TMRD26 Master System Architecture and Design

Ipswich Connected Vehicle Pilot (ICVP)
Cooperative and Automated Vehicle Initiative (CAVI)

March 2022

Queensland Government

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Departmental approvals

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19/08/2021	Nicholas Brook	Principal Engineer	Create	Q4 2021
22/12/2021	Ronald Elunai	Principal Engineer	Create/update	Q4 2021
24/12/2021	Nicholas Brook	A/Director	Review	Q4 2021
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28/01/2022	Ronald Elunai	Principal Engineer	Update	Q1 2022
31/01/2022	Nicholas Brook	Principal Engineer	Review	Q1 2022
31/01/2022	Miranda Blogg	Director	Review / approve	Q1 2022

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1.01	21/12/2018	David Ross	Review initiated; pending item 6 obsoleted; minor edits and corrections
1.02	18/6/2020	Stuart Allen-Keeling	Review and Update – Contract examination finalised; risk assessment referenced
2.0	23/07/2020	Stuart Allen-Keeling	Updated system description, reviewed controls
3.0	05/07/2021	Peter Chalmers	Major update and restructure
3.1	05/07/2021	Nicholas Brook	Review of proposed structure
3.2	19/08/2021	Nicholas Brook	Review and content creation
3.3	25/11/2021	Ronald Elunai	Review and Update – restructure to use the ARC-IT model, and graphics from the SET-IT tool
3.4	24/12/2021	Nicholas Brook	Review updated version
3.5	27/01/2022	Ronald Elunai	Updated post-review
3.6	31/01/2022	Nicholas Brook	Final review
3.7	31/01/2022	Miranda Blogg	Final review and approval

Executive Summary

This document describes the pilot system architecture and interactions. The architecture is described using the (USDOT) Systems Engineering Tool for Intelligent Transportation (SET-IT) Version 9.0 program, which is a part of the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) method. ARC-IT is used for other Cooperative Intelligent Transport Systems (C-ITS) deployments internationally and aligns with international C-ITS architecture - making the outcome of this effort more consistent. ARC-IT also has predefined artefacts, making the creation of the pilot architecture simpler.

The architecture defines four views, each of which provides a different user perspective of how the system operates and allows users to answer different questions about the system, these are:

- enterprise – interaction between organisational actors within and on the system
- functional – functions of objects within the system
- physical – interaction between objects within the system, and
- communications – detailed communication mechanism between objects within the system.

The ARC-IT defines service packages that are "slices of the physical view that address specific services" for example a particular use case like road works warning. This representation allows users to understand the physical objects and interactions that are required to meet that specific service package. Enterprise, functional and communications views are generated as a collation of each service package and displayed at a holistic system level.

Acronyms and Glossary

Refer to the *Glossary of terms and acronyms* for all project terminology and definitions.

Reference Documents

Reference documents include the following:

- Pilot Deployment Plan (PDP) – the what, when, and how the pilot was deployed.
- Project Specific Technical Specifications (PSTS) suite – vehicle and roadside station and use cases
- Vehicle ITS Station design summary
- Roadside ITS Station design summary
- Central ITS Facility design summary (internal publication only)

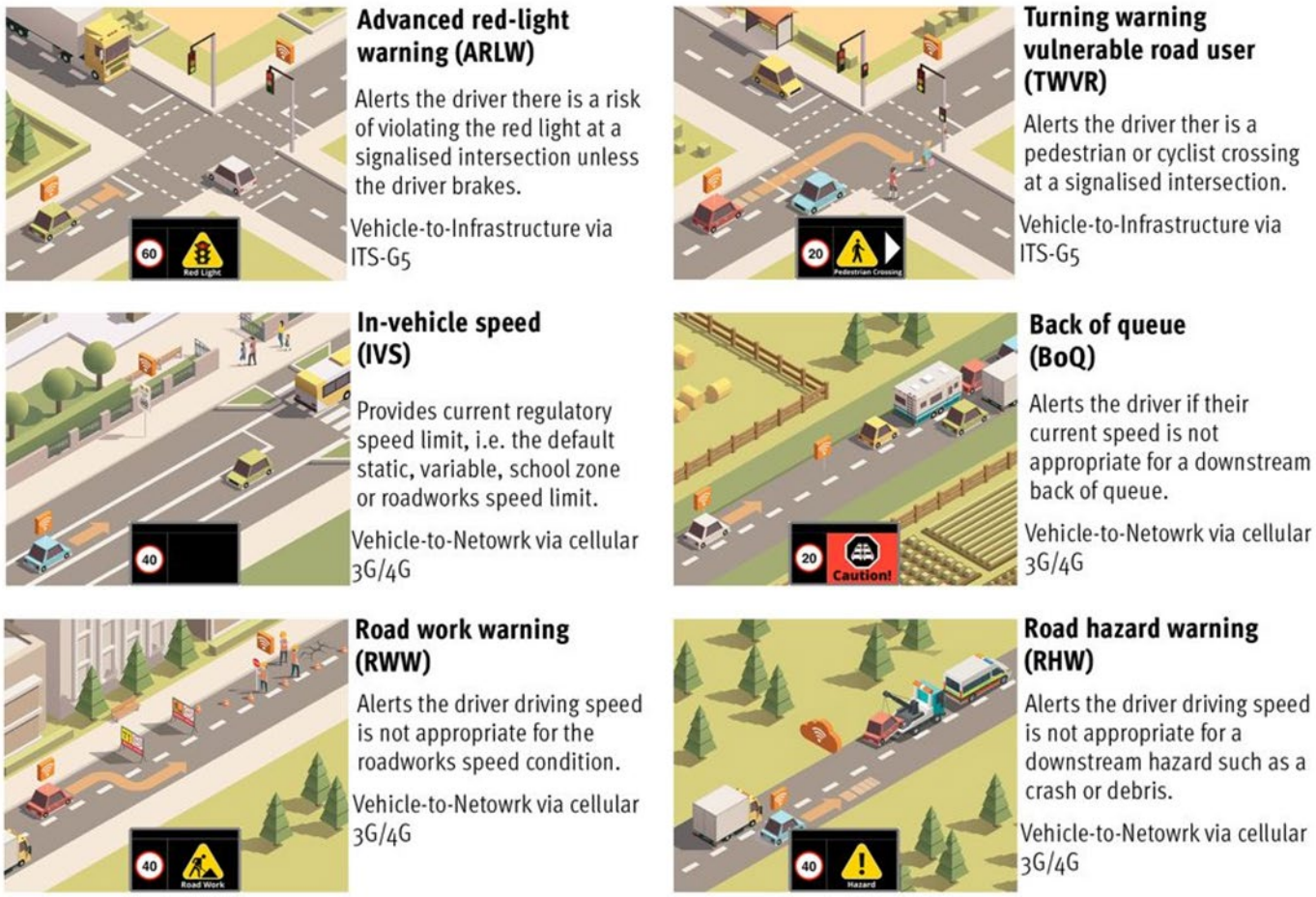
Contents

1 Introduction

Cooperative Intelligent Transport Systems (C-ITS) enable traffic management centres, infrastructure, vehicles, and other road users to interact as peers. The shared information is used to generate cooperative road safety, traffic efficiency and traveller information.

Within the Ipswich Connected Vehicle Pilot (ICVP), six cooperative road safety use cases were implemented. These are described in Figure 1.

Figure 1 – ICVP use cases



The implementation of the six ICVP use cases required secure interaction between three core ITS stations, namely

- The Central ITS Station (C-ITS-S)
- the Roadside ITS Station (R-ITS-S), and
- the Vehicle ITS Station (V-ITS-S).

In addition, a set of enabling services, were used in implementing the ICVP system including:

- Security Credential Management System (SCMS)
- Telecommunications
- Operation & Maintenance of ITS stations.

For more information about the pilot, standards and specifications used, the reader should refer to the listed reference documents.

1.1 Purpose

This document describes the pilot system architecture and interactions for the six use cases, the ITS stations and the enabling services. The architecture is described using the ARC-IT method, as used for other C-ITS deployments internationally, and created using the US Department of Transport (USDOT) SET-IT program. ARC-IT aligns with international C-ITS architecture - making the outcome of this effort more consistent. ARC-IT also has predefined artefacts, making the creation of the pilot architecture simpler.

The architecture defines four views, each of which provides a different user perspective of how the system operates and allows users to answer different questions about the system, these are:

- enterprise – interaction between organisational actors within and on the system
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The ARC-IT defines service packages that are "slices of the physical view that address specific services" for example a particular use case. This representation allows users to understand the physical objects and interactions that are required to meet that specific service package. Enterprise, functional and communications views are generated as a collation of each service package and displayed at a holistic system level.

2 ICVP system components

The ICVP high level system components, interfaces and actors are shown in Figure 2(b) and detailed in Table 2. The high-level system will be followed by detailed physical views for each for each service package in subsequent sections Ipswich Connected Vehicle Pilot (ICVP) Master System Architecture and Design.

The high-level view in Figure 2(b) is based on the Architecture Reference for Cooperative and Intelligent Transportation (arc-it.net) and combines all the six use cases and the two enabling services of security and maintenance to create a single view showing all the elements that feature in the system. This view gives the reader a summary and often is a preferred starting view leading to detailed analysis of the ICVP system.

A descriptive list of each element is shown in Table 2.

ITS elements are classified as *Centre, Field, Vehicle, Support, Personal, People* or *General ITS*. The legend in Figure 2(a) describes the meaning of each coloured element for context.

Figure 2(a) – ARC-IT Physical legend

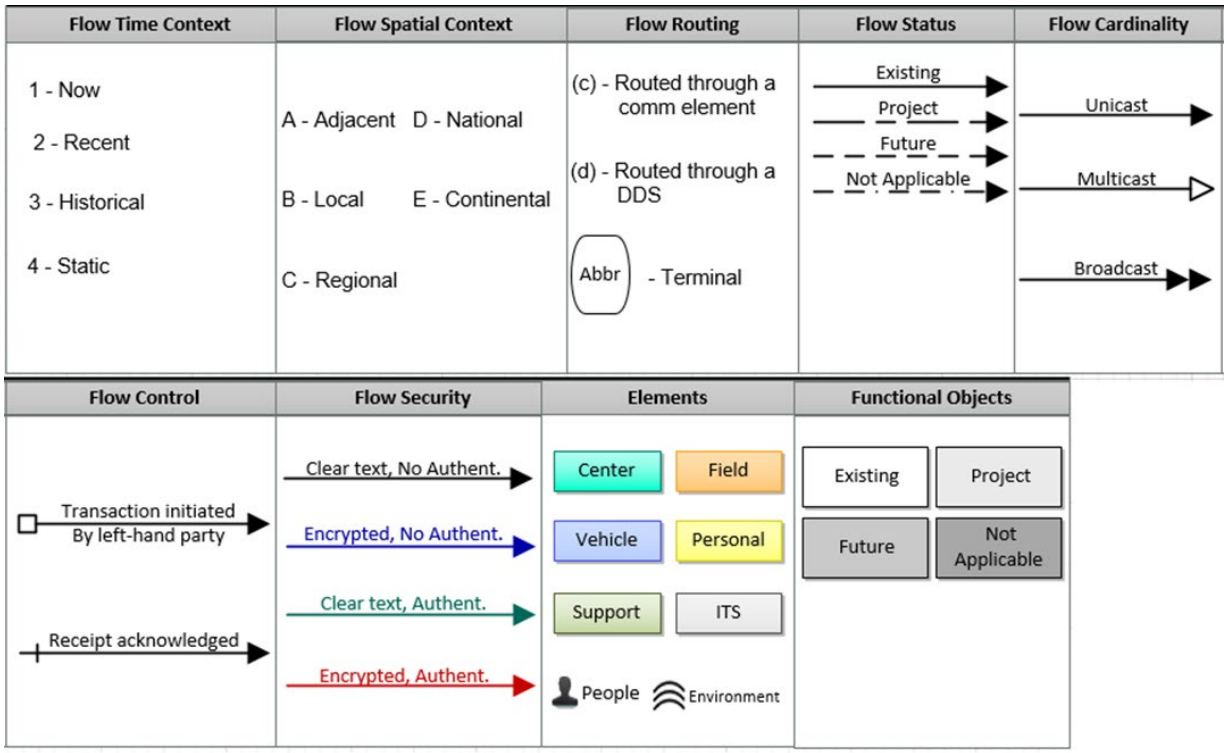


Figure 2(b) – ICVP high level system design

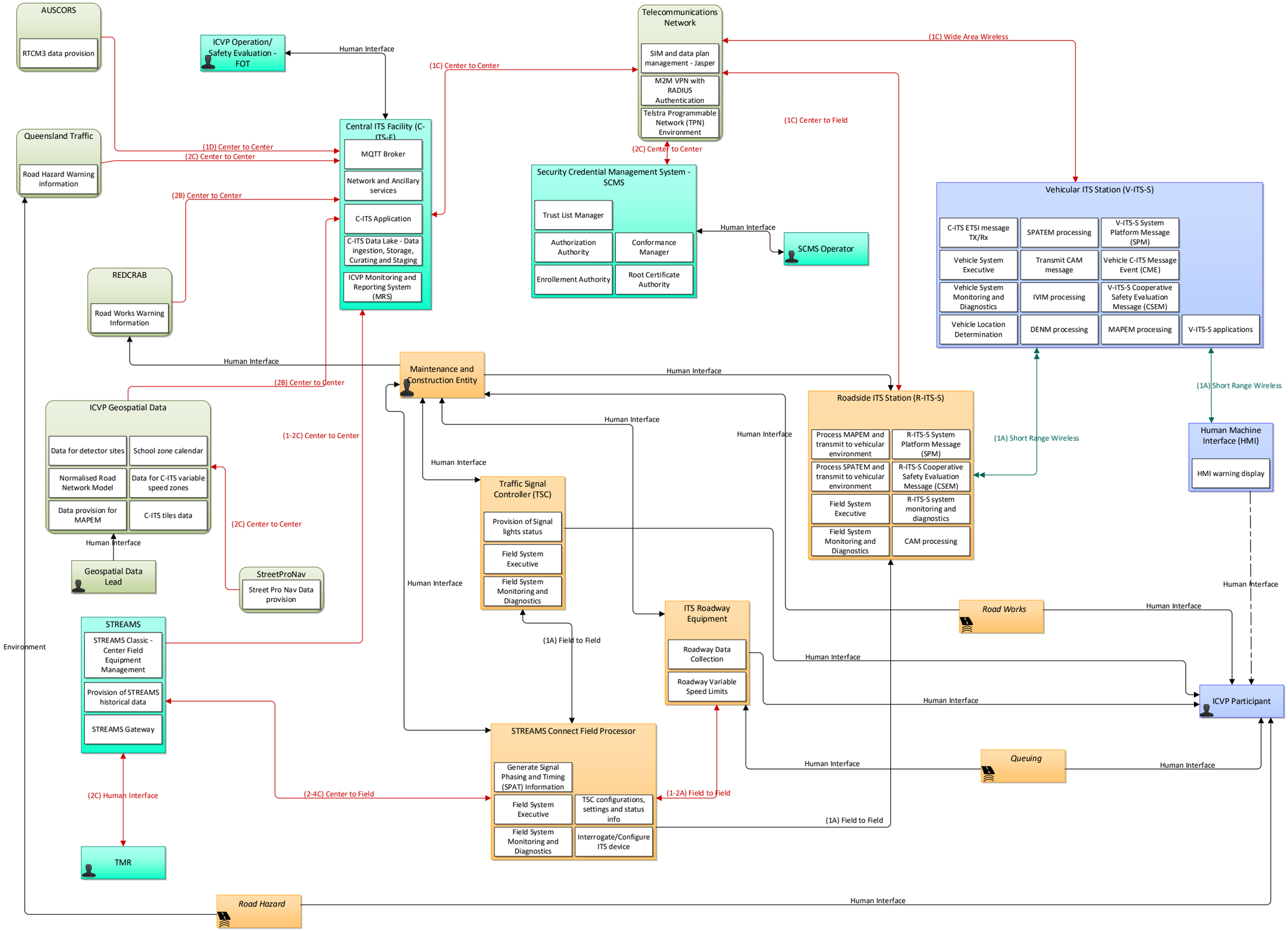


Table 2 – ICVP system architecture components

Class	Name	Description
Centre	Central ITS Facility (C-ITS-F)	The central ITS Facility is a combination of services and functional elements that form the back end of the C-ITS. The C-ITS-F contains the Central ITS station (C-ITS-S). It is built using a hosted server-less / cloud-based architecture.
	ICVP Operation/ Safety Evaluation	This comprises at least two roles, namely, a role that is tasked with the day-to-day operation of the ICVP system and a role that is tasked with the analysis to evaluate the safety impacts of the C-ITS use cases implemented by the ICVP.
	SCMS Operator	Manages and operates the SCMS
	Security Credential Management System - SCMS	The SCMS is a vehicle to everything (V2X) identity management system mandated by European, US and International standards. It uses Public Key Infrastructure concepts to allow devices that have had no prior contact to anonymously distinguish between a trusted and an untrusted device. The SCMS is one of the security systems that enables C-ITS to meet its safety objectives and defend against cyber-attacks. The SCMS implements this by issuing authorisations and credentials to authenticate C-ITS devices for the purpose of maintaining a secure operating environment.
	STREAMS	STREAMS is a traffic management system used to operate, configure and monitor many TMR ITS assets. The Gateway function in STREAMS used queuing events and VSL speed zones data to generate DENM and IVIM respectively, which are then broadcast to vehicles via the C-ITS-F broker
	TMR	The Department of Transport and Main Roads is the initiator of the ICVP trial. Transport and Main Roads owns and operates the state roads and associated ITS assets in Queensland.
Field	ITS Roadway Equipment	This includes all ITS equipment featuring in the C-ITS project and include Variable Speed Limit signs, Traffic Signal Controllers, School zone signs etc.
	Maintenance and Construction Entity	The maintenance and construction entity is responsible for the field device maintenance as well as populating the Redcrab application, where the resulting data is used by the C-ITS-F for dissemination into the vehicular environment.
	Queuing	Vehicle queuing event is detected by STREAMS queue detection algorithms based on data obtained from the vehicle detector (VD) on motorways. These events are used generate BoQ Decentralised Environmental Notification Message (DENM), which are broadcast to vehicles via the C-ITS-F broker
	Road Hazard	Hazards on the road, including slippery road, debris, fog etc. These events are captured through QLDTraffic and are used to generate RHW DENM, which are broadcast to vehicles via the C-ITS-F broker
	Road Works	Ongoing road works
	Roadside ITS Station (R-ITS-S)	The R -ITS-S receives Signal Phasing and Timing Extended Message (SPATEM) messages related to Traffic Lights from the FP and MAPEM (intersection layout) from the C-ITS-F and transmits it over ITS-G5 to the V-ITS-S for intersection safety applications. It also captures the Continues Awareness Messages (CAMS) from V-ITS-S and relays it to the C-ITS-F for analysis.
	STREAMS Connect Field Processor	Field Processor converts the TSC data to a C-ITS SPATEM message, which is sent to the R ITS-S. The FP maintains isolation between the existing Transport and Main Roads ITS network and the C-ITS environment.

Class	Name	Description
	Traffic Signal Controller (TSC)	The traffic signal controller manages intersection lights and is controlled by STREAMS via the STREAMS connect device in the field. The TSC provides signalised intersection data to the R-ITS-S via STREAMS® Connect FP.
Support	AUSCORS	Provides positioning augmentation information using the Radio Technical Commission for Maritime Services (RTCM) version 3 data format.
	Geospatial Data Lead	A role that is held by members of the Transport and Main Roads Geospatial Team. Members of this team are tasked with the production of spatial data used by the ICVP system
	StreetProNav	StreetPro Navigation Premium (1:10,000 scale) provides the ability to calculate the most precise, efficient route between points on a road network, taking average speed profiles for time of day and vehicle height, width, and weight restrictions into account.
	ICVP Geospatial Data	Provides various geospatial information including MAPEMs, Road Network Model, C-ITS Detectors location, C-ITS Tiles, VSL Zones and school zone calendars used to generate IVIM.
	QLDTraffic	QLDTraffic Road hazard data that are extracted in near real-time. These data are used by the C-ITS-S to generate an RHW DENM message.
	Redcrab	Redcrab is a pilot tool that is used to manage roadwork permits and provide the location of active roadworks signs. It is also the source data used by the C-ITS-S to generate RWW DENM messages.
	Telecommunications Network	The ICVP telecommunications Network utilizes the Telstra Programmable Network (TPN) components for connectivity and security between multiple internal and external networks required for the ICVP solution.
Vehicle	Human Machine Interface (HMI)	The HMI is the source of information and alerts to the driver based on C-ITS messages about the vehicular environment
	ICVP Participant	The Participant role in the ICVP is held by a person that operates a vehicle (or Driver) with C-ITS equipment installed and connected to the ICVP system. More than one person can operate the same vehicle
	Vehicular ITS Station (V-ITS-S)	The V-ITS-S provides the main communication and processing needs for a cooperative vehicle and consists of the hardware, firmware, software, applications, communication interfaces, antennae, cabling and any other items required to enable operation to the technical specifications defined. The V-ITS-S interfaces to, C-ITS-F, SCMS, R-ITS-S, other V-ITS-S, GNSS and the HMI.

3 ICVP architecture

This section aims to describe the six ICVP use cases, ITS stations and enabling services utilising the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) model and artefact conventions.

Internationally, the ARC-IT model has been used to describe C-ITS deployments, thus making it easy to customise. ARC-IT refers to service packages, which have been tailored to describe ICVP use cases and services. The ARC-IT free software (SET-IT) is used to generate the various views - Enterprise, Functional, Physical and Communications views. These are illustrated in the subsequent sections. A definition of all artefacts is also included in Appendix 1.

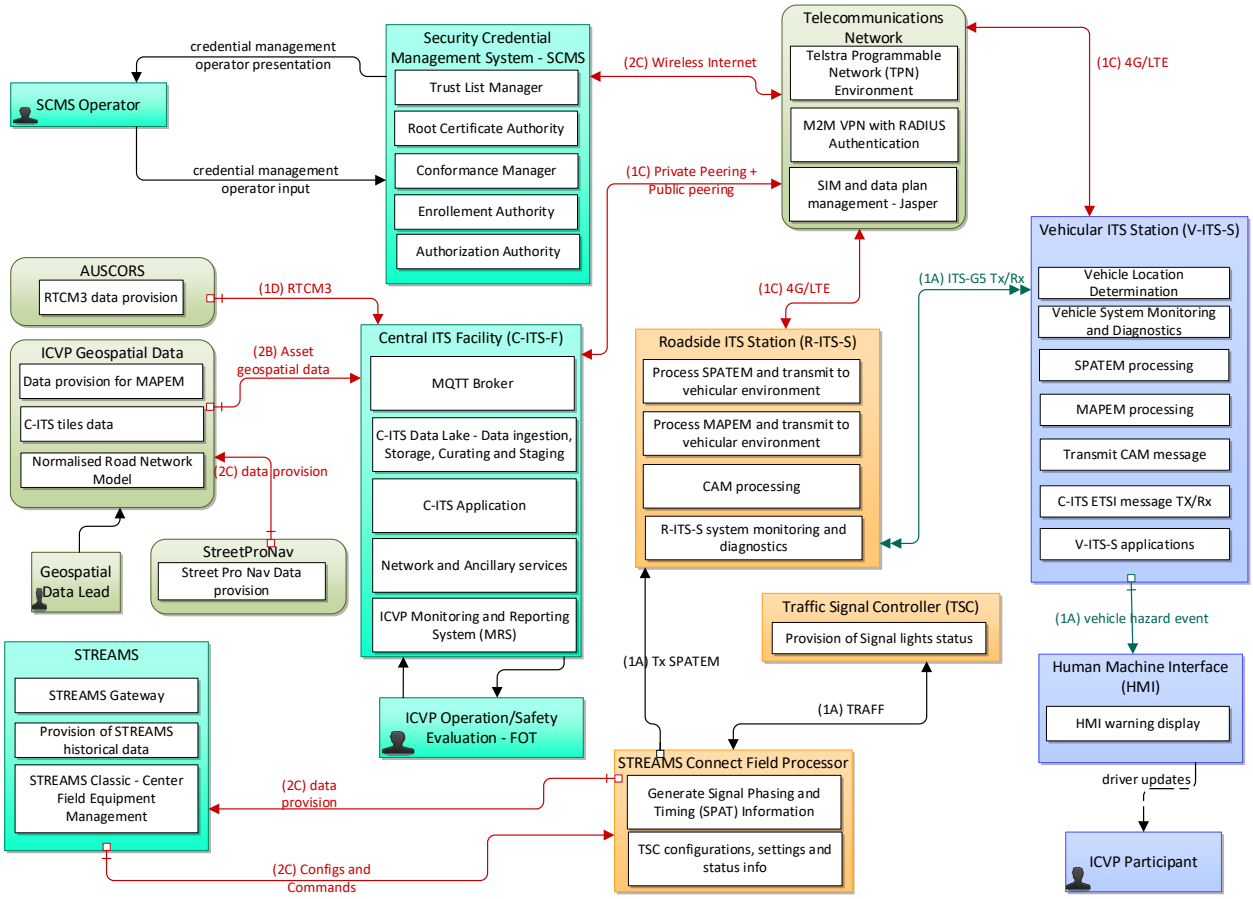
3.1 Physical view

The ARC-IT physical view describes physical objects (systems and devices) and their functional objects as well as the high-level interfaces between those physical objects. This section describes the physical view of the implemented ICVP use cases. The individual physical elements were defined in Table 2.

3.1.1 Advance Red Light Warning – ARLW

ARLW is an ITS-G5 based use case where the applications require communication between R-ITS-S and the V-ITS-S for the exchange of SPATEM and MAPEM messages. Cellular communication is still used for monitoring and maintenance. The figure below shows the components used in implementing the ARLW use case.

Figure 3.1.1 – ARLW use case



3.1.2 Turning Warning for Vulnerable Road User – TWVR

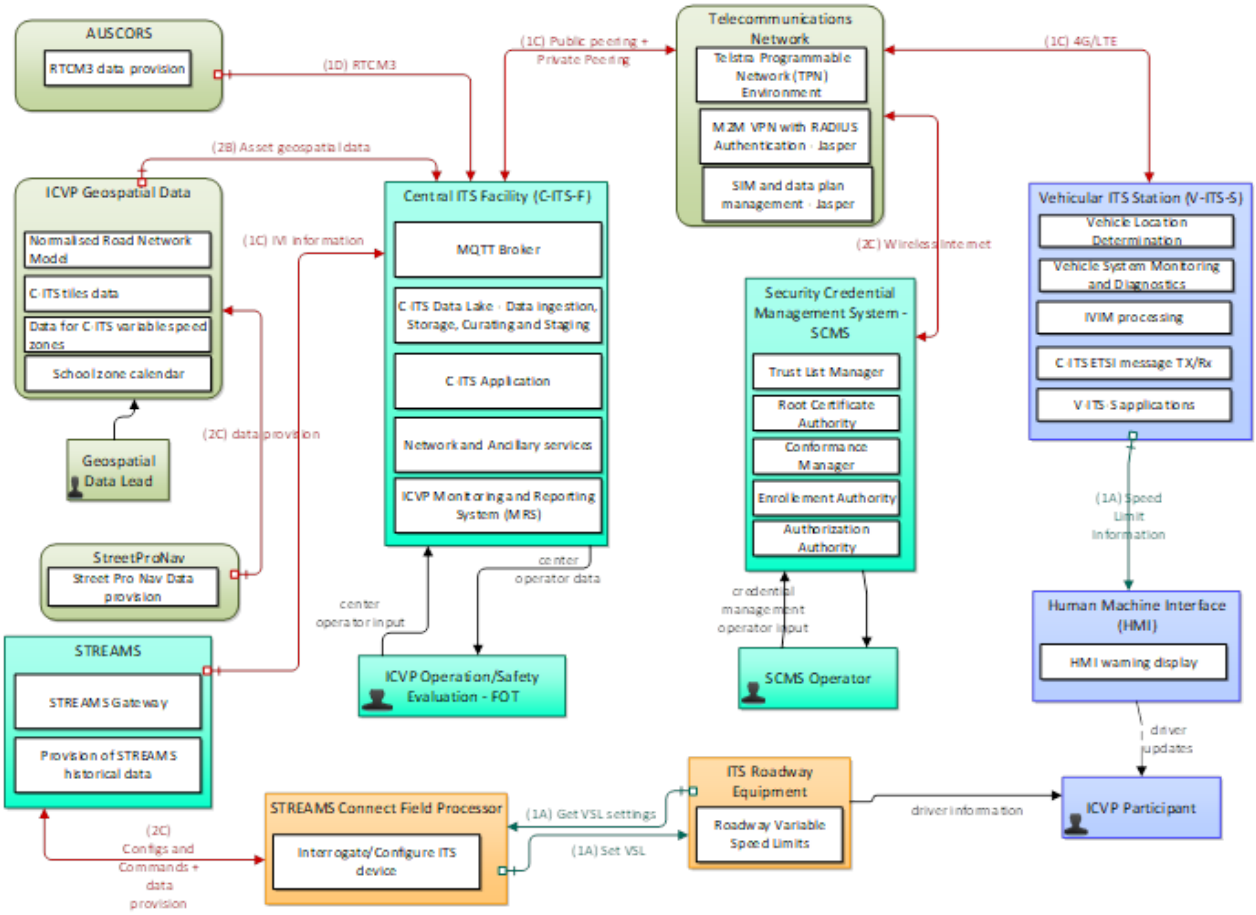
This physical functional representation of TWVR is similar in function to the ARLW. The only difference is that the *Provision of signal light status* function in the TSC is used in the ARLW application to indicate signals related to vehicular movement, whereas it is intended to mean pedestrian signals when used in relation to TWVR application.

Refer to functional description of the *Provision of signal light status* function.

3.1.3 In-Vehicle Signage – IVS

IVS is a cellular use case, meaning, the application requires data communication between the C-ITS-F and V-ITS-S using the 4G/LTE network. The figure below shows the components used in implementing the IVS use case.

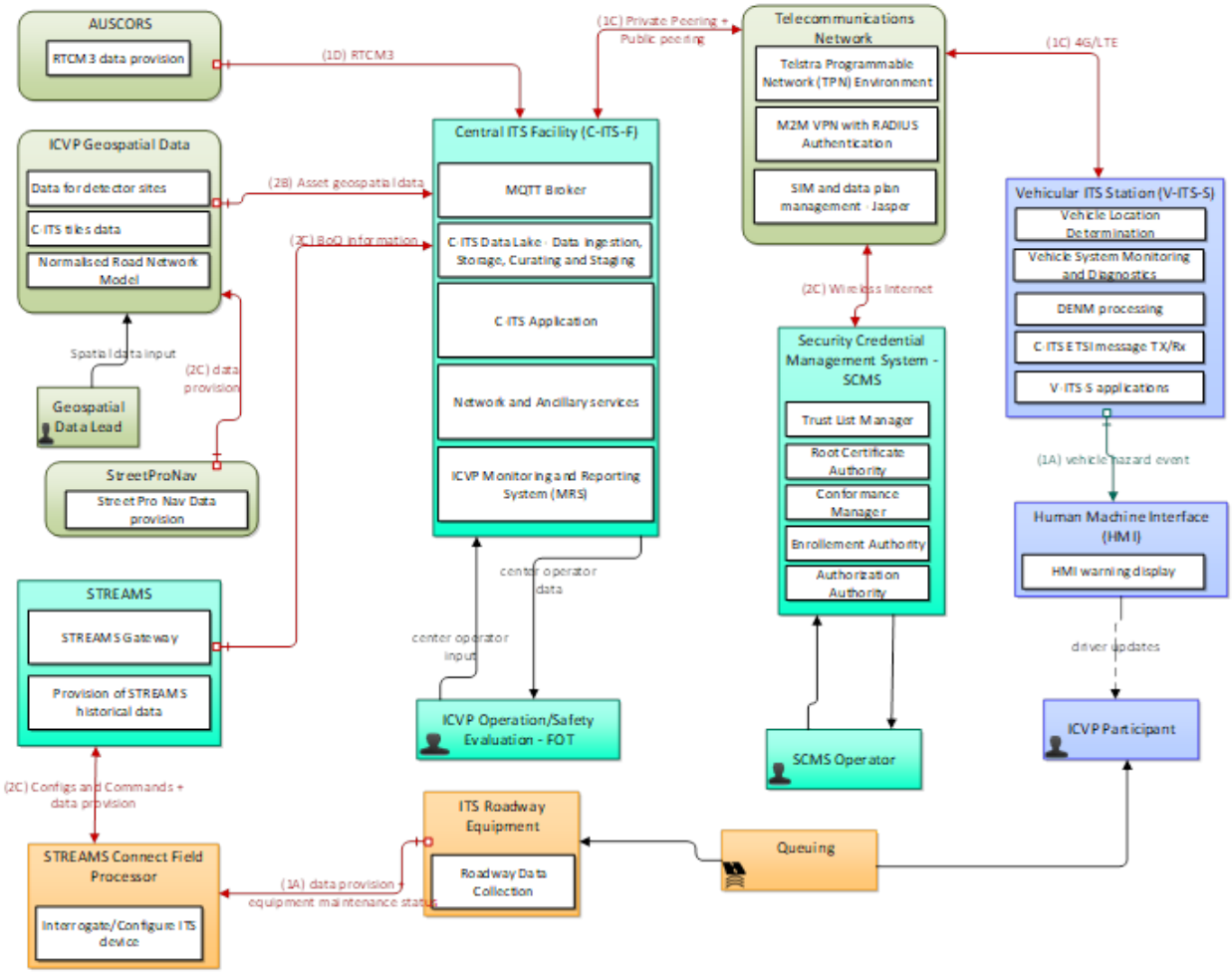
Figure 3.1.3 – IVS use case



3.1.4 Back of Queue – BoQ

BoQ is a cellular use case, meaning, the application requires data communication between the C-ITS-F and V-ITS-S using the 4G/LTE network. The figure below shows the components used in implementing the BoQ use case.

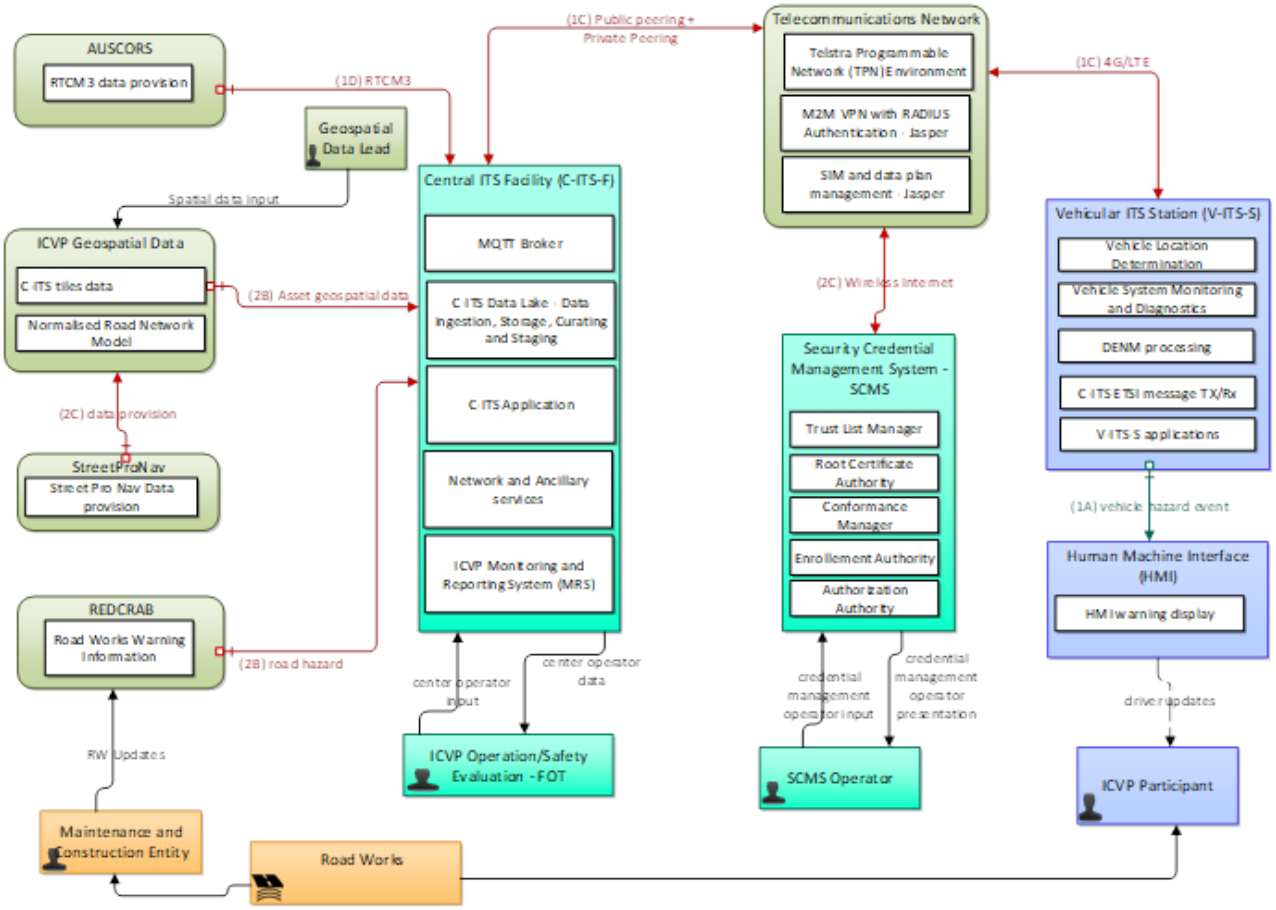
Figure 3.1.4 – BoQ use case



3.1.5 Road Works Warning – RWW

RWW is a cellular use case, meaning, the application requires data communication between the C-ITS-F and V-ITS-S using the 4G/LTE network. The figure below shows the components used in implementing the RWW use case and their high-level connections.

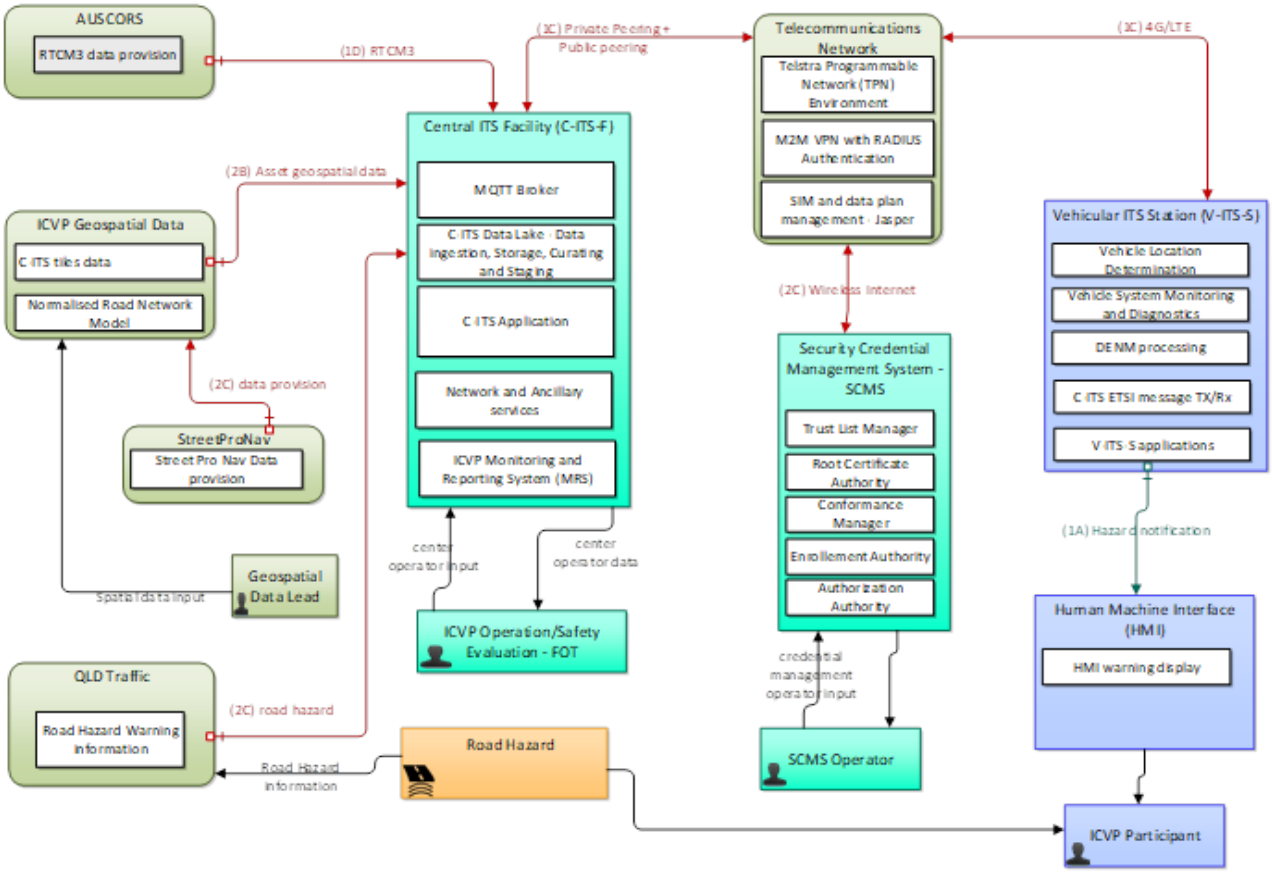
Figure 3.1.5 – RWW use case



3.1.6 Road Hazard Warning – RHW

RHW is a cellular use case, meaning, the application requires data communication between the C-ITS-F and V-ITS-S using the 4G/LTE network. The figure below shows the components used in implementing the RHW use case.

Figure 3.1.6 – RHW use case



3.1.7 Telecommunications network and Security Credential Management System

The figure below shows the components used in implementing the Telecommunications network and the Security Credential Management System - SCMS. Each physical object is as defined in Table 2.

The flows between the SCMS, C-ITS-F and the ITS stations through the ICVP telecommunications network are described in Table 3.1.7.

Figure 3.1.7 – SCMS implementation

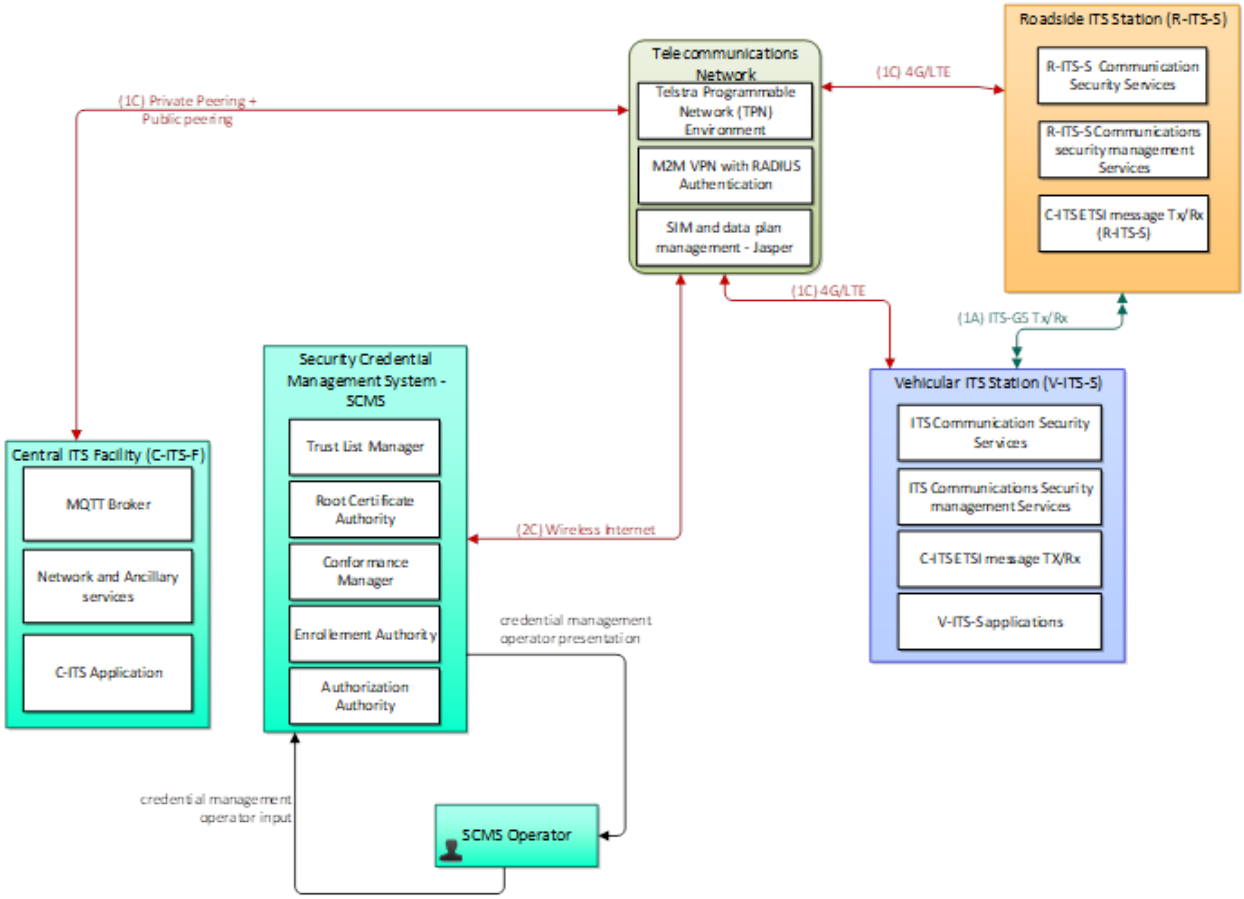


Table 3.1.7 – Data flow between SCMS and C-ITS environment

Source / Destination Pair		Flow Name	Flow Description
Central ITS Facility (C-ITS-F)	Telecommunications Network	Private Peering	Private peering to C-ITS-F is utilised with a data flow up to 100Mbps. Network Traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations and enrolments.
Central ITS Facility (C-ITS-F)	Telecommunications Network	Public peering	Public peering to C-ITS-F is utilised with a data flow up to 1Gbps. Network Traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations and enrolments.
Roadside ITS Station (R-ITS-S)	Telecommunications Network	4G/LTE	The 4G/LTE connection links the V-ITS-S and R-ITS-S to the ICVP network. Network traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations, enrolments, and authentications of the ITS stations.

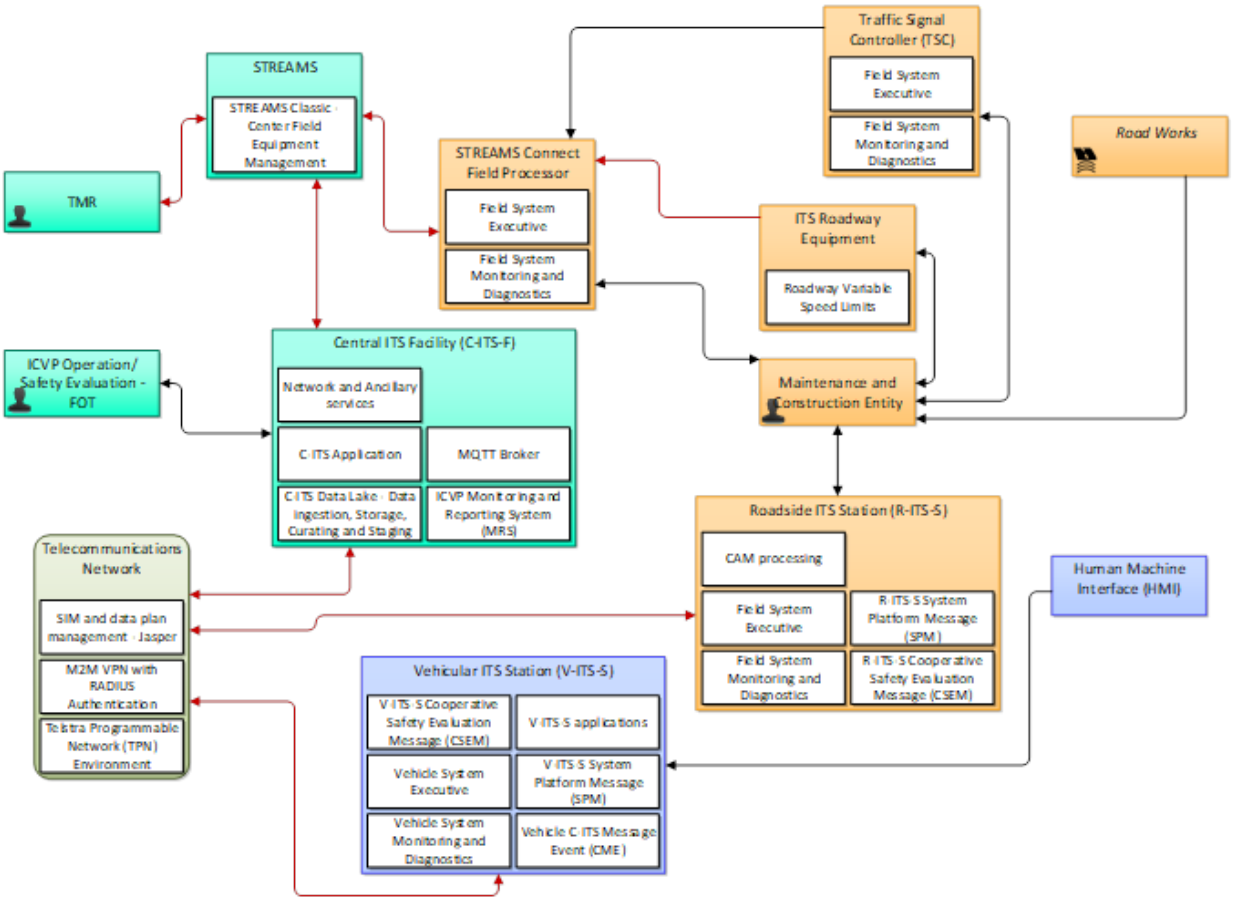
Source / Destination Pair		Flow Name	Flow Description
SCMS Operator	Security Credential Management System - SCMS	Credential management operator input	Installation and updates of information necessary for security management in ITS-S during operation.
Security Credential Management System - SCMS	SCMS Operator	Credential management operator presentation	Status of the SCMS system.
Security Credential Management System - SCMS	Telecommunications Network	Wireless Internet	Wireless internet is used for linking some of the ICVP components to the ICVP network. Network Traffic include SCMS authorisations, enrolments, and authentications of the ITS.
Telecommunications Network	Vehicular ITS Station (V-ITS-S)	4G/LTE	The 4G/LTE connection links the V-ITS-S and R-ITS-S to the ICVP network. Network traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations, enrolments, and authentications of the ITS stations.

3.1.8 ICVP Field device Operation and Maintenance

The figure below shows the components used in implementing the ICVP field maintenance function and the Field Operational Test (FOT) function. The target field devices include the R-ITS-S, V-ITS-S, HMI as we as ITS equipment which existed before the trial such as Traffic signals and the STREAMS field processor. These provide the required data for the operation and maintenance function for the ICVP.

The elements are defined in Table 2, and the functions of each element (boxes within the elements) are defined in Section 3.2

Figure 3.1.8 – C-ITS maintenance and safety evaluation data exchange



Note that these are sometimes used concurrently where the equipment (health) status provides context to any safety analysis resulting from the operation of the ICVP system.

3.2 Functional View

The ICVP physical view in Figure 2(a) is a high level description showing the physical objects and the associated functional objects. It is the functional objects that provide a detailed functional description of those physical elements. The individual functions of each physical element in the ICVP system are described in Table 3.2 below.

Table 3.2 – ICVP functional objects definition

Element	Functional Object	Description	Applicable Use Cases
AUSCORS	RTCM3 data provision	The Radio Technical Commission for Maritime Services (RTCM) version 3 data is a positioning augmentation information provided by AUSCORS. The central facility shares these data with the vehicle station, which can be processed by the vehicle station using Real-Time Kinematic (RTK) positioning augmentation methods to support improved positioning accuracy.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
Central ITS Facility (C-ITS-F)	C-ITS Application	The C-ITS-S in the C-ITS-F performs the roles of Position Augmentation, Central ITS Station (C-ITS-S) implementation, C-ITS Message Signing Service (C-ITS-S security layer), Safety Evaluator Data Logging, SSH Service, Participant Management API, Software Update Service, STREAM Gateway BoQ/VSL and Configuration Management. For a detailed description refer to the Pilot Deployment Plan (PDP)	Advance Red-Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	C-ITS Data Lake - Data ingestion, Storage, Curating and Staging	The C-ITS-S Data Lake is used to ingest, stage and curate store data sets which are of wide-spread interest to the TMR organisation and include QLDTraffic, Red Crab and STREAMS® data. The data stored in the C-ITS Data Lake are ingested by individual data adapters on schedule or pushed on change. The C-ITS Data Lake is also used to store ICVP data sets which are project specific and include system configuration data such as the Road Network Model and C-ITS application parameters and also operational data logs such as CME and CSEM safety evaluation data. Data from the C-ITS-S Data Lake is consumed by the C-ITS Application by modules such as the C-ITS-S which used the data to produce C-ITS message and by the Monitoring and Reporting Service to create dashboard visualisations.	Advance Red-Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	ICVP Monitoring and Reporting System (MRS)	The monitoring and reporting system (MRS) performs a number of roles including Monitoring & Reporting Service, Extract, Transform, Load (ETL) Calculations and Storage, Visualisation, Tableau Hyper Extract, and Data Packaging and Delivery. Refer to the PDP for a detailed description of the MRS roles.	Advance Red-Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
	MQTT Broker	The MQTT broker function performs the following roles: *'MQTT Data Access Management'*: defines the access mechanisms, structures, and restrictions for inbound (from providers) and outbound (to consumers) data. *'MQTT Data Collection and Aggregation*' collects data 'deposits' from producers including meta data such as the generation location and time. It authenticates and validates the data deposits and logs all associated meta data. Authenticated, valid data is bundled based on information type and location and made available as data products to consumers who are interested in the data. It establishes delivery parameters for data consumers that subscribe based on parameters including content type and geographic region of interest and delivers data to consumers based on these parameters. *Publish/Subscribe*: A messaging pattern which is a feature of the MQTT protocol, and which provides one-to-many message distribution and decoupling of applications	Advance Red-Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Network and Ancillary services	Network and Ancillary functions include provision of AWS Direct Connect services, Internet, Virtual Private Networks, pipeline deployment management, Jira, AWS CloudWatch, AWS CodeCommit and AWS Cloud Formation. Refer to the PDP for detailed definitions.	Advance Red-Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
Human Machine Interface (HMI)	HMI warning display	A situational awareness alerts system operating in a Human Machine Interface (HMI) which consists of hardware, firmware, software, applications, communication interfaces, cabling and any other items required to enable operation to the technical specifications defined. The HMI connects to the V-ITS-S as the interface between the C-ITS and the driver.	Advance Red Light Warning - ARLW, Back of Queue - BoQ In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
ICVP Geospatial Data	C-ITS tiles data	The C-ITS tiles data are predetermined geofenced tiles for which messages are published on the Message Broker for use by the vehicle stations.	Advance Red Light Warning - ARLW, Back of Queue - BoQ In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Data for C-ITS variable speed zones	Spatial data for the segments of the road network model controlled by STREAMS® variable speed signs.	In-Vehicle Signage - IVS
	Data for detector sites	Spatial data for STREAMS® detector sites.	Back of Queue - BoQ,
	Normalised Road Network Model	The road network model is a bespoke ICVP pilot dataset that includes geospatial information, lane counts, lane widths, static speed data and school zone speed data used by C-ITS-F for the generation of spatial and road information attributes in DENM and IVIM. The road network model is a GeoJSON document created from a base Street *Pro Navigator shapefile*. The street Pro Navigator data requires significant modification to meet the needs of the pilot. An elevation model *TMR Altitude* data is added to the Pro Navigator resulting in a 3D model. The model is manually uploaded into the C-ITS-F via the Configuration Manager (see CFD13) and is updated when necessary.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Data provision for MAPEM	ETSI Road Lane Topology basic service information for the signalised intersection use-cases.	Advance Red Light Warning - ARLW, Turning Warning for Vulnerable Road User - TWVR
	School zone calendar	The school zone calendar is used by the C-ITS-F to provide time relevant information to the V-ITS-S for the IVS (in-vehicle signage) application.	In-Vehicle Signage - IVS

Element	Functional Object	Description	Applicable Use Cases
ITS Roadway Equipment	Roadway Data Collection	'Roadway Data Collection' collects traffic, road, and environmental conditions information for use in transportation planning, research, and other off-line applications where data quality and completeness take precedence over real-time performance. It includes the sensors, supporting roadside infrastructure, and communications equipment that collects and transfers information to a centre for archival.	Back of Queue - BoQ
	Roadway Variable Speed Limits	'Roadway Variable Speed Limits' includes the field equipment, physical overhead lane signs and associated control electronics that are used to manage and control variable speed limits systems. This equipment monitors traffic and environmental conditions along the roadway. The system can be centrally monitored and controlled by a Traffic Management Centre or it can be autonomous, calculating and setting suitable speed limits, usually by lane. This application displays the speed limits and additional information such as basic safety rules and current traffic information to drivers.	ICVP Maintenance, In-Vehicle Signage - IVS
Queensland Traffic	Road Hazard Warning information	Road Hazard Information generated by QLD traffic for the purpose of dissemination to the C-ITS-S and then to the vehicular environment.	Road Hazard Warning - RHW
REDCRAB	Road Works Warning Information	The planned road works information is manually input into the RedCrab system for dissemination to the C-ITS-F	Road Works Warning - RWW
Roadside ITS Station (R-ITS-S)	CAM processing	The R-ITS-S receives CAMs from the V-ITS-S and relays that to the C-ITS-S	Advance Red Light Warning - ARLW, ICVP Maintenance, ICVP Telecommunications Network, Turning Warning for Vulnerable Road User - TWVR
	C-ITS ETSI message Tx/Rx (R-ITS-S)	The generality of ETSI defined C-ITS messages transmitted and received by the V-ITS-S and includes DENM, CAM, IVIM, SPATEM and MAPEM as applicable.	ICVP SCMS

Element	Functional Object	Description	Applicable Use Cases
Roadside ITS Station (R-ITS-S), STREAMS Connect Field Processor, Traffic Signal Controller (TSC)	Field System Executive	'Field System Executive' includes the operating system kernel and executive functions that manage the overall device software configuration and operation and support configuration management, computer resource management, and govern software installation and upgrade.	ICVP Maintenance
Roadside ITS Station (R-ITS-S), STREAMS Connect Field Processor, Traffic Signal Controller (TSC)	Field System Monitoring and Diagnostics	'Field System Monitoring and Diagnostics' includes background self-tests, diagnostics, watchdog timers, and other hardware and software that monitors the operating condition of field equipment. The status of the equipment and diagnostic information is provided to local maintenance personnel and the operating centre.	ICVP Maintenance
Roadside ITS Station (R-ITS-S)	Process MAPEM and transmit to vehicular environment	MAPEM is transmitted to the vehicular environment every 500ms. MAPEM updates are received from the C-ITS-S.	Advance Red Light Warning - ARLW, ICVP Telecommunications Network, Turning Warning for Vulnerable Road User - TWVR
Roadside ITS Station (R-ITS-S)	Process SPATEM and transmit to vehicular environment	SPATEM is transmitted to the vehicular environment every 100ms.	Advance Red Light Warning - ARLW, ICVP Telecommunications Network, Turning Warning for Vulnerable Road User - TWVR
	R-ITS-S Communication Security Services	'ITS Communication security service' include service categories defined in ETSI TS 102 940 V1.4.1 and include Security Associations management, Single message services, Integrity services, Replay Protection services and Plausibility validation.	ICVP SCMS
	R-ITS-S Communications security management Services	'ITS Communication security management service' include service categories defined in ETSI TS 102 940 V1.4.1 and include Enrolment, Authorization, Accountability, Remote management, Misbehaviour reporting and Identity management.	ICVP SCMS
	R-ITS-S Cooperative Safety Evaluation Message (CSEM)	The CSEM data gathered generated by the R-ITS-S and used for evaluation by the C-ITS-S.	ICVP Maintenance

Element	Functional Object	Description	Applicable Use Cases
	R-ITS-S system monitoring and diagnostics	Monitoring and diagnostics data are sent to the C-ITS-S	Advance Red Light Warning - ARLW, ICVP Telecommunications Network, Turning Warning for Vulnerable Road User - TWVR
	R-ITS-S System Platform Message (SPM)	This is a system health heart-beat data created and reported by the R-ITS-S. This message is sent to the C-ITS-F where it is logged and used for evaluation.	ICVP Maintenance
Security Credential Management System - SCMS	Authorization Authority	The Authorisation Authority (AA) issues authorisation ticket to a requesting ITS-S that has been enrolled with and been authenticated by an Enrolment Authority (EA). The authorisation ticket grants the ITS-S specific permissions within the enrolment authority's domain and the AA's authorization context. Each authorization ticket specifies a particular authorization context which comprises a set of permissions (Refer to ETSI TS 102 940 v1.4.1 for details).	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Conformance Manager	The conformance manager ensures that the participating ITS-Stations meet the enrolment trust requirements stipulated in ETSI 102 940.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Enrolment Authority	The Enrolment Authority (EA) issues a proof of identity after authenticating the requesting ITS-S, in the form of an Enrolment Credential. The proof of identity does not reveal the canonical identifier to a 3rd party and shall be used by the ITS-S to request authorization of services from an Authorisation Authority (AA) -Refer to ETSI TS 102 940 v1.4.1 for details.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
	Root Certificate Authority	The Root CA is the highest level CA in the certification hierarchy. It provides the Enrolment Authority (EA) and the Authorisation Authority (AA) with proof that it may issue enrolment credentials, and authorization tickets respectively.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Trust List Manager	Trust List Manager is responsible for creating the list of root CA certificates and TLM certificates and signing it. The signed list issued by the TLM is called the ECTL	Trust List Manager
STREAMS	Provision of STREAMS historical data	This data is used to validate the operation of the C-ITS against the ground truth as rendered by the known system – STREAMS®. This includes intersection movement, phase and state data used to verify ARLW and TWVR use cases, queue data to verify the BOQ use case and variable speed data used to verify the IVS use case.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, In-Vehicle Signage - IVS, Turning Warning for Vulnerable Road User - TWVR
	STREAMS Classic - Centre Field Equipment Management	'STREAMS Classic - Centre Field Equipment Management' is the existing STREAMS back office application that supports monitoring and maintenance of field equipment. It monitors the performance and configuration of the field equipment. This includes management of the infrastructure configuration as well as detection, isolation, and correction of field equipment problems. The application also includes monitoring of performance of the field equipment, including communications links.	ICVP Maintenance,
	STREAMS Gateway	The STREAMS Gateway is a function that provides the BoQ data as well as geo-tagged variable speed limits (VSL) data	Advance Red Light Warning - ARLW, Back of Queue - BoQ, In-Vehicle Signage - IVS, Turning Warning for Vulnerable Road User - TWVR
STREAMS Connect Field Processor	Generate Signal Phasing and Timing (SPAT) Information	The SPAT is generated from the raw information obtained from the TSC	Advance Red Light Warning - ARLW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
	Interrogate/Configure ITS device	The STREAMS connect FP interrogates and/or configures the ITS field device as a proxy to STREAMS	Back of Queue - BoQ, In-Vehicle Signage - IVS
	TSC configurations, settings and status info	The STREAMS FP stores the configuration and settings of the TSC as well as signal status and other operational status and maintenance information such as faults.	Advance Red Light Warning - ARLW, Turning Warning for Vulnerable Road User - TWVR
StreetProNav	Street Pro Nav Data provision	Data from Street Pro Nav is used by the Normalised Road Network Model function in the ICVP Geospatial element, to develop a set of georeferencing system used by the C-ITS-F	Advance Red Light Warning - ARLW, Back of Queue - BoQ, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
Telecommunications Network	M2M VPN with RADIUS Authentication	The M2M (Machine to Machine) VPN solution service with RADIUS Authentication, connects all the ICVP SIMs with Telstra Managed Radius service;	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Maintenance, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	SIM and data plan management - Jasper	Jasper provides IoT data plan management giving visibility, efficiency and control of ICVP cellular devices.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Maintenance, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Telstra Programmable Network (TPN) Environment	The TPN (Telstra Programmable Network) environment provides a peering and termination point between ICVP networks including Telstra IP WAN, the Internet, AWS private peering, and AWS public Peering. A virtual Palo Alto Network (PAN) firewall is utilised within the TPN environment, which also allows access to DNS.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Maintenance, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR

Element	Functional Object	Description	Applicable Use Cases
Traffic Signal Controller (TSC)	Provision of Signal lights status	The status of the traffic signal lights is stored in the TSC for transmission to the STREAMS Connect FP using the TRAFF protocol	Advance Red Light Warning - ARLW, Turning Warning for Vulnerable Road User - TWVR
Vehicular ITS Station (V-ITS-S)	C-ITS ETSI message TX/Rx	The generality of ETSI defined C-ITS messages transmitted and received by the V-ITS-S and includes DENM, CAM, IVIM, SPATEM and MAPEM.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	DENM processing	Dynamic Environmental Notification Message (DENM) processing. DENM is the format used by the RWW application.	Back of Queue - BoQ, ICVP Telecommunications Network, Road Hazard Warning - RHW, Road Works Warning - RWW
	ITS Communication Security Services	'ITS Communication security service' include service categories defined in ETSI TS 102 940 V1.4.1 and include Security Associations management, Single message services, Integrity services, Replay Protection services and Plausibility validation.	ICVP SCMS
	ITS Communications Security management Services	'ITS Communication security management service' include service categories defined in ETSI TS 102 940 V1.4.1 and include Enrolment, Authorization, Accountability, Remote management, Misbehaviour reporting and Identity management.	ICVP SCMS
	IVIM processing	In-Vehicle Information message (IVIM) is the format used for the IVS application	In-Vehicle Signage - IVS
	MAPEM processing	MAPEM received from the R-ITS-S is processed by the	MAPEM processing
	SPATEM processing	SPATEM received from the R-ITS-S is processed by the	SPATEM processing
	Transmit CAM message	The V-ITS-S transmits CAM messages to the R-ITS-S via ITS-G5 to relay to the C-ITS-S	Advance Red Light Warning - ARLW, Turning Warning for Vulnerable Road User - TWVR
	Vehicle C-ITS Message Event (CME)	This is an even specific data created by the V-ITS-S and broken into stages; sourced, created, relevant, notified, presented	ICVP Maintenance,

Element	Functional Object	Description	Applicable Use Cases
	Vehicle Location Determination	'Vehicle Location Determination' receives current location of the vehicle and provides this information to vehicle applications that use the location information to provide ITS services.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	Vehicle System Executive	'Vehicle System Executive' provides the operating system kernel and executive functions that manage the software configuration and operation and support computer resource management, security, and software installation and upgrade.	ICVP Maintenance,
	Vehicle System Monitoring and Diagnostics	'Vehicle System Monitoring and Diagnostics' includes on-board sensors and integrated self-test software that monitors the condition of each of the vehicle systems and diagnostics that can be used to support vehicle maintenance. The status of the vehicle and ancillary equipment and diagnostic information is provided to the driver and service centre.	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Maintenance, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	V-ITS-S applications	V-ITS-S applications handles various functions including thread analysis and formatting for HMI display	Advance Red Light Warning - ARLW, Back of Queue - BoQ, ICVP Maintenance, ICVP SCMS, ICVP Telecommunications Network, In-Vehicle Signage - IVS, Road Hazard Warning - RHW, Road Works Warning - RWW, Turning Warning for Vulnerable Road User - TWVR
	V-ITS-S Cooperative Safety Evaluation Message (CSEM)	The CSEM data gathered generated by the V-ITS-S and used for evaluation by the C-ITS-S.	ICVP Maintenance,
	V-ITS-S System Platform Message (SPM)	This is a system health heart-beat data created and reported by the V-ITS-S. This message is sent to the	V-ITS-S System Platform Message (SPM)

3.3 Enterprise View

The enterprise view in ARC-IT, describes the relationships between organizations and the roles those organizations play within the connected vehicle environment. These enterprise relationships have a source and destination object and a role that forms the relationship. Refer to Figure 3.3(b), and the associated legend in Figure 3.3(a) for the ICVP enterprise view. A table listing stakeholders and their roles in delivering the system is shown in the table in Appendix Two. Stakeholders' roles with reference to the physical objects are shown in Figure 3.3, and represented in Table 3.3(a).

Figure 3.3(a) – ARC-IT Enterprise Legend

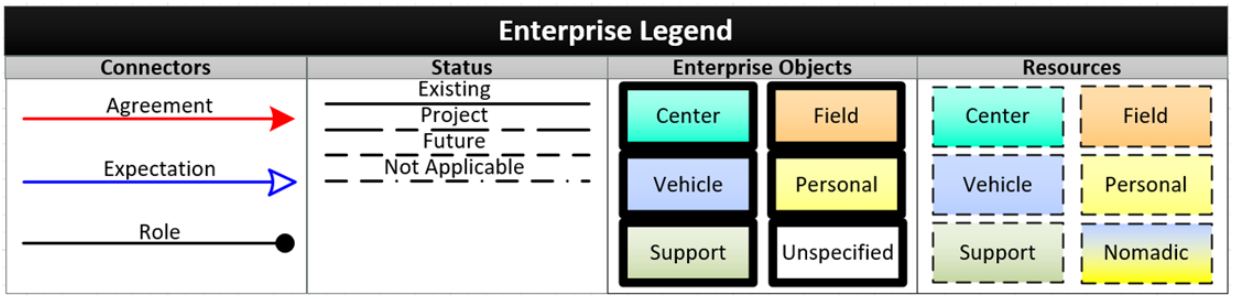


Figure 3.3(b) – ICVP Enterprise View

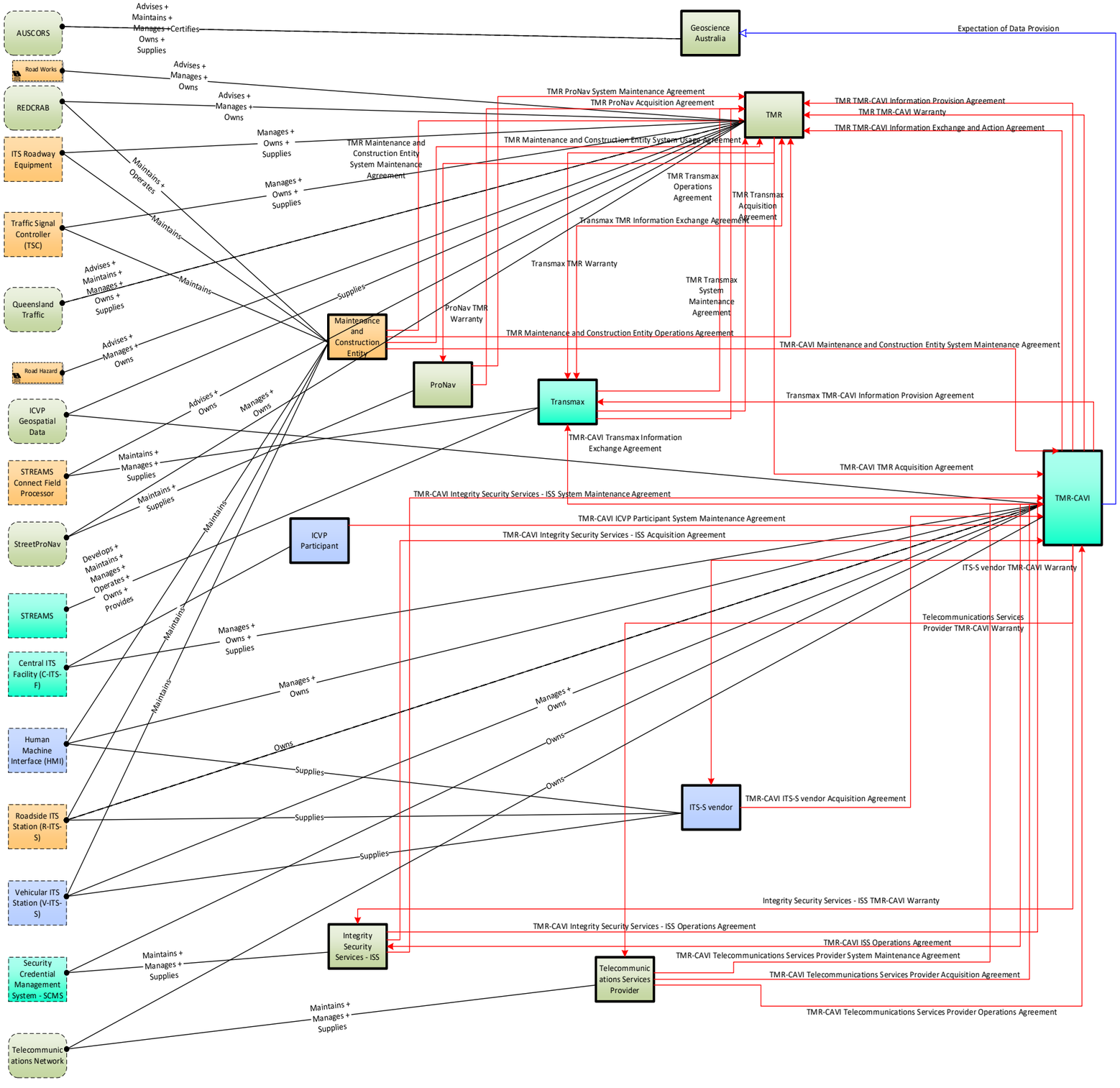


Table 3.3(a) – Stakeholder roles

Physical Object (Element)	Stakeholder(s)	Role
AUSCORS	Geoscience Australia	Maintains, Manages, Owns, Supplies
Central ITS Facility (C-ITS-F)	ICVP Participant, TMR-CAVI	Maintains, Manages, Owns, Supplies
Geospatial Data Lead	TMR	operates
Human Machine Interface (HMI)	ITS-S vendor, Maintenance and Construction Entity, TMR-CAVI	Supplies, Maintains, Manages, Owns
ICVP Geospatial Data	TMR, TMR-CAVI	Supplies, Maintains, Manages, Owns
ICVP Operation/Safety Evaluation - FOT	TMR-CAVI	Operates
ITS Roadway Equipment	Maintenance and Construction Entity, TMR	Maintains, Manages, Owns, Supplies
Maintenance and Construction Entity	Maintenance and Construction Entity	
MQTT broker	TMR-CAVI	Maintains, Manages, Owns, Supplies
Queensland Traffic	TMR	Maintains, Manages, Owns, Supplies
REDCRAB	Maintenance and Construction Entity, TMR	Maintains, Operates, Manages, Owns
Road Hazard	TMR	Manages, Owns
Road Works	TMR	Manages, Owns
Roadside ITS Station (R-ITS-S)	ITS-S vendor, Maintenance and Construction Entity, TMR-CAVI	Supplies, Maintains, Manages, Owns
SCMS Operator	Integrity Security Services - ISS	Operates
Security Credential Management System - SCMS	Integrity Security Services - ISS, TMR-CAVI	Maintains, Manages, Supplies, Owns
STREAMS	Transmax	Develops, Maintains, Manages, Operates, Owns, Provides
STREAMS Connect Field Processor	TMR, Transmax	Owns, Maintains, Manages, Supplies
StreetProNav	ProNav, TMR	Maintains, Supplies, Manages, Owns
Telecommunications Network	Telecommunications Services Provider, TMR-CAVI	Maintains, Manages, Supplies, Owns
TMR	TMR	
Traffic Signal Controller (TSC)	Maintenance and Construction Entity, TMR	Maintains, Manages, Owns, Supplies
Vehicular ITS Station (V-ITS-S)	ITS-S vendor, Maintenance and Construction Entity, TMR-CAVI	Supplies, Maintains, Manages, Owns

In addition to the stakeholder roles (relation to physical objects) ARC-IT provides a relationship between the stakeholders based on their roles in the system. These relationships can be agreements or expectations as the case may be. Relationships between the ICVP stakeholders is summarised in Table 3.3(b).

In Figure 3.3(a) agreements are shown in red lines and expectations in blue lines.

Table 3.3(b) – Stakeholder relationships

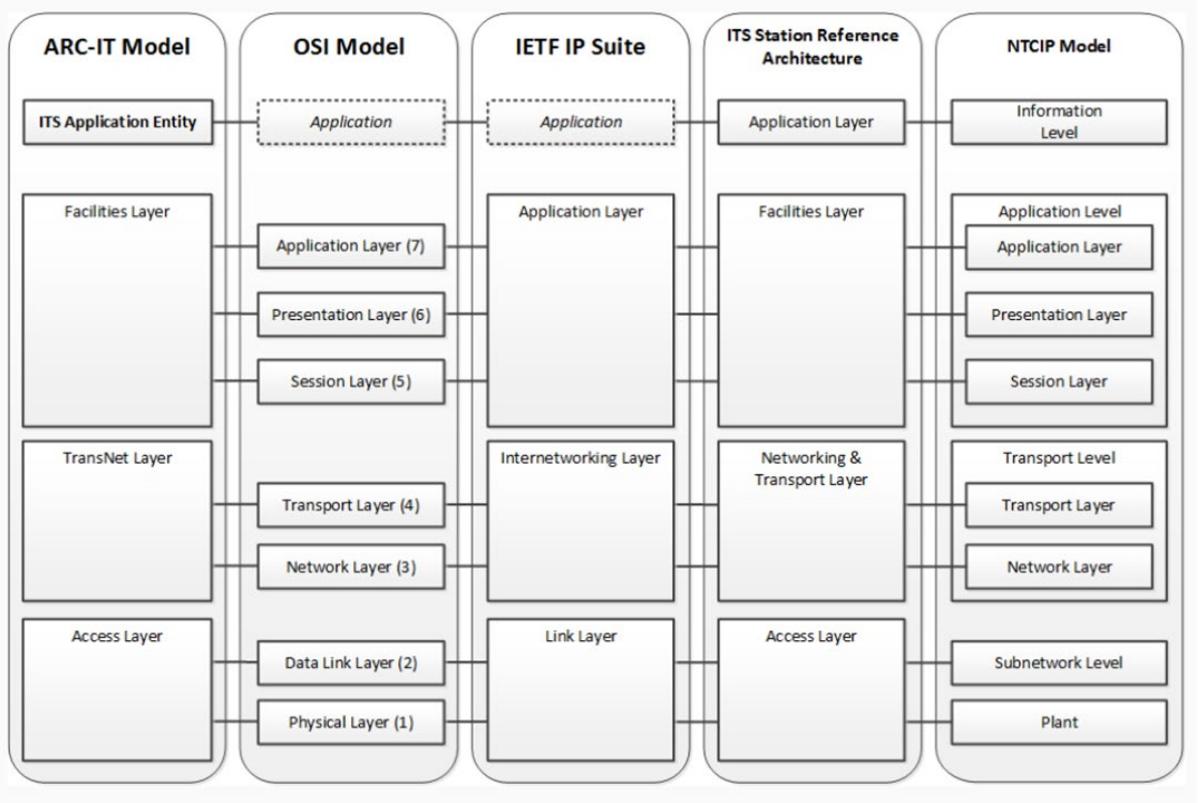
Source	Destination	Coordination Type	Description
Integrity Security Services - ISS	TMR-CAVI	Agreement	This is a(n) Warranty between Integrity Security Services - ISS and TMR-CAVI
ITS-S vendor	TMR-CAVI	Agreement	This is a(n) Warranty between ITS-S vendor and TMR-CAVI
ProNav	TMR	Agreement	This is a(n) Warranty between ProNav and TMR
Telecommunications Services Provider	TMR-CAVI	Agreement	This is a(n) Warranty between Telecommunications Services Provider and TMR-CAVI
TMR	Maintenance and Construction Entity	Agreement	This is a(n) Operations Agreement between TMR and Maintenance and Construction Entity
		Agreement	This is a(n) System Maintenance Agreement between TMR and Maintenance and Construction Entity
		Agreement	This is a(n) System Maintenance Agreement between TMR-CAVI and Telecommunications Services Provider
		Agreement	This is a(n) System Usage Agreement between TMR and Maintenance and Construction Entity
TMR	ProNav	Agreement	This is a(n) Acquisition Agreement between TMR and ProNav
			This is a(n) System Maintenance Agreement between TMR and ProNav
TMR	TMR-CAVI	Agreement	This is a(n) Information Exchange and Action Agreement between TMR and TMR-CAVI
		Agreement	This is a(n) Warranty between TMR and TMR-CAVI
TMR	Transmax	Agreement	This is a(n) Acquisition Agreement between TMR and Transmax
		Agreement	This is a(n) Operations Agreement between TMR and Transmax
		Agreement	This is a(n) System Maintenance Agreement between TMR and Transmax
TMR-CAVI	Geoscience Australia	Expectation	An expectation where one party believes another party will provide data on a regular and recurring basis, and that that data will be useful to the receiver in the context of the receiver's application. This thus includes some expectation of data fields.
TMR-CAVI	ICVP Participant	Agreement	This is a(n) System Maintenance Agreement between TMR-CAVI and ICVP Participant

Source	Destination	Coordination Type	Description
TMR-CAVI	Integrity Security Services - ISS	Agreement	This is a(n) Acquisition Agreement between TMR-CAVI and Integrity Security Services - ISS
		Agreement	This is a(n) Operations Agreement between TMR-CAVI and Integrity Security Services - ISS
		Agreement	This is a(n) System Maintenance Agreement between TMR-CAVI and Integrity Security Services - ISS
TMR-CAVI	ITS-S vendor	Agreement	This is a(n) Acquisition Agreement between TMR-CAVI and ITS-S vendor
TMR-CAVI	Maintenance and Construction Entity	Agreement	This is a(n) System Maintenance Agreement between TMR-CAVI and Maintenance and Construction Entity
TMR-CAVI	Telecommunications Services Provider	Agreement	This is a(n) Acquisition Agreement between TMR-CAVI and Telecommunications Services Provider
		Agreement	This is a(n) Operations Agreement between TMR-CAVI and Telecommunications Services Provider
		Agreement	This is a(n) System Maintenance Agreement between TMR-CAVI and Telecommunications Services Provider
TMR-CAVI	TMR	Agreement	This is a(n) Acquisition Agreement between TMR-CAVI and TMR
TMR-CAVI	Transmax	Agreement	This is a(n) Information Exchange Agreement between TMR-CAVI and Transmax
Transmax	TMR	Agreement	This is a(n) Information Exchange Agreement between Transmax and TMR
		Agreement	This is a(n) Warranty between Transmax and TMR
Transmax	TMR-CAVI	Agreement	This is a(n) Information Provision Agreement between Transmax and TMR-CAVI

3.4 Communications View

The communications view in ARC-IT, matches the ITS reference Architectures (ISO 21217) which is the model used by CAVI in implementing the ICVP. A comparison of the ARC-IT model with other standard models is shown in Figure 3.4(a).

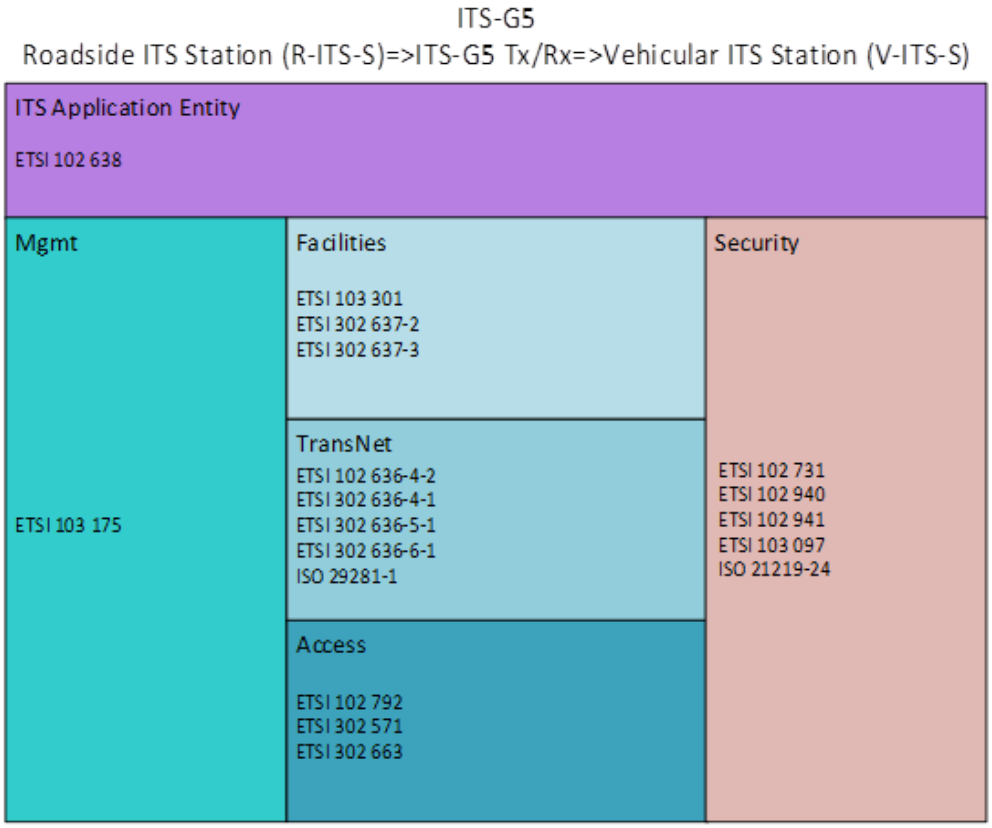
Figure 3.4(a) – Communication model comparison (source: arc-it.net)



Each flow linking ICVP elements can be represented using the ARC-IT communication model. The most common of these links is the ITS-G5 solution of the ICVP which connects the R-ITS-S and the V-ITS-S. This is as represented in Figure 3.4(a).

A list of other selected ICVP solutions linking C-ITS components are also shown in Appendix Two.

Figure 3.4(b) – ICVP ITS-G5 solution



3.4.1 ICVP communication flows

The communication between the physical objects for the use cases described in Section 3.1 are summarised below.

In the table, the flow name, Source elements and destinations elements correspond to the designated name shown in the high level diagram in Figure 2(a) as well as the use case diagrams shown in the section on physical view.

Table 3.4.1 – Communication flows between ICVP Elements

Flow Name	Flow Description	Source Element	Destination Element
4G/LTE	The 4G/LTE connection links the V-ITS-S and R-ITS-S to the ICVP network. Network traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations, enrolments and authentications of the ITS stations.	Roadside ITS Station (R-ITS-S)	Telecommunications Network
		Telecommunications Network	Roadside ITS Station (R-ITS-S)
		Telecommunications Network	Vehicular ITS Station (V-ITS-S)
		Vehicular ITS Station (V-ITS-S)	Telecommunications Network
Asset geospatial data	Geospatial data for ITS assets and landmarks	ICVP Geospatial Data	Central ITS Facility (C-ITS-F)
BoQ information	BoQ information from STREAMS gateway to the C-ITS-F	STREAMS	Central ITS Facility (C-ITS-F)

Flow Name	Flow Description	Source Element	Destination Element
Centre operator data	Data presented to a Centre operator. This flow represents general status output and other data that broadly applies to transportation Centres.	Central ITS Facility (C-ITS-F)	ICVP Operation/Safety Evaluation - FOT
Centre operator input	Input from a Centre operator. This flow represents operator input that broadly applies to transportation Centres.	ICVP Operation/Safety Evaluation - FOT	Central ITS Facility (C-ITS-F)
Configs and Commands	STREAMS sends commands to query current setting of VSL device and STREAMS connect FP, as well as configure the VLS device and STREAMS connect FP	STREAMS	STREAMS Connect Field Processor
		STREAMS Connect Field Processor	STREAMS
Credential management operator input	Installation and updates of information necessary for security management in ITS-S during operation	SCMS Operator	Security Credential Management System - SCMS
Credential management operator presentation	Current status of the SCMS system	Security Credential Management System - SCMS	SCMS Operator
Data provision	Data provision provides the source material for a publish-subscribe or query-retrieval data distribution scheme. This is the 1 of the 1:N data distribution architecture. This flow is a super-flow; it does not define data elements but is inclusive of any flow implemented using publish-subscribe or query-retrieval methods.	ITS Roadway Equipment	STREAMS Connect Field Processor
		STREAMS	STREAMS Connect Field Processor
		STREAMS Connect Field Processor	STREAMS
		StreetProNav	ICVP Geospatial Data
Device identification	An identifier and device type designation that is used to uniquely identify a device in the Connected Vehicle Environment.	STREAMS Connect Field Processor	STREAMS
Driver information	Regulatory, warning, and guidance information provided to the driver while en-route to support safe and efficient vehicle operation.	ITS Roadway Equipment	ICVP Participant
Driver updates	Information provided to the driver including visual displays, audible information and warnings, and haptic feedback. The updates inform the driver about current conditions, potential hazards, and the current status of vehicle on-board equipment.	Human Machine Interface (HMI)	ICVP Participant
Equipment maintenance request	Identification of field equipment requiring repair and known information about the associated faults.	Central ITS Facility (C-ITS-F)	STREAMS
Equipment maintenance status	Current status of field equipment maintenance actions.	ITS Roadway Equipment	STREAMS Connect Field Processor
		STREAMS	Central ITS Facility (C-ITS-F)
		Traffic Signal Controller (TSC)	STREAMS Connect Field Processor

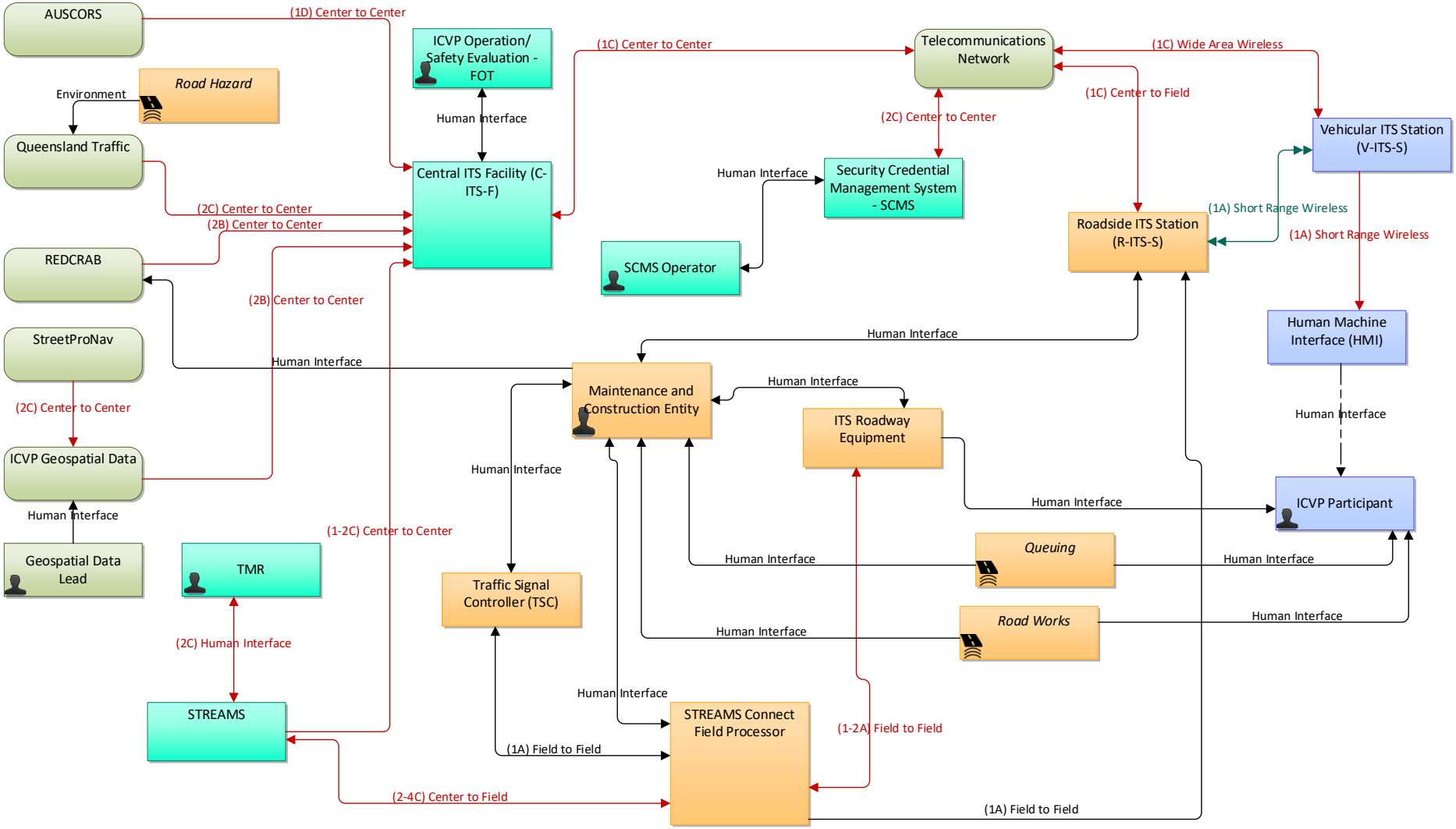
Flow Name	Flow Description	Source Element	Destination Element
Field equipment configuration settings	Control settings and parameters that are used to configure field equipment.	STREAMS	STREAMS Connect Field Processor
Field equipment software install/upgrade	This flow supports installation and update of software residing in ITS roadway equipment. It supports download of the software installation files, including executable code and associated support files.	STREAMS	STREAMS Connect Field Processor
Field equipment status	Reports from field equipment (sensors, signals, signs, controllers, etc.) which indicate current operational status.	STREAMS Connect Field Processor	STREAMS
Field equipment status presentation	Presentation of operational status of field equipment (sensors, signals, signs, controllers, etc.) to field personnel.	ITS Roadway Equipment	Maintenance and Construction Entity
		Roadside ITS Station (R-ITS-S)	Maintenance and Construction Entity
		STREAMS Connect Field Processor	Maintenance and Construction Entity
		Traffic Signal Controller (TSC)	Maintenance and Construction Entity
Field personnel equipment input	User input from field personnel that supports querying, controlling, and configuring field equipment.	Maintenance and Construction Entity	ITS Roadway Equipment
		Maintenance and Construction Entity	Roadside ITS Station (R-ITS-S)
		Maintenance and Construction Entity	STREAMS Connect Field Processor
		Maintenance and Construction Entity	Traffic Signal Controller (TSC)
Get VSL settings	The FP interrogates the VSL for its current settings	ITS Roadway Equipment	STREAMS Connect Field Processor
HMI status	This flow between the HMI and V-ITS-S, is used for monitoring the status of the HMI	Human Machine Interface (HMI)	Vehicular ITS Station (V-ITS-S)
ITS-G5 Tx/Rx	ITS-G5 Link between the R-ITS-S and V-ITS-S to transmit/receive ETSI messages	Roadside ITS Station (R-ITS-S)	Vehicular ITS Station (V-ITS-S)
		Vehicular ITS Station (V-ITS-S)	Roadside ITS Station (R-ITS-S)
IVI information	Variable speed limit information provided by STREAMS to C-ITS-F	STREAMS	Central ITS Facility (C-ITS-F)
Maintenance and construction Centre personnel input	User input from maintenance and construction Centre personnel including routing information, scheduling data, dispatch instructions, device configuration and control, resource allocations, alerts, incident and emergency response plan coordination.	TMR	STREAMS

Flow Name	Flow Description	Source Element	Destination Element
Maintenance and construction operations information presentation	Presentation of maintenance and construction operations information to Centre personnel. This information includes maintenance resource status (vehicles, equipment, and personnel), work schedule information, work status, road and weather conditions, traffic information, incident information and associated resource requests, security alerts, emergency response plans and a range of other information that supports efficient maintenance and construction operations and planning.	STREAMS	TMR
Private Peering	Private peering to C-ITS-F is utilised with a data flow up to 100Mbps. Network Traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations and enrolments.	Central ITS Facility (C-ITS-F)	Telecommunications Network
		Telecommunications Network	Central ITS Facility (C-ITS-F)
Public peering	Public peering to C-ITS-F is utilised with a data flow up to 1Gbps. Network Traffic include, ICVP operations data, ICVP maintenance data and SCMS authorisations and enrolments.	Central ITS Facility (C-ITS-F)	Telecommunications Network
		Telecommunications Network	Central ITS Facility (C-ITS-F)
Road hazard	Traffic road hazard warning	Queensland Traffic	Central ITS Facility (C-ITS-F)
		REDCRAB	Central ITS Facility (C-ITS-F)
Road Hazard information	Road Hazard information acquired by QLD traffic by various means including web-cams, CCTV etc	Road Hazard	Queensland Traffic
RTCM3	Radio Technical Commission for Maritime Services (RTCM) version 3	AUSCORS	Central ITS Facility (C-ITS-F)
RW Updates	Road works updates	Maintenance and Construction Entity	REDCRAB
Set VSL	Set VSL parameters by sending a request	STREAMS Connect Field Processor	ITS Roadway Equipment
Spatial data input	Spatial data is manually entered into the ICVP Geospatial Data repository	Geospatial Data Lead	ICVP Geospatial Data
Speed Limit Information	The posted speed information as displayed by a road sign or electronic signs such as variable speed limit signs (VSL).	Vehicular ITS Station (V-ITS-S)	Human Machine Interface (HMI)
TRAFF	Serial communication between the TSC and the FP using the TRAFF protocol.	STREAMS Connect Field Processor	Traffic Signal Controller (TSC)
		Traffic Signal Controller (TSC)	STREAMS Connect Field Processor
Tx SPATEM	The FP transmits SPaT data to the R-ITS-S	STREAMS Connect Field Processor	Roadside ITS Station (R-ITS-S)
Hazard notification	Hazard event notification to HMI resulting from the RHW application.	Vehicular ITS Station (V-ITS-S)	Human Machine Interface (HMI)

Flow Name	Flow Description	Source Element	Destination Element
Wireless Internet	Wireless internet is used for linking the SCMS to the relevant ICVP components to the ICVP network. Network Traffic include SCMS authorisations, enrolments and authentications of the ITS stations.	Security Credential Management System - SCMS	Telecommunications Network
		Telecommunications Network	Security Credential Management System - SCMS

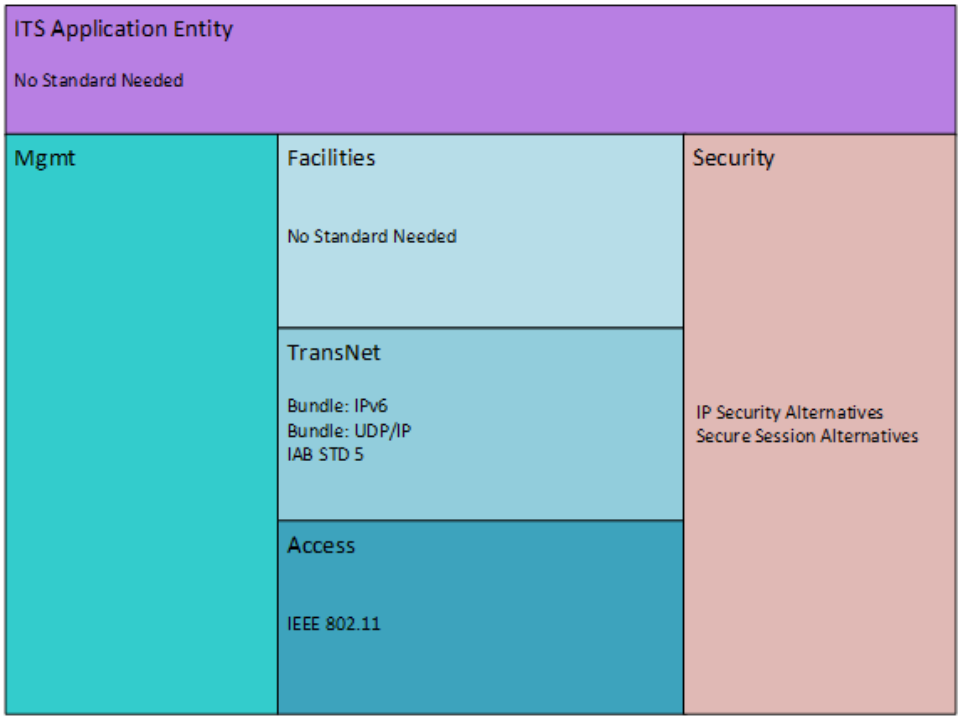
4 Appendices

4.1 Appendix One: High Level (ARC-IT layer 0) ICVP System View

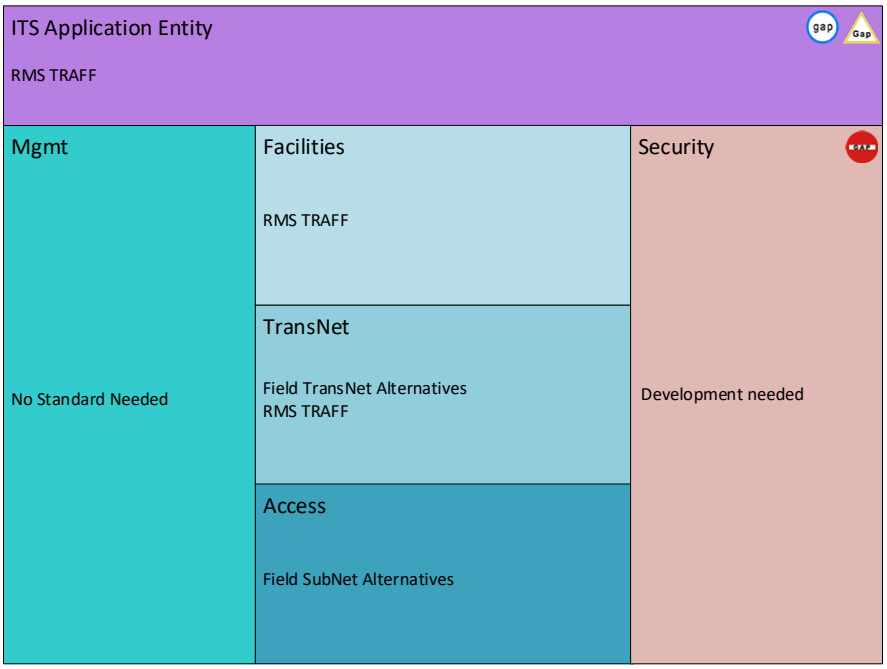


4.2 Appendix Two: Selected Communications Solutions

OBU-HMI LAN
Vehicular ITS Station (V-ITS-S)=>vehicle hazard event=>Human Machine Interface (HMI)

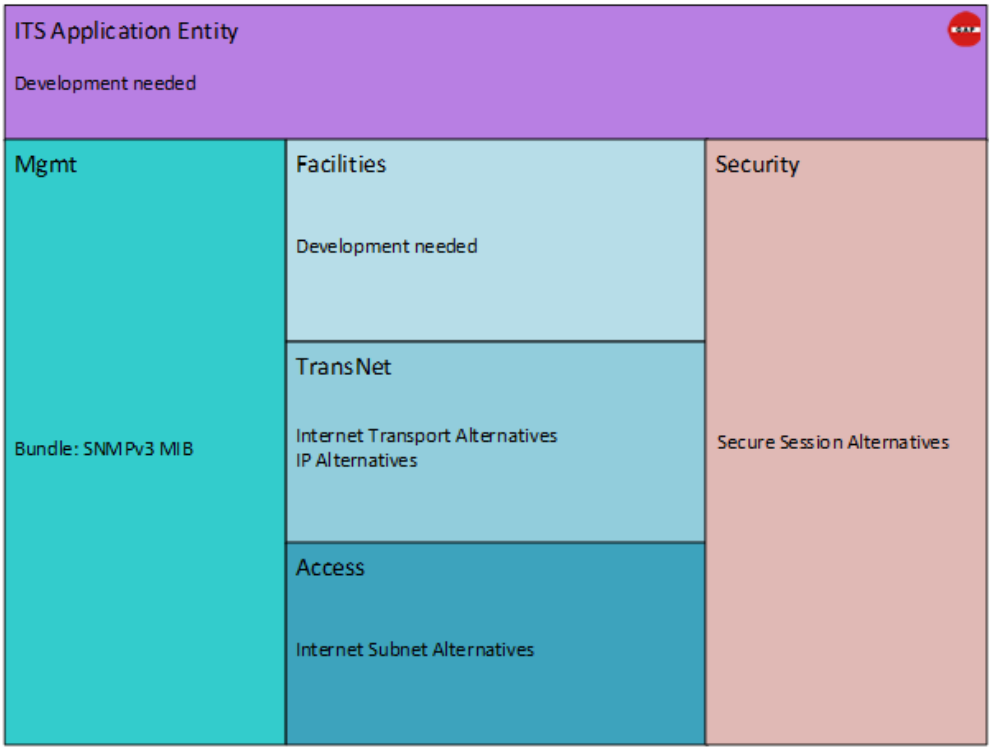


TRAFF
Traffic Signal Controller (TSC)=>TRAFF=>STREAMS Connect Field Processor



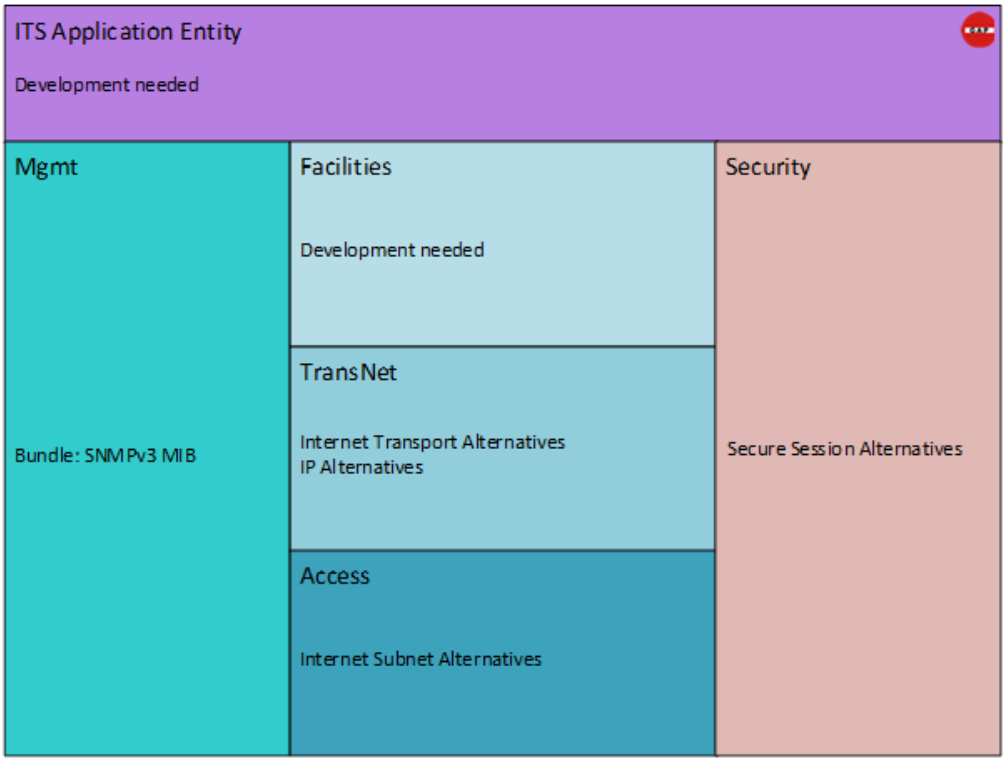
1) The solution does not provide any significant security and a communications link using this solution is easily hacked.
2) Some of the data elements for this information flow are not fully defined.
3) The document is publicly available and widely used but it is not currently a formal standard.

(None-Data) - Secure Internet (ITS)
STREAMS Connect Field Processor=>Set VSL=>ITS Roadway Equipment



1) Performance, functionality, and the upper-layers of the OSI stack have not been defined for this information flow.

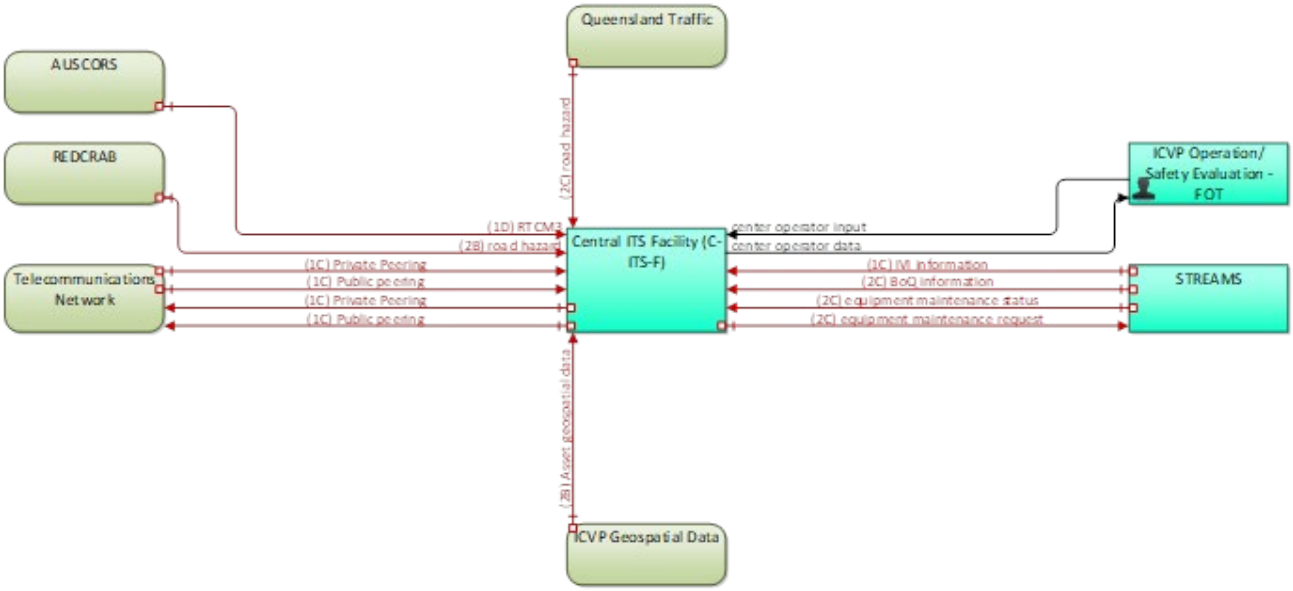
(None-Data) - Secure Internet (ITS)
Telecommunications Network=>4G/LTE=>Roadside ITS Station (R-ITS-S)



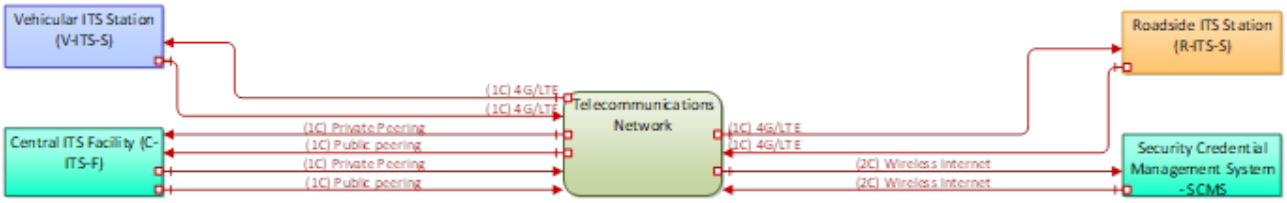
1) Performance, functionality, and the upper-layers of the OSI stack have not been defined for this information flow.

4.3 Appendix Three: Selected ICVP Context Diagrams

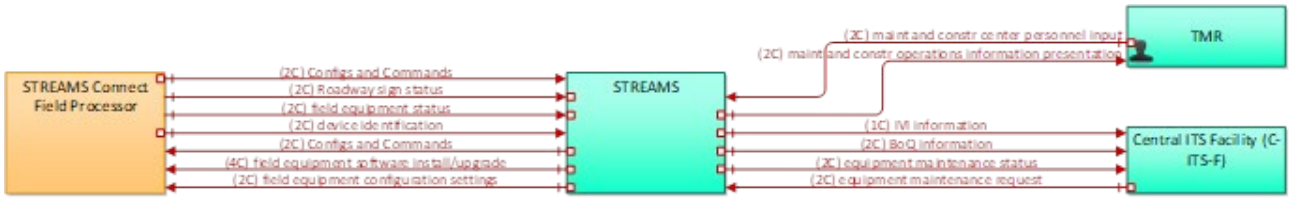
C-ITS-F



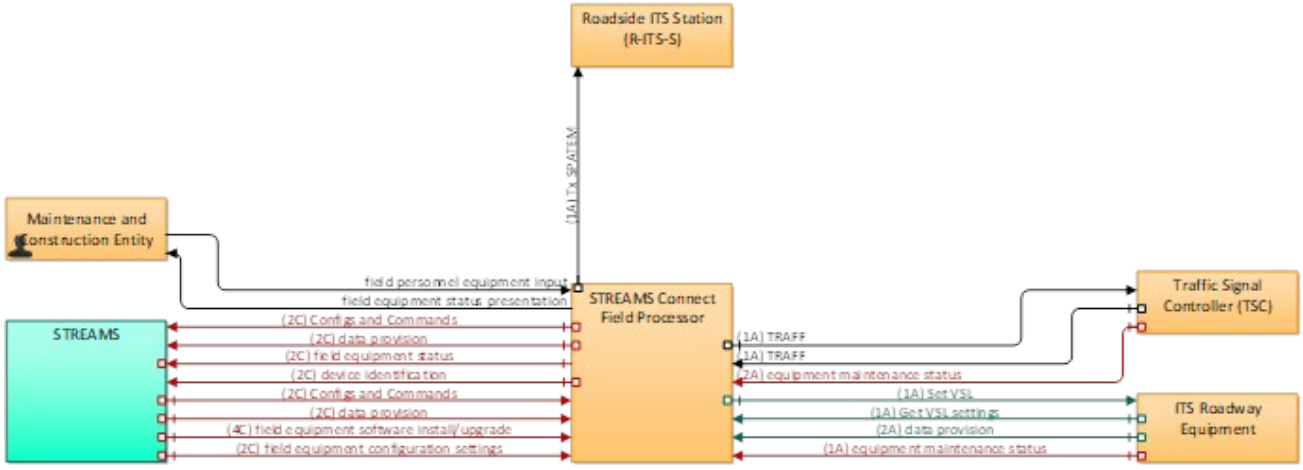
Telecommunications Network



STREAMS

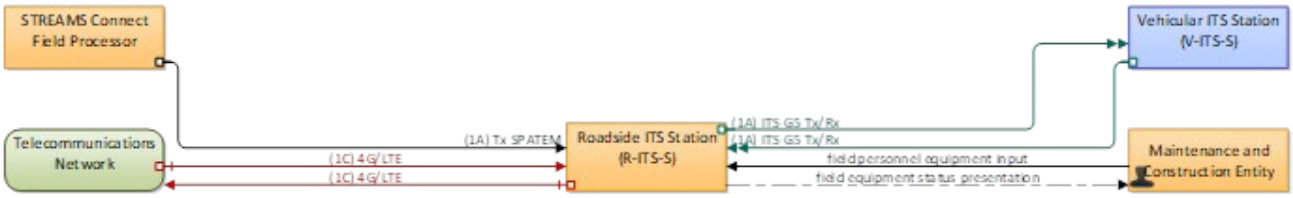


STREAMS-Connect (FP)

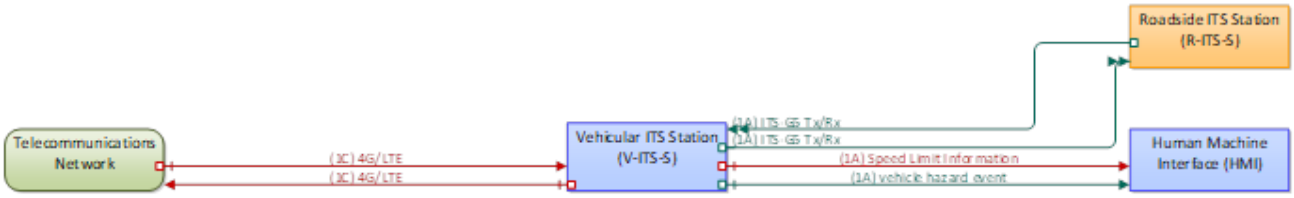


SCMS

R-ITS-S



V-ITS-S



4.4 Appendix Four: Standards applied in ICVP

No	Standard/Document	Name	Version	Date
1	ETSI EN 302 571	Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU	2.1.1	2017-02
2	ETSI EN 302 636-1	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 1: Requirements	1.2.1	2014-04
3	ETSI EN 302 636-2	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 2: Scenarios	1.2.1	2013-11
4	ETSI EN 302 636-3	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture	1.2.1	2014-12
5	ETSI EN 302 636-4-1	Intelligent Transport Systems (ITS); Vehicular Communication; Geonetworking; Part 4 Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media- Independent Functionality.	1.3.1	2017-08
6	ETSI EN 302 636-5-1	Intelligent Transport Systems (ITS); Vehicular Communication; Geonetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocols.	2.1.1	2017-05
7	ETSI EN 302 636-6-1	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 6: Internet Integration; Sub-part 1: Transmission of IPv6 Packets over GeoNetworking Protocols		

No	Standard/Document	Name	Version	Date
8	ETSI EN 302 637-2	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service	1.3.2	2014-11
9	ETSI EN 302 637-3	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service.	1.2.2	2014-11
10	ETSI EN 302 663	Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band	1.2.1	2013-07
11	ETSI EN 302 665	Intelligent Transport Systems (ITS); Communications Architecture	1.1.1	2010-09
12	ETSI EN 302 931	Vehicular Communications; Geographical Area Definition	1.1.1	2011-07
13	ETSI TR 103 415	Intelligent Transport Systems (ITS); Security; Pre-standardization study on pseudonym change management	1.1.1	2018-04
14	ETSI TS 101 539-1	Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification	1.1.1	2013-08
15	ETSI TS 101 539-3	Intelligent Transport Systems (ITS); V2X Applications; Longitudinal Collision Warning (LCRW) application requirements specification	1.1.1	2013-11
16	ETSI TS 102 636-4-2	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 2: Media-dependent functionalities for ITS-G5	1.1.1	2013-10
17	ETSI TS 102 637-1	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements	1.1.1	2010-09
18	ETSI TS 102 687	Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part.	1.2.1	2018-04
19	ETSI TS 102 724	Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band.	1.1.1	2012-10
20	ETSI TS 102 731	Intelligent Transport Systems (ITS); Security; Security Services and Architecture	1.1.1	2010-09
21	ETSI TS 102 860	Intelligent Transport Systems (ITS); Classification and management of ITS application objects	1.1.1	2011-05
22	ETSI TS 102 894-1	Intelligent Transport Systems (ITS); Users and applications requirements; Part 1: Facility layer structure, functional requirements and specifications	1.1.1	2013-08

No	Standard/Document	Name	Version	Date
23	ETSI TS 102 894-2	Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and Facilities layer common data dictionary	1.2.1	2014-09
24	ETSI TS 102 940	Intelligent Transport Systems (ITS); Security; ITS communications security Architecture and security management	1.2.1	2016-11
25	ETSI TS 102 941	ITS Security - Trust and Privacy Management	1.2.1	2018-05
26	ETSI TS 102 942	Intelligent Transport Systems (ITS); Security; Access Control	1.1.1	2012-06
27	ETSI TS 102 943	Intelligent Transport Systems (ITS); Security; Confidentiality services	1.1.1	2012-06
28	ETSI TS 102 965	Intelligent Transport Systems (ITS); Application Object Identifier (ITS - AID); Registration list.	1.3.1	2016-11
29	ETSI TS 103 097	ITS Security - Security header and certificate formats	1.3.1	2017-10
30	ETSI TS 103 175	Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium	1.1.1	2015-06
31	ETSI TS 103 248	Intelligent Transport Systems (ITS); GeoNetworking; Port Numbers for the Basic Transport Protocol (BTP)	1.1.1	2016-11
32	ETSI TS 103 301	Intelligent Transport Systems (ITS) - Vehicular Communications - Basic Set of Applications - Facilities layer protocols and communication requirements for I2V messages	1.1.1	2016-11
33	IEEE 802.11	IEEE Standard for Information technology — Telecommunications and information exchange between systems, local and metropolitan area networks — Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications		2016
34	IEEE 1609.2	Wireless Access in Vehicular Environments--Security Services for Applications and Management Messages		2017
35	ISO/TS 14823	Intelligent transport systems -- Graphic data dictionary		2017-05
36	ISO 17419	Intelligent transport systems — Cooperative systems — Globally unique identification		2018
37	ISO/TS 19091	Intelligent transport systems — Cooperative ITS — Using V2I and I2V communications for applications related to signalized intersections		2017
38	ISO/TS 19321	Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures		2015-04
39	SAE J2735	Dedicated Short Range Communications (DSRC) Message Set Dictionary		2016
40	SAE J2945/1	On-Board System Requirements for V2V Safety Communications		2016-03

No	Standard/Document	Name	Version	Date
41	ISO 14816	Road transport and traffic telematics; Automatic vehicle and equipment identification; Numbering and data structure		2005
42	ISO 3166-1	Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes		2013
43	ISO/IEC 20922	Information technology -- Message Queuing Telemetry Transport (MQTT)	3.1.1	2016
44	ISO/IEC 27001	Information technology -- Security techniques -- Information security management systems -- Requirements		2015
45	RTCM 10403.3	Differential GNSS (Global Navigation Satellite Systems) Services - version 3:2016		2016-10
46	ITU-T X.691/ISO/IEC 8825-2	Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)		