake lights
- highway merge assistant
- lane change warning
- post-crash warning
- pre-crash sensing
- vehicle-based road condition warning
- vehicle to vehicle road feature notification
- visibility enhancer
- wrong way driver warning.

There are also non-safety related applications for DSRC such as tolling, traveller information, weather conditioning warning and congestion management however, DSRC is not often used for those applications as they can be serviced using other systems. The unique features of DSRC, such as the low latency of around 200 microseconds (μs) and a data rate of 6 to 27 megabits per second (Mbps) (University of Michigan, 2006), makes it more ideal for safety applications, particular collision avoidance which may not be equally served by using in-vehicle telematics over the 3G or 4G mobile network.

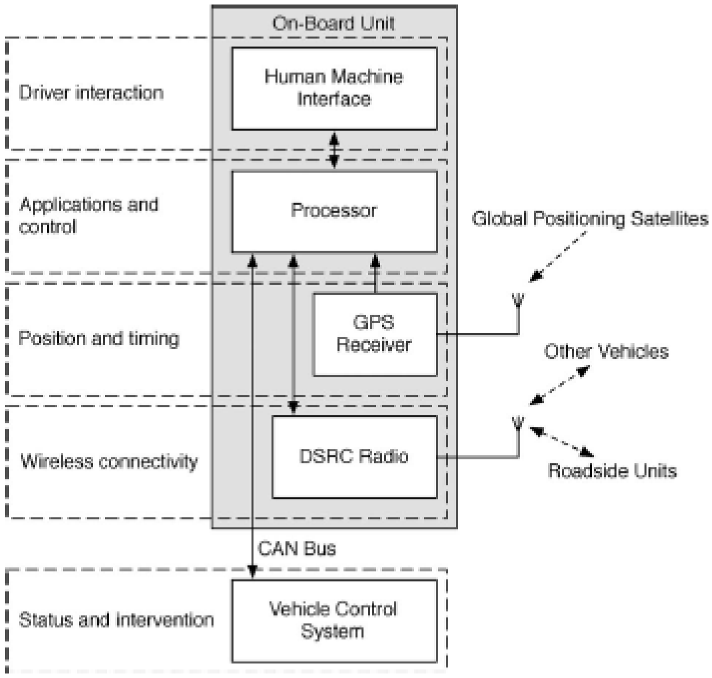
A.2.1 Hardware and components

The following sections explore the hardware and components of DSRC, standards and overseas trials.

There are two main components of the DSRC system: on-board unit (OBU) and roadside unit (RSU). The RSU is often installed on gantries at intersections or roadsides, but it can also be mounted on a vehicle and operated only when stationary. The RSU acts similar to a wireless LAN access point and can provides communication with the infrastructure. If required, the RSU must be able to allocate channels to OBUs. Additionally, there are Public Safety OBUs (PSOBU) which are vehicles with capabilities for providing services normally offered by RSU in emergency situations, such as those in police cars, fire trucks and ambulances.

The OBU is a unit that attaches to the CAN-bus of the vehicle and continually collects information about the speed of the vehicle, distance travelled and other relevant vehicle parameters. It may also have a GPS receiver to locate the vehicle on the route network and broadcasts that information in the form of a safety message to surrounding vehicles and infrastructure, typically at a rate of 10 times a second. The OBU would also be equipped with a DSRC transceiver or radio to enable communication with other OBUs and RSUs. The OBU may have its own human machine interface (HMI) or alternatively connect into the vehicle's HMI in order to provide visual, auditory and /or haptic (e.g. vibration) warnings to the drivers. A schematic of an OBU is depicted in Figure A 5 (Alexander et al, 2011).

Figure A 5: DSRC On-board unit



Source: Alexander et al, 2011

Additional hardware and sensors can be used to provide further information about road, traffic and weather conditions. The data and information systems can be integrated into the road side units, or transmit information to the road side units in order to provide information relating to traffic flow, congestion, weather and hazard warnings.

A small but growing range of Wireless Access in Vehicular Environment (WAVE) hardware devices are currently being developed and marketed by various vendors, including but not limited to programmable OBUs, roadside units, antennas and in-vehicle display units. The connectivity provided by some of the devices enable new applications to be developed by combining data from various sources.

Figure A 6: In-vehicle display, which can be a generic LED or LCD screen connected to the OBU

Figure A 7: Combined antenna for WAVE and GPS (left), roadside omni-directional antenna (right)

Figure A 8: In-vehicle display developed for demonstration using LCD TV

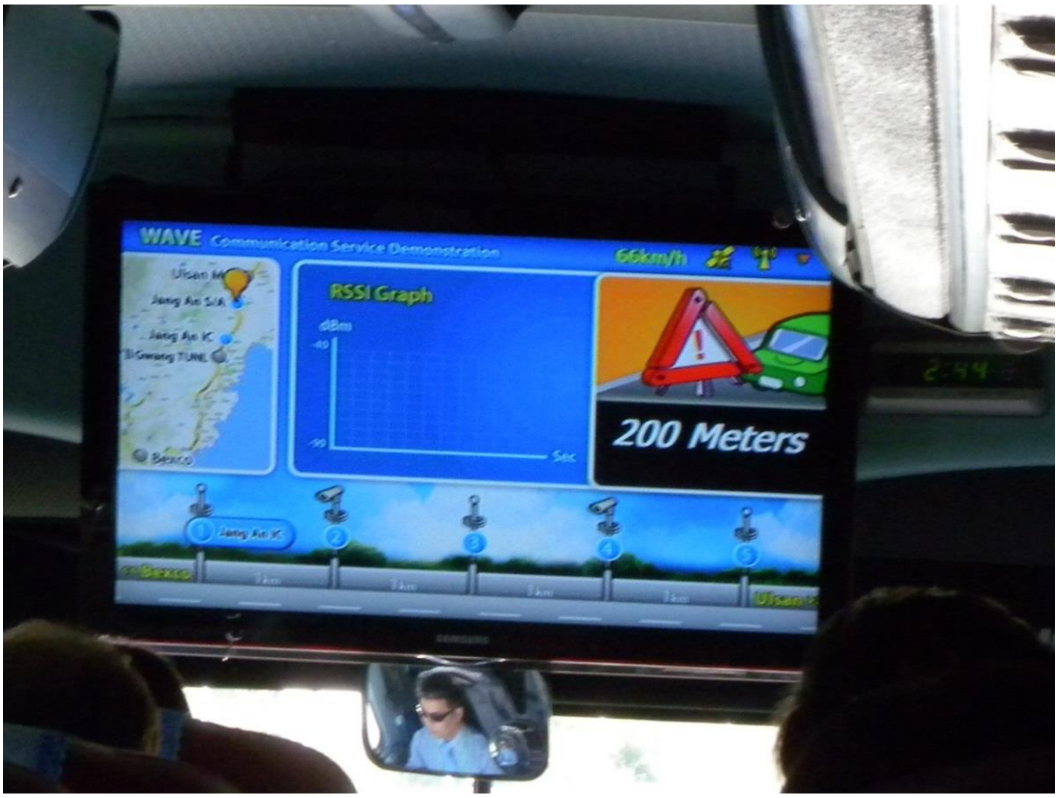


Figure A 9: Programmable roadside device for WAVE (V2I) applications

Figure A 10: On-board unit (equipment) for vehicles

Figure A 11: Back panel of on-board unit (equipment), noting serial, USB and LAN compatibility for connecting a range of equipment for potential applications

A.2.2 Standards

DSRC in the US and Europe operates in the protected 5.9 GHz frequency band which prevents interference with its safety applications. In order to provide greater support for safety applications, standardisation was introduced by IEEE for the wireless air interface under 802.11p (Now technically 802.11-2012), and other aspects relating to security, networking services and support for low latency V2V connections. Message sets have also been standardized under SAE J2735 by the society of Automotive engineers which provides the common language needed for vehicles to communicate with and understand one another. The standardised message sets cover the following, though the list is not extensive (Alexander et al, 2011):

- intersection collision warning
- lane change warning
- forward collision warning
- approaching emergency vehicles
- road work
- traffic signal phase
- pedestrians present.

The multiple channels in DSRC may be assigned to certain applications with some channels used for V2I collision avoidance, V2V collision avoidance, tolls, traveller information and more. The IEEE standards outline all the channel requirements along with the packet latency and more.

The Standards also divide the channels into two categories: a control channel and service channels. The Control channel broadcasting and coordinating communications which generally takes place in other channels. Although DSRC devices are allowed to switch to a service channel, they must continuously monitor the control channel. There is no scanning and association as there is in normal 802.11. All such operations are done via a beacon sent by RSUs in the control channel. While OBUs and RSUs are allowed to broadcast messages in the control channels, only RSUs can send beacon messages.

A.2.3 Australian and overseas trials of DSRC

This section lists the trials that have been undertaken, or are in progress in Australia and overseas involving DSRC. The majority of the studies are testing the technical aspects of the technologies, such as their communication and processing capabilities and standards rather than the safety or productivity outcomes gained resulting from the use of this technology.

Australia

There are several DSRC trials in progress within Australia and overseas. The first Australian trial known as ConnectSafe, conducted by the University of South Australia and sponsored by Cohda Wireless, who also developed the DSRC system and radio. The DSRC field trials tested over 15 different V2V and V2I scenarios for the effectiveness of the Cohda radio system, a few examples are listed below:

- intersection collision warning
- left turn assistant
- lane change warning
- pre-crash sensing
- road side unit.

Cohda conducted over 700 trials covering around 10,000 km of distance travelled and transmitted over 100 GB of data (Gray et al, 2009). The results showed that the system was able to transfer information accurately at low latency and high speeds, thereby demonstrating its suitability for applications in crash prevention, although specific quantitative measures of benefits have not yet been published.

United States

The USDOT's Research and Innovative Technology Administration has been conducting the SafeTrip-21 (now incorporated into Connected Vehicle) with the hope of reaching up to 10,000 volunteers participating in the program. As the field tests have not concluded, there are very few results on the benefits and improvements on safety and congestion. The Connected Vehicle program aimed to demonstrate the effectiveness of wireless technology in providing connectivity in V2V, V2I and V2D (vehicle to devices carried by pedestrians, cyclists and so on) interactions. The wireless communication system is about to identify, collect, process, exchange and transmit data in real time to drivers and other road users in order to provide awareness of potential events, threats and hazards within the user's environments. As of yet, there has been no quantitative estimates of crash reduction made from these trials (Austroads, 2011).

Europe

In Europe, a consortium of large vehicle manufacturers and suppliers, telecommunications companies, research organizations and road authorities established the Safe Intelligent Mobility – Test Area Germany (SIM-TD) study with the intention of developing and improving communication and connectivity between infrastructure and vehicles to improve safety and mobility. This study involved instrumenting network vehicles and infrastructure with communication devices using an automotive-optimised version of WLAN standard. This study used real time traffic information collected from the OBUs of passing vehicles sent to RSUs positioned at selected traffic nodes. The information is then sent to a major traffic control centre for processing, with relevant information forwarded to vehicles that may be affected by the contents of that information (Austroads 2011).

So far, the focus of the SIM-TD study has been more on the technical development and capabilities of the systems used rather than safety, for example:

- communication systems that enable devices of various makes for vehicle and traffic management systems to communicate effectively
- techniques for determining vehicle position and map creation
- extended protocols for vehicles and infrastructure to verify and share data with other vehicles and infrastructure in close proximity.

Safespot is another study in Europe utilising DSRC to communicate safety information between vehicles and infrastructure but with the aim to improve road safety. (Safespot, n.d) There are currently test sites in Italy, Sweden, Netherlands, Germany, France and Spain. Each test site examine the impact on accidents in different application scenarios and for either suburban, urban or motorway contexts. Since the trials are still in progress, no results on safety improvements have been published.

A.3 In-vehicle telematics

In-vehicle telematics are devices that can be installed into the CAN-bus (Controller Area Network) of a vehicle that then proceeds to collect information about the vehicle's speed, and distance travelled, braking, etc., while using a GPS receiver to locate the vehicle on the road network. A transceiver is an integral component of vehicle telematics devices as they need to be able to communicate wirelessly using mobile data (3G or 4G) with the service provider or with other controllers. They may also be equipped with short range communication devices for communication with other vehicles or roadside infrastructure.

The information collected is then processed on-board, stored or transmitted to a server for processing. Data relating to the vehicle's speed, position, braking, acceleration and idle time can all be analysed to determine if there is congestion on the network or a hazard further up ahead. This can also be used to estimate travel time, hence the application of this technology for productivity benefits is promising. Some telematics devices are also equipped with additional sensors and accelerometers for remote diagnostics, compliance warnings or to alert drivers of changing situations up ahead, i.e. road works, collisions, change in the posted speed limit, etc.

The list of applications for in-vehicle telematics is shown below; it is by no means exhaustive:

- Safety applications
  - fatigue detection
  - early collision warning and avoidance
  - roll-over warning
  - speed warning,
  - modifying/monitoring driver behaviour
  - hazard warning
- Railway intersection warning
- Compliance and monitoring
- Load monitoring (i.e. has something fallen off?)
- Convey locations of rest stops
- Productivity and efficiency applications:
  - travel time estimation
  - alternate route planning
  - signal pre-emption (i.e. extended green time going uphill and force stops going down hills for grade)
  - compliance monitoring through the intelligent access program
  - congestion alleviation
- Commercial applications
  - inventory tracking and monitoring
  - platooning
  - emissions monitoring and fuel consumption
  - maintenance and asset management
  - insurance
  - security
- Road user charges/pricing
- Tollways
- Data collection on roads and structures.

In-vehicle telematics is highly adaptable and customisable. When coupled with geo-fencing it has the potential to provide speed limit warnings, steep grade warnings and signal pre-emption warnings. There are some uncertainties relating to whether or not telematics devices are able to interoperate with external systems such as traffic signal controllers and the data and information systems. The main advantage in in-vehicle telematics is that there will be very little infrastructure investment required on behalf of state road authorities to provide.

The road freight sector may benefit from the uptake of in-vehicle telematics in a number of ways, from reducing operational and maintenance costs by monitoring fuel consumption and driving behaviour, improving driver safety through fatigue management, to increasing efficiency and productivity by gaining better access to infrastructure. Recognising the direct benefits to freight operators and the secondary benefits of improved productivity, safety, compliance and environmental outcomes, the National Transport Commission (NTC) highlighted the need to develop a policy framework to address (and encourage) the uptake of in vehicle telematics among the freight industry (NTC, 2011). The report also provides several case studies arguing the benefits for industry as well as providing insight into concerns held by some operators regarding in-vehicle telematics.

The potential benefits of in-vehicle telematics for road freight operators are emphasised repeatedly. A case study in the report highlighted the initiative taken by Woolworth's transport division, in which the company adopted new technologies and specifically designed trailers in 2009 to better plan, optimise track and monitor outbound freight movements. Some of the reported benefits included 'real-time visibility' of the vehicle fleet that enabled proactive management of delivers into stores. Woolworths also had plans to reduce emissions by 25% per carton by 2012, by reducing trips and improving supply efficiency. Similarly, Linfox promoted the advantages telematics due to the convenience and ease of real-time tracking of truck movements as compared with 'out-dated paper-based record keeping'.

Ample benefits and opportunities also exist for governments and communities through greater uptake of in-vehicle technology. Improving road safety and compliance are high priorities for road managers and asset owners, so too is the management of vulnerable infrastructure, such as bridges, and proper environmental management. Additionally, high productivity and cost efficient freight may have the effect of reducing the costs of goods and services, thereby making Australian exports more competitive. The reduction of road fatalities and injuries through safety compliance is of great benefit to all road users, and a reduction in the number of truck trips leading to lower energy use and vehicle emissions is a desirable outcome for the environment.

The doubts surrounding the above assertions stem mainly from three factors: regulatory certainty, financial investment and privacy. Industry may be reluctant to invest in in-vehicle telematics due to a lack of policy certainty, so there is the fear that they may end up investing in systems that may not be recognised by government policy further down the line. There is also the concern that the lack of coordination between states regarding telematics policies may mean the need to invest in multiple black boxes for companies that regularly travel cross borders. Nevertheless, balance is required to ensure some certainty for industry without stifling technological innovation through excessive prescriptive standards. Another key issue involves privacy. The Executive Director of the Australian Road Train Association, John Morris, raised concerns from operators about the GPS unit in the in-vehicle telematics aiding in 'big brother' style enforcement which may lead to prosecution over minor breaches. As such, government has a role to provide policy and regulatory certainty to encourage industry and businesses to invest in in-vehicle telematics thereby promoting greater voluntary up take. This may involve cooperation between government, community and industry to develop the framework necessary to support new technologies that would benefit all stakeholders. The NTC report (2011) states that a national approach is necessary for telematics use as national consistency 'delivers economies of scale' that would result in greater uptake within the industry

A.3.1 Productivity

For freight operators, the desired outcome of implementing new technology is to maximise profits by carrying more payload per trip, while improving the safety of their drivers and vehicles, to reduce operation and maintenance costs, improve efficiency (reducing down time for their vehicles) and reduce costs associated with non-compliance with regulations and laws. Improving these outcomes for the road freight industry also benefits the wider community as productivity growth is typically linked to better standards of living (BITRE, 2011)

Technological innovations and advances, increasing organization efficiency and re-allocation of resources to more productive areas (BITRE, 2011) are the main contributing factors to increasing productivity. In terms of technological innovation, there was a shift from using rigid trucks to articulated semi-trailers, B-doubles and now, B-triples and AB-triples. The road freight industry was able to increase productivity by 300 per cent since 1971 due to improvements in vehicles that allowed a doubling of freight carried per vehicle kilometre from 9.7 tonnes to 20 tonnes and an increase in the average distance travelled by articulated truck to over 90,000 km per vehicle per annum in 2007 (BITRE 2011). Eventually the upper limit in the size and mass of vehicles that can be supported by road infrastructure will be reached. As such, other innovations in technology, organisational efficiency and re-allocation of resources would be required to drive the growth. In-vehicle telematics is the technological innovation that facilitates organizational efficiency.

The BITRE report (2011) also highlighted future prospects for freight productivity growth involving greater volumes of the road freight carried by B-doubles and larger combination vehicles such as AB-triples and B-triples, as well as greater uptake of PBS vehicles and increasing participation in IAP.

The BITRE report (2011) did not mention the impacts that bigger, heavier combinations will have on pavements, surfaces and structures. However, the financial cost of the maintenance and repairs required to provide an acceptable level of service, may rise due to the interaction of heavier vehicles on the road network. This issue may require reform of current heavy vehicle charging and road funding models may be required, and the information collected from in-vehicle telematics devices may be used to inform policy and technical decisions of this nature.

In-vehicle telematics have potentially limitless applications directly relating to productivity or could address other issues such as safety, emissions, fuel consumption or remote diagnostics which may indirectly benefit productivity and network efficiency.

Intelligent Access Program

An application for in-vehicle telematics devices for heavy vehicle operations The Intelligent Access Program (IAP) enables participating vehicles to have greater access to the road network in exchange for monitoring. The vehicles participating are not necessarily prescriptive and may be innovative vehicles. These may include Performance Based Standards (PBS) vehicles, vehicles with a quad axle group which enables them to carry a greater payload, mobile cranes and special purpose vehicles. IAP is a national program but the operating conditions and requirements are set by each of the jurisdictions, however, participating vehicles and transport operators must only use service providers and devices that have been certified and approved by Transport Certification Australia (TCA) to operate.
There are benefits for both the transport operators and the road authority/owner from implementing compliance monitoring using in-vehicle telematics. D’Souza et al. (2005) explored the economic benefits from implementation of IAP in New South Wales by the Road Transport Authority (now Roads and Maritime Services) using the Mobile Crane Concessional Benefit Scheme (MCCBS) as a case study. There was a reported benefit to crane operators, as a result of improved efficiency and productivity, is in excess of $250,000 annually.

The benefits far outweighed the cost of the fitting the vehicles with GPS tracking equipment. Additionally, RMS (formerly RTA), reported benefits including better confidence in compliance, better enforcement, and high level of overall compliance with route restrictions. It was also reported that no regulatory amendments were required for the MCCBS; rather, it was developed by RMS and agreed to by the Crane Industry Association of NSW. As such, RMS developed their own service provider requirements and accredited the providers themselves. Nevertheless this is a case where IAP, and thus in-vehicle telematics and cooperation between industry and government, has demonstrated quantifiable productivity benefits.

Signal pre-emption and extended green times

Greater network access for vehicles exceeding size and mass limits usually works to improve productivity, but another is reducing the total travel time and operating costs of laden vehicles to their destination.

This could be achieved in a number of ways such as reducing the amount of time spent queuing at intersections and reducing the time spent below the posted speed limit. Signal pre-emption, extended green times and green waves can reduce a heavy vehicle's time slowing down at intersections, queuing, waiting at the lights and accelerating to the speed limit. The impact of vehicle noise as a result of reducing truck acceleration and deceleration will also be reduced.

This is particularly beneficial for heavier combinations approaching intersections located on upgrades, as starting the vehicle and accelerating to the speed limit from a total stop generally requires more work and consumes more fuel, causing wear and tear on the engine and result in less time spent at the posted speed limit. This is also true for the vehicles travelling behind the heavy vehicle, especially if they have no means of overtaking or turning off. Signal pre-emption for laden heavy vehicles, implemented on key freight routes and enabled during non-peak periods, may have a beneficial effect on productivity without inconveniencing other road users.

Signal pre-emption is typically reserved for emergency vehicles and public transport (buses, trains, and so on). The literature search was not able to find a great deal of past experiences and analysis on the specific application of signal pre-emption for heavy vehicles, and as such, the economic implications may need to be explored in greater detail in future projects. This section will discuss current signal pre-emption technologies and trials, and how in-vehicle telematics may be used to serve the same purpose.

Signal pre-emption is a system that integrates with a signal controller that disrupts the controller's regular operation to enact a pre-emptive state upon receiving a pre-empt signal. The pre-empt state often involves manipulating the phase of traffic signals in the path of the subject vehicle, thereby reducing its journey time. The most common application of signal pre-emption at intersections is for emergency vehicles, but it can also be found in railroad pre-emption.

The existing hardware for the pre-emption system and their properties are outlined in Table A 3.

Table A 3: Systems for signals pre-emption

Device	Description	Advantages	Disadvantages
Acoustic sensor	▪ Acoustic sensor is linked to the traffic controllers. ▪ Activated by sound pattern, i.e. sequence of tweets and wails. Source: (Mascarenhas et al, 2013)	▪ Inexpensive system ▪ Easy to integrate with existing traffic signals ▪ Can be modified to accept signals already on emergency vehicles (no need for special equipment)	▪ Sound waves easily reflect off buildings or large vehicles which can trigger pre-emption events in wrong direction. ▪ May trigger pre-emption events in streets adjacent to emergency vehicle

Device	Description	Advantages	Disadvantages
Emitter and receiver	▪ Vehicle is equipped with emitter and the signals have receivers. ▪ Uses infrared signals or visible strobe light emitted at a specific frequency. ▪ Requires line of sight to function. Once vehicle passes the signal, normal operation resumes.	▪ Can be used to prioritise specific vehicles by the frequency of the emissions received, i.e. emergency vehicles may have higher frequencies than buses or trucks. ▪ The set-up is not complicated.	▪ Any objects that block line of sight between emitter and transmitter can be an obstruction. ▪ Direct sunlight on receiver may prevent it from detecting signal. ▪ Heavy precipitation may reduce the distance at which system may function. ▪ Signal may be picked up by many traffic lights along a stretch of road, causing undesired activation. ▪ Additional infrastructure equipment to maintain.
Global Positioning System	▪ Tracks the location of activating vehicle. ▪ Software needs to know where the vehicle is heading, which lights to pre-empt and then activate the lights. Source (Dock, 2010)	▪ No more line-of-sight issues or issues with range, obstruction or weather. ▪ No infrastructure information to maintain. ▪ Automated control system pre-empts vehicle route. ▪ Software is upgradeable. ▪ Relatively inexpensive	▪ Tall buildings can obstruct GPS signals that are required for triangulation to determine location. ▪ Subject to Single point of failure risk unless redundant system is installed. ▪ Dense cloud cover can prevent system from acquiring three GPS satellite signals.
Radio-based systems	▪ Radio-based system using the 900 MHz band of the spectrum. ▪ Operates over a short range. ▪ Recent application of frequency hopping spread spectrum to overcome interference with signals from other devices.	▪ Not impeded by physical obstructions, weather or light conditions ▪ Adjustable range attained through varying strength of radio signals. ▪ Collision avoidance warning is also possible if surrounding vehicles have the same hardware installed.	▪ Short range operation

STREAMS trial in Queensland using GPS system for emergency vehicles

In Queensland, Transmax, (provider of the adaptive traffic management system and ITS platform, STREAMS), and the Queensland government started trialling the Emergency Vehicle Pre-emption (EVP) project. The system utilises a combination of computer-aided dispatch, GPS and traffic management technology in order to locate an emergency vehicle en-route, calculate times of arrival at intersections and signal to traffic signal controllers to provide a green light in advance of the vehicle's arrival. The EVP is also highly adaptable and is able respond to route changes made by emergency vehicle. (Transmax, 2013).

Transmax reported that no specialist hardware was required, rather, the existing in-vehicle devices (mobile data terminals used for incident/case information reporting), was used to provide the vehicle tracking information. The signal controls were also readily modified on the STREAMS back end to accept the signals, hence the cost associated with EVP was not very high while delivering benefits to emergency services, road authorities and communities.

The trials first ran in Bundaberg in 2008, after successful implementation it was expanded to Southport on the Gold Coast in November 2012. A case study of 20 EVP-enabled emergency response vehicles in Southport showed improvements in travel time of between 10-18% along major routes. The vehicles received more than 600 green traffic lights per week supporting more than 100 incidents per week.

Pre-emption using in-vehicle telematics is a relatively novel concept; therefore the technical details are not readily available. Verbal correspondents with telematics service providers, such as MTData, revealed that it is possible to accomplish this on the telemetry data provider side.

Conceptually, this can be done by establishing a geo-fence in the vicinity of the intersection. When a heavy vehicle goes through that geo-fence, the on-board telemetry device sends a signal to the data provider’s server, i.e. a form of polling, advising the heavy vehicle’s presence. The information can then transmitted to an external system, e.g. STREAMS, via an application programmable interface (API). It is understood that STREAMS can accept data/ triggers from external sources and thus it is conceptually feasible to implement signal pre-emption using in-vehicle telematics devices with system modifications and application development.

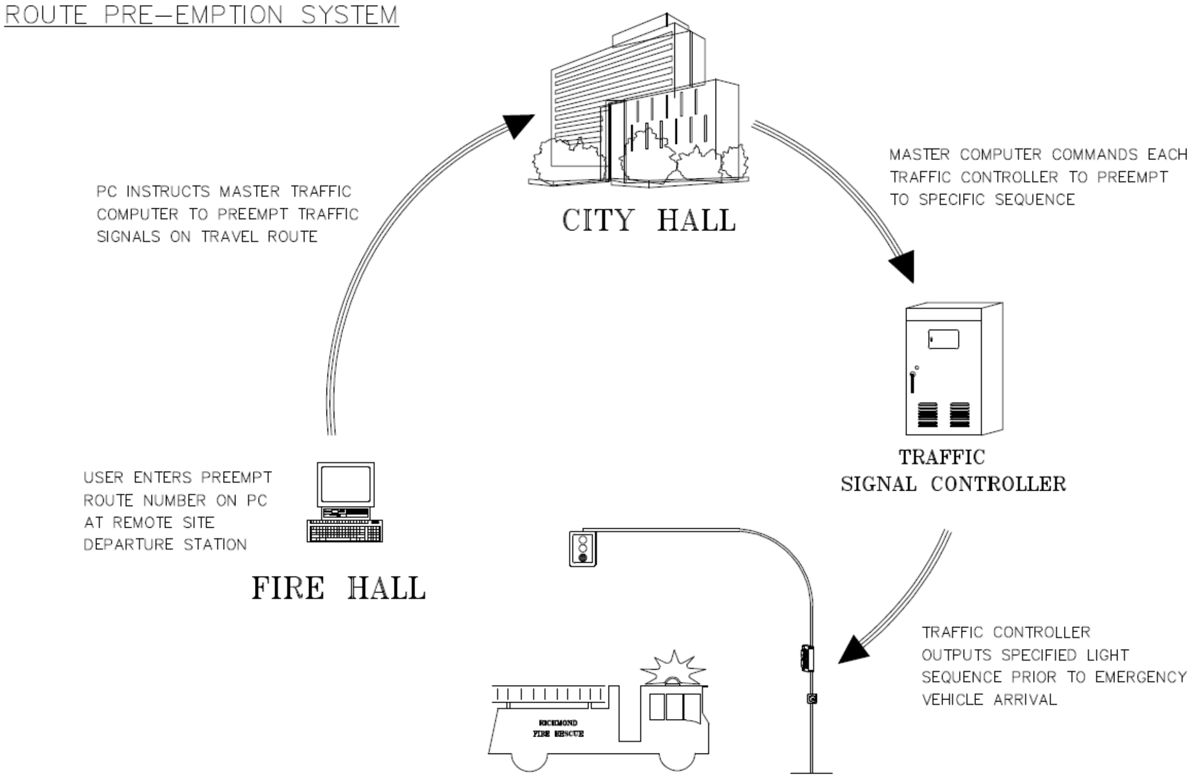
The latency of 3G/ 4G systems is not considered an issue in this type of applications, but that is subject to the quality of coverage at the intersection. This will have to be verified with the telecommunications supplier prior to site selection.

Pre-emption trials in British Columbia in Canada

Bycraft (2000), reported on the success of a software based route-pre-emption system implemented in Richmond, British Columbia (Canada) for emergency vehicles. The system, was designed by the City of Richmond in cooperation with the traffic signal system hardware and software supplier. The pre-emption system has a traffic control centre which monitors all pre-emption activity. This system differs from the systems mentioned above, as it does not utilise emitters/receivers or GPS but instead, the route the emergency vehicle takes needs to be entered into the system in advance and as the vehicle passes key monitoring locations the signals change to accommodate them. This method is shown in Figure A 12.

The signal pre-emption requires the route to be entered before-hand, and as such, if the vehicle goes off course, the pre-emption will no longer be effective. Using a GPS based in-vehicle system may enable dynamic route pre-emption thereby allowing the vehicle to take another route if necessary without losing the signal pre-emption.

Figure A 12: Route pre-emption system for the City of Richmond, Columbia



This method could be utilised if cooperation between the telematics providers and Transmax could be obtained. It may require the driver of the heavy vehicle entering a pre-planned route into the system, is then sent to a computer at STREAMS that handles these requests. STREAMS can then send the commands to traffic signal controllers to pre-empt to the signal by that specific vehicle. Instead of the installing beacons around various points in the area to pick up the vehicle's signal, a geo-fence can be established. When the vehicle crosses the geo-fence, the signal controllers would receive the signal and begin their phase to give the vehicle a green light when it arrives at the intersection.

A.3.2 Applications for safety

This section outlines safety applications for in-vehicle telematics, such as preventing accidents that are the result of driver fatigue and driver behaviour. It may also include advance hazard warnings regarding flooding, bush fires, adverse weather conditions or accidents enough time and distance in advance of the vehicle to enable the driver or fleet operator to revise their plans.

Fatigue management and mitigation

Fatigue is a major safety issue for the transport industry as they could lead to accidents and resulting in potential loss of life. Heavy vehicle drivers are required by law to plan rest breaks into their travel time, and also to complete entries in written work diaries that record the number of hours they have driven without rest, and the length of their rest breaks for each journey. This is to ensure that they comply with the requirements of fatigue laws.

Electronic Work Diaries (EWD) are an alternative to the paper based work diaries that are time consuming for drivers to fill out, with no mechanism for ensuring that the information entered is accurate. An electronic system that enables the driver to interact with an electronic interface, i.e. pressing a button for when they start driving, and pressing it again when they stop to take a break, requires less effort on the drivers part, as the system collects the information. There are other advantages in electronic based systems over paper systems, mainly in functionality. Electronic systems have the capacity to transmit information to fleet managers that could monitor the progress of their fleet and compliance of their drivers to fatigue laws in real time. Depending on the functionality of the EWD, they can also be used to verify the driver's entries with information relating to engine operation (such as stop time, running time and idle time) and detect breaches of the law.

Currently, electronic systems are not mandated by law, but freight operators have started adopting the technology to better manage driver fatigue and speed compliance. The NTC (2010) released a policy paper addressing the key policy issues surrounding electronic work diaries and electronic systems used for managing fatigue while Transport Certification Australia (TCA) released a report on 'EWD Functional and Technical Specification' (TCA, 2013) providing specifications for in-vehicle units Type-approval, electronic work diary service providers and User Interfaces Type-approval.

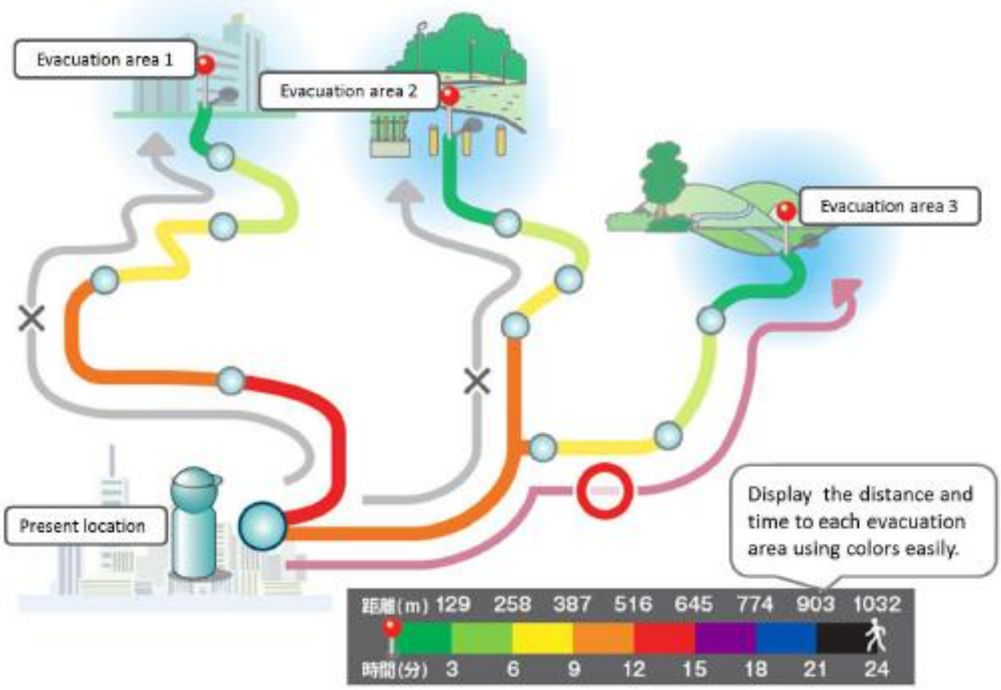
Hazard detection, reporting and warning

The majority of in-vehicle devices, depending on the type, have a screen to communicate information to the driver such as warnings for exceeding the speed limit, route, total driving time and more. These devices thus have the potential to convey to the driver, information relating to disasters, road hazards, accidents and severe weather warnings. The information could be taken from floating car data, road side beacons or from websites such as the Bureau of Meteorology and 13 19 40. However, a data portal to fuse and share the information feeds is not currently available in Queensland.

Matsuda et al (2013) described how the Internavi system by Honda Motor Co was utilised during the 2011 Japan Earthquake and Tsunami. Honda provides a free communication service called "Link up free", for registered customers with the Internavi systems installed in their vehicles. The communication service enables data from the system to be uploaded for free to a centralise server which, provides the latest traffic information back to the user in return.

The vehicles are always connected to the server so they are notified of any changes to the conditions ahead in real time. During the Earthquake, a map showing areas of seismic activity and intensity followed by icons of waves to indicate tsunami advisory or warning was shown for drivers in the vicinity of the disaster. Emails were also sent out to registered emails of friends and families of the driver who was in the vicinity of the incident, notifying them of the situation and providing a location of the car and its safety. The system was also particularly sophisticate as it was able to identify areas of major congestion from floating car data, and identifies the safest route to an evacuation area as demonstrated in Figure A 13.

Figure A 13: Honda Internavi system that identifies quickest routes to an evacuation area during disasters



The system, however, still relies on telecommunication networks for broadcasting the warnings, and may be affected by the disasters resulting in ineffective communication.

Currently, TMR's 13 19 40 web site provides a large amount of useful information for users. However, the layout is not considered suitable for use en-route. The provision of the datasets via an API will allow third party providers to push the data to drivers via in-vehicle display units. More effective sharing of incident information can enable better route selection or diversion, which will reduce the overall costs borne by heavy vehicle operators.

The telemetry data from third party providers may also be useful for TMR to identify incidents if their information is shared with TMR. An algorithm can be developed using heavy vehicle telemetry data and on-board sensors to detect abnormal driving behaviours calibrated to local conditions. The initial results of a Chinese research indicated that such system has good potential in detecting abnormal driving behaviours, with 100% detection rate, 6.0 seconds of mean detection time, and less than 0.5% false alarm rate (Wang et. al., 2009). This is an area of research with significant potential.

In the United States, researchers looked at using vehicle telemetry data for prediction of severe injury crashes to help determine appropriate emergency medical service response (Ayoung-Chee et. al., 2013). The early results appeared promising and such applications can reduce the overall costs of road trauma and incident response.

Collision avoidance

The aim of most collision avoidance system is to notify drivers that there is an obstacle in their path, e.g. stalled vehicle, dropped load, stationary queue.

In order for real time collision avoidance applications to be effective, the latency for the transmission must be very low. For DSRC, the typical latency is 200 microseconds for in-vehicle telematics transmitting over the mobile network utilising GSM may have latencies between 1.5 to 3.5 seconds (University of Michigan, 2006).

Since 2006, the advent of 3G and 4G networks means that latencies over mobile networks are as low as 100 milliseconds. Safety applications in this area remain promising but no known integration with in-vehicle telematics and mobile communications have been found. It is also considered that vehicle manufacturers have a greater role in developing collision avoidance systems using V2V technologies than road authorities using V2I technologies.

A.3.3 Interoperability

Interoperability is described as the ability of different systems to work together to produce a desired outcome. Interoperability can apply to both technical systems and social systems. The unpublished Austroads report, ‘C-ITS interoperability with existing ITS infrastructure’, outlines how road authorities may integrate emerging and existing C-ITS and ITS technologies and the benefits and risks associated with them.

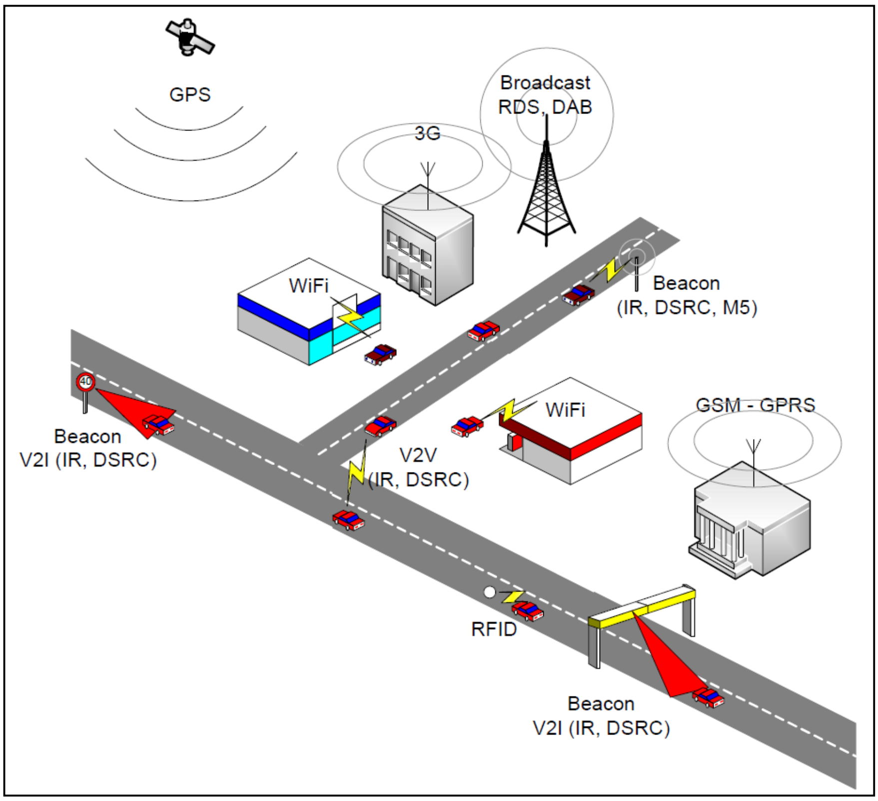
The report mainly discusses how interoperability can be achieved for DSRC 5.9 GHz ITS, vehicle ITS, speed limit systems and traveller data collection systems. For the purpose of this report, interoperability will be examined in the context of vehicle telematics, traffic signals and travel information collection technologies rather than 5.9 GHz architecture which the report mainly focuses on. Interoperability is important to enable new and old ITS technologies to communicate and function with minimal disruptions between them but the challenges lies in interoperability between many different in-vehicle telematics systems and the TMR infrastructure.

The report identifies four categories of interoperability:

- The technical operability refers to hardware/software of the system and the platforms that enable communication between machines.
- Syntactical interoperability refers to the agreed upon data format which is the ‘language’ that enables understanding between machines.
- Semantic interoperability refers to comprehension of the message received by the machine that enables it to execute commands to achieve the objectives of the message.
- Organizational interoperability refers to the ability of the organisation to exchange data across systems. The business processes and architecture are required to have consistency and is highly dependent on the level of syntactical, semantic and organizational interoperability for its success.

C-ITS provides connectivity between road users and the roadside environment. Figure A 14 illustrates C-ITS utilising a number of wireless mediums and technology, each of which will need to be interoperable with the vehicle. The uses of a variety of wireless technologies, in addition to the fact that these different wireless technologies and services may be managed by different entities (incl. private companies) adds an extra layer of complexity with respect to the interoperability of ITS.

Figure A 14: Wireless media required for ITS



Source: Austroads (2011)

Architecture

The conceptual model defining the structural components and relationships of a system is its architecture. The three layers that make up system architecture are:

- reference architecture
- logical architecture and
- physical architecture.

The reference architecture, which is the highest level, provides the scope and concepts of the system architecture and delivers a framework for the logical and physical architectures to build on, including plans for current and future services, facilities and the functional linkages between them. The logical architecture expands on the details relating to components of the systems, the functional linkages and interrelationships required for the service to function.

The logical and reference infrastructure systems represents the strategic national ITS deployment scenario. The physical architecture defines the actual physical systems to enable the services to be delivered. The physical architecture ensures that the interfaces are standardised to enable interoperability.

Austroads project NS1696 (Austroads, 2014) recommended the adoption of the European FRAME architecture, by Australia and New Zealand, for the reference and logical tiers of the system architecture due to it being less prescriptive and aligning with local ITS requirements. The key features of this architecture, as described by FRAME (nd):

> '…is that it is designed to have sub-sets created from it, and is thus unlikely to be used in its entirety. Indeed, on occasions, it contains more than one way of performing a service and the user can select

the most appropriate set of functionality to deliver it in that environment. Thus the FRAME architecture is not so much a model of integrated ITS, as a framework from which specific models of integrated ITS can be created in a systematic and common manner'.

The FRAME reference architecture level provides concepts based on users, the services and the functional linkages for ITS while the logical architecture level provides details on actual components of the system and how they inter-relate. This is an area that may need further consideration in developing future projects.

ITS Station Architecture, based on the COMeSafety Architecture, involves various ITS layers as summarised in Table A 4.

Table A 4: ITS station reference architecture

Layer	Function
Horizontal layers	
'I' – ITS access technologies	▪ Communication infrastructure ▪ Operating system ▪ Routers ▪ Gateways and hardware (sensors, actuators, antennas, etc) ▪ Combination of the media access control (MAC) and physical (PHY) layers of the seven layer open systems interconnection model (OSI)
'N' – ITS network and transport layer	▪ Runtime layer on which applications operate
'F' – ITS facilities layer	▪ Provides functions to support applications for tasks. ▪ Tasks include access to data inputs from other systems (such as vehicles and roadside sensors) ▪ Provides communications and access to information such as maps
'A' – ITS application layer	▪ Provides applications of end-user services
Vertical layers	
'M' – ITS management layer	▪ Responsible for configuration and exchange of information between layers
'S' – ITS security layer	▪ Provides security and privacy for users

Source: Unpublished Austroads report NS1785

Internal interfaces between the layers are categorised into:

- ITS station management interfaces: enables interaction between M and the I, N, F, S and A layers.
- ITS station security interfaces: enables interaction between S with and the I, N, F and A layers.
- ITS station communication interfaces: enables interaction between N and I, F and N, and F and A.
- ITS station application programing interfaces: implementation of MA, FA and SA intersections. Connects ITS station applications to the ITS station facilities layer sand the ITS station security and management entities.

Interoperability with STREAMS

It is understood through ARRB's discussions with TMR that STREAMS has the ability to communicate with external systems. Therefore, the interoperability of systems with STREAMS does not appear to be a major concern, provided that the specifications of the API's are clearly understood by parties involved with the information sharing and system triggering arrangements.

A.4 Regulatory guidelines

A.4.1 Role of Industry

The term 'industry' is used to encompass the in-vehicle telematics suppliers and service providers as well as the freight industry. This section outlines the role of industry in the C-ITS discussion, particularly relating to in-vehicle telematics.

Some operators are using in-vehicle technology for the following applications:

- vehicle performance and driver monitoring
- scheduling improvements
- route optimisation
- vehicle and load tracking
- safety management analysis.

The Uptake of in-vehicle technology, or other innovative technologies relating to the freight industry for that matter, has been found to be variable (NTC, 2011) with larger fleet operators being considerably more well equipped than smaller fleets that do not have the benefit cost ratio to justify the purchase of in-vehicle telematics. As such, regulatory and policy certainty are important for encouraging uptake of new technologies by smaller fleets.

Industry can assist government efforts through cooperative action to develop standards and share information along the supply chain, ensuring that the benefits of technological investments for all parties are clearly identified (NTC 2011).

A.4.2 Role of government

As of 2006, there were 695 telematics companies listed on the Telematics Update Business Directory (Telematics Update, 2012). It is uncertain how many of these companies service Australian businesses, however, it is clear that in order to obtain wider benefits in terms of productivity and safety, using in-vehicle telematics, especially with regards to interoperability of individual units and infrastructure system, regulatory framework would be require.

The role of government in providing policy certainty for emerging technologies is not negligible, as alluded to earlier. Regulation frameworks and policies could lend certainty to operators, especially small operators, by clearly identifying the regulatory compliance benefits to be gained from investing in in-vehicle telematics (NTC 2011).

The NTC report identified that although telematics has been addressed in specific areas of regulation such as access, fatigue, and speed and mass compliance, the approach to dealing with these and new responses lack consistency, due mainly to the absence of a central policy. Government and industry would need to collaborate in order to devise a regulatory policy that would facilitate the take up of in-vehicle telematics.

How much the wider community will benefit from in-vehicle telematics (in an economic, environmental and societal sense), relies on in-vehicle telematics being widely implemented. Another aspect where regulation is crucial is the information sharing in the supply chain which involves sharing vehicle or inventory data between operators.

Smaller operators may view the idea of data transparency to be less beneficial to them than to the big operators. Government policy can help to inform industry by developing information technology standards and platforms to enhance the transfer of information along the supply chain.

The following responses required of the partnership between industry and government were suggested by the NTC (2011):

1. Remove barriers and any form of market or policy failure necessary to assist users of telematics applications to obtain benefits from uptake of new services and products, and providers of telematics to achieve adequate return on their investment.
1. Promote standards development and interoperability protocols through a government industry partnership, with a focus on removing barriers and market and policy failures, as well as promoting second-order benefits.
2. Identify large and multi-user applications which can be brought-to-market by major stakeholder(s) to grow scale and scope in the telematics market, as a contribution to an industry and market development plan.
3. Ensure that any application which has a regulatory function, whether mandated or otherwise, is subject to normal COAG regulatory assessment principals.
4. Encourage the pursuit of telematics services, standards and protocols that deliver additional benefits to industry and the community.

Progress being made in this area will be monitored and considered during the development of future projects.