TMRD5 Pilot Deployment Plan

Ipswich Connected Vehicle Pilot (ICVP)

March 2022

Queensland Government

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Document control options

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Departmental approvals

Refer to the appropriate Risk Assessment Tool for relevant reviewer and approver

Date	**Name**	**Position**	**Action required** *(Review/endorse/approve)*	**Due**
08/06/2018	Katharine Mosley / Nicholas Brook	Principal Advisor / Principal Engineer	Create	08/06/2018
30/05/2021	Package Leads	Various	Update	Ongoing/Monthly
16/09/2021	Max Jamwal-Girdler	Principal Advisor	Review/Update	28/2/2022
	Miranda Blogg	Director, CAVI	Final Approval for public release	Pre-publication

Risk Level

☐ GACC major ☐ GACC minor ☐ High risk (but not GACC) ☒ Medium risk

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Version history

Version no.	Owner	Date	Nature of amendment
0.1	KT/NB	08/06/2018	New structure, updated HL schedule, breakdown of components, updated content
0.2	MB	11/06/2018	Added Roles, RASCI, Procurement, Benefits, Data management, minor review
0.3	NB	14/06/2018	Consistency and content improvement – all sections.
1	NB	15/06/2018	Infrastructure Investment Committee Gate 4 release
1.01	NB	29/06/2018	Package D tender release
1.1	NB	17/09/2018	Update with team recommended changes (multiple comments and edits)
1.2	NB	30/11/2018	Update document to post procurement, release 3.
1.3	KM/ VM	20/12/2018	Incorporated delivery plan content
1.4	MB/ NT	6/03/2019	Incorporated new document deliverables/ status, added new Governance
1.5	NT	09/05/2019	Incorporating baseline for documents to assist with reporting
1.6	MB/ NT	05/06/2019	Document review and general update
1.7	MB/KT/VM /NT/SAK/CM	12/07/2019	Update V-ITS, R-ITS, SCMS/Work Package C, Comms milestone/document dates
1.8	SC	25/07/2019	Minor corrections to test program
1.9	NT	16/09/2019	Updated TMR Strategic Plan
1.10	JW	30/09/2019	Added PAM 4 deliverables.
1.11	MB	7/01/2020	Update of due dates and general text updates
1.12	SH	10/02/2020	Document review, update of due dates and general text update
1.13	SH	10/03/2020	Update of due dates
1.14	SH	16/03/2020	Update of due dates and general text updates
1.15	SH	6/5/2020	Update of due dates
1.16	SH	8/6/2020	Update milestone due dates and installation text updates
1.17	MB	30/06/2020	Review and update
1.18	PC	01/07/2020	Update section 20.2
1.19	JW	01/07/2020	Added Tiles section 20.5 Added new document ID TMRD29 (SH)
1.20	PC	02/07/2020	Updated the architecture drawing and component and interface descriptions
1.21	SH	07/07/2020	Consolidated Human Machine Interface (HMI) updates that were updated in v1.20-ZT.
1.22	JW	15/07/2020	Added figures 20.2, 20.3. Fixed some figure numbering.
1.23	MB/VM	26/7/2020	Review and updates
1.24	VM	31/7/2020	Review and updates
1.25	SH	11/08/2020	Updated documentation and Milestones/Hold Points due dates
1.26	SH	25/08/2020	Updated Package F Documentation and Milestone tables Updated and Package C Documentation Due Dates

Version no.	Owner	Date	Nature of amendment
1.27	SH	14/09/2020	Monthly review and update
1.28	MJG	12/10/2020	Monthly review and update (including update to Benefits Management to align with TMR Strategic Plan 2019–2023 (revised for 2020–21)
1.29	MJG	20/11/2020	Monthly review and update
1.30	REB	04/01/2021	Monthly review and update in preparation for MAIC Audit
1.31	REB	05/02/2021	Monthly review and update in preparation for MAIC Audit
1.32	VF	12/02/2021	Monthly review and update
1.40	CMs	08/03/2021	Monthly review and update
1.41	MJG	13/04/2021	Monthly review and update
1.42	MJG	13/05/2021	Monthly review and update
1.43	MJG	11/06/2021	Monthly review and update
1.44	MJG	12/07/2021	Monthly review and update
1.45	MJG	11/01/2022	Finalise for publication
2.0	NSB	28/01/2022	Final clean and submit to publications

Glossary

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

It should be noted that the Cooperative Intelligent Transport Systems (C-ITS) Pilot (the Pilot) is publicly referred to as the Ipswich Connected Vehicle Pilot (ICVP).

It should also be noted that the Pilot team refers to Transport and Main Roads and vendors.

Contents

1 Introduction

Globally, work on connected vehicles is occurring at unprecedented levels. Connected vehicles currently account for 5% of all vehicles, but it is forecast by 2031 that 90% of new vehicles will be connected in some manner (Austroads, 2021). Europe's C-Roads is evidence of this momentum, with 18 countries working toward the deployment of standardised connected vehicle services – referred to as cooperative intelligent transport system (C-ITS).

C-ITS allows vehicles, infrastructure, and other users to communicate in real-time, which is used to provide road users with information or warnings relevant to their current situation. C-ITS support a range of applications (or use cases) that provide drivers with warnings that can positively impact safety, congestion, and emissions.

Industry expectations are that Australia will align with the European C-ITS standards, which if deployed, would require governments to enhance digital and physical infrastructure. In Queensland, this can be achieved by modernising the Department of Transport and Main Roads' roadside infrastructure, back-office systems, processes, and data.

In response to the emerging C-ITS deployment, Transport and Main Roads conducted an on-road Field Operational Test (FOT) of C-ITS technologies in Ipswich, South East Queensland. The FOT assisted the department in understanding the benefits and deployment needs; readying deployment partners; and exposing the department's customers to the technology through six safety use cases.

The C-ITS Pilot (the Pilot) assessed six safety use cases in 355 participants' vehicles retrofitted with a European compliant C-ITS vehicle station (V-ITS-S) and a human machine interface (HMI). Once installed in the vehicle, the participants used the equipment for nine months. Data was shared between the V-ITS-S, roadside stations (R-ITS-S), and the central station (C-ITS-S), which was used to generate warnings that were displayed to the driver as visual or audible advice. The response to the warning was not automated in the vehicle - the driver was always in control of the vehicle. Data collected through the pilot will be used for a safety evaluation to estimate the likely impacts on crashes.

This document presents the *C-ITS Pilot Deployment Plan (PDP)* developed for the *C-ITS Pilot Phase 2: Pilot Deployment*. The *C-ITS Pilot Phase 1: Planning* was completed in June 2018.

This document serves as the overarching deployment plan for the pilot. The document was baselined and approved in June 2018, was updated regularly to reflect the completion of the deliverables, and issued to internal customers, the project board, and vendors.

1.1 Background

The Pilot (known externally as the Ipswich Connected Vehicle Pilot, or ICVP) sits within the broader Cooperative and Automated Vehicle Initiative (CAVI). The Pilot was intended to prepare for, and accelerate, the emergence of connected vehicle technologies onto Queensland roads, to maximise benefits for road users now and in the future.

The Pilot was in response to the national call for priority trials and research of transformative transport technologies including smart infrastructure, connected vehicles, and digital security (*National Policy Framework for Land Transport Technology, Action Plan: 2016-2019* and *2020-2023* (Department of Infrastructure, Transport, Regional Development and Communications, 2016)).

The initiative is part of the *Queensland Transport and Roads Investment Program* (QTRIP), managed through the Targeted Road Safety Program (TRSP) and is a '*OneTMR Major Project'*.

The initiative was managed using the whole-of-government Project Assessment Framework (PAF) gating process. Under PAF Stage 30[1], the business case (ITS Pilot Project Business Case) was approved by the Infrastructure Investment Committee (IIC) in May 2016. In July 2018, IIC PAF Stage 4 gate was approved allowing the pilot to progress procurement, development and deployment of the field operational test.

1.2 Objectives

The Pilot objectives were to:

- **validate** the safety impacts and user perceptions C-ITS use cases
- **demonstrate** technologies publicly and build public awareness and uptake
- **grow** the department's technical and organisational readiness for C-ITS technologies
- **encourage** partnerships and build capability in private and public sectors.

The objectives are linked to the *Transport and Main Roads Strategic Plan (2016-2020)* and were updated for the 2019-2023 plan. Table 1.2 shows Pilot objectives as follows:

Table 1.2 – C-ITS Pilot Transport and Main Roads Strategic Plan alignment

Transport and Main Roads Strategic Plan 2016-2020	Transport and Main Roads Strategic Plan 2019-2020
Customer focus (building public awareness)	**Accessible** - Tailored connections for our customers and workforce to create an integrated and inclusive network (Facilitate solutions to improve accessibility and customer experience)
Innovation (cooperative and automated technologies)	**Responsive** - Our network, services and workforce respond to current and emerging customer expectations (Enable adaptive solutions that respond to emerging transport technologies, customer expectations and government priorities.)
Liveable cities (safety)	**Safe** - Safe and secure customer journeys and Transport and Main Roads workplaces (Enable the safe introduction of new technologies and services onto the network. Prioritise safety in all the work we do. Design, operate and maintain a secure, safe and resilient transport system)
Contemporary workforce (grow department's readiness)	**Responsive** - Our network, services and workforce respond to current and emerging customer expectations (Provide continuous learning opportunities to support an innovative and future-ready workforce)
Sustainable funding (encourage partnerships)	**Efficient** - Partnerships, integration, innovation and technology advance the movement of people and goods (Work more effectively with internal and external stakeholders to create benefits for our customers. Leverage technology, data and information to enhance network and organisational performance)
Building of prosperity (alignment with international standards)	**Sustainable** - Planning, investment and delivery outcomes support a more liveable and prosperous Queensland (Prioritise planning and investment decisions that enhance benefits realisation)

[1] PAF Stage 1 and 2 were not required due to endorsement of the pilot by the Executive Leadership Team and Minister Bailey in 2015. The Project is a pilot and as such an investigation of the solution toward full deployment. Options typically explored in the business case will be explored in the project.

1.3 Applicable standards

Through Austroads, Australia has informally agreed to align with the European C-ITS standards – which the Pilot adopted. The standards include European Telecommunications Standards Institute (ETSI), Institute of Electrical and Electronics Engineers (IEEE), International Standards Organisation (ISO), and Society of Automotive Engineers (SAE) documents. While the Pilot aligned with these standards, several of the standards are still emerging or are untested. Some pilot requirements were bespoke or an extension of the international standards.

The Pilot services and equipment also met relevant Australian Standards.

Finally, Transport and Main Roads also have a set of relevant technical specifications that were considered in the planning phase and were consulted throughout the deployment phase.

A list of the standards can be found in the project specifications (see Section 1.5 Pilot Documentation)

1.4 Documentation

Figure 1.4 below presents the documentation structure and owners for the Pilot. Clear, consistent, and considered documentation of all components was required to ensure repeatability, and to enable learnings to be shared with stakeholders.

Figure 1.4 – C-ITS Pilot documentation structure

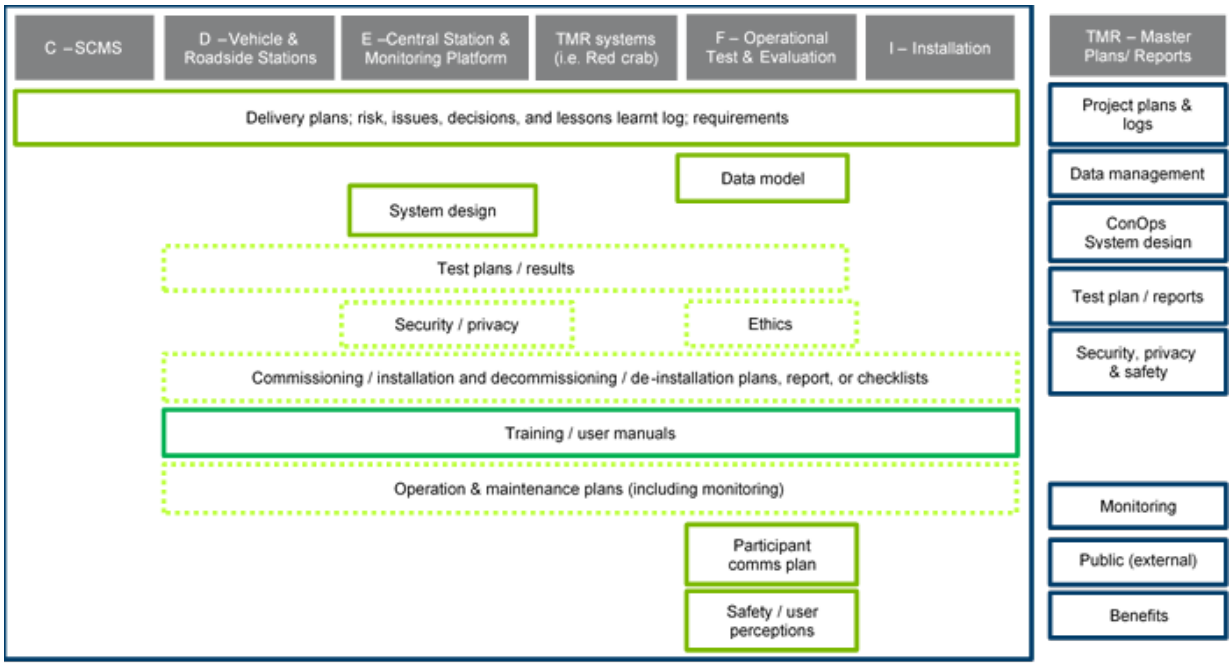


Table 1.5(a) lists the specific documentation delivered by Transport and Main Roads and each package provider. Documentation was reviewed, updated, and re-released as required, some are pending release post-pilot (such as the Safety Evaluation Report).

The *Project Management Plan (PMP)* included a quality management plan, a safety management plan (planning, design, development, and testing) and a business continuity plan. A series of *Project Specific Technical Specifications (PSTS)* were developed in the planning phase for procurement of the V-ITS and R-ITS stations. The PSTS documents will inform future development of Transport and Main Roads technical specifications for C-ITS.

1.5 Pilot documentation

A status dictionary was used for tracking documents through their lifecycle (Table 1.5(a) to Table 1.5(k)):

- In progress - Document/product is under development.
- Final - Document/product approved by the relevant delegate for external distribution.

The tables capture whether the documents are publicly released, as per publication release status below:

- **Public** – will be available for public release. Not all of these are available on Transport and Main Roads publications page, however these can be made available on request.
- **Internal Only** – are **not** available for public release.
- **Restricted/Sensitive** – are **not** available for public or internal release.

Table 1.5(a) – Transport and Main Roads documentation

Package and documents	Completed date	Update frequency / status	Publication
TMRD1. Business Case	Q3 2020	As required	Internal only
TMRD2. Project Management Plan	Q4 2020	Annually	Internal only
TMRD3. Benefits Realisation Plan	Q2 2021	As required	Internal only
TMRD4. Asset Management Plan	Q4 2020	As required	Internal only
TMRD5. Pilot Deployment Plan (PDP)	Q1 2022	Final	Public
TMRD6. Project Standards and Tech Specs (PSTS)	Q3 2020	Final	Public
PSTS001. System Overview (High-level Design)	Q3 2020	Final	Public
PSTS0011 to 18 Use Case Specifications	Q3 2020	Final	Public
PSTS002 V-ITS-S Specification	Q3 2020	Final	Public
PSTS003 HMI Specification	Q3 2020	Final	Public
PSTS004 Field Processor Specification	Q2 2020	Final	Public
PSTS005 R-ITS-S Specification	Q3 2020	Final	Public
PSTS006 Data Elements	Q3 2020	Final	Public
PSTS007 C-ITS-S Protocol Specification	Q3 2020	Final	Public
PSTS008 Security Certificate Protocol	Q3 2020	Final	Public
TMRD7. Sample C-ITS Data (no change)	Q2 2018	Final	Public
TMRD8. Risk, Issues, Decision & Lessons log	Q1 2022	Final	Internal only
TMRD8. Lessons Learned Report	Q1 2022	Final	Public
TMRD9. System Requirements	Q3 2020	Final	Internal only
TMRD11. Privacy Impact Assessment	Q4 2020	Final	Public
TMRD12. Data Management Plan	Q3 2020	Final	Internal only
TMRD13. Security Management Plan	Q4 2020	Final	Sensitive
TMRD15 Stakeholder & Communications Plan	Q4 2020	Final	Internal only
TMRD16 Pilot Safety Management Plan	Q3 2020	Final	Internal only
TMRD18. Master Test Strategy, Plan and Report	Q3 2020	Final	Internal only

Package and documents	Completed date	Update frequency / status	Publication
TMRD19. Master Operations and Maintenance (O&M) Plan	Q3 2020	Final	Internal only
TMRD23. Master Future Options Analysis	Q1 2022	Final	Internal only
TMRD24. Master Maintenance Log	Q4 2021	Final	Sensitive
TMRD25. Concept of Operations	Q2 2022	Final	Public
TMRD26. Master System Architecture and Design	Q1 2022	Final	Public
TMRD28. System Performance Summary	Q1 2022	Final	Public
TMRD29. Account, Roles and Users Register	Q3 2020	Final	Internal only
TMRD30. Dress Rehearsal Technical Note	Q3 2020	Final	Internal only

Table1.5(b) – Vehicle station (V-ITS-S) vendor documentation

Package and documents	Completed date	Update frequency / status	Publication
VSD1. Delivery Plan (V-ITS-S) and PDP update	Q4 2018	Final	Public
VSD2. Design Proposal & Initial User Manual (V-ITS-S)	Q4 2018	Final	Internal only
VSD3. Test Plan (V-ITS-S)	Q4 2018	Final	Internal only
VSD4.1 Updated User Manual (V-ITS-S FAT)	Q2 2020	Final	Internal only
VSD4.2 Updated User Manual (V-ITS-S SIAT)	Q2 2020	Final	Internal only
VSD5. Operation and Maintenance Plan (V-ITS-S)	Q2 2020	Final	Internal only
VSD6. Quality Control Checklists (V-ITS-S)	Q4 2020	Final	Internal only
VSD7. Commissioning Test Sheets (V-ITS-S)	Q4 2020	Final	Internal only
VSD9. New IP Detailed Design and Source Code (V-ITS-S)	Q1 2022	Final	Public

Table 1.5(c) – Roadside station (R-ITS-S) vendor documentation

Package and documents	Completed date	Update frequency / status	Publication
RSD1. Delivery Plan (R-ITS-S) and PDP update	Q4 2018	Final	Public
RSD2. Design Proposal & Initial User Manual (R-ITS-S)	Q4 2018	Final	Internal only
RSD3. Test Plan (R-ITS-S) (was FAT plan & strategy)	Q1 2019	Final	Internal only
RSD4.1 Updated User Manual (R-ITS-S FAT)	Q2 2020	Final	Internal only
RSD4.2 Updated User Manual (R-ITS-S SIAT)	Q3 2020	Final	Internal only
RSD4.3 Updated User Manual (R-ITS-S Pilot)	Q1 2022	Final	Internal only
RSD5. Operation and Maintenance Plan (R-ITS-S)	Q2 2020	Final	Internal only
RSD6. Commissioning Test Sheets (R-ITS-S)	Q2 2020	Final	Internal only
RSD7. Quality Control Checklists	Q2 2019	Final	Internal only
RSD9. New IP Detailed Design and Source Code (R-ITS-S)	Q1 2022	Final	Public

Table 1.5(d) – Central facility/station (C-ITS-F) team documentation

Package and documents	Completed date	Update frequency / status	Publication
CFD1. Update PDP with delivery approach (C-ITS-F)	Q4 2018	Final	Public
CFD2. Design Proposal (C-ITS-F)	Q3 2020	Final	Internal only
CFD3. Security Plan (C-ITS-F)	Q4 2020	Final	Internal only
CFD4. Test Plan (C-ITS-F)	Q4 2018	Final	Internal only
CFD6. Administration and Maintenance Manual	Q3 2020	Final	Internal only
CFD7. Commissioning Report	Q3 2020	Final	Internal only
CFD8. Future Options Analysis (C-ITS-F)	Q3 2021	Final	Internal only
CFD9. Decommissioning Report (C-ITS-F)	Q4 2021	Final	Internal only
CFD11. IP Source Code & Detailed Design (C-ITS-F) suite	Q2 2021	Final	Internal only
CFD11.1 C-ITS-F High-level Architecture	Q2 2021	Final	Internal only
CFD11.2 C-ITS-F Detailed Design - C-ITS application	Q2 2021	Final	Internal only
CFD11.3 C-ITS-F Detailed Design - C-ITS data lake and analytics	Q2 2021	Final	Internal only
CFD12. Monitoring and Reporting System User Manual	Q4 2020	Final	Internal only
CFD13. Configuration Manager User Manual	Q4 2020	Final	Internal only

Table 1.5(e) – Security (SCMS) vendor documentation

Package and documents	Completed date	Update frequency / status	Publication
iMOVE agreement	Q1 2018	Final	Internal only
SCD0. SCMS User Manual	Q2 2018	Final	Internal only
SCD0. SCMS Workshop Report	Q2 2018	Final	Internal only
SCD1. State of C-ITS Cybersecurity Report	Q3 2018	Final	Internal only
SCD3. SCMS Interim Report	Q1 2021	Final	Internal only
SCD4. SCMS Close Out Report	Q4 2021	Final	Internal only
SCD5. SCMS Strategic Directions Report	Q4 2021	Final	Internal only

Table 1.5(f) – Field Operational Test (FOT) and Evaluation vendor documentation

Package and documents	Completed date	Update frequency / status	Publication
FED0. iMOVE Project Agreement	Q4 2019	Final	Internal only
FED1. Study Plan (final update in FED1.1)	Q4 2019	Final	Internal only
FED1.1 Study Plan (Addendum)	Q1 2021	Final	Internal only
FED2. Ethics Submission	Q3 2020	Final	Internal only
FED3. Data Model and Interface Specification	Q1 2019	Final	Internal only
FED5.1 Participant Communications Strategy (Recruitment and Management) & Materials	Q3 2020	Final	Internal only
FED5.2 Training & Briefing Strategy & Materials	Q3 2020	Final	Internal only
FED6. Feedback & Reporting Design & Materials	Q3 2020	Final	Internal only

Package and documents	Completed date	Update frequency / status	Publication
FED7.1 Test plans (HMI Usability, Ergonomics, Rehearsal)	Q2 2020	Final	Internal only
FED8. Installation & De-installation Guidance	Q3 2020	Final	Internal only
FED9. Test Reports (HMI Usability & Ergonomics)	Q3 2020	Final	Internal only
FED10. Driving Simulator Test Plans/ Reports	Q4 2021	Final	Public
FED11. FOT Progress Reports (participant correspondence)	Q4 2021	Final	Internal only
FED13.1a. Preliminary Findings, User Perceptions Interim Reports	Q4 2021	Final	Internal only
FED13.1b. Preliminary Findings (Safety Evaluation Draft Report)	Q4 2021	Final	Internal only
FED13.2a. Final Report including lessons learned (User Perceptions)	Q4 2021	Final	Internal only
FED14.a Data & Tooling Report Proof of Concept (Hold Point)	Q4 2020	Final	Internal only
FED14.b Data & Tooling Report Proof of Concept (Dress Rehearsal),	Q4 2020	Final	Internal only
FED14.c Data & Tooling Report Final	Q1 2021	Final	Internal only
FED15. Hypotheses Evaluation Reports	Q4 2020	Final	Internal only
FED16. Safety Evaluation Final Report	Q1 2022	Final	Public

Table 1.5(g) – Infrastructure data – roadworks documentation

Package and documents	Completed date	Update frequency / status	Publication
RCD1. System Specification	Q1 2020	Final	Internal only
RCD2. Test Plan (Red Crab)	Q4 2019	Final	Internal only
RCD3. Red Crab On-Site User Guide	Q1 2020	Final	Public
RCD4. Test Report (Red Crab App and API)	Q1 2020	Final	Internal only
RWD1. Red Crab User Manual	Q1 2020	Final	Public

Table 1.5(h) – Infrastructure data – speed and signals documentation

Package and documents	Completed date	Update frequency / status	Publication
MDD1. MAPEM Files and Procedure	Q3 2020	Final	Public
SDD1. Speed Database Report and Procedure	Q3 2020	Final	Public
SDD2. Tiles	Q3 2020	Final	Public

Table 1.5(i) – Traffic systems documentation

Package and documents	Completed date	Update frequency / status	Publication
TSD2. Mounting Design	Q2 2020	Final	Public
TSD3. Road Asset Commissioning Plan	Q2 2020	Final	Internal only

Table 1.5(j) – Positioning documentation

Package and documents	Completed date	Update frequency / status	Publication
PAD1. Positioning Report	Q4 2018	Final	Public
PAD2. Positioning Options Analysis	Q4 2018	Final	Public
PAD3. Ipswich Positioning Analysis	Q3 2019	Final	Public

Table 1.5(k) – Installation vendor documentation

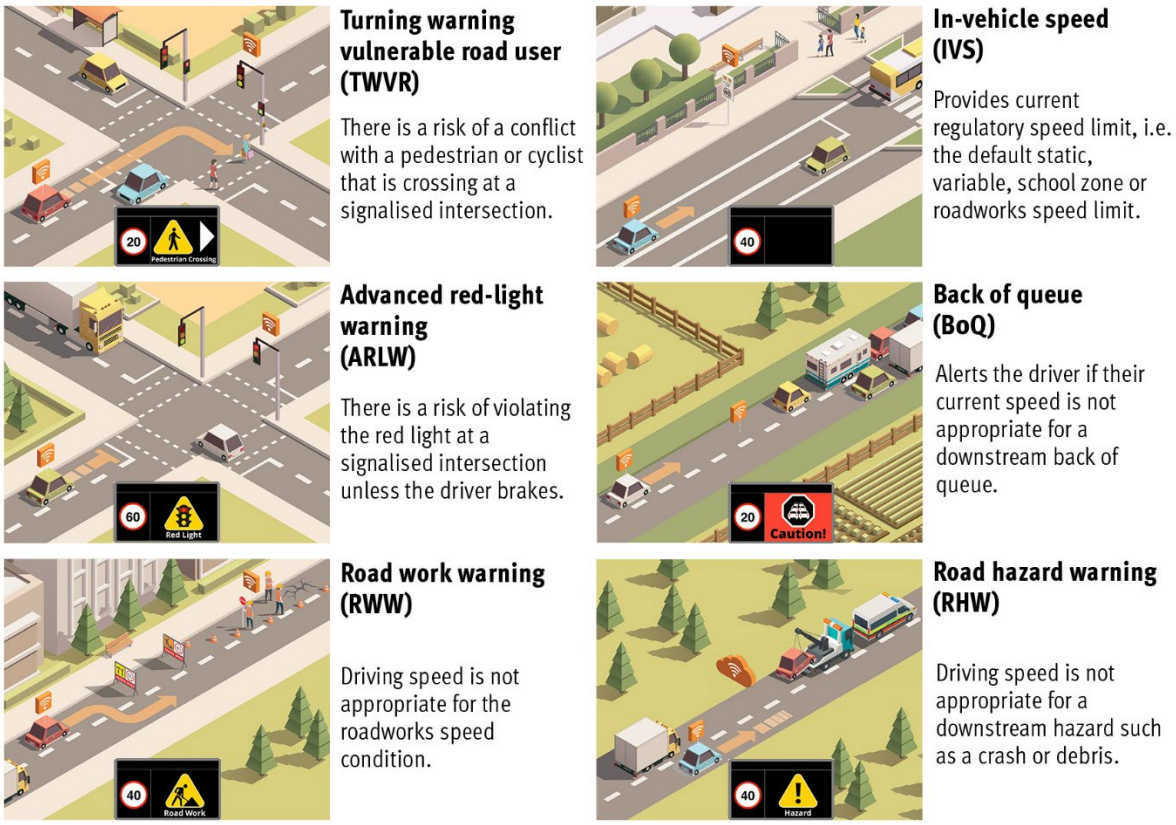
Package and documents	Completed date	Update frequency / status	Publication
IDD2. Installation Plan (was Commissioning Plan)	Q3 2020	Final	Internal only
IDD3. Installation and Decommissioning User Manual (was Installation Plan/procedure)	Q3 2020	Final	Internal only
IDD5. Installation Report & R-ITS-S checklists	Q3 2020	Final	Internal only
IDD6. Installation Report & V-ITS-S checklists	Q3 2020	Final	Internal only
IDD7. Future Options Analysis (Roadside retention agreement)	Q3 2021	Final	Internal only
IDD9. Decommissioning Report (Install)	Q1 2022	Final	Internal only
IDD10. Install Summary Report	Q1 2022	Final	Internal only

2 Pilot Overview

2.1 Pilot scope

The Pilot assessed six safety use cases below (detailed further in Section 2.5 Use cases).

Figure 2.1 – C-ITS Pilot safety use cases



While active, the Pilot included European compliant C-ITS vehicle stations (V-ITS-S) sharing data with roadside stations (R-ITS-S), and the central station (C-ITS-S). The central facility (C-ITS-F) provided tools to monitor and maintain the system. At the end of the pilot period, vehicle equipment was decommissioned from participants' vehicles.

The data generated through the pilot, along with qualitative data derived from the participants' perceptions surveys, was analysed to measure the safety benefits of the technology, as part of the Safety Evaluation Report.

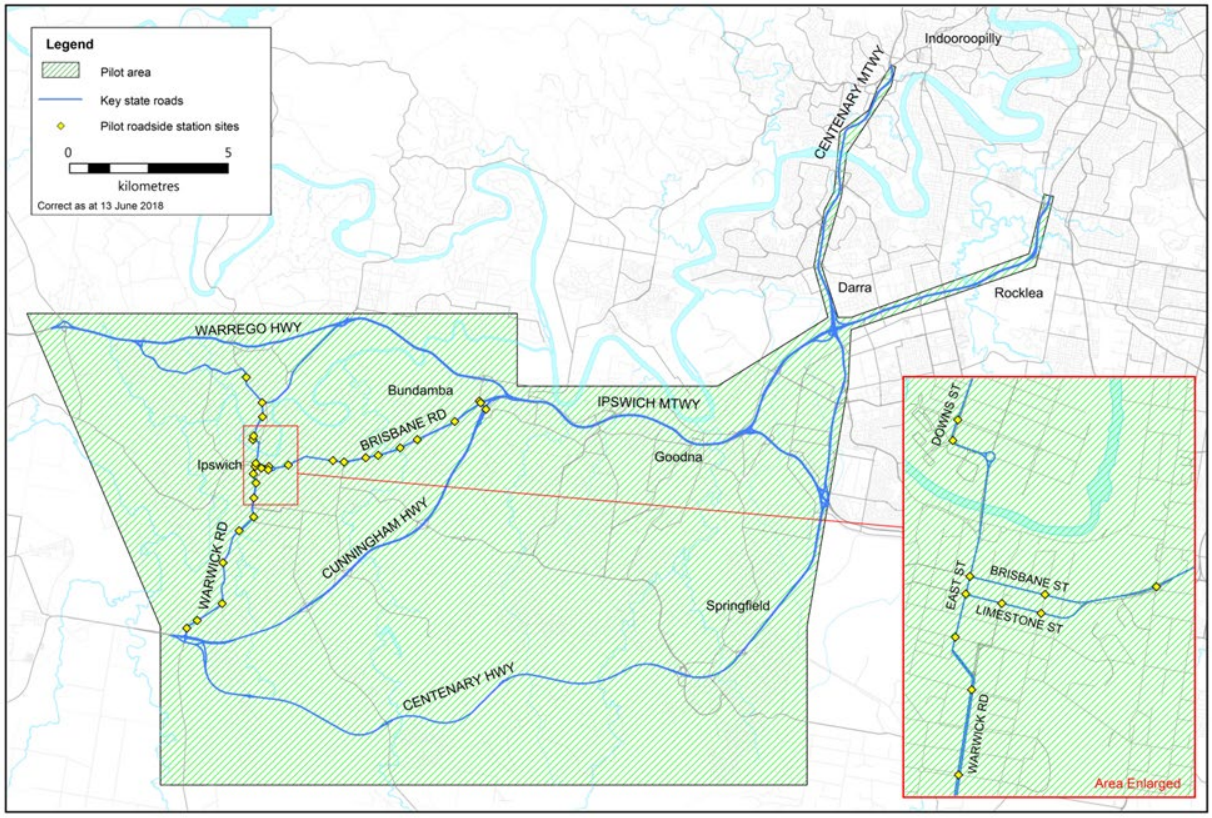
2.2 Pilot area

The FOT took place in Ipswich, to the west of Brisbane, Queensland. Ipswich has an area of 1,090 km² and has a population of 200,000 people, with a population density of 1.83 persons per hectare.

The location was ideally positioned on the national road network served by Ipswich Motorway, Logan Motorway, Centenary Highway, Cunningham Highway, Warrego Highway, Brisbane Road and the Ipswich, Rosewood and Springfield railway lines. The pilot area also included Brisbane Street, Limestone Street, Brisbane Road, Warwick Road, National Highway 15 and M2 Redbank, M7 Ipswich Motorway Wacol, Western Freeway, M7 Ipswich Motorway Darra.

The C-ITS-S covers around 279 km² and R-ITS-S, installed at 29 state road signalised intersections (along Brisbane Street, Limestone Street, Brisbane Road, East Street, Downs Street and Warwick Roads), remain operational post-pilot. Figure 2.2 reflects the pilot area, showing the location of equipped signals and the central station scope.

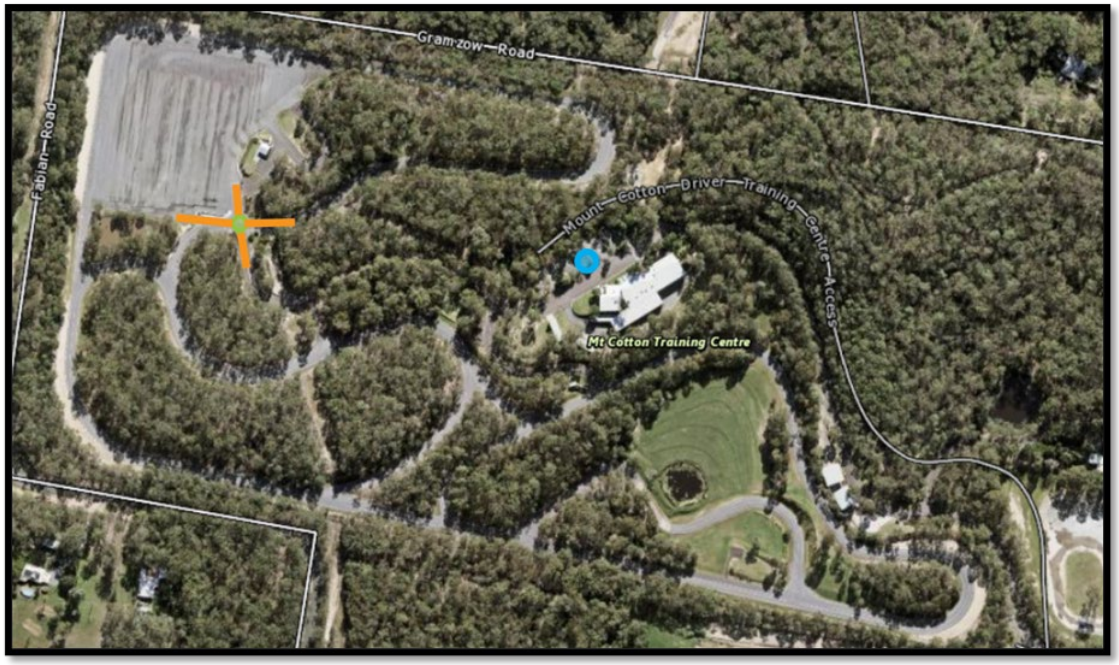
Figure 2.2 – C-ITS Pilot area map tiles and signal locations



2.3 Test site

The RACQ Mobility Centre of Excellence (MCE) at Mount Cotton was used for vehicle testing. The Pilot team equipped the centre with a C-ITS enabled signalised intersection as illustrated in Figure 2.3, this remains on site at the facility.

Figure 2.3 – RACQ Mobility Centre of Excellence Facility - ITS assets (Queensland Globe, 2018)



2.4 Installation site

Vehicle installation, maintenance and removal appointments took place at Ipswich City Council (ICC) premises located at 180-215 Briggs Road, Raceview, QLD – 4305. A map of the site is provided in Figure 2.4.

- Building 1: Vehicle installation and commissioning.
- Building 2: Participant administration, including participant interviews.
- Building 3: vehicle inspections and handover were performed here.
- Other highlighted areas were not available for use by the Pilot team.

Figure 2.4 – Briggs Road installation site (Google Maps, 2020)

2.5 Use cases

The Pilot focussed on six vehicle-to-infrastructure (V2I) use cases intended to improve safety. Drivers were alerted under the following conditions:

- **Advanced Red-light warning (ARLW)** - There is a risk of driving through a red light ahead.
- **Turning warning Vulnerable Road Users (TWVR)** - Pedestrians or bicycle riders potentially crossing at the signalised intersection.
- **Road Hazard Warning (RHW)** - There is a risk of travelling at an unsafe speed for a hazard up ahead, such as water on the road, road closures or a crash.
- **Back-Of-Queue (BoQ)** - There is a risk of travelling at an unsafe speed for upcoming traffic queue.
- **In-Vehicle Speed (IVS)** - Information on the current speed limit.
- **Road Works Warning (RWW)** - There is a risk of travelling at an unsafe speed for upcoming road works additionally, alert if the speed limit is exceeded within the road works.

Transport and Main Roads developed a suite of PSTS including a specification for each use case (PSTS011 through to PSTS018).

Safety advice was provided to the driver through the following value chain:

- **Observe the situation** - C-ITS messages generated and shared by stations. Stations were installed in vehicles (V-ITS-S) and roadsides (R-ITS-S) and enabled centrally (C-ITS-S).
- **Assess the situation** - the C-ITS messages were assessed by the V-ITS-S stations. Vehicle to infrastructure (V2I) used data collected by Transport and Main Roads (such as speed limits, incidents, and signal phase and timing data) that were broadcast from the R-ITS-S or C-ITS-S. The cooperative vehicles used their own movement data to assess the hazard risk, and if relevant, provided a warning to the driver.
- **Deliver the advice** - the V-ITS-S has preconfigured advice based on the use case and condition. The advice was delivered to the driver via the human machine interface (HMI) as visual, audible, haptic and so on.
- **Driver reads and reacts** - the driver receives the advice and takes evasive or alternative action.

The use cases data was based on ETSI standard message types and delivered via short-range (ITS-G5) or cellular communications (3G/4G). The use cases were supported by ETSI C-ITS message protocols, including:

- **Continuous Awareness Message (CAM)** - the vehicle’s position, speed, and so on. broadcast up to 10 times per second
- **Decentralised Environmental Notification Message (DENM)** - generated by a vehicle, infrastructure or the central system to warn other users of a hazard such as hard-braking or roadworks
- **In Vehicle Information (IVI)** - typically regulatory information such as a posted speed sign
- **Signal Phase and Timing (SPaTEM)** - for a signalised intersection
- **MAPEM** - digital representation of the geometry of roadway intersections.

Indicative descriptions and diagrams for V2I use cases are provided in Table 2.5.

All cooperative vehicles generate and share CAMs. A DENM message can be generated and shared by the roadside or the central station, or another cooperative vehicle. The roadside or central station can also generate and share an IVI or SPaTEM and MAPEM message.

Within the pilot, the V-ITS-S vendors did not have access to the vehicle's Controller Area Network (CAN) bus data. Additionally, vendors did not have access to data related to an active handbrake, turning indicator status, brake lights or steering.

Table 2.5 – C-ITS Pilot V2I use cases

Use Case Name and Graphic	Use Case Description and Features
Advanced Red Light Warning (ARLW) 	**Description**: There is a risk of driving through a red light ahead. **Vehicle Interface:** R-ITS-S → V-ITS-S **Vehicle Communications:** ITS-G5 **Message Format:** MAPEM and SPATEM **Data Source:** SPATEM – Traffic controller via the FP. MAPEM – Transport and Main Roads database via the C-ITS-S.
Turning Warning Vulnerable User (TWVR) 	**Description:** Pedestrians or bicycle riders potentially crossing at the signalised intersection. **Vehicle Interface:** R-ITS-S → V-ITS-S **Vehicle Communications:** ITS-G5 Message Format: MAPEM and SPATEM **Data Source:** SPATEM – Traffic controller via the FP. MAPEM – Transport and Main Roads database via the C-ITS-S.
In-Vehicle Speed (IVS) 	**Description:** Information on the current speed limit. **Vehicle Interface:** C-ITS-F → V-ITS-S **Vehicle Communications:** 3G/4G **Message Format:** IVI **Data Source:** STREAMS Gateway (variable speed limits), Transport and Main Roads database (static/school)
Road Work Warning (RWW) 	**Description:** There is a risk of travelling at an unsafe speed for upcoming road works additionally, alert if the speed limit is exceeded within the road works. **Vehicle Interface:** C-ITS-F → V-ITS-S **Vehicle Communications:** 3G/4G **Message Format:** DENM and IVI **Data Source:** Transport and Main Roads Red Crab (road works sign tool)

Use Case Name and Graphic	Use Case Description and Features
Road Hazard Warning (RHW) 	**Description:** There is a risk of travelling at an unsafe speed for a hazard up ahead, such as water on the road, road closures or a crash. **Vehicle Interface:** C-ITS-F → V-ITS-S **Vehicle Communications:** 3G/4G **Message Format:** DENM **Data Source:** QLDTraffic
Back of Queue (BoQ) 	**Description:** There is a risk of travelling at an unsafe speed for upcoming traffic queue. **Vehicle Interface:** C-ITS-F → V-ITS-S **Vehicle Communications:** 3G/4G **Message Format:** DENM **Data Source:** STREAMS Gateway

2.6 Human Machine Interface (HMI)

The vehicle system within the Pilot included a Human Machine Interface (HMI) providing warnings to the driver to encourage safer road user behaviour. Within the planning phase, no V-ITS-S vendors had mature or commercially available HMIs. In response, the department developed PSTS002 which defines the HMI hardware, software, and interfaces. This was a bespoke specification based on in-vehicle HMI standards and best practice guidelines. Table 2.6(a) provides an overview of the HMI display.

Table 2.6(a) – HMI display

Image	Description
	Each region displays different information: • Region 1: Blank section. The region originally indicated system 'health' that is, connections to GPS, cellular, G5, and so on. This was removed prior to recruitment of participants, as usability testing determined that it did not provide participants with actionable information. • Region 2: Presents speed limit information. This comprises the relevant posted speed limit – static, school, variable, or roadworks speed. It is always active. • Region 3: Presents use case warnings when relevant. (Described further below).
	Illustrative example of the HMI display for a participant driving in an area with: • A speed limit of 20km/h, and • A pedestrian crossing ahead, which the driver may not be able to stop safely in time.

The system was designed to operate as per below and will continue to be used beyond the pilot.

On approach to a hazard, use case warnings displayed according to the urgency of the warning, and the system accuracy of the warning. For the latter reason, the warning levels (medium or high) were different for each use case. Some warnings had audible alarms to notify the person to be alert ("boop") or immediately act ("beep"). Warnings were only presented if the driver's speed and location relative to the hazard did not meet certain thresholds. If the driver was already travelling slowly, then no warnings were presented.

Where two or more use cases were relevant, the driver was presented with the priority warning, which relates to the more urgent or critical hazard (also outlined in PSTS002).

For some use cases, additional warnings were provided within the 'event zone' of a hazard. For example, for the ARLW use case, a high (red) warning was provided if a vehicle entered the conflict zone of an intersection.

For road works, a warning was also provided if the driver exceeded the roadworks speed limit (within the roadworks, not the buffer speeds). Speed non-compliance warnings were not provided outside of roadworks zones as speed compliance is a common use-case in many vehicles today.

Warnings in event zone should always be high-level, as this is activated when the driver is highly likely to be acting dangerously (driving above the speed limit in a road works zone or driving through a red light). Table 2.6(b) illustrates the indicative HMI display for each use case.

Table 2.6(b) – C-ITS Pilot indicative HMI content (V-ITS-S version 25 - subject to change)

Use case	Approach warning	Event warning
Road Works (PSTS015)	 Medium level; Audio alert ("boop")	 High level; Audio alert ("boop")
Road Hazard (PSTS016)	 Medium level; No audio	No warning
Back of Queue (PSTS017)	 Medium level; No audio	No warning
Advanced Red Light (PSTS013)	 Medium level; No audio	
	 High level; Audio alert ("beep" x3)	 High level; Audio alert ("beep" x3)

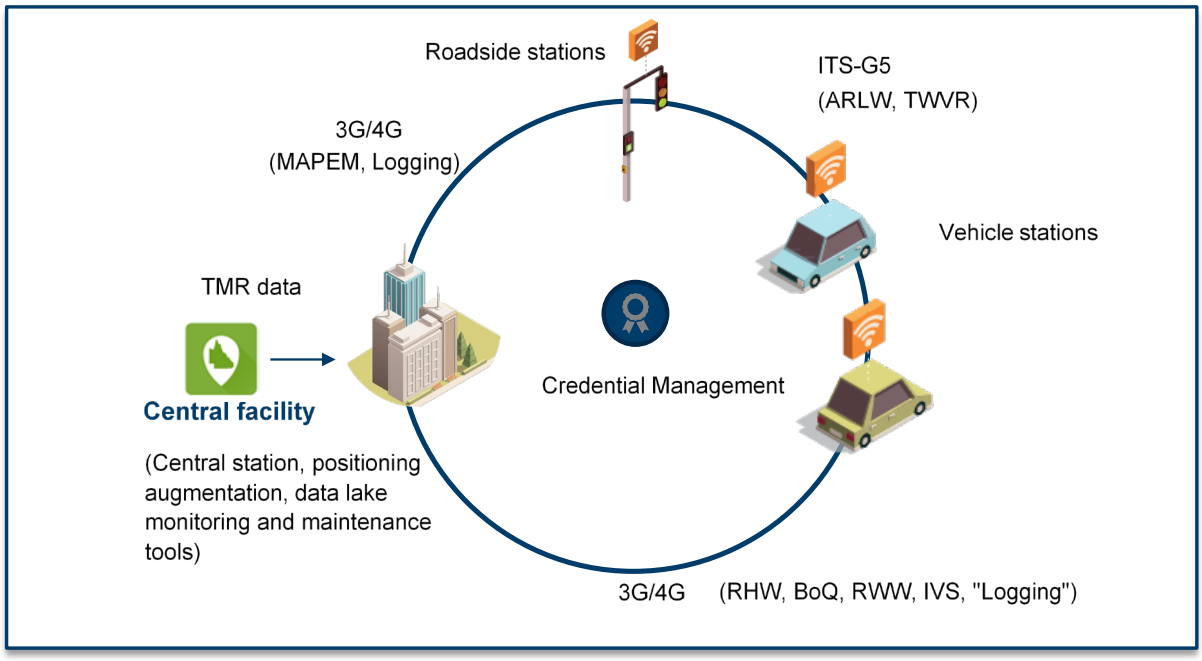
Use case	Approach warning	Event warning
Turning Warning Vulnerable Road Users (PSTS014)	 Medium level (with directional arrow if applicable); Audio alert ("boop")	 Medium continues in event; Audio alert ("boop")

In addition to the C-ITS use case warnings, a participant login screen displayed during HMI start-up and only when the vehicle was stationary, for the driver to acknowledge they were a consenting participant or non-participant.

2.7 Communication architecture

Transport and Main Roads adopted a hybrid model (Figure 2.7) which includes short-range ITS-G5 (5.9GHz) and long-range (3G/4G) communications. Short-range communications support low latency enabling rapid updating, safety-critical C-ITS messages for use cases such as ARLW and TWVR. Long-range communication between the central station and field stations extends the reach of the system beyond the locations equipped with roadside stations, which is a viable option when the message is not time-critical such as RHW, RWW, IVS, and BoQ. All data generated or observed by the field devices was and will continue to be shared with the central station.

Figure 2.7 – Hybrid communications model



The central station shared limited information with the roadside stations – specifically the signalised intersection's spatial data (MAPEM). For the pilot, the roadside station did not broadcast the RHW, RWW, IVS, and BoQ messages – though it is possible and common.

The central station is in the cloud and uses a common Internet of Things (IoT) protocol – Message Queuing Telemetry Transport (MQTT) (ISO/IEC 20922:2016), it remained operational post pilot completion. Vehicles subscribed to relevant topics in the central station message broker, the topics included overlapping tiles that make up the Ipswich area with the relevant IVS, RWW, RHW and BoQ messages.

During the Pilot the Security Credential Management System (SCMS) issued certificates over 3G/4G so that the central, roadside and vehicle stations could sign the C-ITS messages. This functionality remains while systems are kept operational.

2.8 System architecture

The Pilot system architecture, description and interfaces are illustrated in Figure 2.8 and described in Table 2.8(a) and Table 2.8(b) respectively.

Figure 2.8 – C-ITS Pilot system architecture components

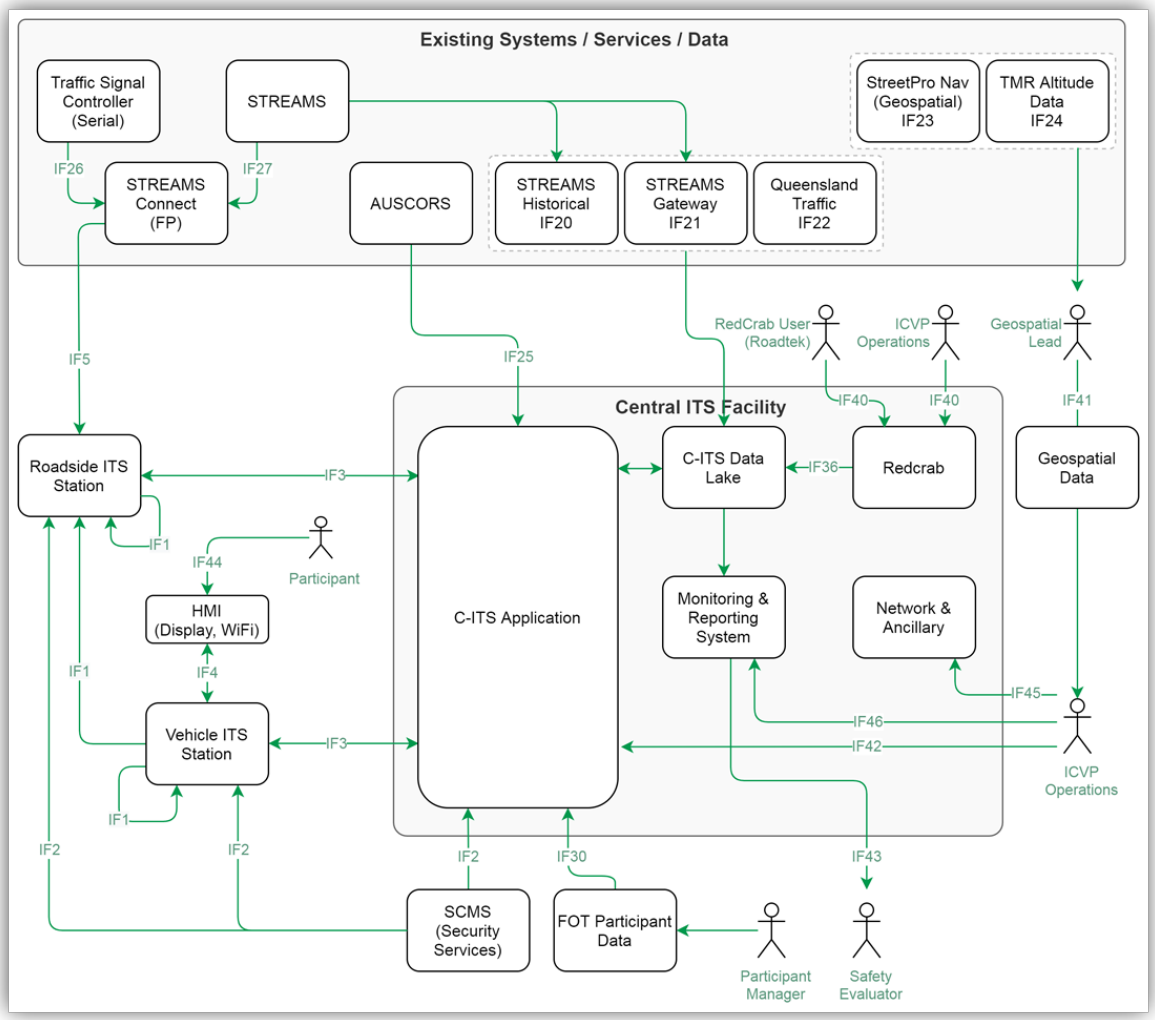


Table 2.8(a) provides further details on the Pilot system architecture components.

Table 2.8(a) – C-ITS Pilot system architecture components

Category	Element	Details
Existing Systems / Service / Data	AUSCORS	Positioning augmentation information by providing Radio Technical Commission for Maritime Services (RTCM) version 3 data. 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.
	Traffic Signal Controller (TSC)	Provides signalised intersection data to the R-ITS-S.
	STREAMS® Connect (FP software)	Converts the TSC data to a C-ITS SPATEM message, which is sent to the R ITS-S. There is no connection from the C-ITS environment to either Transport and Main Road's existing ITS network or STREAMS® control system.
	STREAMS®	Transport and Main Road's ITS network control system.
	STREAMS Historical	This data is used by the MRS to validate the operation of the C-ITS against a 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.
	STREAMS® Gateway	Back-of-queue and variable speed limit data that are extracted in near real-time. These data are used by the C-ITS-S to generate a BoQ DENM message and an IVS IVIM message.
	Queensland Traffic	Queensland Traffic Road hazard data that are extracted in near real-time. These data are used by the C-ITS-S to generate a RHW DENM message.
	Altitude Data	Altitude data that is required by the Spatial Service to enhance the C-ITS message.
	StreetPro Navigator spatial data	Geospatial data that are used to generate the Road Network Model, which are used by the Spatial Service to enhance the C-ITS message.
Central ITS Facility (C-ITS-F)	C-ITS Data Lake	The C-ITS-S Data Lake is used to ingest, stage and curate store data sets which are of wide-spread interest to the Transport and Main Roads 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 **Pilot 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.

Category	Element	Details
	C-ITS Application	**Position Augmentation** forwards RTK data using the RTCM version 3 protocol delivered over MQTT to V-ITS-S consumers. Position Augmentation provides automatic fallback to a variable number of, typically three, AUSCORS mountpoints. The **Central ITS Station** (C-ITS-S) is an implementation of the ETSI 302 665 V1.1.1 concept. The C-ITS-S ingests data such as QLDTraffic from the data lake and uses an implementation of the ETSI DEN, IVI and RLT basic services to generate DENM, IVIM and MAPEM respectively. The spatial content in the ingested data is modified to conform to the system's road network model. C-ITS messages are signed to meet ETSI 103 097 V1.3.1 requirements using the C-ITS Message Signing Service. The **C-ITS Message Signing Service** (C-ITS-S security layer) requests and protects the C-ITS-S certificates issued by the SCMS. A physical Hardware Security Module is provided by the cloud supplier (AWS). The certificates are used by the C-ITS-S to sign the messages. The **Safety Evaluator Data Logging** service provides decoded pilot data and system performance metrics to the C-ITS Data Lake. The **SSH Service** is a secure shell for emergency remote maintenance on V-ITS-S or R-ITS-S stations. The **Participant Management API** enables the participant management team to provide updates to the V-ITS-S stations as needed to conduct the safety evaluation. The **Software Update Service** allows V-ITS-S and R-ITS-S vendors to update the software on the stations while within the private Pilot mobile network. The **STREAM Gateway BoQ** ingestor is running on the AWS Elastic Container Service to meet latency requirements. The **STREAM Gateway VSL** ingestor is running on the AWS Elastic Container Service to meet latency requirements. The **Configuration Manager** is a web interface to manage the Pilot deployment by the C-ITS-F Administrator and Change Lead.
	Monitoring and Reporting System	The **Monitoring & Reporting Service** (MRS) uses Tableau to provide dashboard visualisations of the logged data. The visualisations are not real time – yesterday's data is processed overnight. Process data is also made available to the third-party Safety Evaluator via the Data Lake. The **Extract, Transform, Load Calculations and Storage** retrieves data from the C-ITS Data Lake daily to monitor system performance and report on system metrics. **Visualisation** of the system performance is provided by the Transport and Main Roads Shared Services Tableau instance that is managed by the department's Information Technology Branch. The **Tableau Hyper Extract** queues and pushed hyper files to the Tableau instance. **Data Packaging and Delivery** is a service that provides safety evaluation data to the Field Operational Test safety evaluation team on a daily schedule.
	Network and Ancillary	The **AWS Direct Connect** provides a physical, dedicated and secure connection from AWS infrastructure to the Firewall. The **Firewall** is a virtual Palo Alto firewall that provides access to the private CAVI APN mobile network that the V-ITS-S and R-ITS-S operate within.

Category	Element	Details
		Internet access is provided via the Firewall for access by the V-ITS-S and R-ITS-S to DNS resolution and the SCMS endpoint. The **Virtual Private Network** provides a backup for secure private communications that would usually occur over the AWS Direct Connect should the AWS Direct Connect fail. The **Pipeline Deployment Management** service provides deployment governance over the C-ITS application by enabling "hands off" deployment of the software from the AWS Pipeline account. **Jasper** is commercial of the shelf software for managing the cellular sim cards and associated data plans and is provided as a managed service by Telstra. **Jira** is commercial of the shelf software used for managing and tracking issues throughout the development, testing and production stages. **AWS Cloudwatch** is a managed service provided by AWS to review system logs within each AWS account. **AWS CodeCommit** is a software repository that is used to store source code and trigger builds on commit. **AWS CloudFormation** is used to define and deploy software and is stored within AWS CodeCommit software repositories.
	Red Crab (roadworks application)	Red Crab is a bespoke tool that is used to manage roadwork permits and provide the location of active roadworks signs. These data are used by the C-ITS-S to generate RWW DENM messages.
Geospatial Data	MAPEM	ETSI Road Lane Topology basic service information for the signalised intersection use cases.
	Road Network Model	Provides the full static speed limit set including school zones.
	Detector Location	Spatial data for STREAMS® detector sites.
	Tiles	Predetermined geofenced tiles for which messages are published on the Message Broker for use by the vehicle stations.
	Variable Speed Sign Zones	Spatial data for the segments of the road network model controlled by STREAMS® variable speed signs.
Roadside ITS station		The Roadside ITS Station (R-ITS-S) role is to provide the status of signalised intersection data to be broadcast locally for V-ITS-S to interpret the state of the signalised intersection ahead in the context of the road network it is traversing. The R-ITS-S interfaces to: • The C-ITS-S to obtain configuration and MAPEM and for operational and logging requirements • The SCMS for security information • Their local STREAMS Connect (Field Processor) for signal status updates • V-ITS-S for informing of infrastructure status.
Vehicle ITS Station		Provides the main communication and processing needs for a cooperative vehicle. The V-ITS-S 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: • The C-ITS-F for operational and logging requirements • The SCMS for security information • R-ITS-S for intersection information

Category	Element	Details
		• Other V-ITS-S for surrounding vehicle information • Global navigation satellite service (GNSS) • Configured HMI for driver awareness and interaction.
HMI		Provides the driver with content situational awareness/alerts, system status and participant selection. The HMI consists of the 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 system and the driver.
SCMS (Security Services)		The Security Credential Management System (SCMS) is a 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.
FOT Participant Data		Participant Manager (Package F) provides the C-ITS-F with participant information (anonymised) for V-ITS-S configuration relating to the HMI display and logging.
Actors	Participant	The Participant role in the Pilot is held by a person that operates a vehicle with C-ITS equipment installed and connected to the Pilot system. More than one person can operate the same vehicle.
	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 Pilot system.
	Pilot Operation	A role that is tasked with the day-to-day operation of the Pilot system.
	Safety Evaluator	A role that is tasked with the FOT analysis to evaluate the safety impacts of the C-ITS use-cases implemented by the Pilot.
	Participant Manager	The Participant Manager is part of the FOT team that provides anonymous V-ITS-S station configurations to the C-ITS-F. The C-ITS-F publishes the station configuration to the V-ITS-S as required.
	Red Crab User	A role that is tasked with the day to day duties of updating the application with relevant road works warnings within the pilot area.

Table 2.8(b) presents the main interfaces in the C-ITS Pilot.

Table 2.8(b) – C-ITS pilot system interfaces

Interface	Description	Interface Types
C-ITS communications		
IF1	V-ITS-S ↔ R-ITS-S ↔ V-ITS-S	ITS-G5 (DSRC)
IF2	SCMS → C/R/V-ITS-S	HTTPS (Internet)
IF3	C-ITS-F ↔ R/V-ITS-S	MQTT, HTTPS
IF4	V-ITS-S ↔ HMI	UDP (802.11b/g/n)
IF5	FP → R-ITS-S	UDP (Ethernet)

Interface	Description	Interface Types
Existing Systems / Services / Data		
IF20	STREAMS® Historical → Enterprise data set (STREAMS® historical)	SFTP
IF21	STREAMS® Gateway (BoQ/VSL) → Enterprise data set (STREAMS® Gateway)	API (Internet)
IF22	Queensland Traffic → Enterprise data set (QLDTraffic)	API (Internet)
IF23	StreetPro Nav → Geospatial Data Lead	TMR tooling
IF24	Geoscience Australia Altitude → Geospatial Data Lead	TMR tooling
IF25	AUSCORS → Position Augmentation	RTCM (Internet)
IF26	TSC ↔ FP	Serial
IF27	STREAMS® → STREAMS® Connect	HTTPS (ITS network)
Others		
IF30	FOT Participant Data → C-ITS-S	API Gateway (Internet)
IF36	Red Crab → Enterprise data set	HTTPS (Internet)
Actors		
IF40	Operations and Maintenance → Red Crab	HTTPS (Internet)
IF41	StreetPro Nav and Altitude Data → Geospatial Lead	TMR tooling
IF42	Operations and Maintenance → C-ITS-S (Configuration Manager)	API Gateway (Internet)
IF43	FOT Data Export Service → Safety Evaluator	HTTPS (Internet)
IF44	Participant → HMI	Human
IF45	Operations and Maintenance → Network & Ancillary	HTTPS (Internet)
IF46	Operations and Maintenance → MRS	HTTPS (Internet)

2.9 Project delivery methodology

Transport and Main Roads projects follow the OnQ project management methodology, however, some of the framework was not directly relevant for conducting a pilot. Therefore, the Pilot Phase 1 incorporated Agile-like methodologies using a series of Epics and Sprints, whilst Phase 2 comprised a waterfall methodology program of delivery with agile tasks and components (such as device vendor development and testing periods). This approach was taken to mitigate the risk of technology and/or the national direction changing over the initiative timeframe, as well as evolution of the scope.

Further detail on the methodology and components is captured in the CAVI Project Management Plan (QTRIP project number 13678 was updated to 1485694 from 1 July 2020). The agile-like processes enabled comprehensive options assessment during Phase 1 of the project, which then informed the system design and deployment plan for the six C-ITS use cases in Phase 2.

2.10 Pilot assumptions

At the onset of the Pilot, the following assumptions were made:

- Vendors will meet delivery timeframes.
- Vendors will deliver to specifications.
- The integrated system can meet KPIs.

- QUT Human Research and Ethics Committee will approve the vendors' approach to the participant's involvement.
- Participation will meet the target sample size.
- Data collection will be sufficient for analysis.
- The Pilot team will be stable, with access to necessary resources.

2.11 Out of scope

The following elements were not be delivered by the C-ITS Pilot:

- proprietary solutions that do not attempt to meet the C-ITS standards
- applications that do not have a safety benefit
- development of final Transport and Main Roads Technical Specifications (MRTS)
- a production-ready back-office solution for widespread C-ITS deployment
- a national safety credential management system, and
- automated vehicle testing or research.

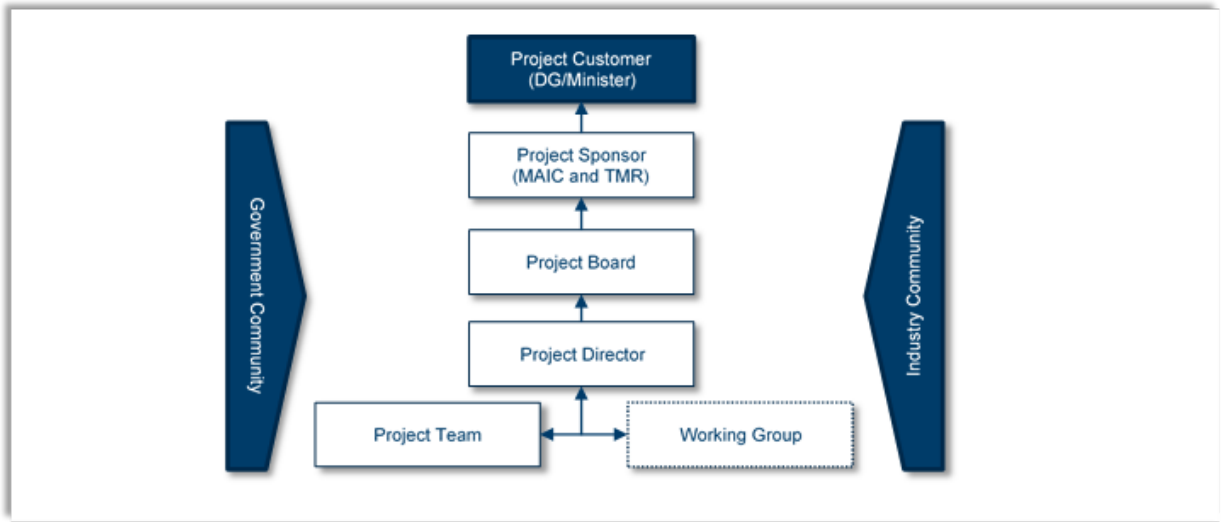
3 Governance

The IIC approved the Business Case in May 2016. The Director-General Transport and Main Roads is the Project Customer. The primary Project Sponsors (funders) are Transport and Main Roads and the Motor Accident and Insurance Commission (MAIC).

Technical support was provided by the Technical Working Group (TWG). Project Board and TWG Charters were developed, which included thresholds for escalation for decisions to the Project Board. The Pilot governance structure is shown in Figure 3; Table 2.8(b) presents the Governance Model that oversaw the C-ITS Pilot.

Project oversight was provided by the CAVI Project Board, detailed in the Project Board Charter. Whilst sub-committees of the Project Board for management of high risks with specific focus on topics relevant to the skill sets of the board and CAVI team members. The risk sub-committees and members are listed in Table 4.

Figure 3 – CAVI governance structure



4 Risk assessment

For CAVI Phase 2, project risks are consolidated within the *TMR - CAVI Program Risk Register*. As of January 2020, CAVI transitioned to risk governance as a sub-program under the Targeted Road Safety Program (TRSP). Prior to January 2020, risks were managed in Transport and Main Road's enterprise Risk Management System (RMS). CAVI RMS risks were archived March 2020.

Risk levels were elevated or reduced as required, within the Risk Sub-Committee groups. The Sub-Committees were required to meet every second month and were responsible for reviewing existing and emerging risks, the progress and effectiveness of treatments in place as required, and escalating matters to the project board. To ensure consistency and management oversight of project risks, all risk Sub-Committees were chaired by the delegated Risk Owners and supported by the Principal Advisor, Governance (CAVI). Attendance was also required by at least one board member, the work package lead, and relevant staff (see Table 4).

Table 4 – C-ITS Pilot Governance Model

Risk area/ CAVI Board representation	Chief Engineer, E&T (IMD)	Chief Operating Officer (COO), Office of Director-General	Deputy Chief Engineer, Engineering and Technology	Executive Director, Safer Roads Infrastructure (E&T)	Deputy-Director General (CSSR)	Executive Director (Performance) (ITB)	Deputy-Director General (PPI)	Deputy-Director General (IMD)	Regional Director	Principal Engineer (Traffic Systems) Ipswich	Business Improvement Team Leader, MAIC
Governance, Communications Stakeholders (including Change Management) Risk Owner: Chief Engineer, Engineering and Technology	x	x		x	x		x	x			
C-ITS Pilot D/I Risk Owner: Deputy Chief Engineer, Engineering and Technology			x	x					x	x	
C-ITS Pilot C/E Risk Owner: Executive Director (Performance), Information and Technology			x	x		x					
C-ITS Pilot F Risk Owner: Executive Director, Safer Roads Infrastructure		x		x						x	x
CHAD Pilot Risk Owner: Chief Engineer, Engineering and Technology	x	x		x							x
VRU Pilot Risk Owner: Chief Engineer, Engineering and Technology	x			x							x

5 Roles and responsibilities

5.1 Pilot vendors and partners

The Motor Accident Insurance Commission (MAIC) was a significant financial contributor, and as such, a co-sponsor of the pilot. For Packages C and F, Transport and Main Roads partnered with iMOVE Australia and associated industry and research partners (including Department of Infrastructure, Transport, Regional Development and Communications (DITRDC)) and Queensland University of Technology (QUT), respectively). iMOVE provides Australian Government/partner contributions. Telstra were also financial contributors providing access through their telecommunications network for the Pilot.

Transport and Main Roads had a memorandum of understanding with the Ipswich City Council (ICC) for the Pilot. In addition, the following vehicle insurance agencies provided assurance that pilot participants' respective insurance policies were valid whilst undertaking the pilot:

- RACQ
- Suncorp (including: Shannons, Vero, Bingle, AAMI, Apia)
- Allianz
- QBE
- IAG (includes: NRMA)
- AMP
- Budget Direct
- Youi

Transport and Main Roads led the deployment phase with support from several vendors across each delivery package, as described in Table 5.1. Transport and Main Road's delivery vendors and financial partners for the C-ITS Pilot are summarised in Figure 5.1.

Figure 5.1 – C-ITS Pilot delivery and financial partners

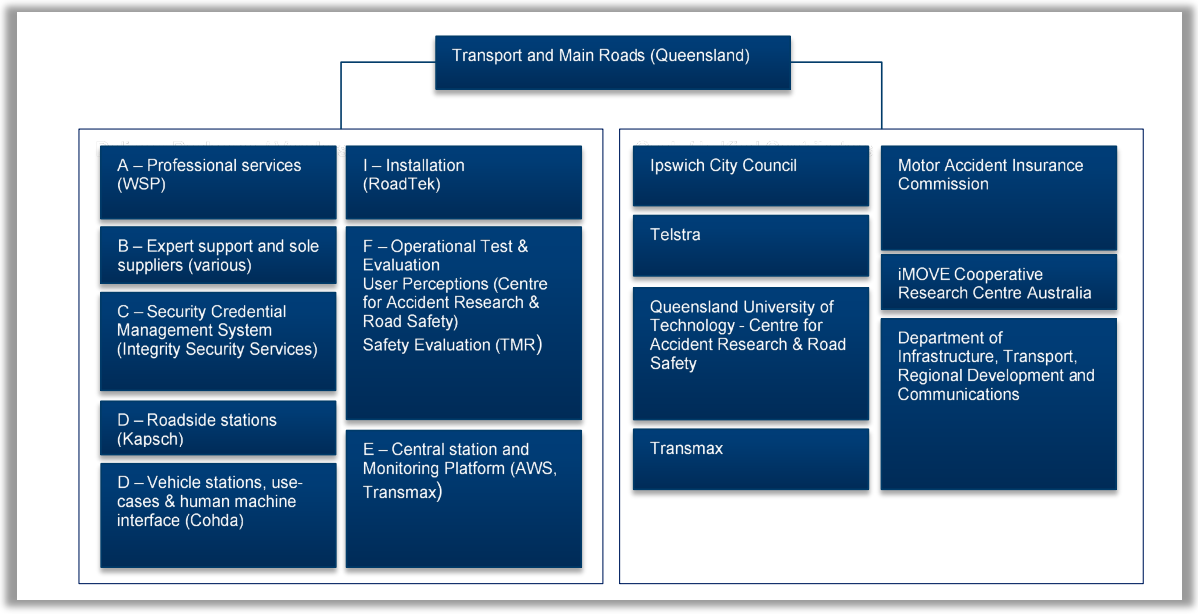


Table 5.1 – C-ITS work packages

Work Package	Scope Summary
A: Planning Professional Services	• Management of the Pilot planning phase based on agile-like delivery framework. • Provision of expert resources for system architecture, integration and implementation to support Pilot deployment.
B: Expert Support	• Expert support and sole suppliers required to assist pilot planning and deployment. • Identified suppliers include subject matter experts in C-ITS and Transport and Main Road's existing systems/practices (various); road/ITS design and construction for upgrade of Mt Cotton testing facility (RoadTek); and enhancement of existing departmental systems that supply data to the C ITS use case applications (Transmax, QUT).
C: Security Credential Management System (SCMS)	• Provision of SCMS software. • Management of an SCMS for the C ITS Pilot and lessons learnt reporting. • Security research – intrusion detection (not to be implemented in FOT).
D: R-ITS-S, V-ITS-S, HMI, Use Cases	• Up to 30 R-ITS-S. • Up to 550 V-ITS-S and HMIs, and six safety use cases. • Development and testing of hardware and software to meet Transport and Main Road's specification. • Professional services to support the installation and maintenance of devices throughout the pilot.
E: C-ITS-F Integration and Monitoring Services	• C-ITS message integration/engine, including interfaces with Transport and Main Roads and third-party systems providing data to C-ITS use cases, and field devices. • Device management. • Archival data store. • Data monitoring tool/dashboard. • Interface to the FOT Safety Evaluation Data Repository (managed by Package F).
F: Field Operational Test (FOT) and Evaluation	• Delivery of safety and user perceptions evaluation (including study design, data analysis and reporting). • Management of human participation in the pilot (including recruitment, briefing, training, management during the FOT and de-briefing).
I: Field Device Installation	• Integration with Pilot team to develop commissioning, maintenance and decommissioning plans, procedures, tests and reports. • Commissioning and decommissioning of the R-ITS-S at signalised intersections at the Mt Cotton test facility and the Ipswich pilot area. • Commissioning and decommissioning of V-ITS-S (and HMI) to participants' vehicles.

5.2 Organisational chart

The Pilot team co-located in Brisbane was made up of a mix of Transport and Main Roads and contractor staff as illustrated in Figures 5.2(a) and (b) below. Vehicle and roadside station vendor teams are more extensive than listed and are not co-located.

Figure 5.2(a) – Team organisational chart as at pilot launch

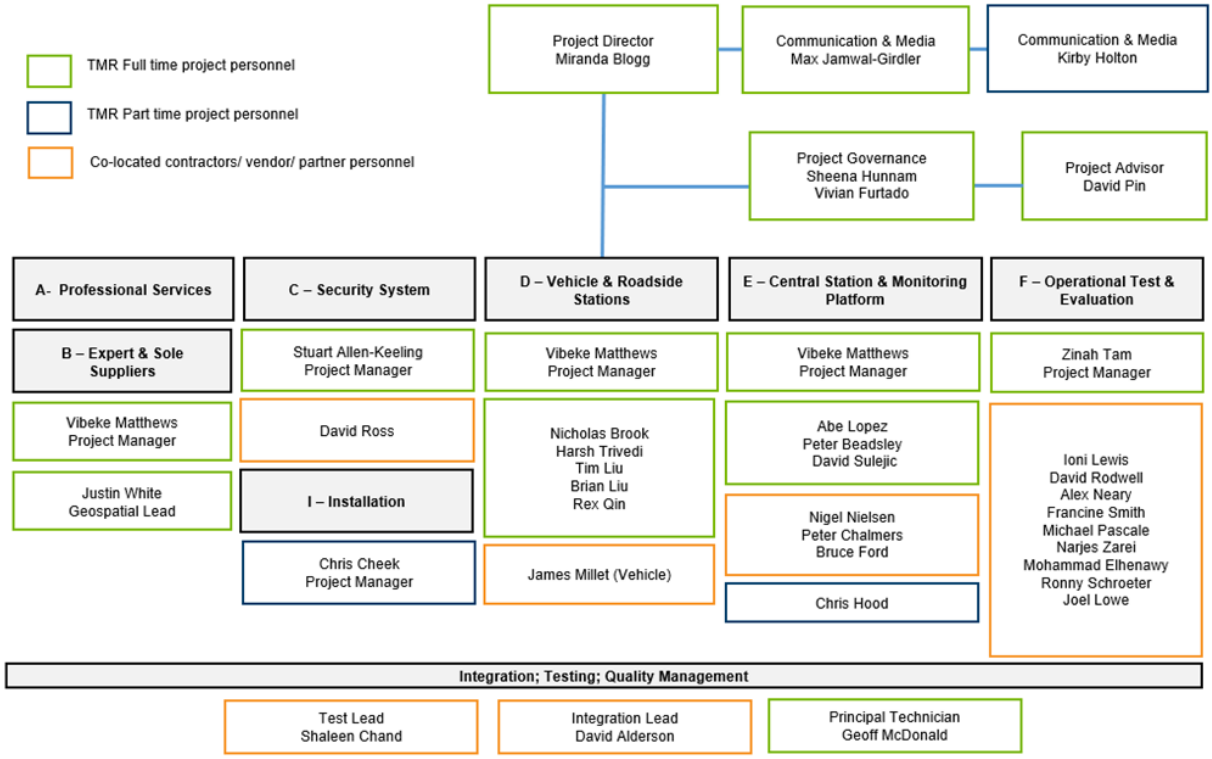
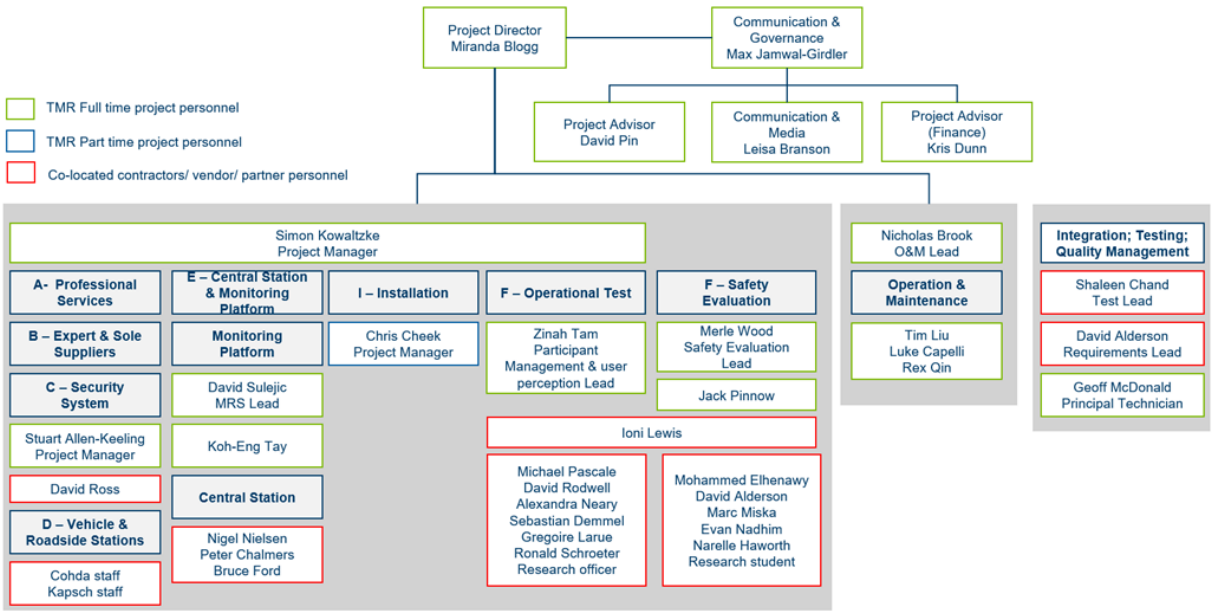


Figure 5.2(b) – Team organisational chart post-field operational test completion (September 2021)



5.3 Responsibility assignment matrix

A Responsibility Assignment Matrix, or RASCI matrix, was developed for the Pilot team. These matrices indicate the intended participation of various stakeholders and resources in the different stages of the pilot delivery.

The deployment RASCI matrix is presented in Table 5.3(a), and the Pre, post and pilot RASCI matrix is presented in Table 5.3(b), whilst a live version of these is tracked in the Quality Management document. For the pilot, the RASCI matrix was updated with the addition of a supportive assignment, therefore the letters represent:

- R = responsible for doing the task
- A = accountable for the successful completion of the task
- S = supportive by assisting with the work, but not involved all the time
- C = consulted for input or review (subject matter experts)
- I = informed of task plans, procedure, outputs and outcomes

Table 5.3(a) – Pilot deployment RASCI

Deliverable	Sponsor / Board	Director (CAVI)	Principal Technician	Communications Lead	Governance Lead	Package A/B Lead	Package C Lead	Package D Lead	Package E Lead (Project Manager and Technical Lead)	Package F Lead (FOT Lead and Safety Evaluation Lead)	Package I Lead (Installation Lead)
Package A/B	I	A	C	S	S	R	S	S	S	S	S
Package C	I	A	C		I	S	R	C	C	I	
Package D	I	A	C		I	S	S	R	C	C	C
Package E	I	A	C		I	S	C	C	R	C	
Package F	I	A	C	S	I	S	S	C	C	R	
Package I	I	A	C	C	I	S	C	C	C	C	R
Red Crab	I	A	C		I	S	C	R	S	I	
Governance	I	A		S	R	C	C	C	C	C	C
Finance	I	A			R	C	C	C	C	C	C
Safety	I	A	I	I	R	I	I	I	I	I	I
Communication & Media	I	A	I	R	S	C	C	C	C	S	C
Benefits Management	A	R	I	S	S	I	I	C	I	S	I
Security Management	I	A	I		I	I	R	S	S	S	I
Privacy Management	I	A	I	C	I	I	R	S	S	S	S
Data Management	I	A	I		I	I	S	S	R	S	I

Table 5.3(b) – Pre, post and pilot RASCI

Pre, post and pilot tasks	Participant	Participant Manager	Safety Evaluator	SCMS Vendor	V-ITS-S Vendor	R-ITS-S Vendor	C-ITS-F Team	Telecomms Vendor	Red Crab Vendor	Installation Vendor	Red Crab Users	Integration Lead	Test Lead	Change Lead	Operations and Mainstream Lead	Geospatial Lead	Relevant Package Leads	TMR PD&O	Various SMEs	SME details
Develop/ enhance C-ITS products		R	R	R	R	R	R	R	R	C			S		S	R	A	C	C	Department of Resources
Test C-ITS products		S	S	S	S	S	S	S	S	S		S	R			S	A	S		
Manage integration and requirements		C	C	C	C	C	C	C	C	C		R				C	A	C	C	Department of Resources
Recruit and manage participants	C	R								S					S		A		S	Insurance providers
Pre-commission/ commission C-ITS products		R	R	R	R	R	R	R	R						S	R	A	S		
Install/ re-install C-ITS products	C	S								R					S	S	A		S	CORS
Use C-ITS products	R	S									R						A			
Monitor C-ITS products		S					S								R		A			
Confirm approval for pilot changes														R		S	A	S		
Uninstall/ decommission C-ITS products	C	R								R					S		A			
Evaluate performance		R	R				S								R		A			

6 Schedule

6.1 Milestones and Hold Points

Key Pilot Milestones and Hold Points are summarised in Table 6.1 – the baseline dates are per the approved phase 2 gate (June 2018) as listed in the various vendors' contract.

Table 6.1 – Pilot Phase 2 Milestones and Hold Points

Baseline June 2018	Final	Milestones
Q2 2018	Q3 2018	Infrastructure Investment Committee Approval
Q4 2018	Q4 2018	Procurement completed
Q4 2018	Q3 2019	Ethics approval
Q1 2019	Q3 2019	Device FATs completed
Q1 2019	Q2 2020	Integration testing (bench) passed
Q2 2019	Q2 2019	Mount Cotton installation completed
Q2 2019	Q3 2020	Recruitment commenced
Q2 2019	Q2 2020	Site Integration Acceptance Test (Mt Cotton) passed
Q3 2019	Q2 2020	Hold Point: Roadside commissioning (Ipswich) completed
Q3 2019	Q2 2020	Hold Point: Site Integration Acceptance Test (Ipswich) passed
Q4 2019	Q3 2020	Participant vehicle install/FOT commenced
Q1 2020	Q4 2020	Participant vehicle install completed
Q3 2020	Q3 2021	FOT completed
Q3 2020	Q3 2021	Permission to uninstall/ uninstall completed
Q2 2021	Q2 2022	Pilot completed (including safety evaluation)

Separate to this document, a detailed master schedule was maintained by the Pilot team.

6.2 Pilot staging

The pilot activities and outputs of each stage are described below:

- **Plan, design & develop** - The Pilot team developed project plans, negotiated project requirements; and developed the products for testing.
- **Test** - Factory Acceptance Test (FAT) was conducted by the vendors and witnessed by Transport and Main Roads. Integration Test (IT) and Site Integration Acceptance Test (SIAT) was performed by the department with support from vendors. SIAT was performed at Mount Cotton test site and Ipswich Pilot area. As each station was installed/commissioned, separate installation / commissioning sheets were completed to provide assurance that devices were correctly installed and functioning at time of commissioning.
- **Production** - Staged production/fabrication of the stations was performed by the vendors. The production stages included:
    1. Small sample for Mount Cotton tests - 2 R-ITS-S, 10 V-ITS-S and 2 C-ITS-F tiles
    2. Samples for Ipswich tests - all R-ITS-S and C-ITS-S Ipswich tiles and 10 V-ITS-S
    3. Remaining V-ITS-S for the pilot deployment, in batches.

- **Recruit** - Participant recruitment followed QUT Ethics approval. Participant recruitment commenced 6 weeks prior to the FOT start date on 1 August 2021. Recruitment included participant training and briefing.
- **Install** - Installers, station vendors, Participant Managers and Transport and Main Roads asset owners collaborated, tested and implemented a repeatable install procedure for both vehicles and roadside devices. Roadside install occurred prior to the vehicle install to allow for Ipswich site testing. Vehicle install was completed by end November 2020.
- **Field Operational Test (FOT)** - V-ITS-S operated in participants' vehicles for up to 9 months - including approximately 3 months of installation, the total FOT duration was 12 months. Stations were monitored and maintained by a Pilot team comprising: Transport and Main Roads, device contractors, the Participant Manager and the Safety Evaluator. The department's asset owner maintained their existing assets. Participant Managers periodically collected qualitative data (questionnaires).
- **Decommission** - On completion of the pilot, the vehicle stations were decommissioned from participant vehicles. The roadside stations were also decommissioned and then re-initiated for further opportunities.
- **Analysis and reporting** - Safety Evaluators conducted analysis of the quantitative and qualitative data produced from the pilot and finalised reporting of findings post-FOT decommissioning. Transport and Main Roads prepared final reports (see Section 1.5 documentation lists).

7 Stakeholder communications

The Pilot public communications plan included communication and recruitment tactics relevant to the recruitment of pilot participants (which were based on QUT's Participant Communications Strategy), communicating pilot deliverables, and ongoing stakeholder engagement activities. The plan was developed by Transport and Main Roads to support QUT's existing Participant Communications Strategy, in consultation with Package F. Package F had the primary responsibility for recruitment and management of the participants through QUT's Participant Communications Strategy.

The plan comprised six key phases:

1. ongoing general awareness,
2. pre-FOT
3. pre-recruitment
4. recruitment
5. FOT-live, and
6. post-FOT.

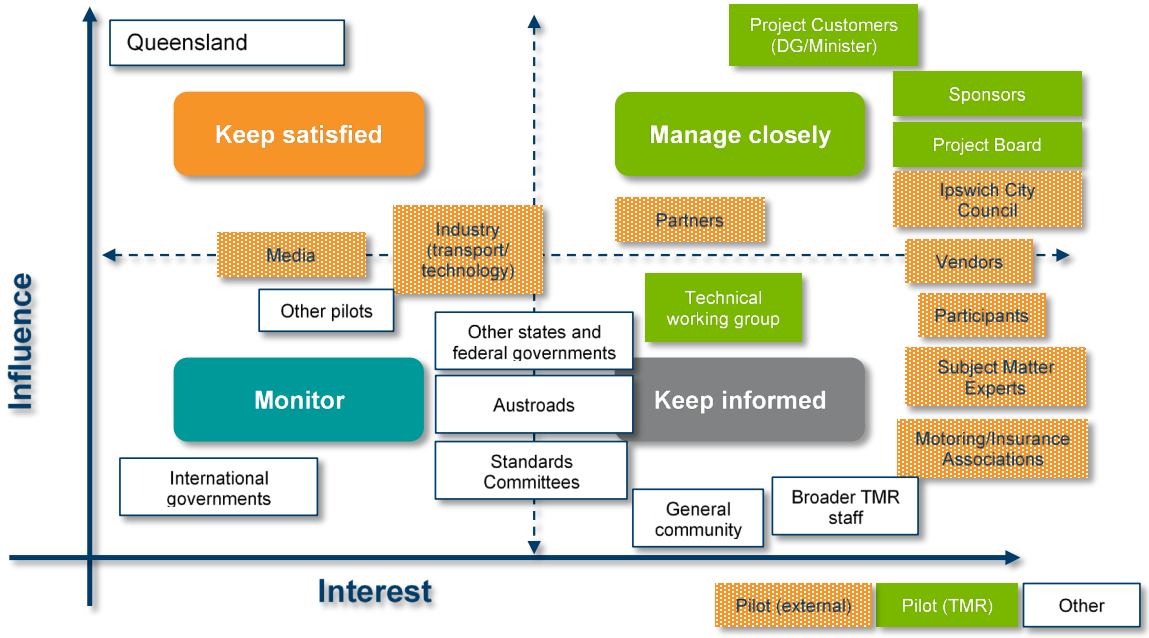
The plan objectives were:

- public education
- key stakeholder engagement, and
- participant recruitment.

The communication plan focused on generating material suitable for both internal and external engagement. Stages of communication activity were approved by the Director General (Project Customer).

To inform the plan, a stakeholder analysis was completed, as shown in Figure 7. The project board and sponsors are comprised of both Transport and Main Roads and external representatives. MAIC and Transport and Main Roads are both board members and sponsors.

Figure 7 – Stakeholder analysis matrix



Communication activities focussed on ongoing general awareness of C-ITS. The FOT commenced with several internal and external publications, presentations and messages. This included an article in the RACQ Road Ahead magazine (June/July 2018 edition), with circulation figures of over 1 million readers and an article in the Sunday Mail (July 2020 edition), with a readership of around 300,000. Promoting general awareness continued throughout the Pilot and included targeted stakeholder engagement.

Prior to and during the recruitment phase, a pilot website was developed and maintained; there was a pilot launch attended by state and local officials and media, and several news and radio interviews were performed. As recruitment numbers were not achieving expected momentum with planned tactics, a letter box drop targeting the Ipswich area was used to maximise recruitment activities, which effectively boosted recruitment.

Pilot stakeholders, including Ipswich City Council, QUT, vehicle insurance providers, and other stakeholders, were provided with communications materials and messages which could be tailored to their staff and customers, assisting to promote education and recruitment.

During the FOT-live phase, communication activities focused on providing updates, results and positive participant experiences which were managed by the Participant Managers. Post-FOT communication extended on the results and experience focussed messaging from the FOT-live phase, including reference to the pilot conclusion.

Each phase included specific communication materials and messages for both external and internal audiences. See Table 7.

Table 7 – Stakeholder communication milestones

Milestone (Event)	Baseline June 2018	Final	Type of Communication	Audience
CSM1. Tender Outcome	Q4 2018	Q4 2018 Complete	Formal announcement	Industry, TMR, Minister
CSM2. Mt Cotton Testing	Q2 2019	No longer in-scope	Media announcement / demonstration	TMR, Minister, Public
CSM3. Recruitment	Q2 2019	Q3 2020	Physical, media, email, through partners, minister	Public
CSM4. Ipswich first launch	Q3 2019	Q3 2020	Media announcement / demonstration	TMR, Minister, Public
CSM5. FOT Commenced	Q4 2019	Q3 2020	Ongoing communication, newsletters, media updates	TMR, Public, Participants
CSM6. FOT Completed	Q4 2020	Q4 2021	Ongoing communication, Media announcement through partners minister	TMR, Minister, Public, Participants, Industry
CSM7. Completion / results	Q2 2021	Q1 2022	Media announcement, email, through partners, minister	TMR, Minister, Public, Participants, Industry

8 Procurement

The Pilot Project Procurement Plan was signed in November 2016. This plan outlined the procurement for Package A, B, D (Phase 1) and F. Addendums to this document were approved for Phase 2 of Package D, and Packages C and E – as well as to note a change in procurement approach for Package F. In summary:

- **Package A** - An invitation to offer was issued to market through QTenders (Queensland Government tenders and contracts website) in December 2016. The agreement with WSP was finalised in March 2017.
- **Package B** - This package mostly comprised of ad-hoc and sole source procurement. The two main sole source offers included Transmax (the existing ITS systems provider) and RoadTek (Transport and Main Roads preferred supplier for ITS installation and maintenance), along with several expert support consultancy services.
- **Package C** - A request for information was issued to industry through Austroads in 2017. A national review panel shortlisted three companies who were then asked to respond to a tender request with detailed requirements through a Transport and Main Roads/iMOVE Australia / DITRDC partnership agreement. The agreement with Integrity Security Services was finalised in April 2018.
- **Package D** - An invitation to offer for Phase 1 (early vendor involvement (EVI)) was issued to market through QTenders in January 2017. The agreements with Cohda, Wireless, QFree, Excel/Savari, and Kapsch were finalised in May 2017. Phase 2 involved a restricted 'invitation to offer' to the four EVI vendors and contracts were finalised in November 2018. Kapsch TrafficCom was selected as the roadside R-ITS-S vendor, and Codha as the vehicle V-ITS-S vendor.

- **Package E** - A proof of concept was developed through sole-source arrangements using Transport and Main Road's existing agreements with Transmax and NetBI. Phase 2 commenced with direct negotiation resulting in a six-week accelerator program with an altered partnership of Transmax and Amazon Web Services (AWS) to develop the foundation of the C-ITS-F platform. An exception report was completed outlining the benefit of Transport and Main Roads developing monitoring and data management skills in-house negating the necessity for an external BI provider, therefore partnering with just AWS and Transmax. An additional addendum was developed and approved to reflect the selected approach of directly engaging Transmax and AWS individually (an enterprise agreement was in place between AWS and Transport and Main Roads) as a contractual partnership to complete the integration platform. The two contracts were finalised in November 2018.
- **Package F** - The original Procurement Plan noted this package would be procured via an invitation to offer; subsequently a partnership was developed with iMOVE Australia/QUT CARRS-Q to deliver the research and an agreement was signed in December 2018. In May 2020, it was decided that the Safety Evaluation component of the agreement would be delivered by Transport and Main Roads and QUT were retained to assist in this scope.
- **Package I** - This package was being led by RoadTek. A sole source arrangement enabled through Package B that was approved in the original plan. RoadTek managed the procurement of subcontractors (auto-electricians/ technicians) as required.

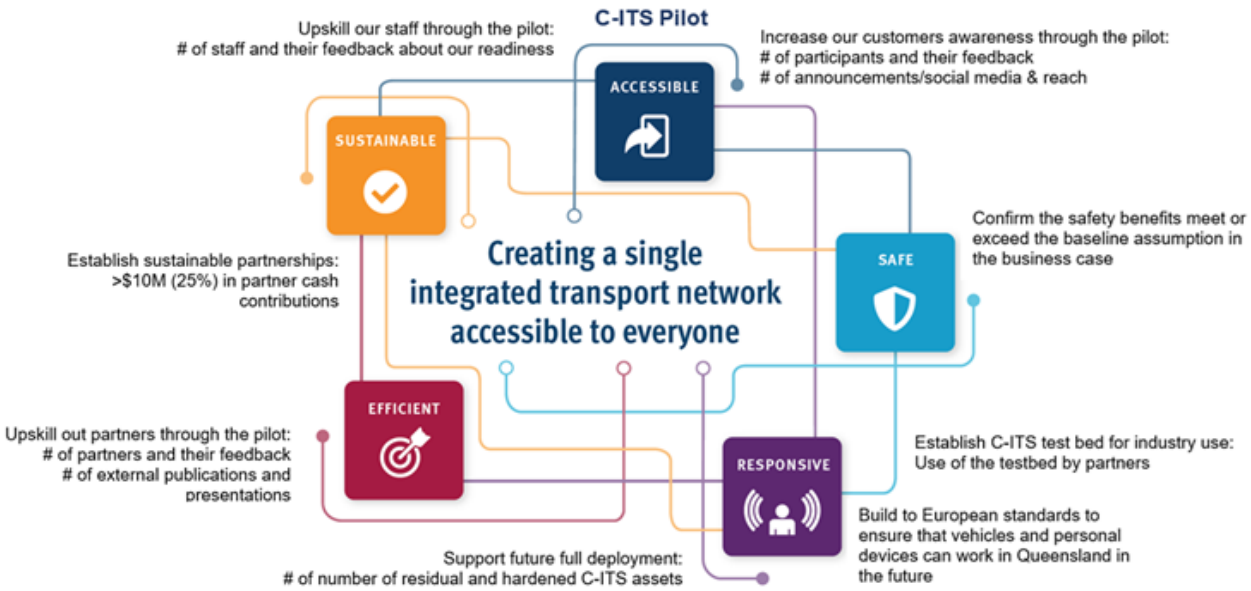
9 Expected benefits

A Benefits Realisation Plan (BRP) was used to effectively manage the achievement of pilot benefits. All information relating to the structure, measuring and reporting, management and realisation of the pilot benefits are captured in the BRP. Transport and Main Road’s Portfolio Management Office facilitate post-pilot benefits reviews, as per Queensland State and Federal government requirements.

The pilot benefits were consistent with the pilot objectives and Transport and Main Road’s strategic goals. Figure 9 presents the pilot benefits metric themes aligned with Transport and Main Road’s strategic goals. Each contains an output and outcome: the count of certain attributes – such as the number of participants – is an output, while their feedback is an outcome.

A discussion of the benefits and metrics are as follows, ordered by objective. The costs of measuring the benefits are covered by the project during its lifetime. Ongoing benefits – such as use of residual test beds and assets by industry –required minimal effort for reporting and were the responsibility of the Project Sponsor.

Figure 9 – Pilot benefits



9.1 Validate the safety benefits and user perceptions

Transport and Main Roads and Package F were responsible for delivering the safety evaluation and the pilot participant user perceptions analysis. Data sources used included, but were not limited, to the following:

- participant surveys and interviews
- before and after, and control group C-ITS data around the use case events
- contextual data (for example, weather data and traffic congestion data).

9.2 Demonstrate and build public awareness and confidence

Transport and Main Roads was responsible for delivering the Pilot Communications Plan, which set out a series of public forums in which the pilot was publicised. Forums included events involving senior politicians, and presentations/stands at local and international events.

Data sources being used include, but are not limited, to the following:

- participant and public surveys
- public feedback
- communications log, media releases, articles, and social media
- survey and social media reach/engagement statistics.

9.3 Grow technical and organisation readiness

Transport and Main Roads was responsible for tracking the technical and organisational readiness resulting from the pilot activities. The pilot was intended to encourage Transport and Main Road's readiness as follows.

- Upskill internal staff within the pilot team; upskill other staff through test and pilot activities; upskill boarder staff cohort through internal communication outreach.

- Deploy pilot assets that can be used beyond the pilot – an off-road test site, and roadside and central stations.
- Assess the pilot system and document lessons learnt and next steps, including the degree to which the pilot could align with Europe's C-ITS model.

Data sources used included, but were not limited to the following:

- Transport and Main Roads staff surveys
- system data
- resource records
- lessons learned.

9.4 Encourage partnerships and build capability

Transport and Main Roads was responsible for measuring the success of its partnerships and their capability growth. Measures included the contribution of funding toward the pilot, partner/industry use of the RACQ Mobility Centre of Excellence C-ITS equipment, and their feedback.

Data sources included, but were not limited to the following:

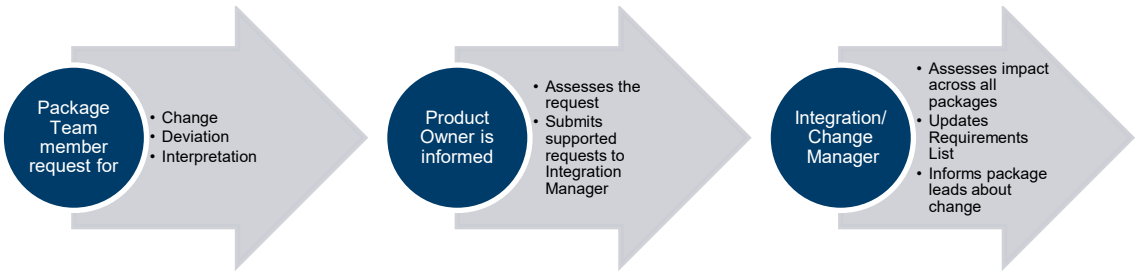
- partner surveys
- financial data
- testbed use.

10 Requirements management

A defined set of technical requirements were developed during Phase 1 of the C-ITS Pilot. The requirements were managed and maintained by the Integration Lead, on go-live this role transitioned to the Change Lead. For a successful pilot, it was critical that the requirements were managed carefully and any changes/deviations and even assumptions of how to interpret the requirements being communicated across all packages. To avoid the requirements being changed without proper assessment of impact only the Change Lead could change the Requirements List.

The process for how changes or deviations to requirements were tracked are illustrated in Figure 10 below:

Figure 10 – Process for changing requirements



11 Test program

A Master Test Strategy and Plan was developed for the Pilot. The overall objectives of the testing were:

- To provide clear, consistent compliance expectations as part of the device vendor documentation, to assist in baselining quality from tender submissions.
- To confirm that the C-ITS environment was operating as an integrated solution that was fit-for-purpose for Pilot Deployment, with regards to functional and non-functional requirements and considerations for the system.

The strategy and plan defined how the testing was undertaken, set the roles and responsibilities of the various parties involved, and described the test environments and associated resources required. It was based on the department's MRTS201 *General Equipment Requirements*. The test stages are illustrated in Figure 11.

Figure 11 – Testing methodology

Factory Acceptance Testing (FAT) **Bench**	• Individual device components • V-ITS-S, HMI, R-ITS-S, SCMS, FP, C-ITS-F • Some emulation for critical components IE 3G/4G, logging
Interface Testing **Bench**	• Interface testing between devices • Data flow and performance of each interface
Component Itegration Testing (CIT) and System Integration Testing (SIT) **Bench**	• End to end, including HMI management and nteractions • Use cases and positioning augmentation • Logging, monitoring and maintenance services
System Integration and Acceptance Testing (SIAT) **Mount Cotton**	• End to end • Real world test cases – but off-road and controlled
System Integration and Acceptance Testing (SIAT) **Ipswich**	• End to end • Real world test cases – on-road and integrated with existing systems
Commissioning	• Installation checks – Package I • Commissioning checks – Package D and E

An analytical requirements-based strategy was adopted for testing. Analysis of the requirements specification formed the basis of the tests as defined in *TMRD9. System Requirements* – of which there are some 500 requirements. In addition, QUT was responsible for HMI Usability and Ergonomics Testing, which was integrated with the test stages outlined above.

Despite significant delays to delivery timeframes experienced at the FAT, CIT and SIT milestones, all testing stages described in the *Master Test Strategy and Plan* framework were completed. In response to delays, several requirements were removed from the testing scope baselined in the *Master Test Strategy and Plan*:

- **Use Case** - Emergency Electronic Brake Lighting (EEBL) - reduced scope for V-ITS-S vendor to mitigate delivery delays, and done in other pilots
- **Use Case** - Slowed/Stopped Vehicle (SSV) - reduced scope for V-ITS-S vendor to mitigate delivery delays, and done in other pilots
- **Geo-networking** - forwarding of messages or message hopping.

- **Decentralized Congestion Control (DCC)** - deemed a low risk of activating in the pilot. Also, DCC standard ETSI TS 102 687 V1.1.1 (2011-07) was under review.

Over 654 hours and 21,400 kilometre of drive testing was completed. At the conclusion of on-road testing activities, qualitative assessments by drivers independent to the project deemed the pilot's use cases to be timely, relevant and useful.

The Pilot team continued to drive equipped vehicles to monitor, test and report on the system's performance throughout the FOT, with team or participant defects managed using the same processes. These processes are defined within *TMRD19 Operation and Maintenance Manual*, and managed by the Issues Manager, with support from the Change Lead and Operations and Maintenance Lead.

The Mt Cotton and Ipswich SIAT test results are summarised in Table 11(a) and Table 11(b) respectively. At Mt Cotton, approximately 85% of the proposed tests were completed - 95% of these passed, those that were rectified then received a pass rate of 98.5%.

Table 11(a) – Mt Cotton SIAT test results

Use Cases / other	Rectified – Pass	Rectified – Fail
Enablers	16	0
ARLW	39	0
BoQ	6	0
IVS	9	0
RHW	4	2
RWW	18	0
TWVR	21	0
Combined cases	29	0
Totals	142 (98.6% pass rate)	2 (1.5% fail rate)

The Ipswich tests were based on the number of use case events observed and validated/rectified during both opportunistic and targeted drives by the Pilot team. Approximately 93% of the tests passed – 7% failed and were managed through the issue resolution process – noting remaining issues were not deemed to be critical for the Pilot progression. For more details, refer to the *TMRD18. Master Test Report*.

Table 11(b) – Ipswich SIAT test results

Use Case	Events	Pass %	Fail %
ARLW	672	91%	9%
BoQ	57	93%	7%
IVS	67332	89%	11%
RWW	501	94%	6%
RHW	29	97%	3%
TWVR	125	93%	7%
Total	68716		

11.1 Test phases

The vendors are contracted to deliver Test Plans relevant to their nature which detail the tests performed within each of the test phases described in Table 11.1. These plan forms part of the *TMRD18. Master Test Strategy, Plan and Report*. Specific test phase details for each type of element are contained within their relevant section in this document.

Table 11.1 – Pilot test phases (across vendors)

Test Phase	Description
Development	Transport and Main Roads to witness points throughout the vendors development. Vendor to provide log data for the C-ITS-F development. Transport and Main Roads to provide bench access for the emulation of SPaTEM. C-ITS-F team to provide the emulation environment for MAPEM.
FAT (Device)	Vendor to demonstrate the functions of the device against the requirements. Transport and Main Roads to approve.
Security Testing (Device)	Transport and Main Roads to manage third party penetration testing of the device.
IT (Bench)	Vendor to demonstrate the integration of the device with other systems. Transport and Main Roads to manage test plan development and to approve.
SIAT (Mt Cotton)	Vendor to demonstrate all functions at the Mt Cotton test site. Transport and Main Roads to manage test plan development and to approve.
SIAT (Ipswich)	Vendor to demonstrate the integration in on-road environment testing all functions. Transport and Main Roads to manage test plan development and to approve.
Commissioning	Vendor to perform installation tests post device installation on site and completion of SIAT. Commissioning test sheets shall be developed with Transport and Main Roads.
Rectification	During the maintenance period, ad hoc testing of proposed rectification shall be performed prior to commissioning. Transport and Main Roads to approve.

12 Data and data management

12.1 Type of data

Within the pilot, C-ITS data included the following:

- **System data** - quantitative data collected from the pilot system, including all C-ITS messages sent and received by the vehicle, roadside and central stations.
- **Non-system data** - quantitative data collected from external systems and databases.
- **Meta data** - quantitative data used to describe the data's context.
- **Survey / interview data** - qualitative data collected through questionnaires and interviews.

The quantitative system data, metadata and schemas are captured within the C-ITS-F Detailed Design.

12.2 Data management

The *Data Management Plan* (DMP) addresses the management of data within systems internal to Transport and Main Roads. The DMP addresses the following:

1. **Pilot and system overview** - describes the scope and architecture of the pilot environment which form the basis of data and use.
2. **Data identification and collection** - describes data available through the pilot environment, and estimated volume of the data.
3. **Research questions and metrics** - describes the research questions and associated metrics that rely on the pilot data.
4. **Data platform and organisation** - describes the selected data platform tools, accounts, structure, and naming convention.
5. **Data documentation** - describes "metadata" schema and implementation within the data platform.
6. **Quality assurance and quality control** - describes processes that are employed to measure, assess, and improve the quality of the data and associated analysis.
7. **Storage and preservation** - describes the retention and preservation requirements for the pilot data, including how long the data will be accessible.
8. **Data policies, privacy and security** - describes licensing or sharing, legal and ethical restrictions on data access.
9. **Dissemination** - describes when, how, and what data will be made available.
10. **Data management roles** - describes the roles and responsibilities of individuals and organisation associated with the pilot data.

12.3 Data privacy and security

Personal information collected during the pilot included the following:

- The participant's personal information (for example name, contact and vehicle details).
- The vehicle data – this data exposes the origin and destination of a participant's trip.

All members of the Pilot team had to abide by the *Queensland Information Privacy Act* (2009) (IP Act) eleven *Information Privacy Principles* (IPPs) and underwent regular training.

Under the *Right to Information Act* (RTI Act), a participant can request access to their data. Data can be provided to external parties for legitimate and relevant research requests, with an accompanied and approved ethics submission, or if subpoenaed under the law.

Published data and results do not include personal information – data such as interview quotes are de-identified.

The pilot followed best practice, security approach – including but not limited to firewalls, data encryption in transit and at rest and access management. Only the Safety Evaluator had access to all data. The data was stored in Australian data centres and external audits and penetration testing were completed.

Data privacy and security was managed through the controls identified in the following documents:

- *TMRD11. Privacy Impact Assessment*.
- *TMRD13. Security Management Plan*.
- *FED2. Ethics Submission – Third party Ethics Board approved submission*.
- *CFD3. Security Plan – C-ITS-F specific controls*.

13 Safety Management

Understanding the safety risks and preparing suitable controls, ensured the implementation of the Pilot provided a safe experience for all involved. Safety during the pilot was managed in accordance with Transport and Main Road's safety management system, including RoadTek's *Safety Risk Management Procedure Framework*.

A *Safety Management Plan* was developed for the pilot, which addressed safety risks for a variety of activities, and was developed in consultation with the pilot vendors, partners, and Transport and Main Roads internal stakeholders.

The plan used a risk assessment approach to identify hazards and develop suitable safety measures for the Pilot team, participants, and the public. The plan focused on controls for high-risk activities at Transport and Main Roads work sites and in public areas – with many controls also suitable for lower risk hazards. Key risks included injury to staff personnel during testing or installation, and participant injury/crash caused by the C-ITS equipment.

All safety incidents and near-misses were reported as per department's reporting workplace incident procedures. Pilot personnel were required to comply with workplace health and safety legislation, relevant codes of practice, and site-specific plans and rules. Terms required contractors to operate within a standard that were in accordance with, or exceeding department's safety management system, were also incorporated into contracts, where possible. Vendors were required to inform Transport and Main Roads of pilot related incidents. Transport and Main Roads also held the option to audit vendors to demonstrate compliance.

The Operation and Maintenance Plan provided measures for assuring safety throughout the deployment process. The Safety Management Plan was considered in the public communications and participant communications plans to ensure a rapid and coordinated response across pilot packages/stakeholders should a crash or other safety issue occur.

14 Roadside Intelligent Transport Systems Station

Through a tender process Kapsch TrafficCom (Kapsch) was selected as the successful R-ITS-S vendor.

14.1 Objectives

The R-ITS-S vendor delivered an ETSI compliant R-ITS-S that met the specification of the project which enabled the ARLW and TWVU use-cases and safety evaluation.

14.2 Scope

The R-ITS-S professional service scope consisted of planning, design, development, testing, device fabrication, commissioning, and FOT operations and maintenance.

The R-ITS-S vendor scope was:

- The development of R-ITS-S hardware and software per the specifications
- Fabrications, commissioning and maintenance of R-ITS-S, including mounting equipment
- The development of various reports and artefacts
- Support during all phases of the pilot (local collocated and back of office).

The following was not within the R-ITS-S vendor's scope:

- Roadside installation
- The provision of SIM cards for cellular communications.

14.3 Milestones and Hold Points

Table 14.3 below lists Milestones and Hold Points for R-ITS-S provision.

Table 14.3 – R-ITS-S Milestones and Hold Points

Milestone (Hold Point)	Baseline June 2018	Final	Deliverable	Dependent (on/for)*
RSH1. (was RSM1) Contract award	Q4 2018	Q4 2018	Signed contract	
RSM1. (was RSM2) Planning and design completed	Q4 2018	Q1 2019	Delivery Plan and PDP update Design proposal and Initial user manual Test Plan	For: TMR Master Plan For: TMR Master Plan
RSM2. (was RSM3) Development completed	Q1 2019	Q3 2019	2 x R-ITS-S ready for testing Transport and Main Roads witness points throughout Device log data	On: SCMS vendor For: C-ITS-F development
RSH2. (was RSM4) Testing – FAT	Q1 2019	Q3 2019	Completed and accepted tests	On/For: all integrating parties
RSM3. (was RSM5) Testing –integration (IT)	Q1 2019	Q1 2020	Completed and accepted tests	On/For: all integrating parties On: TMR to provide NTU for communications to C-ITS-F

Milestone (Hold Point)	Baseline June 2018	Final	Deliverable	Dependent (on/for)*
RSH3. (was RSM6) Testing – Mt Cotton (SIAT)	Q2 2019	Q1 2020	Commissioning Test Sheets for 2 x R-ITS-S Completed and accepted tests Updated User Manual (moved to RSH5)	On: Installation vendor to commission devices On: TMR to provide NTU for communications to C-ITS-F On/For: all integrating parties For: Installation vendor Installation Manual/ Plan and TMR traffic signal design
RSM4. (was RSM8, includes RSD7) Fabrication	Q2 2019	Q2 2019 30 units Supplied	30 x R-ITS-S and brackets Quality Control Checklist Changed: Additional 2 devices requested.	On: SCMS vendor to provide enrolment certificates/ authorisation tickets/ unique IDs
RSH4. (was RSM9) Ipswich commissioned	Q3 2019	Q1 2020	(Installation occurred at Ipswich in late 2019; commissioning finalisation pending) Operation and Maintenance (O&M) Plan R-ITS-S go live and ad hoc support for troubleshooting and maintenance Commissioning Test Sheets for 3028 x R-ITS S (M2763 descoped; M2779 device failure prior to commissioning, moved to RSH5	For: TMR Master Plan On: TMR to provide NTUx30 for communications to C-ITS-F On: TMR to initiate service requests On: TMR for access to the C-ITS-F maintenance portal for OTA service On: Installation vendor to access and service devices
RSH5. (was RSM7, includes RSD6) Testing – Ipswich (SIAT)	Q3 2019	Q2 2020	Commissioning Test Sheets for 3028 x R-ITS S (moved to RSH4) Completed and accepted test M2779 installation and commissioning Updated User Manual	On: TMR Program Delivery and Operations (PD&O) for signal design approvals On: Installation vendor to access signals and commission devices On/For: all integrating parties
RSD8-10. Submission of final reports (was RSM11.)	Q4 2020	Q2 2022	New IP Detailed Design and Source Code	For: TMR Master Report

* Task is dependant “on”, or is a dependency “for”

The list of documents required as outputs is in Table 1.5(c) R-ITS-S vendor documentation (1.5 Pilot documentation). In addition to these, Kapsch has committed to provide:

- Quick Start Guide for RIS-9160 THb-4700000xxxx-01

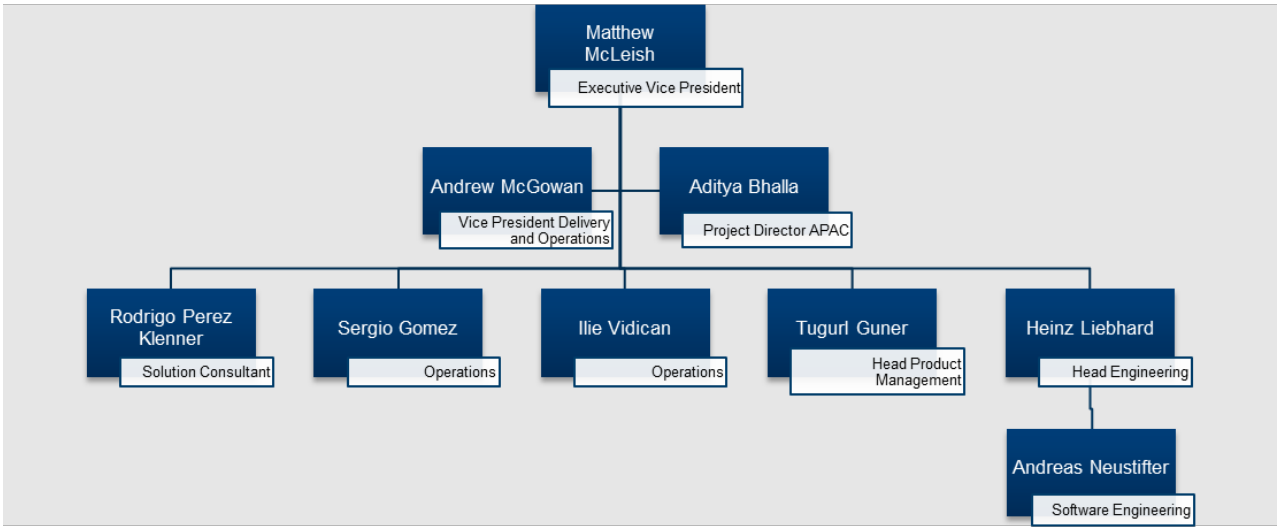
- Installation and Commissioning Guide for RIS-9160 THb-4700000xxxx-01
- Technical Manual for RIS-9160 THb-4700000xxxx-01
- User Manual for RIS-9160 THb-4700000xxxx-01

14.4 Delivery approach

14.4.1 Roles and responsibilities

The Kapsch project team organisational chart, as at pilot launch is shown below in Figure 14.4.1. This structure was subject to change through the pilot, as project requirements or staff changed.

Figure 14.4.1 – Kapsch organisational chart for R-ITS-S delivery



Kapsch operated under the following RASI model (Table 14.4.1(a)), where R= Responsible, A = Approval, S = Support, and I = Inform.

Table 14.4.1(a) – Kapsch RASI roles

Kapsch RASI roles			
Project Director	Aditya Bhalla	**Operations Team Members**	Oscar Gimenez, Ilie Vidican, Sergio Gomez
Technical Lead	Heinz Liebhart	**Project Sponsor**	David Bolt
Project Owner	Matthew McLeish	**Project Stakeholders**	Kapsch, TMR CAVI
Customer	TMR CAVI		

Table 14.4.1(b) – Kapsch RASI model

Output	**RASI**
Scope Definition	
• Filed customer requirements including acceptance modalities as first baseline of scope available.	R Project Manager, Technical Lead A Project Owner S Customer, Project Team Members I Project Stakeholder

Output	RASI
Design Baseline	
• Filed and accepted customer release plan • Filed and accepted refined requirements (detailing the solution and service requirements, where required) • Filed and accepted design (technical solution and service design) – on high level by Customer, in total by Project Team Members • Filed and accepted test plan and test specification (covering solution and service requirements) • Filed and accepted updated effort estimation • Filed concept of the transition plan	R Project Manager, Technical Lead A Project Owner S Customer, Project Team Members I Project Stakeholder
Substantial completion	
• Filed and accepted updated customer release plan, if applicable • Filed and accepted updated refined requirements (detailing the solution and service requirements, where required) • Filed and accepted updated design (technical solution and service design) • Filed and accepted updated test plan and extended test specification (covering all requirements) • Filed and accepted updated effort estimation, if applicable • Solution ready to be deployed to acceptance testing environment • Filed test report(s) demonstrating that all solution and service requirements are fulfilled • Filed unresolved defect list, if applicable • Filed transition plan to operations	R Project Manager, Technical Lead A Project Owner S Customer, Project Team Members I Project Stakeholder
System Acceptance	
• Filed test results of acceptance test including test report • Filed documentation of customer acceptance or rejection of realized solution • Filed list of identified defects and open issues • Filed procedure for customer defect reporting • Filed approach to continue	R Project Manager, Technical Lead A Project Owner S Customer, Project Team Members, Operations Team Members I Project Stakeholder
Go live	
• Accepted customer solution in productive environments in commercial operations (under control of Operations team) • Operations team phase in status as defined in transition plan • Operations support (including operations team, procedures and tooling) established as required • Support for go live is ready as required • Up-to-date documentation of leftovers including assigned responsibilities verified by Project Manager and Operations Team	R Project Manager, Technical Lead A Project Owner S Customer, Project Team Members, Operations Team Members, Project Sponsor I Project Stakeholder

14.4.2 Quality assurance

Kapsch's development process (Software, Hardware, Products, Subsystems, System Components) was performed according to the Systems Engineering V-Diagram (The PM Blueprint, 2021). The V-shaped process represents the execution of implementation and testing steps for solutions development. Project management supplies the planning, tracking and controlling of the development project and ensures that the objectives of the project are achieved with respect to requirements (that is, functionality, schedule and cost).

Once the technical process Stakeholder Needs and Requirements Definition was complete, the Pilot team started the System Requirements Definition Process. The customer or their designated personnel participated in the process, helping identify and validate the requirements. The process transformed the stakeholder's user-oriented view of desired capabilities into a technical view of the solution that met the operational needs of the user.

The system requirements definition process generated a set of system requirements using the agreed upon stakeholder requirements that reflected the user's perspective as the baseline. This process used the output of the Stakeholder Needs and Requirements Definition process such as the life cycle concepts, system functional identifications, stakeholder requirements, stakeholder traceability, initial Requirements Trace Matrix (RTM), architecture traceability and any life cycle constraints. This process was both iterative and recursive for the systems, subsystems and each system element.

The output of the System Requirements Definitions Process was a baseline set of complete, accurate, non-ambiguous System RTM, System Functional Interface Identification(s), and Verification Criteria.

The Software Requirements Analysis phase was completed with a review of the requirements specification(s), design documents, software specification(s), and technical provisions by the System and Software Engineering Teams. After review and incorporation of validated comments from the internal review, the system and software requirements specifications form the allocated baseline and were subject to configuration control.

Details on the quality control activities, with a solution focus, are described in the detailed Quality Control Plan for the following topics:

- Resources and their responsibilities
- Description of verifications and validation methods and tools
- Reviews (for example: requirement review, review of development and test artefacts and so on)
- Testing
- Solution verification (for example: unit testing, factory release testing, integration testing and so on)
- Solution validation (for example: acceptance testing)
- Product audits / inspections
- Evaluate review and testing results
- Configuration control

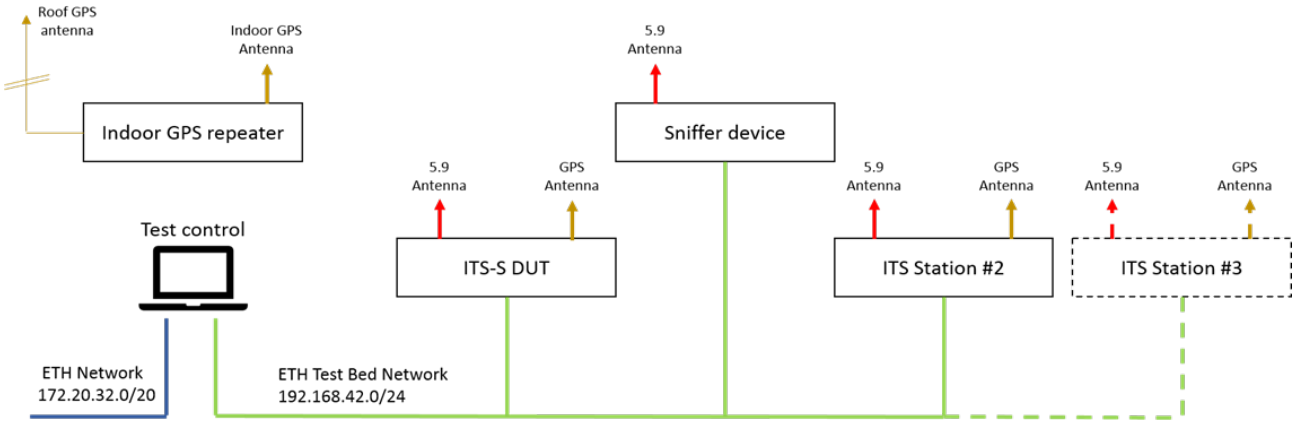
14.4.2.1 Approach

Where feasible the R-ITS-S vendor used automated test environments. A time triggered build for a certain piece of software is followed by an automated rollout to device(s) under test and software execution. This rollout typically covered a full set of roadside software since the build process is designed to build the complete software.

Test results were fed back into Jira where possible, minimum test results were visited on a regular basis to ensure any findings were fed back into the development process in a timely manner.

The testbed had a typical configuration as depicted in the Figure 14.4.2.1 below.

Figure 14.4.2.1 – Typical test bed configuration



14.5 Delivery stages

14.5.1 Planning and design

The R-ITS-S vendor delivered *RSD1. Delivery Plan, RSD2. Design Proposal and the Initial User Manual*.

14.5.2 Development

During the development phase, the R-ITS-S vendor built the hardware, firmware and software to meet the PSTS. Transport and Main Roads witnessed progress throughout the development phase.

The R-ITS-S used Qualcomm Technologies for the security library which supported the security profile (ETSI TS 103 397 v1.3.1) and SCMS backend functionality (ETSI TS 102 941 v1.2.1).

14.5.3 Testing

The R-ITS-S vendor delivered *RSD3. Test Plan* detailing the tests performed within each of the test phases described in Section 11.1. This plan forms part of the *TMRD18. Master Test Strategy, Plan and Report*.

Table 14.5.3 – R-ITS-S test types

Test type	Description
ITS-G5 communications	ITS-G5 communications is in accordance with the requirements of ETSI EN 302 663:2013, ETSI EN 302 571:2017 and the ACMA Radio communications (Intelligent Transport Systems) Class Licence 2017 and uses the IEEE channel 180 to ITS-G5A control channel.
Radio performance	Provides ITS-G5 communications at a high probability of transmission success over 300 metres line of sight and under typical intersection conditions.

Test type	Description
Equipment housing compliance	Equipment housing, coatings and fittings are resilient to environment conditions – for example, corrosion resistant.
Reference architecture	Implements interfaces to: V-ITS-TS, SCMS, C-ITS-F, Field Processor and GNSS per the communications methods, networking and transporting requirements.
Message types	Supports messages for stations configuration, station platform (heartbeat, error logging and platform-level tracking), and safety evaluation (C-ITS) message types.
C-ITS message support	Provides support for: SPATEM, MAPEM, CAM and DENM in accordance with the respective ETSI standard.
Message signing	C-ITS Messages are signed in accordance with TS 103 097 v1.3.1 with Transport and Main Roads modifications.
Session and communication management	MQTT publish/subscribe protocol is used to establish the client/broker connection for communications between R-ITS-S and C-ITS-F, in accordance with requirements of C-ITS Station Protocol Specification and ISO/IEC 20992:2016,
Message decoding and encoding	Decodes MQTT messages for use by applications, management and security functions: MAPEM, software updates and configuration data. Encodes messages sent by R-ITS-S to C-ITS-F via MQTT: logging information.
GNSS Positioning	Stores a manually configurable reference position and maintains a GNSS location for placement verification.
GNSS timing and synchronisation	Synchronised to UTC using GNSS (accurate to within 10ms), maintains a system clock based on timing from local GNSS receiver that manages leap second corrections, and logs an error if the deviation between GNSS time and Field Processor time exceeds configurable threshold.
Data logging	Logging commences on power-up/initialisation of device and continues until power down. Logs C-ITS messages sent/received and station platform messages, as configurable logging rate and limits (parameters are configurable per message type). Data logs are not signed but are encrypted using TLS.
Management	Station implements changes contained in control or configuration requests when received, ensuring that the platform and application use the control and configuration parameters.
Software updates	Provides package management system to support remote security updates and/or platform package updates.
Remote maintenance	Provides remote maintenance access to information on station operation, status, communication channels and diagnostic information.
Security	Station is enrolled in accordance with SCMS certificate policy and C-ITS station protocol specification and can enable/disable SCMS security – for example, signing of messages. Must encrypt all MQTT traffic using the provided X.509 certificates to establish TLS.
Message signing and verification	All ETSI defined messages are signed at transmit source and verified on receipt in accordance with ETSI certificate format ETSI TS 103 097 v1.3.1. Messages that are unsigned or contain an invalid certificate (including an expired certificate) are ignored by the station.
Device access security	A hardware security module (HSM) capable of meeting FIPS 140-2 Level 3 is provided for securely storing, handling and processing crypto material. The R-ITS-S Ethernet interface to the Field Processor is protected by a configurable firewall.
Performance impact	Station performance is acceptable.

The test results are captured in *TMRD18. Master Test Plan and Report*. Several defect rectifications were undertaken during the pilot period, see *TMRD24 Master Maintenance Report*.

14.5.4 Fabrication

A total of 35 R-ITS-S were provided to Transport and Main Roads for installation, which included antennas, mounting brackets and mounting plates. The R-ITS-S vendor has supplied the associated *RSD7. Quality Control Checklists*.

14.5.5 Commissioning

A total of 29 R-ITS-S were commissioned in the field by the R-ITS-S vendor. As part of final commissioning, the 29 R-ITS-S in Ipswich have also been enrolled with the Pilot SCMS. The R-ITS-S vendor supplied the associated *RSD6. Commissioning Test Sheets*.

Analysis was performed to check the associated maximum antenna range, which should equal to or exceed the approach length defined in MAPEM. Of the 101 approaches, 55 had a MAPEM extent of 300 metres – the remaining were shorter due to the presence of upstream intersections. All but one approach had an antennae range that exceeded the MAPEM definition.

Other installation issues were identified during commissioning, included the lack of earthing and inadequate number of mounting straps. These were rectified by the Installation vendor.

Acceptance of the R-ITS-S vendor's commissioning report triggered the start of the warranty period.

14.5.6 Field operational test

The R-ITS-S vendor delivered *RSD5. Operation and Maintenance Plan* for the Field Operational Test (FOT), which included operating procedures, maintenance, diagnostics and troubleshooting, and compliance certificates. The vendor's maintenance responsibilities are outlined in Section 23.4.

14.5.7 Pilot completion

The R-ITS-S vendor contributed to RSD9. New IP Detailed Design and Source Code and the Lessons Learned Report. Because of the strategic importance to the department, *RSD8 – Future Options Analysis* report was developed by Transport and Main Roads and captured within *TMRD23 – Master Future Options Analysis*.

15 Vehicle Intelligent Transport System Station

Through a tender process Cohda Wireless (Cohda) was selected as the successful V-ITS-S vendor.

15.1 Objectives

The V-ITS-S vendor delivered an ETSI compliant V-ITS-S meeting the specification of the project in support of the use-cases and safety evaluation.

15.2 Scope

The V-ITS-S professional service scope consisted of the planning, design, development, testing, device fabrication, commissioning, FOT operations and maintenance, and decommissioning.

The V-ITS-S vendor scope was:

- The development of V-ITS-S /HMI hardware and software per the specifications
- Fabrications, commissioning, and maintenance of 550x V-ITS-S and HMI
- The development of various reports and artefacts
- Support during all phases of the pilot (local collocated and back of office)

The V-ITS-S vendor had several sub-contractors as summarised in Table 15.2 below

Table 15.2 – V-ITS-S Packages

	Scope	Sub-contractor
Production x550 units	Cohda third party supplier located on mainland China. This company was used by Cohda over many years handling all high-volume production of Cohda Mk5 units and associated components.	AZTECH
Trial Support	On-site support during the trial following processes defined by Cohda. Staff to be trained in fault finding of all equipment prior to starting the trial. If this cannot be resolved locally issue to be escalated for resolution by Cohda technical staff.	SAGE Queensland
HMI Units x550 units	Human Machine Interface units provided through Cohda (third party supplier)	Siyata

The following was not in scope:

- Vehicle installation or the associated installation equipment.
- The provision of SIM cards for cellular communications.

15.3 Milestones and Hold Points

Milestones and Hold Points for V-ITS-S provision are listed in Table 15.3 below:

Table 15.3 – V-ITS-S Milestones and Hold Points

Milestone (Hold Point)	Baseline June 2018	Final	Deliverable	Dependent (on/for)*
VSH1. Contract award	Q4 2018	Q4 2018	Signed contract	
VSM1. (was VSM2) Planning and design completed	Q4 2018	Q1 2019	Delivery Plan and PDP update Design Proposal & Initial User Manual Test Plan	For: TMR Master Plan For: TMR Master Plan
VSM2. (was VSM3) Development completed	Q1 2019	Q3 2019	2 x V-ITS-S ready for testing TMR witness points throughout Device log data Changed: security automatic enrolment on hold	On: SCMS vendor For: C-ITS-F development
VSH2. (was VSM4) Testing – FAT	Q1 2019	Q3 2019	Completed and accepted tests	On/For: all integrating parties On: TMR to provide cellular access x 2
VSM3. (was VSM5) Testing – bench integration (IT)	Q1 2019	Q1 2020	Commissioning Test Sheets for 10 x V-ITS-S Completed and accepted tests Changed: Increase from 10 to 25 units	On/For: all integrating parties

Milestone (Hold Point)	Baseline June 2018	Final	Deliverable	Dependent (on/for)*
VSH3. (was VSM6) Testing – Mt Cotton (SIAT)	Q2 2019	Q1 2020	Commissioning Test Sheets for 10 x V-ITS-S Completed and accepted tests Updated User Manual Changed: Increase from 10 to 25 units	On: TMR to provide vehicles On: Installation vendor to commission devices On: TMR to provide cellular access x 10 On/For: all integrating parties For: Installation vendor Installation Manual/ Plan
VSH4. (was VSM7) Testing – Ipswich (SIAT)	Q2 2019	Q2 2020	Commissioning Test Sheets for 10 x V-ITS-S Completed and accepted tests Changed: Increase from 10 to 25 units	On: TMR to provide test vehicles On: Installation vendor to commission devices On/For: all integrating parties
VSM4. (was VSM8) Fabrication commenced	Q3 2019	Q3 2020	550 x V-ITS-S (rolling output) 250 delivered as at Jan 2020 Remaining 300 to be ordered Q3, 2020 Operation and Maintenance (O&M) Plan	On: SCMS vendor to provide enrolment certificates/ authorisation tickets/ unique IDs On: TMR to provide cellular access x 550 For: TMR Master Plan
VSH5. (was VSM9) Participant vehicles commissioning commenced	Q4 2019	Q3 2020	Roll-out of commissioned vehicles	On: Participant Manager and Installation vendor to access vehicles and commission devices
VSM5. (was VSM8) Fabrication completed	Q3 2019	Q4 2020	Fabrication completed	
VSM6. (was VSM9) Participant vehicles commissioning completed	Q4 2019	Q4 2020	Commissioning Test Sheets for V-ITS-S installed All V-ITS-S deployed. Vendor to provide ad hoc support for troubleshooting and maintenance	On: TMR to initiate service requests On: TMR for access to the C-ITS-F maintenance portal for OTA service On: Participant Manager and Installation vendor to access vehicles and service devices
VSM8-10. (was VSM11-12) Submission of final reports	Q4 2020	Q4 2021	New IP Detailed Design and Source Code	For: TMR Master Report
VSM7. Repurpose the V-ITS-S (provisional contract item)	NA	Q4 2021	Repurpose the V-ITS-S as R-ITS-S Scope changed: vehicle station enhanced portability	

* Task is dependant “on”, or is a dependency “for”

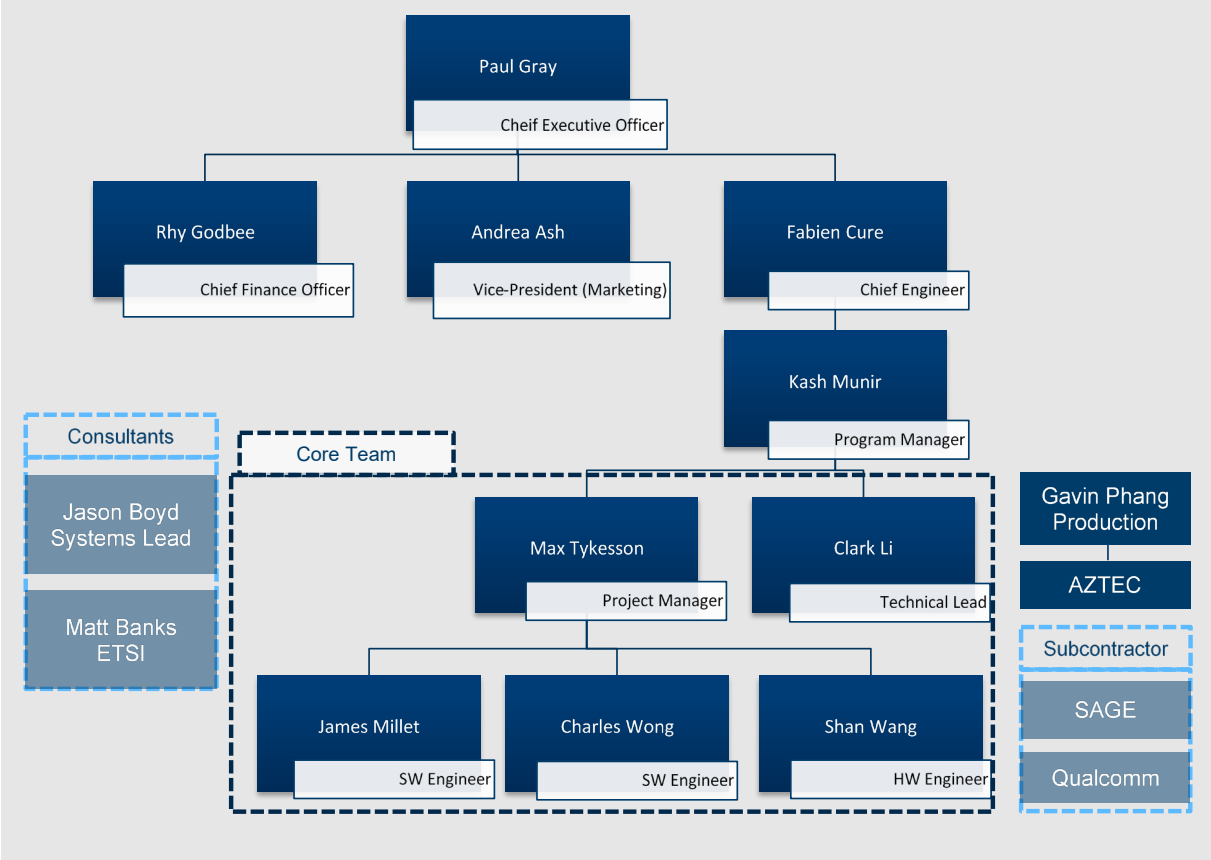
The list of documents required as outputs is in Table 1.5(b) V-ITS-S vendor documentation (Section 1.5).

15.4 Delivery approach

15.4.1 Roles and responsibilities

The V-ITS-S vendor organisational chart, as at the pilot launch is shown below in Figure 14.4.1. This structure was subject to change through the pilot, as project needs, or staff changes.

Figure 15.4.1 – V-ITS-S vendor (Cohda Wireless) organisational chart (at pilot launch)



The original Cohda RASCI for the delivery of the V-ITS-S/ HMI scope is shown in Table 15.4.1(a).

Table 15.4.1(a) – Cohda RASCI

RASI Roles			
Project Manager (PM)	Max Tykesson	**Tester**	Matt Mulder
Technical Lead (TL)	Clark Li	**Operations and Maintenance (O&M)**	Charles Wong
Software Developers (SW)	James Millet; Charles Wong; Keshva Reddy and Ming Zhou	**Subject Matter Expert (SME)**	Jason Boyd
Hardware Developers (HW)	Shan Wang	**Production (PD)**	Gavin Phang

Table 15.4.1(b) – Cohda RASCI matrix

	Role						
Tasks	**PM**	**TL**	**SW**	**HW**	**Tester**	**SME**	**PD**
Architecture SW	A	S				R	
Architecture HW	A	S		R			
Design		R	S	S			
Requirements		R	S	S	C	I	
Development – Coding/reviews			R	R			
Unit test development			R		R		
Quality Assurance		A/R	R	R			
Project Management	R	A					
Change Management	R	R					
Manufacture (550 units)	S	S		S			R
Factory Acceptance Testing (FAT) support			R				

R= Responsible, A = Approval, S = Support, C = Consult and I = Inform

15.4.2 Quality Assurance

Cohda Project Manager/Production Manager was responsible for ensuring contractor compliance with the requirements, in line with Cohda's contract administration practice. Examples of quality requirements included certification and delivery of quality plans, preparation and execution of inspection/ test plans and documentation of test plans. Corrective action requests and non-conformance reports were used to prevent or rectify work or conditions that did not meet specifications under the contract and to record decision-making.

15.4.2.1 Approach

Cohda worked to the Automotive Software Performance Improvement and Capability Determination (ASPICE) quality framework. In accordance with the standard and the Cohda quality policy, the V-ITS-S vendor undertook a range of quality management measures, including:

Defining and managing requirements for design and development:

- Requirements were based on existing EU (ETSI) and Transport and Main Roads standards as applicable. They included any relevant regulatory requirements and guidelines that apply in Queensland (including those relating to C-ITS/ CAV use as provided by Transport and Main Road's Transport Regulation Branch and the National Transport Commission). Identification of relevant regulatory requirements was informed by an independent legal review completed during the ITS Business Case. Requirements focussed on performance and functional requirements where appropriate.

Planning for and checking the quality of project outputs/deliverables:

- SMEs were sourced from within Cohda and externally to undertake peer review of Cohda deliverables as required.
- A responsibilities matrix (RASCI) was developed for all key project deliverables.

- Project outputs from design and development phases were checked against ETSI standards and CAVI design requirements to ensure compliance, and review findings documented.
- Continuous Integration was set up to verify conformance/unit test/use cases and perform static code analysis.
- Field trials were organised in Adelaide/Ipswich to assure the functionality and performance.

Cohda maintained an active Lessons Learned Register throughout the project duration, this register was formally reviewed quarterly or as required. Lessons Learned were reported to Transport and Main Road's V-ITS project manager via a monthly Project Progress Report.

15.5 Delivery stages

15.5.1 Planning and design

The V-ITS-S vendor delivered VSD1. Delivery Plan, VSD2. Design Proposal and the Initial User Manual.

15.5.2 Development

During the development phase, the V-ITS-S vendor built hardware, firmware, and software to meet the PSTS based on A, B and C models defined in Table 15.5.2. Transport and Main Roads witnessed progress throughout the development phase.

The V-ITS-S used Qualcomm Technologies for the security library which supported the security profile (ETSI TS 103 397 v1.3.1) and SCMS backend functionality (ETSI TS 102 941 v1.2.1).

Table 15.5.2 – A, B and C model development

Model	MK5 Unit – OBU	Phone w. Enclosure	Antenna	Cabling
A	Mechanical prototype w. PCB	Prototype w. machined enclosure w. PCB	Prototype - handmade	Prototype - handmade
B	Prototype w. updated PCB	Prototype w. machined enclosure w. updated PCB	Updated prototype	Updated prototype
C	Pre- production run	Pre-production run	Pre-production run	Pre-production run

The final factory build was based on the pre-production run and any feedback from this activity.

15.5.2.1 A-Model development

Table 15.5.2.1(a) shows A-Model Development Tasks and Witness Points Activities.

Table 15.5.2.1(a) – Initial documentation and prototyping tasks

Task Name	Description
MQTT Secure Connection	Sample application which connects to the CAVI MQTT broker using certificates.
ZED9 P I/F Prototype	Testing completed on a ZED 9P external chip to use as a prototype for messaging protocols and GPS testing.
MQTT Publish/subscribe Prototype	Sample application subscribes to the CAVI MQTT broker to receive station configuration messages and publishes a dummy message to verify end-to-end communication.
HMI SW I/F Prototype	Sample mobile phone testing to build a prototype for the CAVI HMI.

Table 15.2.2(b) shows A-Model Development Tasks and Witness Points Activities.

Table 15.2.2.1(b) – A-Model Development Tasks and Witness Points Activities

Task Name	Description
HMI A-Model (PCB, Enclosure and cabling)	HW prototype development
MK5: PCB (ZED 9P and WIFI) + power cabling	As above
MQTT Geo tiling + positioning augmentation	Subscribe to the base GeoTile topic and utilise the current V-ITS-S position to recursively select the geotiles relevant to the current location.
ZED 9P Field trial incl. positioning	Drive test of the V-ITS-S system with the ZED 9P to test accuracy and integrate with the positioning augmentation information.
Witness points: V-ITS-S subscribes to MQTT from 3G/4G	As requested by Transport and Main Roads. Test Lead to attend.
Witness points: V-ITS-S data log back to C-ITS-F	As requested by Transport and Main Roads. Test Lead to attend.
Witness points: V-ITS-S Positioning (Velocity) Accuracy	As requested by Transport and Main Roads. Test Lead to attend.
Witness points: V-ITS-S ITS-G5 (Range)	As requested by Transport and Main Roads. Test Lead to attend.
Witness Point: V-ITS-S ETSI Message Conformance	As requested by Transport and Main Roads. Test Lead to attend.

15.5.2.2 B-Model development

Table 15.5.2.2 shows B- Model Development and Associated Tasks leading up to FAT.

Table 15.5.2.2 – B- Model development and associated tasks

Task Name	Description
Use Cases x 6 apps	Setup 6 use cases in automated test system.
ETSI Security Format & Load Static Cert Bundle	As per task name
ETSI security HSM	As per task name
HMI: Final mechanical design – B Model PCB – draft cabling – specs written and approved	Development of B-Model final hardware with draft specs available for manufacturer.
MK5: Final mechanical design – B model PCB (ZED 9P) – draft cabling - specs written and approved	Development of B-Model final hardware with draft specs available for manufacturer.
Final Installation trial of the above/QUT Feedback	Final test installation working with installer. Feedback from QUT required.
Conformance testing using B-Models	EMC testing of B-Model. This was delayed using C-Model TBD.
“2” B models for TMR + spares (8)	Manufacture of B-Models
MQTT Use case message subscription	Subscribe to Geotile use-case messages and verify their contents. These are to be forwarded to the ETSI facilities for processing in the stack and use-case applications.
MQTT Logging upload	Logging upload manager created and used to publish logs to the CAVI MQTT broker.

Task Name	Description
ADL use case drive test	Use-case drive testing completed in Adelaide to verify use-case requirements are met. This is to be done with V-ITS, R-ITS and replayed C-ITS messages for the Adelaide region.
HMI SW Display Prototype Development	For use in FAT

15.5.3 Testing

The V-ITS-S vendor has delivered *VSD3. Test Plan* that details the tests to be performed within each of the test phases described in Section 11.1. This plan forms part of the *TMRD18. Master Test Strategy, Plan and Report*.

Table 15.5.3(a) – V-ITS-S test types

Test type	Description
Electrical	Device is powered by a relay activated circuit driven by the ignition circuit of the vehicle. This energises safely on start-up of the vehicle and de-energise on switch off the vehicle. Complies with the requirements of AS/NZS 60950.1 and in accordance with electrical legislation.
Environmental Conditions	Capable of operation in enclosure air temperature up to 75°C
ITS-G5 communications	ITS-G5 communications is in accordance with the requirements of ETSI EN 302 663:2013, ETSI EN 302 571:2017 and the ACMA Radio communications (Intelligent Transport Systems) Class Licence 2017 and uses the IEEE channel 180 to ITS-G5A control channel. Transmission power is adjustable to a maximum Equivalent Isotropically Radiated Power (EIRP) of 23 dBm/MHz
ITS-G5 message performance	Transmit a minimum 15 signed ITS-G5 messages per second; process minimum 220 received signed ITS-G5 messages per second
Radio performance	Provides ITS-G5 communications with a high probability of transmission success over 300 meters line of sight and under vehicle traffic conditions.
3G/4G communications	Capable of operating on both the Telstra 3G and 4G networks with configurable Access Point Name (APN), username and password. TCP/IP, IPv4 is used for communications between the C-ITS-F and the V-ITS-S equipment.
Reference architecture	Implements interfaces to: HMI, R-ITS-S, SCMS, C-ITS-F and GNSS per the communications methods, networking and transporting requirements.
Geomessaging (Tile Data)	V-ITS-S subscribe to a geotile message from the C-ITS-F dependant on its current location. As the V-ITS-S moves geographically through tiles, new tiles are subscribed to. V-ITS-S subscribes to any tile within a 500m radius of its current position. Use case messages from C-ITS-F are limited to geotile boundary.
Message types	Supports message types for stations configuration, station platform (heartbeat, error logging and platform-level tracking), geotile, safety evaluation (C-ITS) and signed C-ITS message.
C-ITS message support	Provides support for: SPATEM, MAPEM, CAM and DENM in accordance with the respective ETSI standard
CITS signed message conformance tests	C-ITS messages are signed in accordance with TS 103 097 v1.3.1 with TMR modifications

Test type	Description
Session and communication management to C-ITS-F	MQTT publish/subscribe protocol is used to establish the client/broker connection for communications over 3G/4G between V-ITS-S and C-ITS-F, in accordance with requirements of C-ITS Station Protocol Specification and ISO/IEC 20992:2016
Message decoding and encoding	Decodes MQTT messages for use by applications, management and security functions: C-ITS messages received from the C-ITS-F, tile data, positioning augmentation, software updates and configuration data. Encodes messages sent by V-ITS-S to C-ITS-F via MQTT: logging information.
HMI connection	Supports connection to HMI to allow information to be presented to the driver. Connected through Wireless – WiFi (IEEE 802.11:2016), and provides cable connection via Ethernet
HMI presentation manager	HMI Presentation Manager manages the presentation of content and audio on the HMI. Only one presentation per region is active at a given time. Three (3) HMI regions may be active concurrently. Some presentation requests also include an audio alert.
GNSS positioning	Facilitates the real time calculation of position (XYZ) to an accuracy of at least 1m in the X, Y plane with 95 percent confidence based on clear sky view ideal conditions with augmentation turned on and short baseline data supplied. Performs augmentation using Real Time Kinematic (RTK) based on Radio Technical Commission for Maritime Services (RTCM) version 3 data positioning information received from the C-ITS-F.
GNSS timing and synchronisation	Synchronised to UTC using GNSS (accurate to within 10ms), maintains a system clock based on timing from local GNSS receiver that manages leap second corrections.
Use case applications	Supports six (6) use cases: Advanced Red Light Warning, Turning Warning – Vulnerable Road user, Road Works Warning, Road Hazard Warning, Back of Queue, In Vehicle Speed. The use cases operate independently and allow for the addition/removal of other use cases. Use case applications notify the HMI Presentation Manager of a use case warning with a use case event type identifier, and a warning (image/ audio) identifier.
Prioritisation	When concurrent use case applications create a HMI notification, the HMI Presentation Manager prioritises warnings according to their criticality and urgency. The lowest speed is prioritised for any concurrent speed notifications.
Out-of-Area mitigation mode	V-ITS-S is in an out-of-area tile, the V-ITS-S shall operate in coexistence mode in accordance with ETSI TS 102 792 v1.2.1 Section 5.4. If the V-ITS-S loses positioning confidence (for example, enters a tunnel) it remains in the same mode until positioning confidence is regained.
System start-up	Capable of full operation 3 minutes (at 95% confidence) from a factory start condition and has non-volatile memory to store all information required to meet the operational and technical requirements.
Data logging	Logging commences on power-up/initialisation of device and continues until power down. Logs C-ITS messages sent/received and station platform messages, as configurable logging rate and limits (parameters are configurable per message type). Data logs are not signed but are encrypted using TLS.
HMI status	HMI connection status with V-ITS-S is monitored and logged with the vehicle station platform message.
Management	Station implements changes contained in control or configuration requests when received, ensuring that the platform and application use the control and configuration parameters.

Test type	Description
Software updates	Provides package management system to support remote security updates and platform package updates
Maintenance	Provides remote maintenance access to information on station operation, status, communication channels and diagnostic information. Additionally, local maintenance and configuration activities via direct Ethernet connection.
Security	Station is enrolled in accordance with SCMS certificate policy and C-ITS station protocol specification and can enable/disable SCMS security – for example, signing of messages. Must encrypt all MQTT traffic using the provided X.509 certificates to establish TLS.
Message signing and verification	All ETSI defined messages are signed at transmit source and verified on receipt in accordance with ETSI certificate format ETSI TS 103 097 v1.3.1. Messages that are unsigned or contain an invalid certificate (including an expired certificate) are ignored by the station.
Performance impact	V-ITS-S station performance is acceptable.

The HMI display unit test items are described below.

Table 15.5.3(b) – HMI test types

Test type	Description
Cable connection	HMI communicates to the V-ITS-S interface via Wireless connection (WIFI (IEEE 802.11:2016) and cabled connection (Ethernet) – the latter is used for HMI operating system updates.
HMI presentation manager	Supports the HMI Presentation Manager in the V-ITS-S by: conforming with the data elements for logging specified in the station platform data message and the C-ITS Message Event specification; and providing a mechanism for remotely updating software and configuration through the V-ITS-S.
Visual display	Supports three (3) regions for displaying visual content for use case layout: status bar, speed display region, and use case warning region. In addition, it supports a participant login layout on start of trip.
HMI audio	Supports audio sounds simultaneous with visual display for some use case warnings. Audio is played through an integrated speaker. Allows audio volume within a range of 50 to 84 dBA (at 80cm in open space).
On/off/reset controls	Vehicle users can hard reset the HMI if required for troubleshooting of faulty display. Power and data connections to the HMI are fixed/secured to minimise tampering by vehicle users.
Start-up	The HMI becomes active when vehicle ignition is turned on and connects to the V-ITS-S without use intervention. Controlled status displays are presented during start-up and while the vehicle is stationary – for example, participant login touchscreen. Non-participants do not receive any Pilot displays (incl use case warnings or alerts).
Shutdown	HMI turns off safely with vehicle ignition switch off. HMIs enters a sleep mode shortly after ignition switch off instead of powering off, in order to facilitate a faster display start-up on next ignition of vehicle. However, the HMI display screen must be blank while ignition is off.
Presentation handling	Content display and audio alerts are controlled as requested by the V-ITS-S Presentation Manager. Displays are also controlled during start-up or when there is no connection to the V-ITS-S.
Status reporting	Monitors presentation updates and durations of presentation requests from the V-ITS-S, to log system and event data through the V-ITS-S to the C-ITS-F.
Configuration settings	Applies the configuration settings that were uploaded to the V-ITS-S on the previous HMI start-up.

Test type	Description
Control group and deactivated participants	HMI does not act on requests to present use case warning, speed limit images or audio for participants in the study control group, or who are deactivated.
Display screen	Provides selection input from the driver via touchscreen, provides visual interface for content display (800x420 dpi). Displays are static (not flashing) with configurable minimum display period (set to 2 seconds).
Software updates	Supports download and update of application software through the V-ITS-S software updates. Updates are downloaded without impact to the current trip and are applied at the start of the next trip.
Maintenance	Supported via a SSH connection to the V-ITS-S.
Environmental conditions	The equipment can operate installed in a vehicle dash mount environment, directly in sunlight and up to ambient air temperature of 70°C.

Test results are captured in *TMRD18. Master Test Strategy, Plan and Report*. Several defect rectifications were undertaken during the pilot period within the release 25 branch, see *TMRD24 Master Maintenance Log*.

The V-ITS-S vendor has delivered *VSD4.2 Updated User Manual*.

15.5.4 Fabrication

Two batches of V-ITS-S were delivered – one before and one during installation. Each batch was accompanied with *VSD6. Quality Control Checklists* – including evidence that the station was enrolled with the Pilot SCMS. Because one batch was provided before installation, some SCMS certificates had expired. In response, the V-ITS-S vendor was asked to set up a pre-commissioning bench at the Briggs Road installation site to reduce issues during commissioning. Furthermore, the second batch was fabricated with an enhanced printed circuit board which was tested, by the Pilot team, during the first week of commissioning.

15.5.5 Commissioning

V-ITS-S commissioning was conducted by the V-ITS-S vendor at the Briggs Road installation site. The vendor pre-commissioned on a bench prior to installation. Once installed, the V-ITS-S vendor performed testing in the participants vehicle on the Briggs Road test track to confirm (as per the Transport and Main Roads approved *VSD6. Quality Control Checklist*):

1. secure mounting,
2. correct operation, and
3. all use-case triggered.

Per the penetration testing, minor changes were required during bootstrapping to support the system requirements.

15.5.6 Field operational test

The V-ITS-S vendor delivered VSD5. Operation and Maintenance Plan for the FOT, which included operating procedures, maintenance, diagnostics and troubleshooting, and compliance certificates. The vendor's maintenance responsibilities are outlined in Section 23.5.

15.5.7 Pilot completion

The V-ITS-S was decommissioned by the installation vendor. Transport and Main Road's original plan was to repurpose the vehicle stations as roadside stations; however, this provisional item was instead used to make the vehicle stations more portable for Transport and Main Roads future use and testing.

The V-ITS-S vendor contributed to *VSD9. New IP Detailed Design and Source Code (V-ITS-S)* and lessons learnt report. Because of the lack of strategic importance to the department, *VSD8. Future Options Analysis* report was removed from the scope.

16 Central Intelligent Transport System Facility

The C-ITS-F team included Transport and Main Roads, Transmax, WSP and Amazon Web Services (AWS) and ad-hoc support from Servian.

16.1 Objectives

The Central Intelligent Transport System Facility's (C-ITS-F) objective was to deliver an ETSI compliant C-ITS-S that:

- met the specification of the project in support of the cellular use-cases (RHW, RWW, BoQ, and IVS)
- met the specification of the project in support of the safety evaluation, and
- provided monitoring and maintenance tools for management of the pilot.

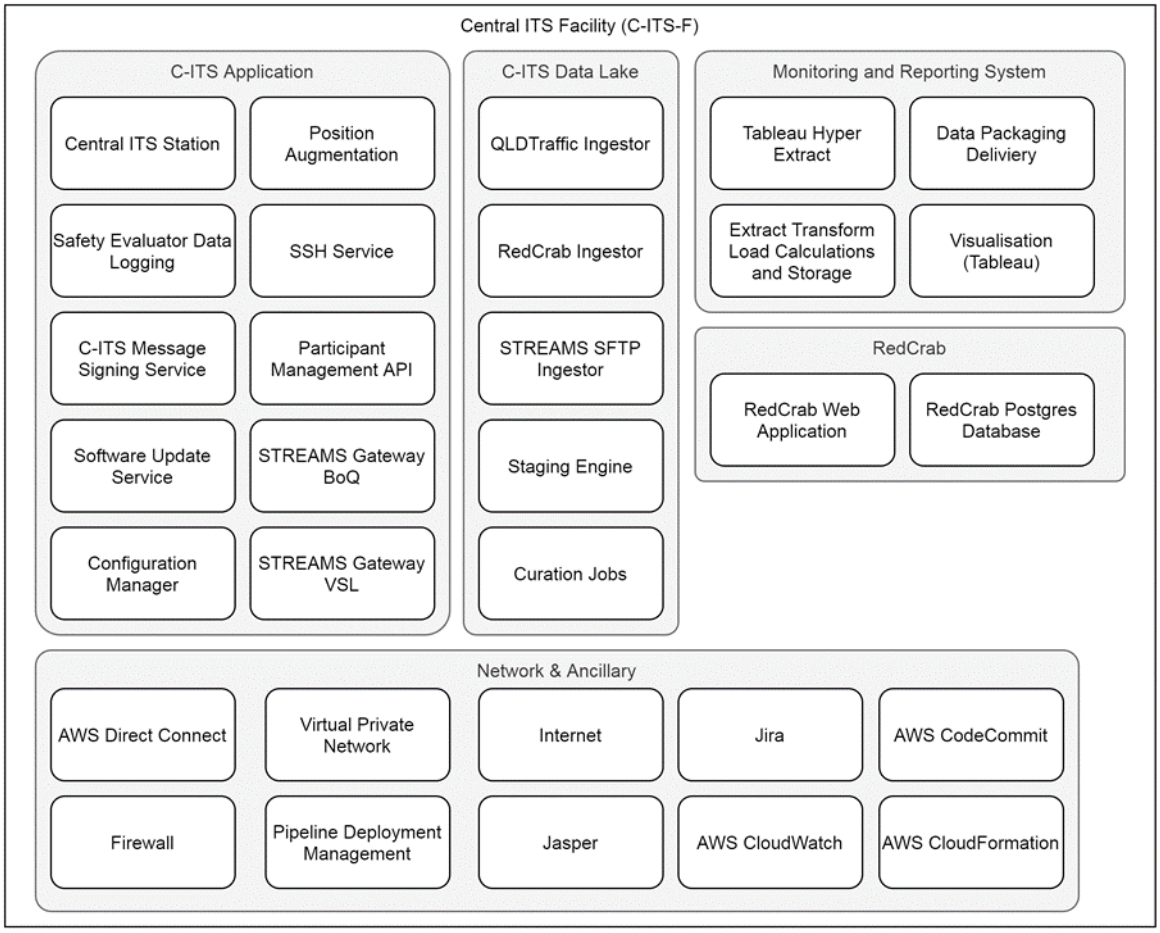
16.2 Scope

The C-ITS-F professional service scope (Figure 16.2) consisted of the planning, design, development, testing, commissioning, FOT operations and maintenance, and decommissioning.

The C-ITS-F scope of work was as follows:

- The development of C-ITS-F, as illustrated in Figure 18
- Commissioning and maintenance of the C-ITS-F
- Development of various reports and artefacts
- On-site support during all phases of the pilot.

Figure 16.2 – C-ITS-F Scope



The development of a roadworks application was out of scope; however, Package E was responsible for hosting, operations and maintenance of the application and database and supporting infrastructure.

16.3 Milestones and Hold Points

Milestones and Hold Points for C-ITS-F provision are listed in Table 16.3.

Table 16.3 – C-ITS-F Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
CFH1. (was CFM1) Contract award	Q3 2018	Q3 2018	Signed contract	
CFM1. (was CFM2) Planning and design completed	Q4 2018	Q4 2018	Update PDP with delivery approach Design Proposal Security and Privacy Plan Test Plan	For: TMR Master Plans
CFM2. (was CFM3) Development completed	Q1 2019	Q3 2019	C-ITS-F ready for testing (2 x sample tiles)	

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
CFH2. (was CFM3) Testing – FAT	Q1 2019	Q3 2019	TMR witness points throughout Completed and accepted tests Emulator for use-cases/positioning	On: SCMS vendor For: R-ITS-S and V-ITS-S vendors
CFH3. (was CFM4-5) Testing –Integration Test (IT)	Q2 2019	Q1 2020	Completed and accepted tests (moved to CFM4)	On/For: all integrating parties
CFM3. (was CFM6) Commission Production – Mt Cotton (2xtiles) SIAT	Q2 2019	Q4 2019	All C-ITS-F components as single product, 2 x tiles set-up Completed and accepted SIAT tests Operation and Maintenance (O&M) Plan (moved to CFM4)	On/For: all integrating parties For: TMR Master Plan
CFM4. (was CFM7) Commission Production – Ipswich	Q3 2019	Q2 2020	All C-ITS-F components as single product, all Ipswich tiles set-up Completed and accepted SIAT tests Operation and Maintenance (O&M) Plan Commissioning Report	On/For: all integrating parties
CFM5. (was CFM6) Training for monitoring and maintenance portal	-	Q3 2020	Training provided to TMR and vendor to use the monitoring tool and maintenance portal, including Updated User Manual (Added: CFD2. Design Proposal (C-ITS-F)	For: FOT commenced
CFM6. (was CFM8) FOT commenced	Q4 2019	Q3 2020	Go live, self-monitoring and maintenance as well as TMR generated service requests	On/For: all integrating parties On: TMR to initiate service requests
CFM7. (was CFM9) Decommissioning completed	Q1 2021	Q4 2021	Access provided to ongoing data storage and source code	
CFM8. Access provided to ongoing data storage and source code	Q4 2020	IP source code and detailed design	CFM8. Access provided to ongoing data storage and source code	
CFM9. Submission of final reports	Q1 2021	Q2 2022	Future Options Analysis IP Source Code and Detailed Design System Performance Summary	For: TMR Master reports For: TMR Master reports

Task is dependant “on”, or is a dependency “for”

The list of documents required as outputs is in Table 1.5(d) C-ITS-F team documentation (Section 1.5).

16.4 Delivery approach

16.4.1 Roles and responsibilities

The C-ITS-F team was co-located in Transport and Main Road's office to foster cross collaboration and work as one team. Package E was delivered under an Agile Project management methodology, supported by Jira as the development and issue management tool during the pilot.

The roles for the individual team members during development and testing were as follows:

- Project Manager
- Scrum Master
- Technical Leads
- Developers and Data Scientists
- Testers.

At the peak of development and testing there were approximately 15 staff, which reduced to five during operation and maintenance.

16.4.2 Quality assurance

To ensure best practice was applied to the development within Package E, AWS undertook a review of the usage of the AWS services to ensure they were deployed in the best and most cost effective way and in accordance with industry best practice. At each sprint a task was assigned to an AWS Senior Consultant (Cloud Architect) to conduct a quality assurance check. In addition, the AWS Staff Consultant (Cloud Architect) undertook random quality assurance checks of one or more tasks to review the detailed code written.

Automation integration tests were developed for each major critical functionality, these tests were incorporated into the build pipeline in order to validate a successful build. The results of these quality assurance tasks were reported to the Technical Lead and Project Manager to assess if any changes needed to be implemented and to promote a build to production.

Dashboards were developed on the AWS platform to ensure the use of the platform services was within the predefined limits set by AWS.

16.5 Delivery stages

16.5.1 Planning and design

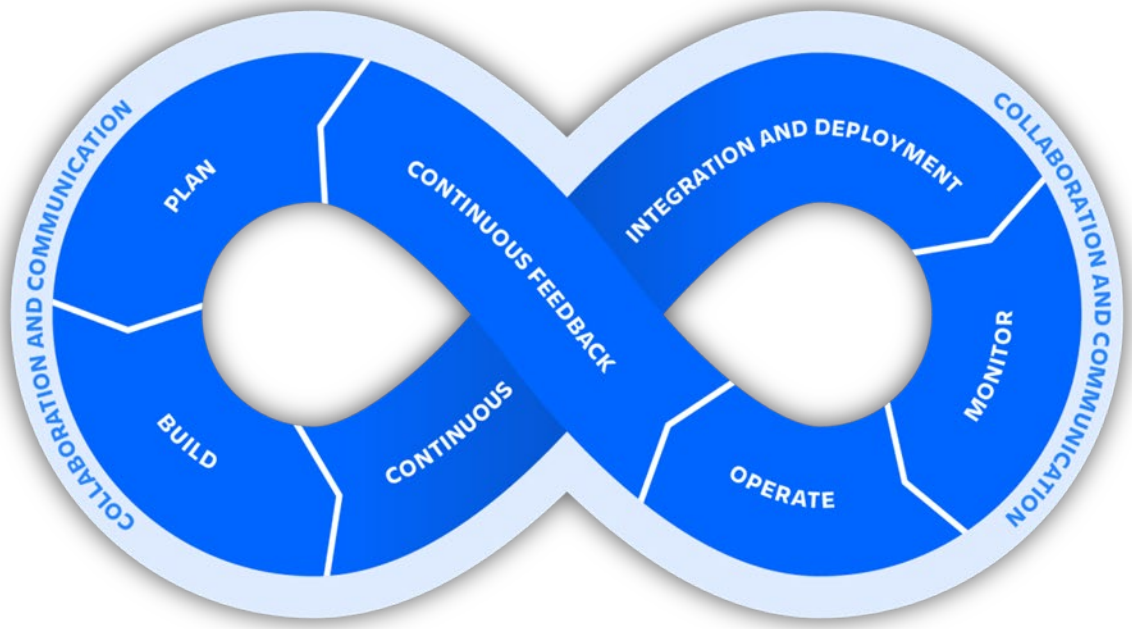
The C-ITS-F team delivered:

- *CFD1. Delivery Plan*
- *CFD2. Design Proposal*
- *CFD3. Security Plan C-ITS-F*.

16.5.2 Development

To deploy a tightly integrated multi-vendor solution the C-ITS-F team took a DevOps approach to development including Continuous Integration / Continuous Deployment (CI/CD) – see Figure 16.5.2.

Figure 16.5.2 – DevOps lifecycle (Atlassian, 2021)



The goal of DevOps is to ensure that the whole team has a stake in and is able to improve the operational reliability of the software. Practices such as automation and infrastructure-as-code are key to achieving this outcome and enable routine use of the deployment, operating, and monitoring processes during the pre-production stages of the software development cycle.

Multi-account AWS development, test and production environments were configured and integrated with the Transport and Main Roads Single Sign-On (SSO) service for ease of access and multi-factor authentication capabilities. All AWS accounts were configured with an AWS Landing Zone initial security baseline to meet Transport and Main Roads governance requirements.

Continuous Integration – Continuous Deployment (CICD) was implemented for the C-ITS Application. CICD process automated manual steps and reduced associated human error. CICD was recommended and adopted for the C-ITS Application but not the data lake and monitoring accounts.

16.5.3 Testing

The C-ITS-F team delivered CFD4. Test Plan that details the tests to be performed within each of the test phases described in Table 16.5.3. This plan forms part of the *TMRD18. Master Test Strategy, Plan and Report*.

Table 16.5.3 – C-ITS-F test types

Test type	Description
Telecommunications test (physical infrastructure)	
CITS signed message conformance tests	C-ITS messages are signed in accordance with TS 103 097 v1.3.1 with Transport and Main Roads modifications

Test type	Description
MQTT broker	Provides message broker service for R-ITS-S and V-ITS-S using MQTT v3.1.1 (ISO/IEC 20922:2016) using MQTT v3.1.1 (ISO/IEC 20922:2016) protocol. Application payload is published as ETSI conformant DENM, IVIM and MAPEM.
C-ITS application	Publishes C-ITS messages for use by R-ITS-S and V-ITS-S per AWS IoT topic structure
C-ITS data lake	Provides notification to the C-ITS-S when data is ingested into the data lake via AWS SNS
Ingestion (for data lake)	Ingestion for data lake from data sources for: RHW and RWW and interface to C-ITS application.
FOT participant data	Correction operations for interface C-ITS application, used by the Participant Manager to control the participation state of the Pilot participant vehicles
Logging	Verify all operational data log messages include the session number under which the message was logged. In combination with the station name the session number uniquely identifies a single operational period for a station.
Reporting on system health	Correctly processes from the C-ITS data lake using data analytics and visualisation platform to provide next-day dashboards for system health monitoring.
Safety Evaluation data set	Data is correctly logged to the data lake for use by the safety evaluation for: configuration data set, ingested data and operational data.
C-ITS message signing service	
Field station software update service	Operations of automated service for managing releases of platform and application software changes to R-ITS-S and V-ITS-S. Field station vendors can upload software releases to their relevant bucket via a secure method.
Configuration management	Provides maintenance functions for the C-ITS-S - allows the management of system and station parameters, the upload of configuration data and the visualisation of C-ITS messages in real time.
Positioning augmentation	Confirm this service extracts RTCM-3 protocol (Radio Technical Commission for Maritime) data from the AUSCORS NTRIP broadcast interface and distributes it via the augment position AWS IoT topic for V-ITS-S use
SSH service	Provides remote access to R-ITS-S and V-ITS-S using AWS EC2 hosts running a bastion image, with access to a web base SSH console with a centrally managed administrative access to systems.

The test results are captured in *TMRD18. Master Test Plan and Report*. Several defect rectifications were undertaken during the pilot period, see *TMRD24 Master Maintenance Log*.

16.5.4 Commissioning

The C-ITS-F team has delivered *CFD7. Commissioning Report* which contains details on the commissioning efforts.

16.5.5 Field operational test

The C-ITS-F team has delivered *CFD6. Administration and Maintenance Manual* for the FOT phase. In addition, the team has delivered *CFD12. Monitoring and Reporting System User Manual* and *CFD13. Configuration Manager User Manual* – these tools are used by all members of the Pilot team.

16.5.6 Pilot completion

Decommissioning of the pilot C-ITS-F was performed per the following schedule:

- C-ITS Application: September 2021, when all vehicles were decommissioned.
- FOT evaluation interface: February 2022, when the safety analysis was completed.
- Raw data storage: per the data management plan requirements.

The C-ITS-F team completed *CFD8. Future Options Analysis*, *CFD9. Decommissioning Report* and *CFD11. IP Source Code & Detailed Design*. As the C-ITS-F agreement was extended to support ongoing activities, the CFD9 document speaks to the transition to a new deployment, which is intended to protect the pilot data and remove access and services that are no longer required.

17 Security Credential Management System

Integrity Security Services (ISS) was selected as the successful Security Credential Management System (SCMS) vendor.

17.1 Objectives

The SCMS provided the identity management services for a C-ITS. It allowed the system to communicate in a secure manner whilst operating in a public space.

The specific objectives for the SCMS project as part of the Pilot were as follows:

- To successfully maintain C-ITS security throughout the field operational test using a European standards-based SCMS
- To provide pilot lessons learned for feedback to national and international stakeholders
- To deliver to time, budget and scope, in collaboration with the Pilot team.

17.2 Scope

The scope included provision of a European (ETSI) compliant SCMS capable of supporting twelve (12) ITS-Stations during the Planning and Design, Development and Testing phases, followed by 500 to 600 ITS-Stations through until decommissioning of the field trial.

Practical observations, lessons learned, recommendations and advice (for Australian Government, State and Federal stakeholders) cover:

- Strategy
- Policy
- Legislation
- Organisation and operation.

17.3 Milestones and Hold Points

Milestones and Hold Points for SCMS provision are shown in Table 17.3 below.

Table 17.3 – SCMS Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
SCM1. Planning completed	Q3 2018	Q2 2018	Early Test environment ready – preparation of test environment (iMOVE milestone 1) State of C-ITS Cybersecurity Report (SCD1)	For: Development (R-ITS-S, V-ITS-S and C-ITS-S)
SCM2. Development and testing completed	Q2 2019	Q2 2019	Vendor workshop held (iMOVE milestone 2) Support for early test environment / review of R&D progress (iMOVE milestone 3) Preparation for test environment (iMOVE milestone 4) Support for test environment (iMOVE milestone 5)	
SCH1. (was SCM3) Commissioning completed	Q2 2019	Q3 2019	Production environment ready – scale up of environment to support 550 vehicles (iMOVE milestone 6). Performed the web trust compliance key ceremony (iMOVE milestone 6A). due Q1 2020 Change: automatic enrolment on hold until Qualcom (former OBS) delivers to roadside and vehicle vendors Integrity Security Services (ISS) provided a Web trust audit - iMOVE 7A – Compliance audit confirming security of SCMS platform.	For: Fabrication (R-ITS-S, V-ITS-S and C-ITS-S) On: TMR to initiate service requests
SCM3. (was SCM4) FOT report	Q2 2020	Q1 2021	SCMS FOT Interim Report (SCD3) – Production Environment (iMOVE milestone 7)	On: Performance Impact of the SCMS Report (SCD2)
SCM4. (was SCM5-6) Decommissioning completed	Q4 2020	Q4 2021	Platform decommissioned (pending decision by Project Board) SCMS close out report – iMOVE milestone 8 & SCD4 Strategic Directions Report (project close out report – IMOVE milestone 9)	On: Decommissioning of all stations (Installer, C-ITS-F team) For: TMR Master report

* Task is dependant “on”, or is a dependency “for”

The list of documents required as outputs is in Table 1.5(e) SCMS vendor documentation (Section 1.5).

17.4 Delivery approach

17.4.1 Roles and responsibilities

Transport and Main Roads and the DITRDC directed the delivery of the SCMS with input as appropriate from the supplier, the Austroads security working group, and the V-ITS-S and R-ITS-S suppliers.

17.4.2 Quality assurance

Quality was assured via:

- Formal contract management
- Formal risk management and escalation process
- Formal technical change management
- Formal incident management
- Technical workshops
- Standardisation (compliance with the ETSI security standards)
- Adoption of the European Certificate Policy (Release 1), and
- Third party security review of appropriate documentation.

As the pilot progressed additional monitoring was requested of the SCMS vendor, such as monthly certificate top-up status per device.

17.5 Delivery stages

17.5.1 Planning and design

The platform was scaled up to support 100 devices and the test environment was brought on-line. The SCMS vendor provided evidence to the Pilot that the Platform was compliant with ETSI security standards, as of February 2019.

17.5.2 Development

The test environment continued to be supported by the SCMS provider and they assisted station providers with any issues connecting to or using the platform during development and testing activities.

17.5.3 Testing

Testing of the SCMS Platform was linked to the V-ITS-S, C-ITS-S and R-ITS-S test items and can be found in their respective components. Specifically, the test items in Table 17.5.3 apply to the SCMS.

Table 17.5.3 – SCMS test types

Test Type	Description
Signing request	A CSR (EC and AT) is sent and received by the station in accordance with ETSI TS 103 941 v1.2.1
SSP adherence	SSP validation will be tested against other stations and the SCMS infrastructure
Validity	Both valid and expired AT and ECs will be tested
Performance impact	Station performance impact will be analysed

17.5.4 Commissioning

The Platform supported up to 500 C-ITS stations. The pilot production environment was compliant with ETSI security standards, current as at February 2019.

17.5.5 Field operational test

Monitoring of the SCMS was provided by both Transport and Main Roads and the SCMS vendor during their respective business hours. Maintenance was performed by the vendor.

Transport and Main Roads conducted a review on its progress and achievements. The SCMS vendor delivered an interim report that highlighted the security provided by the SCMS and any impact on C-ITS performance with then current technologies in a real-world environment across multiple vendors.

17.5.6 Pilot completion

The SCMS provider delivered SCD4 – Close Out Report and contributed to *SCD5 - Strategic Directions Report*. The SCMS platform agreement was extended to support ongoing activities.

18 Field Operational Test and Evaluation

The Queensland University of Technology's (QUT) Centre for Accident Research and Road Safety – Queensland (CARRS-Q) was selected as the Field Operational Test and Evaluation vendor.

18.1 Objectives

The FOT and Evaluation (Package F) vendor was responsible for determining the user perceptions, safety impacts and managing the participants.

The specific objectives of the FOT project were as follows:

- To deliver a C-ITS safety and user perceptions evaluation that:
  - To achieve positive public participation in the Pilot and meet ethical standards
  - To deliver to time, budget and scope, in collaboration with the Pilot team including other suppliers/contractors.

As part of the Business Case, Transport and Main Roads undertook a rapid cost benefit analysis (CBA) of C-ITS in Southeast Queensland. The CBA was based on the deployment of ten (10) “day-one” C-ITS use cases, primarily safety use-cases, with a cumulative crash reduction of 20%. Assuming deployment from 2020, and a moderate penetration of C-ITS in new vehicles over a 30-year period, a benefit-cost ratio of 3.4 could be realised. Additional analysis also indicated a large savings for Queensland’s motor vehicle crash injury insurance scheme.

The Pilot evaluation results were used to validate Transport and Main Road’s CBA assumptions and confirm the investment rationale for the deployment of C-ITS.

18.2 Scope

The following activities were in-scope of Package F:

- Definition of research questions and hypotheses for each use-case
- Experiment (study) design, in alignment with guidance from the FESTA Handbook
- Participation in “collaborative workshops” and “technical sprints” to inform design of and interface to C-ITS systems
- Management of legal, regulatory, and ethical requirements relating to human participation, including ethics approval by a registered Human Research Ethics Committee
- System human machine interface (HMI) review/ testing
- Participant recruitment, training, and management, including design and deployment of participant feedback, monitoring, and reporting systems
- Pre-operational testing for checks on system HMI, usability, and ergonomics, and to pilot test FOT procedures
- Collection of subjective (user perceptions) data
- Collection of supporting data for safety evaluation, which required additional testing through driving simulators, simulations, or other controlled tests
- Data processing and analysis for safety and user perceptions evaluation, including provision of an evaluation data repository/ database and analysis of C-ITS generated (quantitative) data from the FOT (the lead of which was transitioned to Transport and Main Roads with QUT's assistance)
- Reporting on safety and user perceptions evaluation
- Project management to support delivery, including monthly reporting on risks and lessons learned and stakeholder engagement.

The following activities were not in-scope of Package F:

- Overall management of the Pilot, including broader stakeholder engagement beyond pilot participants and the Ipswich City community
- Development of the technical (design) solution and pilot deployment plan for the C-ITS system
- Selection, testing, installation, or de-installation of the ITS station hardware in the participants’ vehicles or infrastructure

- Development, testing and operation of back-end systems providing data to the C-ITS use-case applications
- Leadership of system acceptance testing
- Collection of data from the C-ITS field equipment or back-office systems
- Real-time health/ status monitoring of the C-ITS field equipment and back-office systems, and system fault resolution/ maintenance.

The following analyses were also not in scope:

- quantitative analysis of the in-vehicle speed function
- broader analysis of speeding patterns across the participant sample
- socio-economic analyses (including cost-benefit analysis).

18.2.1 Scope limitations

18.2.1.1 Participant's Vehicle Insurance

Due to the inherent safety risks of driving, Transport and Main Roads insurance services required that participants' have comprehensive car insurance, and assurance that their coverage would not be void because of their participation in the pilot.

Assurance was confirmed with many major insurance companies - RACQ, Suncorp, Allianz, QBE, IAG, AAMI, AMP, APIA, Bingle, Shannons, Vero, Budget Direct, Youi and NRMA. Package F vendor was responsible for collecting the participants' insurance information.

Milestones and Hold Points for vehicle insurance are listed in Table 18.3(b).

18.2.1.2 Participant's Human Machine Interface

Transport and Main Road's Land Transport, Safety and Regulation Branch indicated that legislation prohibits the use of mobile phones by learner and P1 provisional licence holders. If an in-vehicle C-ITS solution was delivered using a mobile phone, learners and P1 provisional licence holders would be prohibited from participating in the pilot, unless amendments were made to section 68 of the Transport Operations (Road Use Management—Driver licensing) Regulation 2010, which deals with the use of mobile phones whilst driving by licence holders.

Except for the use of a mobile phone display by a learner or P1 provisional licence holder, C-ITS applications were within the scope of existing regulatory framework. Thus, learner and P1 provisional licence holders were excluded from the pilot.

18.3 Milestones and Hold Points

Milestones and Hold Points for the FOT are shown in Table 18.3(a) below.

Table 18.3(a) – FOT Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
FEM1. (was FOM1) Planning, design and development completed	Q4 2018	Q4 2018	Study Plan (Draft final) Test Plans (HMI Usability & Ergonomics)	On: TMR Master reports (System Requirements, Test Plan)
FEM2. (was FOM2) Ethics approval	Q4 2018	Q3 2020	Ethics Submission Data Model and Interface Specification High Performance Computing (HPC)/Data & Tooling Design	For: FOT recruitment commenced (with public participants) On: TMR Master reports (System Requirements, PSTS, Data Management Plan, Privacy Impact Assessment, Master Security and Privacy Plan, FOT Safety Management Plan)
FEM3. (was FOM3) Testing – Bench Integration (IT)	Q3 2019	Q1 2020	Input to testing – HMI, Usability and Ergonomics Test Plan (Dress Rehearsal)	On/For: All integrating parties
FEM5. (was FOM3) Testing – Mt Cotton (SIAT)	Q3 2019	Q2 2020	Input to testing – HMI, Usability and Ergonomics Participant Installation/ De-installation Guidance	On/For: all integrating parties On: Installation (I) vendors plans and procedures
FEM11: Dress rehearsal participants recruited	-	Q3 2020	Participant consent/ install interviews scheduled	On/ For: all integrating parties On: Installation site/ vendors ready
FEM4. (was FOM4) Participant recruitment (including consent and training) commenced	Q2 2019	Q3 2020	Commence recruitment of approximately 400) consenting/ trained participants Participant Communications Strategy, Training & Briefing Strategy/ Feedback and Reporting Design and Materials finalised HPC/ Data and Tooling Implementation Report	On: TMR re insurance company agreements to access participants On: ethics approval On: TMR Master reports (Public Communications Plan) On: integrating parties
FEM6. (was FOM3) Testing – Ipswich (SIAT and dress rehearsal)	Q3 2019	Q4 2020	Input to Ipswich SIAT testing – HMI, Usability and Ergonomics Test Report (HMI, Usability and Ergonomics) Lead Dress Rehearsal Test Test Report (Dress Rehearsal) – *was not delivered	On/For: all integrating parties On: All parties ready for Ipswich test (to mimic the operating FOT)

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
FEM7. Decommissioning commenced	Not included	Q2 2021	Commence decommissioning of approximately 350 consenting/ trained participants	On: TMR and Safety Evaluator agree sufficient data collected for analysis
FEM8. (was FOM6) Decommissioning completed	Q3 2020	Q3 2021	Approximately 350 de-briefed participants	On: Installation vendor to manage device removal For: TMR Master reports
	Q3 2020	Q4 2021	Consolidated User Perceptions Report and Presentation, including lessons learned, Safety Evaluation Summary (lessons learned)	
FEM9. (was FOM7) Driving simulator studies completed	Q2 2020	Q3 2021	Driving Simulator Test Reports	
FEM10. (was FOM8) Analysis and reporting completed	Q2 2021	Q4 2021	Summary of Preliminary Findings (Safety Evaluation, User Perceptions)	
	Q2 2021	Q1 2022	Final Reports (Safety Evaluation, User Perceptions)	
FEM12. Data & Tooling (Phase 1 – Methodology review; data and tooling implementation)	NA	Q4 2020	Data Model and Interface Specification: High Performance Computing (HPC)/Data & Tooling Design (was FEM2) HPC/ Data and Tooling Implementation Report (was FEM4)	
	NA	Q4 2020	Data & Tooling Report Proof of Concept (Hold Point), Data & Tooling Report Proof of Concept (Dress Rehearsal), Data & Tooling Report Final**	
	NA	Q4 2020	Hypotheses Evaluation Reports (LOWER_CRASH and SPEED)	
	NA	Q4 2020	Hypotheses Evaluation Report (CELERATION)	

* Task is dependant “on”, or is a dependency “for”

Table 18.3(b) – Vehicle insurance Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
Insurance ethics	Q4 2018	Q4 2018 Complete	FOT & Evaluation vendor confirm ethics requirements	On: Consultation with Ethics Committee
VIH1. (previously VIM2) Insurance approval	Q4 2018	Q4 2018 Complete	Ministerial approval received	
(previously VIM3) Insurers confirmed	Q4 2018	Q3 2019 Complete	TMR to confirm relationship with one or more insurers	
Letters signed		Q3 2019 Complete	Insurers signed TMR letter confirming insurance will not be void by pilot	For: Participant recruitment
VIH2. (previously VIM4) Participants insured	Q3 2019	Q4 2019 Complete	Participant Manager to include confirmation of insurance not being void in participant materials	

* Task is dependant “on”, or is a dependency “for”

18.4 Delivery approach

18.4.1 Roles and responsibilities

Package F vendor had three key roles during the FOT:

- **Safety Evaluator:** Transport and Main Roads' Safety Evaluation team and QUT research team members that were responsible for data infrastructure and analysis in order to support the driving safety evaluation. This role was led by the Transport and Main Roads' Safety Evaluation Team Lead, with 1-2 Full-Time Equivalent (FTE) QUT staff supporting. Towards the end of the pilot QUT provided 1 FTE, while Transport and Main Roads provided the other FTE.
- **User Perceptions Evaluator:** QUT research team member that was responsible for data infrastructure and analysis in order to support the user perceptions evaluation and simulator studies. This role was led by the part-time QUT Package F Lead, with approximately 1.6 FTE staff supporting.
- **Participant Management:** QUT research team members trained to handle participant interactions. This role was led by the part-time QUT Participant Management Lead, with a further 2 FTE staff supporting.

In the pre-FOT stages, QUT staff were co-located with Transport and Main Roads at least one day a week. The Participant Manager had a weekly meeting with the CAVI Principal Advisor (Communications). During the FOT installation/ de-installation stages, the Participant Manager was based in Ipswich at the V-ITS-S Installation site.

During the FOT, outside of installation/de-installation stages, the Participant Manager was again co-located with Transport and Main Roads at least one day a week and had weekly meetings with the Package F Lead. QUT Safety Evaluators were co-located with Transport and Main Roads two days a week since the commencement of the FOT. The QUT Participant Management Lead also had weekly meetings with the Safety Evaluation Lead.

18.4.2 Quality assurance

Quality assurance of FOT and Evaluation delivery was implemented via:

- Recruitment of appropriately qualified and trained staff with expertise in road safety, human factors, driver behaviour and research involving human participants.
- Development of HMI design recommendations in accordance with relevant international and national standards and guidelines.
- Concept testing of proposed HMI design and participant training materials with public participants.
- Review of methodology and deliverables by external subject matter experts.
- Review of ethical considerations by registered Human Research Ethics Committee.
- Review of legal considerations by external law firm.
- Undertaking of the pilot in accordance with relevant regulations, including the Information Privacy Act (Qld) 2009.
- Full pilot dress rehearsal of pilot procedures including interaction with participants.
- Documentation throughout the project, including records of all interactions with participants.

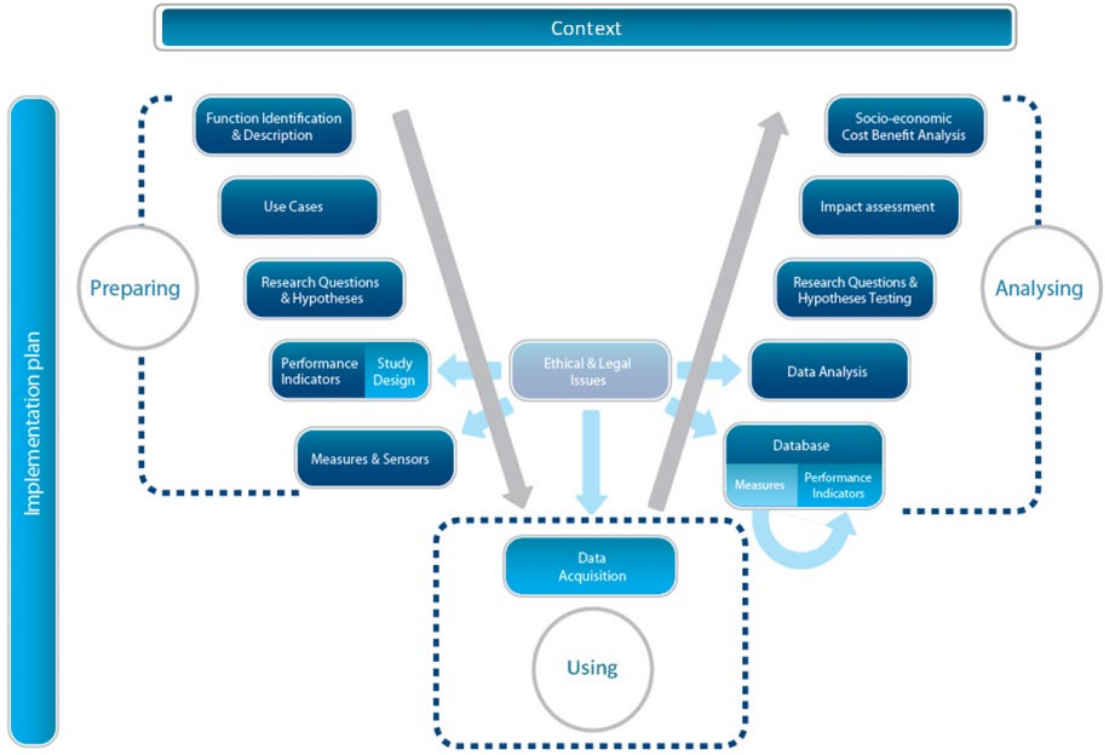
18.4.2.1 Methodology

The Pilot FOT followed the FESTA (Field Operational Test Support Action) methodology (FOT-NET, 2016) drawn from significant international European experience in FOT deployment for C-ITS and advanced driver assistance systems. According to FESTA, a FOT is defined as:

> *"A study undertaken to evaluate a function, or functions, under normal operating conditions in road traffic environments typically encountered by the participants using study design so as to identify real-world effects and benefits."*

As illustrated in Figure 20, FESTA adopts a traditional V approach which first requires mapping of the functions/use cases being tested to research questions, statistically testable hypotheses and measurable indicators for testing. These measures and the detailed study design including data analysis methodology are developed within the constraints imposed by the technologies and legal/ethical considerations. Data acquisition and analysis is then undertaken to test the hypotheses and report on the impacts and research questions. FESTA provides a repeatable foundation for conducting an FOT, allowing for re-use of study results and comparison with the findings with other studies internationally.

Figure 18.4.2.1 – FESTA methodology (v diagram)



18.4.2.2 Research questions and hypotheses

This FOT focused on road safety impacts. Safety impacts are related to exposure, risk of crashes or injury and incidents (for example: abnormal driver behaviour or near crashes). Changes in road safety will result from optimising the relationship between drivers (system users) and the technology.

The research questions answered through the FOT are:

1. Does the system improve or degrade safety for all road users?
2. Is the system acceptable to all users and what is their willingness to use it?

The overarching hypothesis was that C-ITS driver warnings result in a reduction in road crashes. Measurement of crashes during the pilot period was not likely to allow meaningful statistical investigation (it was estimated that there would be .03 fatal and 0.6 serious injuries crashes over the pilot duration[2]). It was only possible to evaluate safety benefits through alternative measures or pseudo-safety measures, which are measures that are known to contribute to crashes – such as speed, harsh braking, and lane changes ('risky' events). There, pseudo-measures were used to estimate the crash reduction potential of the C-ITS technologies. The evaluation will confirm the estimated safety benefits (by crash type) assuming 100% market penetration.

[2] Estimation using the Australian crash statistics and the distance travelled on road by Australians: https://bitre.gov.au/publications/ongoing/files/International%20road%20safety%20comparisons%202015.pdf, http://www.roymorgan.com/findings/australian-moterists-drive-average-15530km-201305090702

Research questions 1 was objectively derived from sensor data generated by the C-ITS system, whilst question 2 was subjectively obtained from questionnaires.

18.4.2.3 Study design

The experimental procedure was designed to ensure that the results of the FOT evaluations are statistically robust, valid, and free from any bias caused by confounding factors. All participant interactions were managed via the Participant Manager as a single point of contact. A summary of the study design is provided in Table 18.4.2.3, with details documented in the final study plan, ethics submission and other planning deliverables.

Table 18.4.2.3 – Pilot study design

Component	Description
Experimental design	The study implemented a Randomised Controlled Trial (RCT) with a Control Group and Treatment Group and included a before-after observational period for the Treatment Group. The Treatment Group was used to measure changes in the behaviour of a participant between a baseline period – where no C-ITS warnings are presented to the driver – and a treatment period – where C-ITS warnings are presented. The baseline and treatment periods were randomly allocated (50% start with baseline, 50% start with treatment). The Control Group[3] never received any C-ITS warnings – to ensure changes in behaviour are actually due to the C-ITS use cases, rather than other unrelated/ confounding factors (that is, seasonality, economic factors, changes in road conditions, participant changing driving behaviour once accustomed to being monitored). Data was collected from these participants per the treatment group.
Sample size and pilot duration	Based on statistical analysis, a sample size of 500 was required, with a control group of 100 participants[4]. In November 2020 this was updated to approximately 400 participants in line with trending recruitment numbers, which eventuated into around 350 confirmed participants. This enabled detection of small to medium effects on driver behaviour (for example, 1 km/h average speed change), whilst allowing a 10% loss of participants per experience of other FOTs. The sample size required the system to be operational in participants' vehicles for nine months (2-3 months baseline; 4-6 months treatment). The size of the control group was also reduced from 20% to 10% of total sample size, to increase the number of participants who experienced use case warnings, given the change in participant numbers.
Participant representation	Attempts were made to recruit a representative sample of public participants with balanced demographics (age, gender, and so on.). The balance of participants was more relevant in the assignment of participants into the control or treatment groups. Eligible participants included drivers with a valid licence (P2 or open), registered light vehicle (for example passenger car or light commercial vehicle, but not a heavy vehicle) and comprehensive insurance. They must also: • be the owner or have the owners' permission to use the vehicle in the pilot • drive regularly in the pilot area (minimum of 3 hours per week) • intend to keep using/ have access to the vehicle for the duration of the pilot • be contactable via mobile phone/ email • be in sufficient good health to see the HMI screen/ hear alerts, and

[3] For the purposes of the Project Specific Technical Specifications, Treatment Group participants undergoing a Baseline Period are categorised as Control Group participants, since the required system operational behaviour is the same.
[4] Sample size and pilot duration were validated through statistical analysis based on assumptions including the scale of the effect of the treatment, and that it will improve safety (refer to Study Plan for details).

Component	Description
	• be able to speak/read/ understand English. Additional vehicle eligibility criteria also applied as assessed by the Installation vendor at the time of the consent or installation appointments, for example, battery condition. Fleet drivers were considered, but not progressed.
Quantitative data collection	The objective data was derived from the vehicle generated C-ITS messages – for example CAMs, use case triggers and warnings. This data was collected from the field and back-office systems by the C-ITS-F and transferred to QUT's FOT Safety Evaluation Data Repository. The Safety Evaluator also collected contextual data from other sources (for example, congestion, weather, enforcement).
Qualitative data collection	The goal of the qualitative aspects of the pilot were to measure participants' expectations, perceived behaviour change, and trust in the C-ITS. These measures may or may not directly connect to the actual change in behaviour, but participants' attitudes towards the technology was hypothesised to directly correlate with their willingness to adopt the C-ITS into their daily driving. Data was also requested on participant demographics, self-reported driving attitudes/behaviours, existing in-vehicle technologies, and general technological acceptance/avoidance. Data was collected via questionnaires, interviews, and focus groups – pre, during and post-FOT.
Ethics	The Pilot had an approved Ethics application from the registered human ethics committee at QUT. This submission considered all aspects of human participation in the pilot to ensure it met ethical and other standards – including use of incentives and data privacy. Incentives were paid for by Transport and Main Roads but were purchased and delivered to participants by the Participant Manager.
Participant management & analysis tools	Participant interactions were managed through participant management and ticketing software, to ensure appropriate lodging, assignment, and resolution in a timely manner. The Safety Evaluator maintained a separate participant data collection database holding personal information of participants and vehicles (for example, name, contact details, vehicle registration) in support of Ethics requirements. Data analysis tools were applied to the research data collection utilising statistical analysis software and custom data transformation/analysis scripts.

18.5 Delivery stages

18.5.1 Planning and design

A Study Plan was developed and reviewed regularly in response to design changes, validation of methodologies, changes to the pilot approach, and ethics committee feedback.

The Package F team contributed to the development of the HMI and use case specifications and the data schema definition.

The Participant Manager developed strategies and materials for participant communications (recruitment and management), training and briefing, and feedback and reporting (surveys), for submission to the ethics committee.

The Participant Manager investigated, and selected software tools required to support participant interactions including the website, training, questionnaire completion (REDCap) and ticketing (for example, issues).

The Safety Evaluator developed a data model and tooling design, and interface specification for receipt of data from the C-ITS-F. This included performance requirements and procedures for data transfer, storage, and retrieval.

The Safety Evaluator identified and validated relevant contextual data sources to support data analysis, with assistance from CAVI regarding access to Transport and Main Roads data sets.

18.5.2 Testing

Package F developed and contrast tested warning image / audio files to be presented on the HMI.

The Safety Evaluator and Participant Manager were witness to the V-ITS-S station led tests for compliance with the Project Specific Technical Specification 003 – HMI.

The User Perception Evaluator and Participant Manager led HMI usability/ergonomics testing which occurred across all test stages including bench, Mt Cotton and Ipswich field testing. This testing was focused on the participant interaction with the system via the HMI and the use case warning timing.

The Participant Manager led the pilot dress rehearsal, which was intended to test all experimental procedures (participant and data analysis) with a small sample of participants that were independent of the Pilot team. The actual pilot dress rehearsal had intended to include at least 15 participants but was only able to recruit a sample of six participants. A few issues were raised by the dress rehearsal participants, for which issue resolution procedures were tested.

The User Perception Evaluator delivered test plans and reports relating to HMI, ergonomics and usability, and the dress rehearsal for incorporation to the Transport and Main Roads Master Test Plan.

18.5.3 Field operational test

18.5.3.1 Recruitment

The Participant Manager in collaboration with the Pilot team and Transport and Main Roads Communications Services developed a detailed Participant Communications Strategy including recruitment and management of participants.

There was an initial public announcement of the opening for recruitment and advertisement of recruitment channels including the QUT Ipswich Connected Vehicle Pilot website. The recruitment process involved a registration of interest and online screening for eligibility (shown in Figure 18.5.3.1).

The recruitment approach utilised 3 key strategies to support general community recruitment:

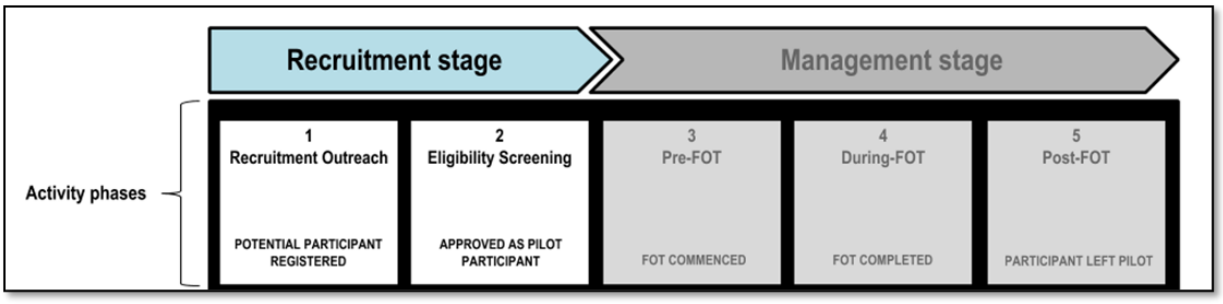
- **Broad-reaching community-wide campaign:** distribution of promotional material communicating general, awareness-raising messages via a range of communications media (including television and radio segments, letterbox drop at approximately 60k residences, social media advertising and face-to-face consultation at community events).
- **Insurance organisations:** insurance companies were sent ethics-approved Pilot information via their existing communication channels to their customers who had comprehensive insurance and who are in the region of the Pilot. (Note: participants were required to be the holder of comprehensive insurance with RACQ, Suncorp, IAG, Allianz, QBE, AAMI, AMP, APIA, Bingle, Shannons, Vero, or NRMA).
- **Other Ipswich-based organisations:** distribution of promotional material to organisations that were willing to promote the Pilot within their organisation and to their employees and/or customers. Any employees recruited through such means participated as individuals of the general community as opposed to fleet drivers. Potential organisations who were approached to assist with dissemination of recruitment materials include, for example, ICC, Transport and Main Roads, Brisbane Catholic Education Schools, TAFE, SEQ Water, Bendigo Bank, and Australia Post (new distribution Centre at Springfield). (Note that RAAF Base Amberley, the largest employer in the Ipswich region as noted by the Ipswich City Council Chief Operating

Officer, was not able to be involved due to potential security conflicts if the equipment was used on their sites).

In addition, organisations with fleets that met the eligibility criteria (including fleet drivers that were the primary driver of the vehicle, rather than shared/ pool vehicles) and in addition had at least 25 – 30 eligible vehicles, could also be accepted into the FOT (further ethics approval was received in September 2020). However, the additional challenges associated with recruiting fleet drivers, such as in relation to legal and ethics considerations, meant that fleets were not the primary focus of recruitment efforts. Ultimately, fleets did not participate in the pilot.

In earlier phases, an identified recruitment and attrition mitigation was additional recruitment activities after the start of the FOT. This could have also extended the FOT duration; however, it was decided that this extension would create difficulties in managing participants and associated research activities. Thus, recruitment closed in early November.

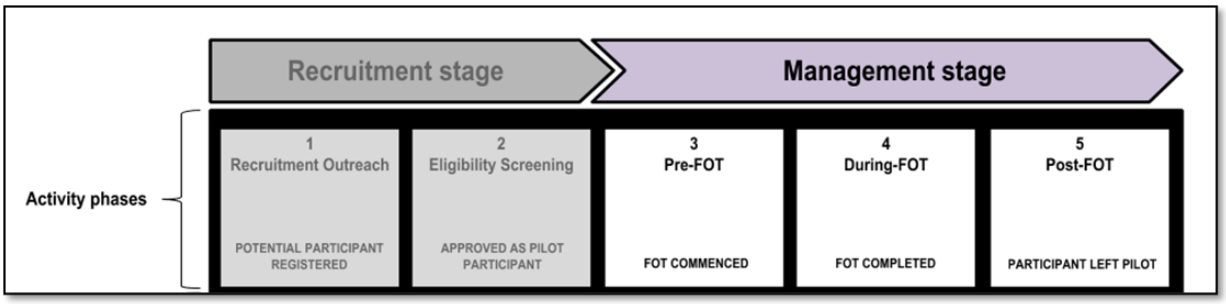
Figure 18.5.3.1 – Participant interaction flowchart - recruitment stage



18.5.3.2 Management

Once participants completed the eligibility screener, they entered the participant management stage per Figure 18.5.3.2. This comprised of pre-FOT, during-FOT and post-FOT activities.

Figure 18.5.3.2 – Participant interaction flowchart - management stage



18.5.3.3 Consent and install

Once participants completed the eligibility screener, they were assessed to confirm they met all requirements for participation in the FOT, including vehicle eligibility criteria.

Once consent to participate in the FOT was confirmed, the participant underwent training, briefing and installation activities. The training was web-based providing first a general explanation of the FOT, participant requirements, and overview of C-ITS, followed by a detailed explanation of the use case warnings. Prior to installation the participant also undertook a pre-FOT questionnaire to collect participants' background information, and attitudes and perceptions of technology/driving. The training and questionnaire were undertaken immediately after they gave consent, at the consent appointment.

Arrangements for in-vehicle equipment installation are per Section 19. In advance of installation, and in consultation with the Installation (I) vendor, the Participant Manager developed a detailed plan and associated procedures relating to interaction with participants during the vehicle installation and decommissioning periods. The Participant Manager acquired details regarding the participants' vehicle (age, make, model, existing roof racks and so on) and any installation preferences at the Consent stage and provided advance notice to the Installation vendor. The Participant Manager also requested that participants bring their vehicle to the consent appointment so that the Installation Lead could undertake a vehicle check to confirm vehicle eligibility / condition and appropriateness for participation in the pilot, prior to the participant giving consent.

The Participant Manager submitted monthly reports to Transport and Main Roads regarding progress of recruitment, installation, training and distribution of incentives.

18.5.3.4 During field operational test

The Participant Manager maintained ongoing communications with participants through three additional questionnaires (early FOT, mid-FOT and post-FOT) and other planned communications such as newsletters and check-ins. Participants were invited to volunteer for an optional telephone interview, with a maximum of 50 participants selected and interviews undertaken during-FOT period.

Participant consent also required that participants be contacted if they were involved in a crash. All participants undertook refresher training as part of their completion of the three questionnaires.

Control Group participants were also given the opportunity at the end of their 9-month data collection phase to have the C-ITS use case information/ warnings activated on the HMI for an optional 2 weeks, so that they could experience the technology. This data was not analysed by the Safety Evaluator.

Participant feedback in relation to faults was managed in accordance with the maintenance workflow illustrated in Section 23.5 and with the aim to minimise disruption to the participant. There were stages of escalation of maintenance requiring participant interaction:

1. No action required (that is, over the air update/configuration change during normal operation)
2. Remote request for input (that is, describe HMI display, leave vehicle on for short period)
3. In person (that is, home visit or to the installation site facility).

In addition to the monitoring activities undertaken by Transport and Main Roads, the Safety Evaluator undertook regular (at least fortnightly) validation checks of quantitative data and preliminary analysis to ensure the data collection was meeting safety evaluation needs. The Participant Manager was required to maintain participant feedback/management systems and data analysis tools.

The Safety Evaluator and Participant Manager submitted monthly progress reports to provide a summary of FOT activities (such as participant distance travelled, number of C-ITS warning events, number of participants that dropped out, participant issue resolution).

18.5.3.5 Post field operational test

V-ITS-S devices including the HMI were removed from the participant vehicles at the end of the pilot (de-installs were completed by 31 August 2021). Participant actions were coordinated by the Participant Manager, with physical removal undertaken by the Installation vendor. Participants also underwent a short debriefing.

Participants were given the opportunity to volunteer to be involved in a focus group, which was held virtually, involving up to 50 participants, and was undertaken within 2 months from when decommissioning activities were completed.

18.5.4 Pilot completion

18.5.4.1 Analysis and reporting

Quantitative and qualitative data from the FOT were analysis to derive measures for hypothesis testing. Three safety surrogate measures were investigated: average speed, celeration (smoother speeds) and near-crashes. For each use case, the differences in driving response between the treatment and baseline/ control participants were subject to statistical testing.

A set of contextual factors and user profiling regressors were added to the statistical models to enhance the representativeness. The driving responses were also investigated within time windows to measure impact of use cases on driving behaviour at different stages of the safety event.

As the data was collected from a naturalistic driving environment, a set of data quality metrics were employed to ensure the data was valid and as accurate as possible.

Quarterly quantitative data analysis reports were prepared to facilitate internal discussion on the methodology and provide preliminary findings for the stakeholders.

The Safety Evaluator and Participant Manager delivered final evaluation reports and contributed to the lessons learnt report.

19 Installation of roadside and vehicle stations

19.1 Objectives

This section describes the physical installation of the V-ITS-S and R-ITS-S at signalised intersections in both Mt Cotton test site and the Ipswich pilot area.

Package I delivered:

- The selection, preparation and delivery of an installation site suitable for the installation of the V-ITS-S equipment.
- The installation, commissioning, maintenance and decommissioning of V-ITS-S and associated equipment in around 350 vehicles.
- The installation, commissioning, maintenance and decommissioning of R-ITS-S and associated equipment at 29 pilot intersections.

19.2 Scope

The installation deployment plan was broken down into four parts:

- **Install site preparation:** Select and negotiate terms for a suitable site for V-ITS-S installation, maintenance and decommissioning activities to be completed within the Ipswich pilot area.
- **Testing:** of all installation undertaken at Mt Cotton as part of broader C-ITS testing, which allowed refinement of the installation and commissioning process. This ensured an optimised procedure to be created ensuring safety, quality and productivity during FOT installation period.

- **Roadside station installation and removal:** involved the installation of 29 R-ITS-S at intersections across the Ipswich pilot area (see Section 14). The installation of the R-ITS-S commenced in June 2019 and was completed in August 2019, to allow for Ipswich SIAT to be completed prior to vehicle installation commencing.
- **Vehicle station installation and removal:** involved installation of V-ITS Stations in 355 public participant vehicles. The vehicle installations started in September 2020 and concluded at the end of November 2020. Deinstallation commenced nine months after the first install in June 2021 and was completed within schedule by 31 August 2021.

The following was out of scope for Package I:

- Commissioning of V-ITS-S and R-ITS-S
- Any issues not related to the hardware installation
- Managing participant experience – noting there are some interactions throughout the process.

19.3 Milestones and Hold Points

Milestones and Hold Points for R-ITS-S and V-ITS-S Installation are shown below in Table 19.3.

Table 19.3 – Installation Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
IDH1. Contract award for installation package lead	Q4 2018	Q4 2018	Signed contract	
IDM1. Planning, design and development	Q4 2018	Q4 2018	Update PDP with delivery approach Test plan Development of resources (expert installers, tools), vehicle installation site and requirements for installation	For: TMR Master Plan On: TMR providing phase 1 installation findings and the station user manuals
IDH2: Installation site confirmed	-	Q3 2019	Installation site selected Agreement for site use formalised Scope and plan for site development	For: Installation site preparation
IDH3. (was IDH2) SIAT installation (Mt Cotton R-ITS-S & test vehicles)	Q2 2019	Q2 2019	Installation of 1 x R-ITS-S at Mt Cotton, 1 X R-ITS-S at Briggs Road Site and 11 x V-ITS-S with Installation Checklists Installation Plan (including procedures and Installation and Decommissioning User Manual (including procedures) (moved to IDM4, March 2020)	On: TMR to provide R-ITS-S and V-ITS-S equipment, and 10 fleet vehicles For: Mt Cotton stations to be used by other vendors for ongoing Mt Cotton testing On: TMR Road Asset Commissioning Plan

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
IDM2. (was IDM3) Installation site preparation	-	Q1 2020	Installation site vacated for CAVI use from July 2019 Installation site update/development for CAVI completed by mid-September 2019. Site is ready for installation when V-ITS is commissioned.	For: FOT dress rehearsal Installation commences On: Agreement
IDM3: Expert installer procured and trained	-	Q3 2020	Up to 6 expert installers for V-ITS-S hired from local Training for all installers completed	On: Training package Device user guides Updated schedule For: Install commence
IDM4. (was IDM2) Roadside installation (Ipswich) completed	Q3 2019	Q3 2019	Installed 29 x R-ITS-S in Ipswich (Complete) Installation Report (R-ITS-S Install Checklists) – one outstanding Operation and Maintenance (O&M) Plan Installation Plan (including procedures and Installation and Decommissioning User Manual (including procedures)	On: PD&O approvals and confirmation for handover by the R-ITS-S vendor For: TMR Master Plan
IDM5. (was IDM4) Testing – Ipswich (SIAT and dress rehearsal)	-	Q3 2020	Installation vendor to participate in the test dress rehearsal – uninstall/ install V-ITS-S into the Mt Cotton test or new vehicles including installation checklists	On/ For: All integrating parties
IDH4. (was IDH3) Participant vehicles commissioning commenced	Q4 2019	Q3 2020	Installation of V-ITS-S in participant vehicles commenced	On: TMR approves FOT commence On: V-ITS-S vendor to provide equipment (in rolling lots) On: Participant Manager to provide vehicle details in advance On: Participant Manager to manage installation schedule with the participant
IDM6. (was IDM4) Participant vehicles commissioning completed	Q1 2020	Q4 2020	Installation Report (V-ITS-S Install Checklists) All V-ITS-S live and vendor to provide support for maintenance of R-ITS-S and V-ITS-S devices as required	On: Maintenance requests via TMR or the Participant Manager On: station vendors available for troubleshooting

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
IDM7. (was IDM6): Participant vehicles decommissioning commenced	-	Q2 2021	Future Options Analysis Decommissioning Plan (including procedures) Commence decommissioning of all V-ITS-S in participant vehicles	For: TMR Master Report On: Participant Manager to manage schedule with the participant On: Safety Evaluator confirms sufficient data collected for analysis
IDM8. (was IDM6) Participant vehicles decommissioning completed	Q4 2020	Q3 2021	Decommission all V-ITS-S from participant vehicles	
IDM9. (was IDM7) Ipswich roadside devices decommissioned	Q4 2020	Q2 2022	Decommission all R-ITS-S** Decommissioning Report Install Summary Report	For: TMR Master report

* Task is dependant “on”, or is a dependency “for”

** R-ITS-S were not removed based on a continuation of asset agreement with PD&O.

The list of documents required as outputs is in Table 12: Installation vendor documentation (Section 1.5).

19.4 Delivery approach

19.4.1 Roles and responsibilities

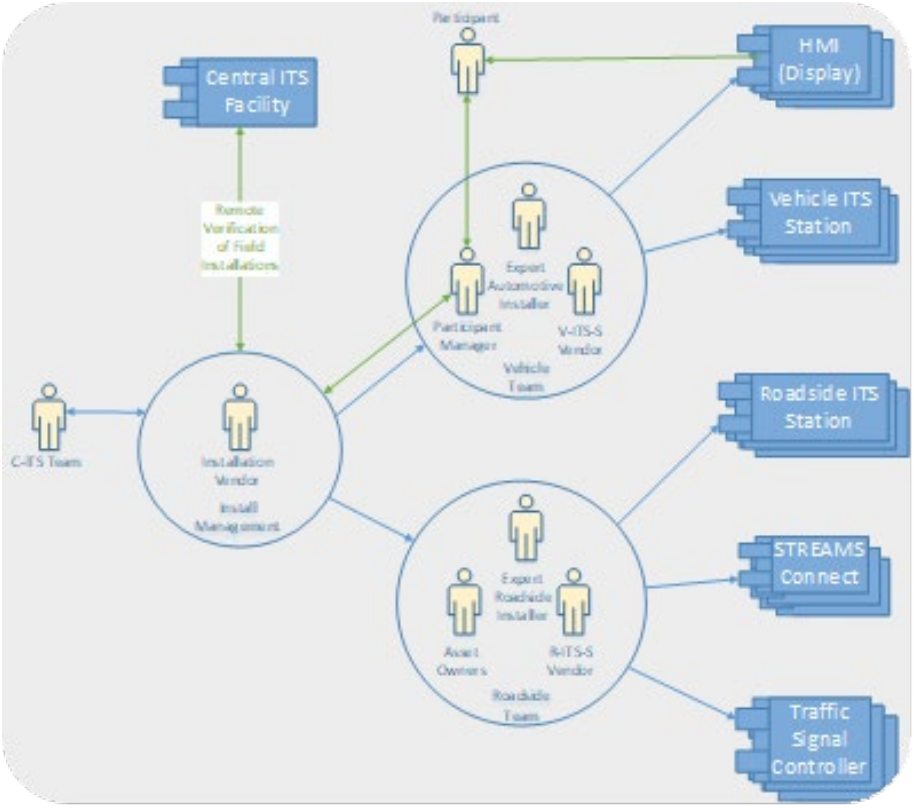
The Pilot system installation of the R-ITS-S and V-ITS-S comprised of several roles, as illustrated Figure 19.4.1. The installation required a collaborative approach between Pilot team, installers, device vendors, asset owners, the Participant Manager and the participant.

Access to the participant’s vehicle was managed by the Participant Manager. In addition to the installation of the V-ITS-S, vehicle suitability and condition inspections were performed by the Installation vendor, and vehicle condition at handback was performed with the participant.

- **Installation vendor (Package I):** The Installation vendor was responsible for organising the relevant parties, preparing plans and reports, testing and refining the procedures, selecting and fitment of the Ipswich installation site (Briggs Road), management of rental cars, and installation of the equipment for the Pilot. The Installation vendor, RoadTek, used sub-contracted expert installers.
- **Expert automotive technician (Package I):** V-ITS-S installation was completed by auto-electricians under the Installation Lead. It was estimated the installation, maintenance and decommission of the equipment totalled up to 3600-man hours. A team of four technicians were engaged, with access to back-up staff, for the install, maintenance and decommissioning periods.
- **Expert roadside installer (Package I):** R-ITS-S installation was completed by RoadTek. RoadTek, Transport and Main Road’s preferred ITS installer.

- **V-ITS-S and R-ITS-S vendors (Package D):** Installation of devices required input and interaction with the V-ITS-S and R-ITS-S vendors. This ensured the device was correctly installed for its optimal operation. The equipment vendors were involved in the development of the procedures and were prepared commissioning test sheets for handover.
- **Participant Manager (Package F):** The Participant Manager ensured the V-ITS-S installation solution was fit-for-purpose, complied with Ethics approval requirements and aligned to the Study Plan. The Participant Manager was responsible for scheduling the installation or servicing of the equipment in the participant's vehicle, and for all interactions with the participant through the installation and FOT period. The participant was offered a rental car, taxi vouchers or other transportation means during the install-/uninstallation (decommissioning) and servicing periods.
- **Asset owner (Transport and Main Roads Infrastructure Management and Delivery Program Delivery & Operations):** Transport and Main Road's traffic signal asset owners were involved to ensure:
  - electrical integration (power supply, network connection, data access)
  - structural integrity (poles, fixtures).

Figure 19.4.1 – Pilot deployment installation roles



Representatives from Transport and Main Roads Program Delivery & Operations, Road Operations and Structures divisions were engaged.

19.4.2 Installation site

In 2016, a Pilot memorandum of understanding was signed between ICC and Transport and Main Roads, which included the potential use of council property for vehicle fitment. ICC identified 180-215 Briggs Road, Raceview, QLD – 4305 and a lease was signed on the 25 July 2019. The lease expires on 31 August 2021. Due to the delays brought about by COVID-19, negotiations were undertaken with ICC with a view to extending the lease for 2 - 3 months duration. ICC formally advised on 27 May 2021 that lease would be extended on a month to month basis.

Site improvements were completed. ICC agreed to undertake the following:

- Structural steel work in one of the sheds
- Accessibility to office spaces
- New fencing
- Repairs to guttering
- Repairs to building cladding
- Lighting upgrades

Other minor works such as line marking, pest control, cleaning, and yard maintenance were arranged by the Installation Lead.

19.4.2.1 Site safety

The Installation Lead, with input from stakeholders, was responsible for Briggs Road safety management including:

- Evacuation procedures
- Security Procedures
- Vehicle Movement plans
- Environmental plans
- Waste disposal
- Site safety plan

The Package I lead developed an Induction Procedure for all staff working at Briggs Road.

19.4.2.2 Branding

To ensure that the installation site was optimised for the participant experience consultations were undertaken with the Communications and Package F teams regarding the branding and appearance of the site. Branding materials were installed at Briggs Road, and all Transport and Main Roads staff were provided with branded project clothing to be worn while on site.

19.5 Delivery stages

19.5.1 Planning and design

IDD2. Installation Plan and *IDD3. Installation and Decommissioning User Manual* were developed by the Installation vendor. *IDD6. V-ITS-S checklists* were developed and approved by the Pilot team.

19.5.2 Testing

Nine (9) Transport and Main Roads vehicles were fitted with V-ITS-S, and one (1) Mt Cotton R-ITS-S and 29 Ipswich R-ITS-S were installed for use throughout the various test phases. *IDD5. R-ITS-S installation report and checklist* was provided to the Pilot team.

19.5.3 Installation and maintenance

19.5.3.1 Roadside stations

As 29 R-ITS-S were installed in Ipswich by RoadTek, per the Pilot team approved checklists. As per the specifications, the antenna should be mounted between 6 and 8 metres in the centre of the intersection. Using existing poles, 14 sites were mounted between 5 and 6 metres, and 15 sites could not be centrally located.

As required by the R-ITS-S vendor and Pilot team, RoadTek performed installation rectifications:

- Grounding path – original installation did not meet the R-ITS-S vendors specifications.
- Bracket mounting – half of the mounting brackets were not installed per the RPEQ drawings
- Cables – many of the cables were not properly connected, and cables did not meet standards.

19.5.3.2 V-ITS Installation

V-ITS-S installation was conducted by the Installation vendors at the Briggs Road installation site in coordination with the Participant Manager and the V-ITS-S vendor per the agree procedures.

Post the initial V-ITS-S installation, the Installation vendor was available up to one day per week at Briggs Road.

To manage out-of-hours requests, participants were directed to call RACQ if they believe there was an issue associated with the vehicle equipment – for example a flat battery. For minor issues, the Participant manager arranged for the vehicle to be booked in for repairs. RACQ contacted the Installation Lead for prior approval to repair vehicle faults. All invoices for repairs were sent to the Installation Lead for payment.

19.5.4 Pilot completion

A new agreement was reached with Transport and Main Road's Road Operations' PD&O team to retain the R-ITS-S equipment until end fiscal year 2022-23. As a result, the R-ITS-S was not decommissioned by the Installation vendor.

The V-ITS-S were decommissioned by the Installation vendor. R-ITS-S were not removed based on a continuation of asset agreement with PD&O. The Installation prepared a decommissioning report - *IDD9. Decommissioning Report* for the V-ITS-S.

20 Geospatial data

This section describes the new C-ITS geospatial datasets used to support the Pilot project use-cases.

20.1 Scope

The ARLW and TWVU use cases used a map (MAPEM) to generate warnings. Transport and Main Roads developed a database that includes the pilot intersections MAPEM. MDD1 - MAPEM Files and Procedure outlines how to generate MAPEM.

20.2 Milestones and Hold Points

Table 20.2 lists Milestones and Hold Points for the MAPEM Database development.

Table 20.2 – MAPEM database development Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
MDM1. Pilot site survey	Q3 2018	Q1 2019	TMR to extract 30 x TMR site survey for reference point with high confidence	
MDM2. MAPEM database created	Q4 2018	Q4 2018	TMR to generate 30 x MAPEM database	On: TMR MAPEM delivery
MDM3. MAPEM database hosting	Q1 2019	Q4 2018	MAPEM database hosted on AWS server within C-ITS-F	On: AWS server available
MDM4. MAPEM database testing	Q4 2019	Q4 2019	MAPEM database ready for C-ITS-F integration and testing MAPEM Report and Procedure	For: C-ITS-F development and testing
MDM5. MAPEM database support during FOT commenced	Not included	Q4 2019	TMR to update the MAPEM database as needed (completed Q4 2019, however further optimisation through testing required).	On: TMR PD&O advising of intersection changes

* Task is dependant “on”, or is a dependency “for”

Transmax also enhanced the signal field processor (FP) firmware to support the generation of SPaTEM. See PSTS004 Field Processor Specification.

20.3 Delivery approach

20.3.1 Road network model

Transport and Main Road’s StreetPro Navigation data and a Transport and Main Roads elevation model were combined to create a three-dimensional road model of the pilot area roads – referred to as the Road Network Model (RNM). The data was consumed by the C-ITS-S to generate the IVIM data for the IVS use-case. The Road Network Model was also used by the C-ITS-S for the development of the trace within the DENM for BoQ, RHW, and RWW use-cases.

20.3.1.1 Posted Speed Limit Data

Transport and Main Roads developed a speed limit database, which includes the static and school zone speeds for the pilot area. Speed data (posted and school zone) was sourced from Ipswich City Council sign data, Transport and Main Roads speed sign survey data and project field surveys.

Transport and Main Roads developed a variable speed limit (VSL) zone or path-of-control database for the pilot area. An export from STREAMS® provided a spatial representation of the location of variable speed signs. The data from STREAMS® was displayed in GIS, along with the Road Network Model and Queensland Government aerial imagery and these datasets were used to locate the start and end of road segments controlled by variable speed signs – or the zone.

The databases were hosted within the C-ITS-F with changes logged to the MRS tool for change tracking and map-based visualisations. The Pilot team was responsible ensuring the information was current – per the *SDD1 - Speed Database Report and Procedure*.

20.3.1.1.1 Milestones and Hold Points

Table 20.3.1.1.1 lists Milestones and Hold Points for the Speed Database development.

Table 20.3.1.1.1 – Speed Database Development Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
SDM1. Speed database creation	Q4 2018	Q4 2018 Complete	TMR will generate the initial speed database	
SDM2. Speed database hosting	Q1 2019	Q4 2018 Complete	Speed database hosted on AWS server within C-ITS-F	On: AWS server available
SDM3. Speed database testing	Q1 2019 (updated quarterly)	Q2 2019 Complete	Speed database ready for C-ITS-F integration and testing Speed Database Report and Procedure	For: C-ITS-F development and testing
SDM4. Speed database support during FOT commenced	Not included	Q2 2020 Complete	TMR to update the speed database as needed (further optimisation through testing).	On: speed limit updates (actors to be decided)

* Task is dependant “on”, or is a dependency “for”

The C-ITS-S also used the RNM to generate traces into the RHW, BoQ and RWW event defined in DENM.

20.3.1.2 Detectors

Transport and Main Roads created an accurate spatial representation of the motorway detectors within the pilot area for the BoQ use-case. An export from STREAMS® provided locations of in-road detectors. The point data from STREAMS® was uploaded to the C-ITS-S, where it was automatically aligned to the road network model data.

20.3.2 Tiles

Transport and Main Roads developed a set of recursive tiles within the pilot area to limit the volume of messages delivered from the central station broker to vehicle stations. The recursive tiles were designed to cover all the world, starting with a continental tile set, down to local (sub-region) tiles. Figure 20.3.2(a) shows the Australia tile and tiles within the Australia tile, while Figure 20.3.2(b) shows the sub-region tiles in the pilot area. The lowest level tiles (sub-regions) contain information about the positioning correction service a vehicle station should subscribe to. This positioning correction information was sourced from the free AUSCORS service and included a prioritised list of up to three Continuously Operating Reference Stations (CORS). For the pilot, the first of the CORS listed for all tiles was a station in Ipswich established by Transport and Main Roads to support the project.

Figure 20.3.2(a) – Australia and state tiles

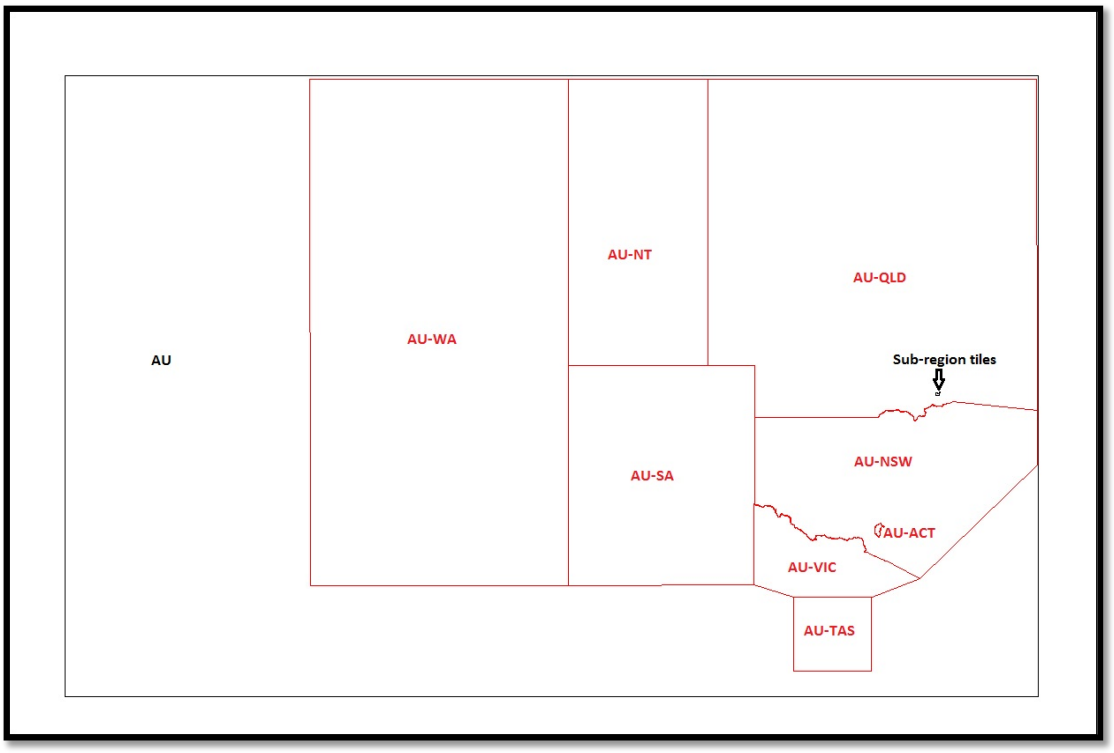
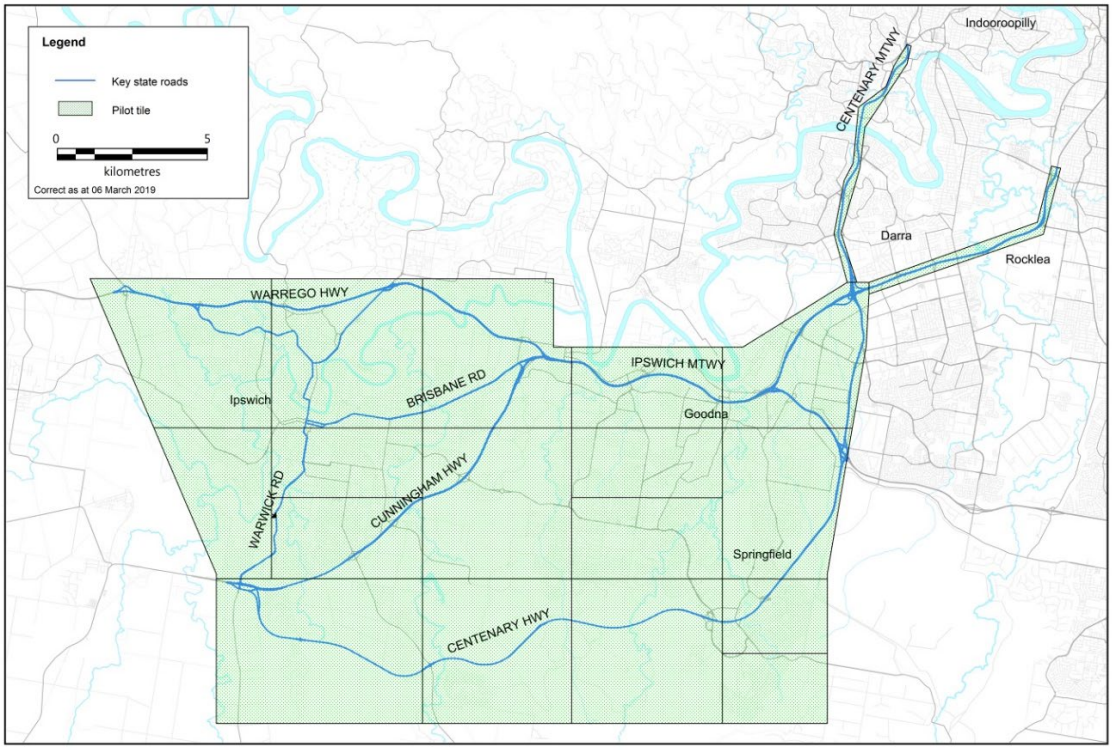


Figure 20.3.2(b) – Pilot sub-region tiles



21 New system – Roadworks application

21.1 Objective

The Roadworks Warning (RWW) use case required the type and location of roadwork signs and any changes of these over time. A tablet application was developed for the Pilot to enable the entry of relevant data to support the use case for static short and long-term roadworks. The application did not support mobile or rolling roadworks. The application included a back-end user interface for initial roadworks input and front-end application for confirmation and changes by road workers in the field.

21.2 Delivery approach

The application hosting was housed within the C-ITS-F. The data was provided through an API per the application API specification.

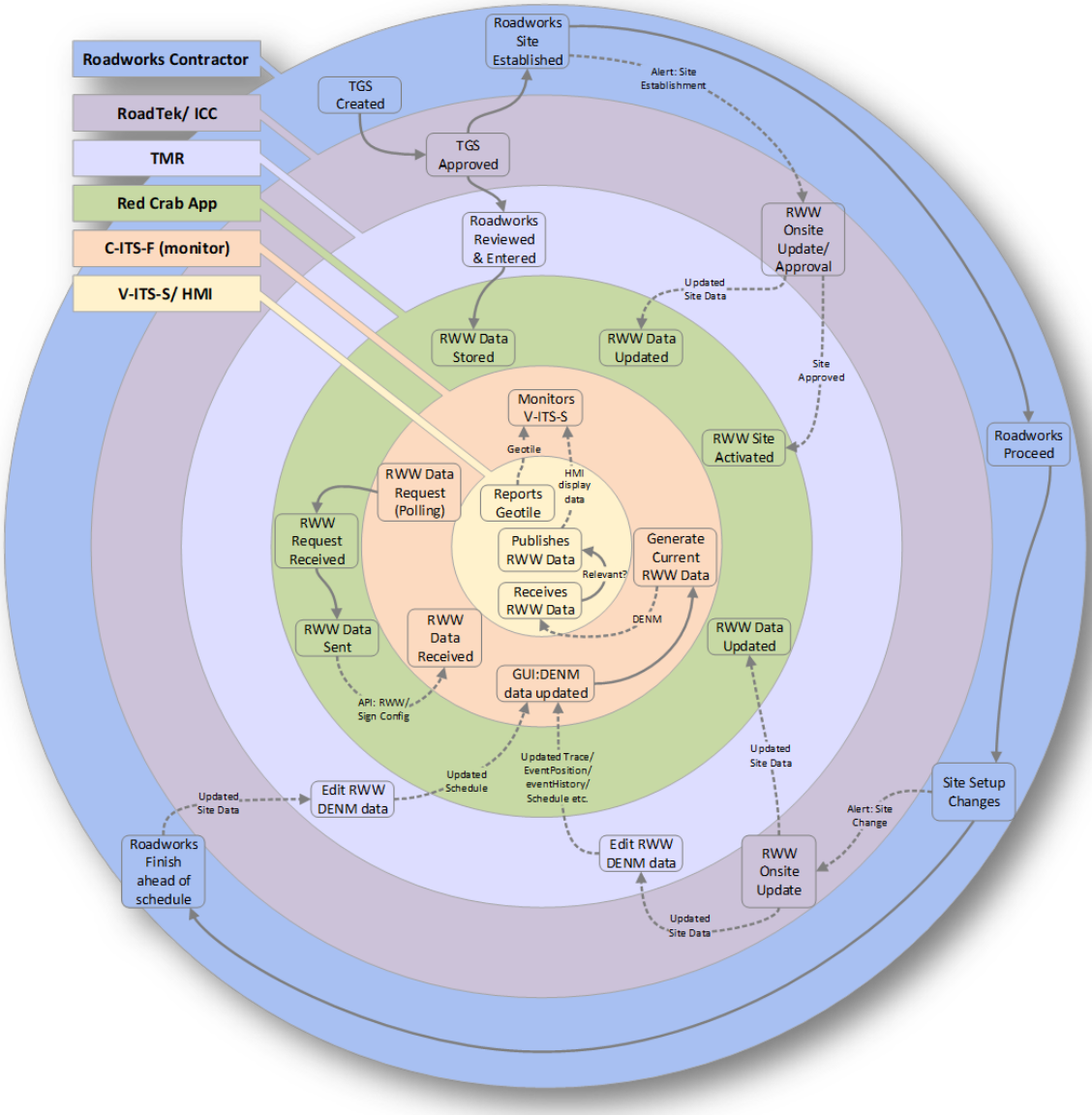
The application workflows are outlined in Figure 21.2.1. The application workflow aligned with requirements of the Manual of Uniform Traffic Control and Devices (Part 3 Works on Road) – the approval of the Traffic Guidance Scheme (TGS), and site inspections required to confirm the commissioning and decommissioning of the TGS.

21.2.1 Roles and responsibilities

Initial data entry of the TGS was undertaken by a Pilot resource, before commissioning the roadworks site. Using the application, the TGS data was reviewed and adjusted as needed by a field resource during the site inspection. Once all details were confirmed, the site was approved by the field resource, which activates the use case warning. The Red Crab users included the Pilot team, RoadTek, Fulton Hogan and Ipswich City Council contractors, who were trained to use the tool.

Further details are provided in *RWD1. Red Crab User Manual*.

Figure 21.2.1 – Red Crab workflow



21.3 Milestones and Hold Points

Table 21.3 lists Milestones and Hold Points for Red Crab (C-ITS roadworks application).

Table 21.3 – Red Crab development Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
RCM1. Red Crab API completed	Q4 2018	Q4 2018	Red Crab vendor to provide Red Crab API System Specification Test Plan (Red Crab) Training/User Manual (Red Crab app) Test Report (Red Crab App and API)	For: C-ITS-F development

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
RWM1. Red Crab hosting (was RDM2)	Q2 2019	Q1 2019	C-ITS-F team hosting	On: TMR providing access to AWS account
RWM2. Red Crab training (was RDM4)	Q2 2019	Q2 2019	TMR Red Crab User Manual TMR training for Red Crab user	On: RoadTek and Ipswich City Council approve
RWM3. Red Crab deployment (RDM5)	Q2 2019	Q3 2019	Red Crab app distributed to users for integration to working practices Red Crab app use for Ipswich SIAT testing and Dress Rehearsal Test	For/On: All actors in workflow Figure 25: Red Crab workflow
RWM4. Red Crab use and support during FOT commenced	Q2 2019	Q2 2020	Red Crab app utilised in field for road works data entry during FOT Ad hoc support for maintenance	For/On: All actors in workflow Figure 25: Red Crab workflow On: TMR to initiate service requests

22 Existing systems, services, and data

This section describes the impacts of the Pilot on Transport and Main Road's existing systems, services, and data.

22.1 Queensland Traffic (QldTraffic)

The Road Hazard Warning (RHW) use case relied on a connection to Transport and Main Road's external facing Queensland Traffic (QLDTraffic) application programming interface (API). The Pilot had a dedicated API service which had a higher capacity limit on API calls. The API was polled every minute, and based on a proof of concept, capacity limits were sufficient, however the API had varying response rates of up to 15 seconds.

22.2 AUSCORS

Lane level accuracy was required for the pilot vehicles. The vehicle's Global Navigation Satellite System (GNSS) receiver used positioning augmentation from Geoscience Australia's AUSCORS service, which relied on data from continuously operating reference stations (CORS). The existing Beenleigh CORS is less than 10km from the Mt Cotton test facility (and the Cleveland station 12 km), which was close enough to support lane-level accuracy. The Beenleigh, Beaudesert, Cleveland and Gatton CORS were too far away from the Ipswich Pilot Area, and could not provide consistency accuracy. As a result, the Pilot installed a CORS near the Centenary Highway south of Springfield. This site is owned by Transport and Main Roads, and has power, communications and a large enclosure that support collocated devices used to monitor land slippage.

22.2.1 Milestones and Hold Points – Positioning Augmentation Arrangements

The positioning study (PAM1) was delivered by QUT. Milestones and Hold Points for Positioning Augmentation arrangements are listed below in Table 22.2.1.

Table 22.2.1 – Positioning augmentation arrangements Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
PAM1. (was PAM1 and 2) Positioning study / positioning report completed	Q3 2018	Q3 2018 Complete Q4 2018 Complete	QUT Positioning Report – testing existing positioning services QUT Positioning Options Analysis Report – option for improvement recommended	For: station development
PAM2. (was PAM3) Base station approved	Q2 2019	Q2 2019 Complete	New positioning base station approved by Geoscience Australia	
PAM3. (was PAM4) Permanent base station installed	Q3 2019	Q2 2019 Complete	Positioning base station installed, tested and ready for pilot use	For: testing – SIAT
PAM4. Base station registration process complete		Q4 2019 Complete	Positioning base station registered	On: PAM3 For: Pilot O&M

* Task is dependant “on”, or is a dependency “for”

22.3 Telecommunications

Standard 3G/4G was used for the pilot. Telstra provided a private cellular network (Access Point Name) for Mt Cotton and Ipswich City Council areas for the duration of the pilot. Telstra also agreed to provide external Network Termination Unit (NTU), and modems/SIM cards and data plans for the stations. Each station was manually commissioned to join the network (see Section 14). Access into and out of the network was restricted. Connection to the network was facilitated by Telstra.

22.3.1 Milestones and Hold Points

Milestones and Hold Points for telecommunications arrangements are shown in Table 22.3.1.

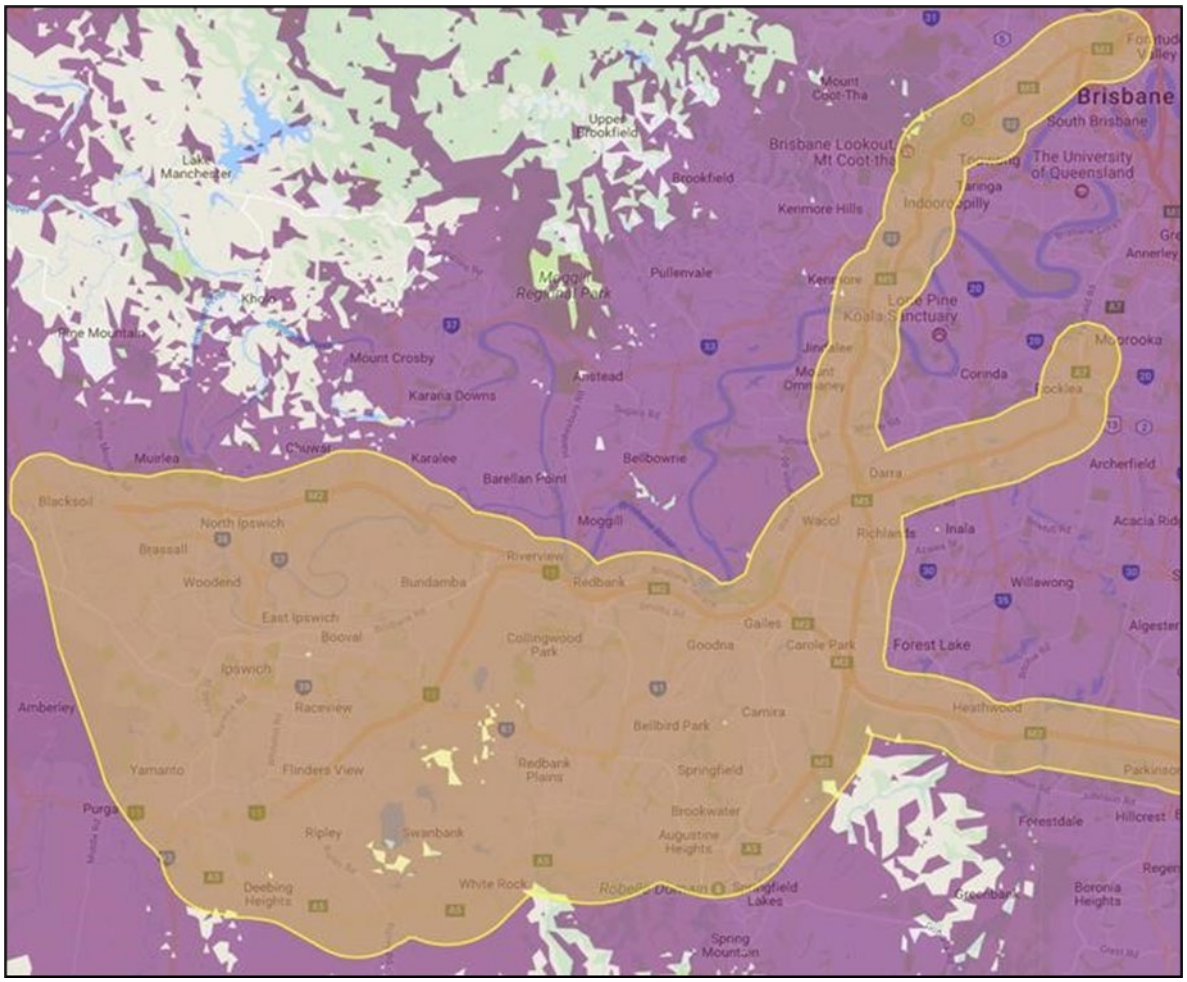
Table 22.3.1 – Telecommunications arrangements Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
TCM1. MOU and project agreements	Q3 2018	Q2 2020 Complete	TMR confirm Telstra’s involvement through TMR MOU and project agreement (updated annually)	
TCM2. Provide external NTU for R-ITS-S (x2)	-	Q4 2018 Complete	Telstra – 2 x NTU for R-ITS-S provided for development and Mt Cotton testing	
TCM3. (previously TCM2) Testing – Mt Cotton (x10 sims)	Q4 2018	Q1 2019 Complete	Telstra – APN available, 10 x modem/sim/plan provided	For: All parties involved in testing
TCM4. (previously TCM3) Testing – Ipswich (x30 NTU)	Q2 2019	Q2 2019 Complete	Telstra – APN available, 30 x NTU provided	For: Installation and R-ITS-S vendors For: All parties involved in testing
TCM5. (previously TCM4) Telecommunications access provided for FOT (550xsims)	Q2 2019	Q3 2019 Complete	Telstra – APN available 550 x modem/sim/plan provided Ongoing support for APN and modem/sim/plan maintenance	For: V-ITS-S vendors fabrication

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
TCM6. Telecommunications decommissioned	Q4 2020	Q3 2021	All sims/ NTU and APN decommissioned	

Telstra conducted a signal to noise ratio survey – a receive signal strength indicator (RSSI) – for a higher rating than would typically be required for a moving vehicle. Figure 22.3.1 highlights several areas of inadequate coverage west of Redbank, east of Ripley and south of Sunnybank. These are shown as lighter areas in the figure.

Figure 22.3.1 – Ipswich area received signal strength indication survey (Telstra, 2018)



Telstra also noted signal strength issues at Mt Cotton, and installed a booster at the test signalised intersection.

22.4 Traffic signals

22.4.1 Milestones and Hold Points

Milestones and Hold Points for the integration of the equipment with the Existing Traffic Systems are shown in Table 22.4.1.

Table 22.4.1 – Existing traffic systems Milestones and Hold Points

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
TSM1. Controller and field processor bench test	Q3 2018	Q3 2018	Confirm impacts TMR PD&O and E&T approval	
TSM2. (was TSM13) Agree on road asset management	Q3 2018	Q2 2019	Confirm agreements with TMR PD&O and E&T road TMR PD&O approvals regarding business as usual (BAU) ITS operations	
TSM3. Review existing signals (was TSM10 & 11)	Q1 2019	Q2 2019	Finalise the review of existing assets TMR to complete the C-ITS Retrofit Signal Design in consultation with TMR E&T TMR PD&O approval	
TSM4. (was TSM12) Field processors procured	Q1 2019	Q2 2019	Procure 30 field processors (FP) Transmax to configure and test FP TMR PD&O to approve/ receive before Ipswich installation	
TSM5. (was TSM12) Signal equipment procured	Q1 2019	Q2 2019	Procure additional signal equipment (traffic controllers, top hats, cables and so on) TMR Pilot team to approve/ receive before Ipswich installation	
TSM6. Confirm mount placement	Q1 2019	Q2 2019	Confirm R-ITS-S mounting placement for each intersection	
TSH1. (was TSM7) Mounting approvals	Q2 2019	Q2 2019	Complete Mounting Bracket Design (in consultation with TMR E&T and V-ITS-S vendor) TMR PD&O and E&T (Structures and Road Ops) to approve design	
TSM7. (previously TSM2) FP firmware FAT	Q4 2018	Q2 2019	Complete and accept tests TMR PD&O and E&T approve FP Specification	
TSM8. Fabricate bracket – Mt Cotton	Q2 2019	Q2 2019	2 x mounting brackets fabricated for Mt Cotton by R-ITS-S vendor Complete Road Asset Commissioning Plan (in consultation with TMR E&T)	On: TMR E&T approval
TSH12. (previously TSM9) Fabricate bracket – Ipswich	Q3 2019	Q2 2019	30 x mounting brackets fabricated for Ipswich by R-ITS-S vendor	On: TMR E&T approval
TSH13. (previously TSM15) Commissioning of road assets completed	Q2 2019	Q1 2020	Installation vendor installs assets, and prepares an installation checklist TMR PD&O approval	For: Testing (Mt Cotton and Ipswich) and FOT

Milestone (Hold Point)	Baseline	Final	Deliverable	Dependent (On/For)*
TSM9. Decommission road assets completed	Q4 2020	Q3 2021	Installation vendor decommissions assets TMR PD&O approval	

* Task is dependant “on”, or is a dependency “for”

22.4.2 Signal shortlisting

A traffic signal assessment was completed for key state roads within Ipswich, which includes approximately 40 intersections along Aberdare Street, Brisbane Road, Brisbane Street, Downs Street, East Street, Limestone Street, River Road, and Warwick Road. These intersections are owned, operated and maintained by Transport and Main Roads PD&O Metropolitan Region. Pilot signals were shortlisted based on the likelihood of a use case trigger for ARLW and TWVU, specifically:

- number of vehicle movements that are filtered/permitted across a pedestrian movement, and
- number of phases per day (as a surrogate for the likelihood to run a red light and in the absence of red-light camera enforcement data).

Six intersections where excluded – five (5) pedestrian intersections and the fire station signal, which are activated infrequently. Under the current Transport and Main Roads directive, all signals were upgraded to support late starts for pedestrian safety, where the turning vehicle has a red phase during the pedestrian's green phase. Driver warnings were displayed if the vehicle entered the intersection during the red phase, or the vehicle entered the intersection during the flashing red pedestrian phase.

A summary of the shortlisted signalised intersection list is provided in Table 22.4.2.

Table 22.4.2 – Shortlisted signalised intersections

#	Intersection Name	#	Intersection Name
M2707	Brisbane Rd/Hoepner Rd	M2767	Brisbane St/Thorn St
M2720	Aberdare St/Sth Service Rd	M2762	East St Roderick St
M2723	Brisbane Rd/Green St	M2777	Downs St/The Terrace
M2724	River Rd/Dinmore St	M2778	Downs St/Lowry St
M2732	Brisbane Rd/Stafford St	M2779	Downs St/Delacy St
M2736	Brisbane Rd/River Rd/Aberdare St	M2753	Downs St/Fitzgibbon St
M2737	Brisbane Rd/Byrne St	M2760	Warwick Rd/Moffat St
M2738	Brisbane Rd/ Mining Rd	M2731	Warwick Rd/Pisasale Dr
M2740	Brisbane Rd/Hamilton St	M2749	Warwick Rd/Bremer School Link Rd
M2741	Brisbane Rd/South Station Rd	M2763	Warwick Rd and Gray St/ Chelmsford Ave and Churchill St
M2743	Brisbane Rd/Chermside Rd/ Glebe Rd	M2764	Warwick Rd/Cemetery Rd
M2746	Limestone St/Gordon St	M2769	Warwick Rd/Salesyard Rd
M2747	Limestone St/East St	M2770	Warwick Rd/Lobb St
M2748	Brisbane St/East St	M2761	Warwick Rd/Powells Rd
M2768	Limestone St/Thorn St		

22.4.3 System demarcation

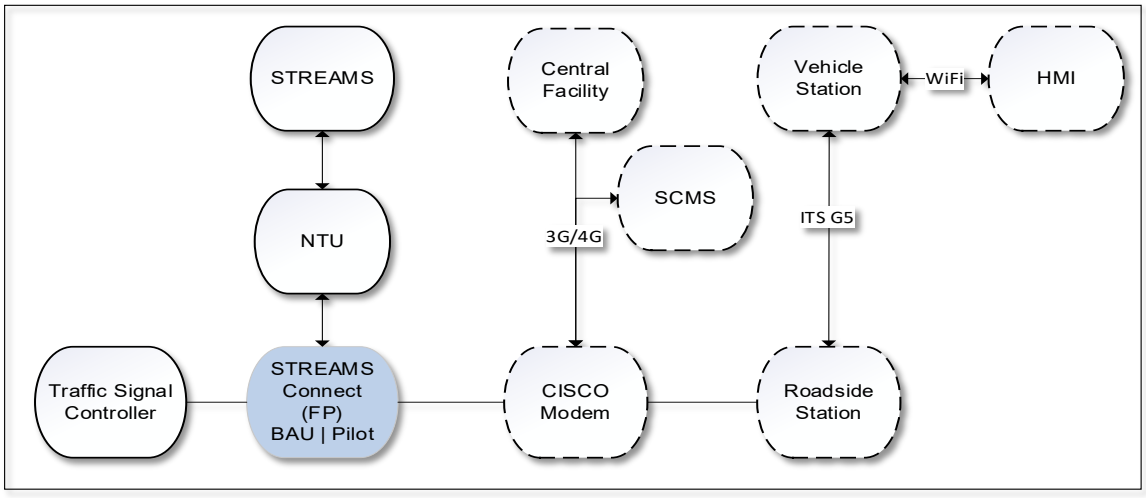
The demarcation of the pilot and business as usual (BAU) signalised intersection systems is shown in Figure 22.4.3. The left side illustrates the BAU system, the right side the pilot system. Both systems share the field processor (FP, which was running STREAMS® Connect software) – which includes new software and a firewall to separate the systems.

The field processor sources lamp colour and running state from the traffic signal controller and converts this data to SPATEM, which is sent to the roadside station. The roadside station broadcast the status of the signal to passing vehicle stations.

The field processor is connected to both of the BAU ITS network via the Network Termination Unit (NTU) and the C-ITS network via the Cisco Modem. Each network is protected by a firewall running on the field processor.

The pilot had its own Cisco Modem, network and central ITS facility.

Figure 22.4.3 – Pilot and BAU roadside components



In summary, the roadside station (R-ITS-S) connected to the following:

- **Central Facility (C-ITS-F):** via 3G/4G/ CISCO modem, over the pilot network – the central facility supports remote monitoring and maintenance of the roadside station, as well as the provision of the signalised intersection map (referred to as MAPEM).
- **Security Credential Management System (SCMS):** via 3G/4G/ CISCO modem, over the pilot network - the roadside station requests certificates from the SCMS for signing SPATEM.
- **Field Processor (FP) via Ethernet:** the FP provides unsigned SPATEM to the roadside station. This connection is firewalled.
- **Vehicle station (V-ITS-S):** via the ITS G5 – the roadside station sends signed SPATEM and receives signed awareness messages from passing vehicle station.

22.4.4 Traffic signal controllers

Per ETSI TS 102 894-2 and ISO/TS 19091:2017, the C-ITS traffic signal information is referred to as a Signal Phase and Timing Extended Message (SPaTEM). SPaTEM reports the signal status (of each signal group red, yellow, green) and timing (start time, minimum time, maximum time) every 100ms.

SPaTEM data is sourced from the traffic signal controller (TSC) using the signal colour polling – because of the limitation of the existing traffic signal controllers, polling is only possible every 500ms, and is then repeated every 100ms to meet the standard. STREAMS® Connect converts the TSC data into a SPaTEM, which is then sent to the R-ITS-S. For test results - see TSC & FP Test Report (2020).

Existing TSC include 18 PSC, 11 Eclipses, and 1 ATSC4. At 1200 baud and 14 or more detectors, the TSC cannot support the generation of 500ms SPaTEM. Within the pilot area, all Eclipse controllers were increased to 9600 baud rate. As the PSC baud rate cannot be increased, the six PSC controllers with 14 or more detectors were replaced by Eclipse controllers. The ATSC4 also failed at 9600 baud and was replaced with an Eclipse controller. For test results - see TSC & FP Test Report (2020). A summary of the TSC replacements is provided in Table 22.4.4.

Table 22.4.4 – PSC and ATSC4 replacement

#	Intersection name
M2707	Brisbane and Hoepner (near motorway entry end)
M2724	River Rd and Dinmore St
M2736	Brisbane and River/Aberdare (near motorway entry end)
M2743	Brisbane and Chermside/Glebe (5ways)
M2741	Brisbane Rd and South Station Rd (ATSC4)
M2763	Warwick and Gray/Chelmsford and Churchill (near hospital)
M2778	Downs and Lowry – (near shopping centre north of river)

22.4.5 Field processors

STREAMS Connect (the field processor) converts the TSC data into a C-ITS message, which is then sent to the R-ITS-S. The Pilot has several FP requirements, as specified in PSTS004, including the following:

- second network interface to isolate the existing ITS and C-ITS networks via a firewall
- second port access for the R-ITS-S
- new SPaTEM software.

As the existing FPs had only one accessible Ethernet port, the FPs were replaced with dual port FPs IT-08. For test results - see *TSC & FP Test Report (2020)*.

22.4.6 Mounting Requirements

R-ITS-S were attached to existing light poles, signal poles, or mast arms using a mounting bracket. Four standard mounting arrangements (A, B, C, D) were agreed between the R-ITS-S vendor, the Pilot team and E&T Structures. The agreed mounting design and bracket, including RPEQ drawings, is provided in *TSD2 – Mounting Design*.

Per the R-ITS-S vendor's advice, the R-ITS-S antenna should be mounted in a location that supports line of sight. A mounting height of 6 metres is required. At some locations vertical extension is desirable – this is captured in the standard mounting option D. Structural analysis was completed by E&T Structures – Type D design increases the existing load by approximately 25% but is still deemed acceptable. Furthermore, it was agreed all poles with missing grout pads must be replaced to ensure structural integrity of the pole. There are 12 signalised intersections that use standard mounting option D – as summarised in Table 22.4.6.

Table 22.4.6 – Locations with vertical extensions - type D

#	Intersection name
M2723	Brisbane Rd and Green St
M2724	River Rd and Dinmore St
M2731	Warwick Rd and Pisasale Dr
M2741	Brisbane Rd and South Station Rd
M2746	Limestone St and Gordon St
M2747	Limestone St and East St
M2762	East St and Roderick St
M2767	Brisbane St and Thorn St
M2770	Warwick Rd and Lobb St
M2777	Downs St and The Terrace
M2778	Downs St and Lowry St

22.4.7 Cabinet requirements

All R-ITS-S require power over ethernet (PoE), surge protection, and enough cabinet space to support the R-ITS-S and an external modem. Based on a field review, five intersections did not have enough cabinet space (Table 22.4.7) and top-hats were installed for the pilot.

Table 22.4.7 – Cabinet capacity assessment

#	Intersection name
M2748	Brisbane St and East St
M2764	Warwick Rd and Cemetery Rd
M2769	Warwick Rd and Salesyard Rd
M2770	Warwick Rd and Lobb St
M2778	Downs St and Lowry St

22.4.8 Installation and commissioning

The ITS at signalised intersections was installed by Transport and Main Roads PD&O's preferred vendor - RoadTek - and commissioned by the R-ITS-S vendors.

22.4.9 Monitoring and maintenance

The Pilot team confirmed with Transport and Main Roads PD&O Metropolitan Region that the daily operations and maintenance of all assets in the pilot area will continue to be managed by PD&O through the existing RMPC contract. The Pilot covered the costs of C-ITS specific asset maintenance, including existing assets issues or defects arising from the pilot installations.

For further details refer to *TMRD4. Asset Management Plan* and *TMRD19. Master Operations and Maintenance Manual*.

23 Pilot monitoring and maintenance

23.1 Roles and responsibilities

Monitoring and maintenance were comprised of several responsible parties as follows:

- Existing systems, services and data were monitored and maintained under existing arrangements by other Transport and Main Roads areas of business. However, when Pilot team identified issues with existing systems, contact was made with the relevant parties and a resolution was requested from the systems owner. This interaction with system owners was required for each data source feeding into the pilot.
- C-ITS system, services and data were monitored by the following:
  - Pilot team, including the respective system vendors.
  - Indirectly by the Safety Evaluator through their analysis efforts.
  - Indirectly by the Participant Manager through the participant requests.
- C-ITS system, services and data were maintained by the following:
  - Vendors of the respective systems.
  - Geospatial lead for the maintenance of the geospatial datasets.
  - RoadTek and Ipswich contractors for the provision of road works application data.
  - Pilot team.

23.2 Monitoring

The C-ITS-F housed the Monitoring and Reporting System (MRS) which was used by the Pilot team to monitor the system, including the following functions:

- daily system health checks
- investigation of issues
- verification of test results.

There were several available dashboards:

- landing page – general pilot dimensions such as the number of active stations.
- exception tree map – up to 125 exception metrics to normal behaviour by station.
- station health – a variety of metrics that indicate the station heath.
- software version – system and station configuration version.
- messages – a summary of daily transmitted and received messages.
- latency and time slip – latency histograms for 5.9GHz and cellular use-cases.
- use-cases – vehicle speed, location relevant to a use-case event, and HMI presentation.
- test wall – a summary of use-case statistics for the test devices on a simulated track (test deployments only).

An overview of the tool is provided in the CFD12: Monitoring and Reporting System Dashboard User Manual.

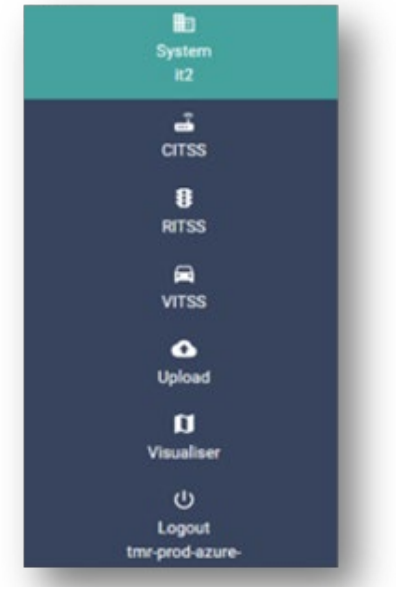
For more detailed investigations Athena queries were used for ad-hoc data access needs. If access to any of the monitoring tools were required by any third parties outside of the Pilot team, then a formal request process was followed.

23.3 Maintenance

The C-ITS-F included the Configuration Manager, which is a web-based application that allowed permitted staff to configure the Pilot system, upload the geospatial data sets, and visualise real-time events.

- System access (bench, test, and pilot environments)
  - Data source parameters
  - Common parameters
  - Use-case parameters
- Device access (C-ITS-S, R-ITS-S and V-ITS-S)
  - Station parameters
  - Data logging parameters
  - Adding new vehicle or roadside stations
- Upload (geospatial datasets)
  - MAPEM
  - RNM (and school calendars)
  - Tile
  - Version report
- Live event visualiser (replicates live events broadcast on C-ITS-S on a map)

Figure 23.3 – Monitoring software navigation pane



CFD13 – Configuration Manager User Manual provides an overview of the tool. In addition, the C-ITS-F supports a Secure Shell (SSH) service, which can also be used to access an individual device.

To track issues and maintenance an issue ticketing system was established, which was accessible to all vendors as part of the maintenance workflows outlined in the section below.

23.3.1 Change management

Any changes to the Pilot devices, C-ITS-F, datasets, configuration and parameters were all under a defined change management process. The Change Lead oversaw the process and approvals. This process included an original request, approval from SME and the Change Lead. The change request also required proof of testing and director approval if it impacted the production (live) pilot systems.

23.4 Roadside stations maintenance workflow

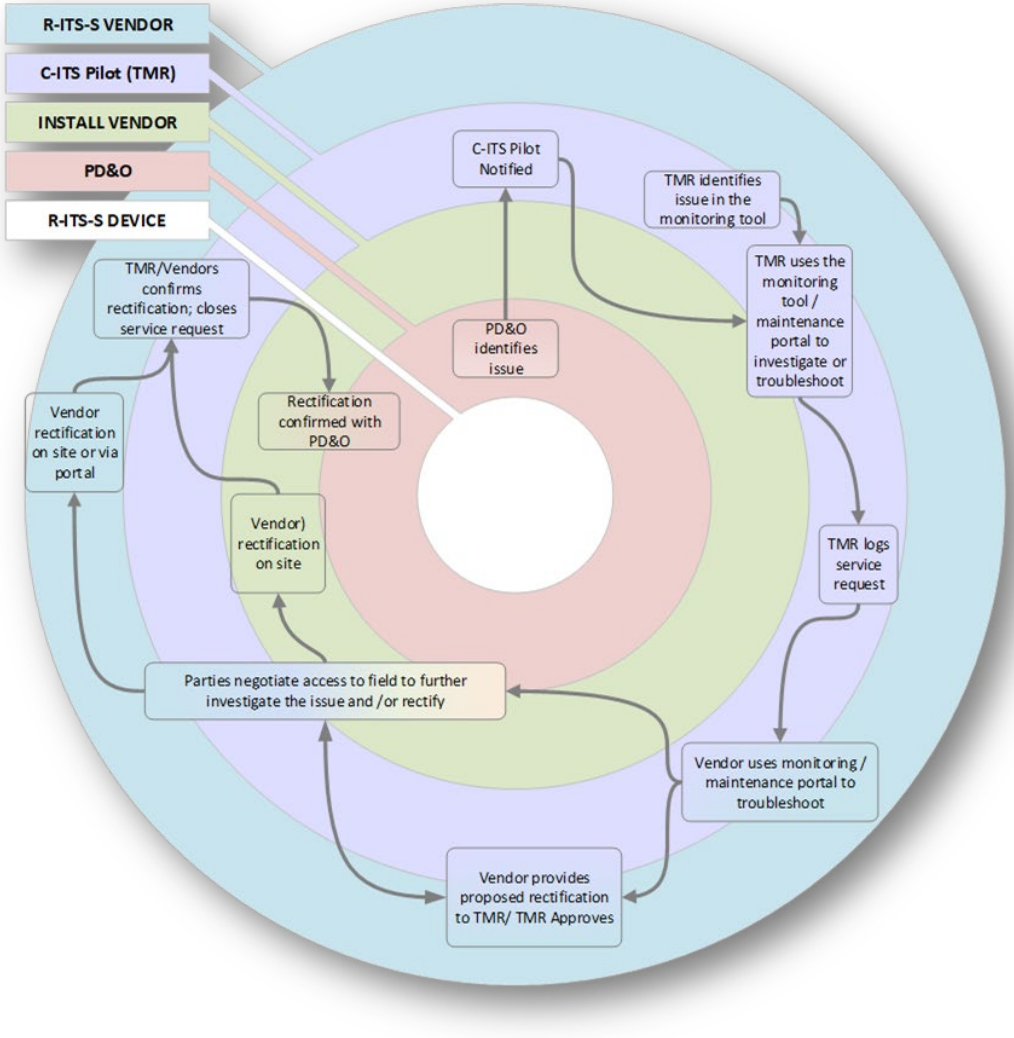
The R-ITS maintenance workflows are illustrated in Figure 23.4, which are as follows:

1. Monitoring of issues was conducted on a next business day basis by the Pilot team. Alternatively, PD&O or other third-party partners identified any issues and alerted the Pilot team. Issue tickets were generated by the Pilot team. The process was managed by the Pilot team's Issue Manager in the issue management tool.
2. The R-ITS-S vendor explored the identified issue via:
    a. the device data reported in the monitoring tool at Transport and Main Road’s or the R-ITS-S vendor office
    b. remote access to the device, via the SSH service, which required approval by the Pilot team, and
    c. physical access to the device, in the field, which required approval by the Pilot team and was managed by the Installation Vendor.

    Depending on the severity of the ticket, as defined by Transport and Main Roads, the R-ITS-S vendor was required to propose remediation per the contractual timeframes.
3. For hardware issues – where the device could not be restored, it was removed and replaced by the R-ITS-S vendor with a new functioning device as soon as practicable. New installations were coordinated with the Pilot team and the Installation Vendor.
4. For software issues, the R-ITS-S vendor provided the Pilot team a proposed rectification build, with relevant release notes and the vendor's bench test quality confirmation. The Pilot team then tested the solution on a test bench and in the field (using the test environment only) before accepting and deploying the solution to the pilot environment. The Pilot team applied the solution using the configuration management tool.

Through the issue management tool, a history of the resolution process for issues was maintained and tracked for future troubleshooting.

Figure 23.4 – Roadside station maintenance workflow



23.5 Vehicle station maintenance workflow

The V-ITS-S maintenance workflows are illustrated in Figure 23.5, which are as follows.

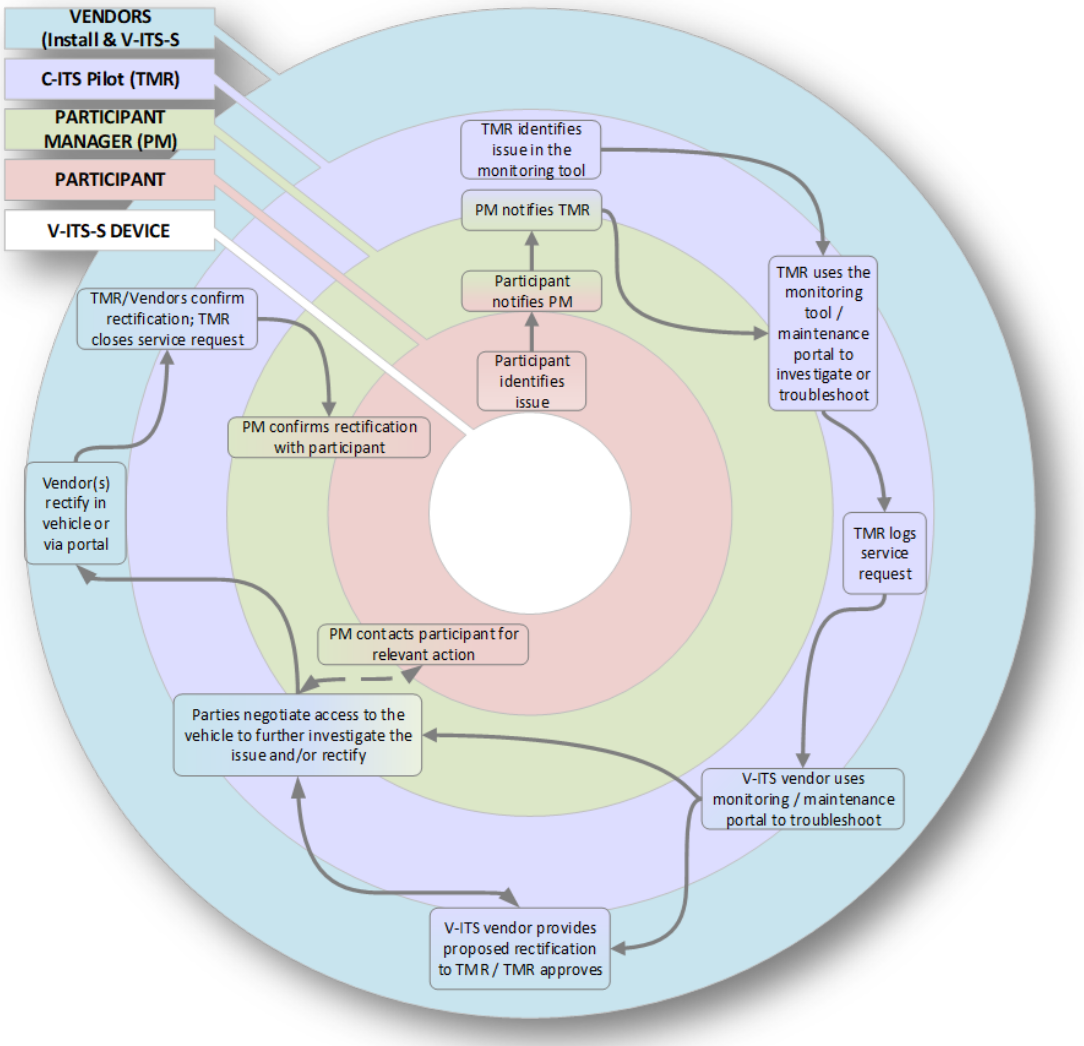
1. Monitoring for issues was conducted on a next business day basis by the Pilot team. Participant identified issues were provided to the Pilot team via the Participant Manager. PD&O and other third-party partners also identified issues and alerted the Pilot team. Issue tickets were generated by the Pilot team and managed by the Test Lead and Change Lead in the issue management tool.
2. The V-ITS-S vendor explored the identified issue via:
    a. the device data reported in the monitoring tool at Transport and Main Road's or the V-ITS-S vendor office
    b. remote access to the device, via the SSH service, which had to be approved by the Pilot team, and
    c. physical access to the device, in the field, which had to be approved by Pilot team, the Participant Manager and the Installation Vendor.

Depending on the severity of the ticket, as defined by Transport and Main Roads, the vendor was required to propose remediation per the contractual timeframes.

3. For hardware issues – where the device cannot simply be restored - it was removed and replaced by the V-ITS-S vendor with a new functioning device as soon as practicable. New installations were coordinated with the Pilot team, the Participant Manager and the Installation Vendor.
4. For software issues, the V-ITS-S vendor provided the Pilot team a proposed rectification build with relevant release notes and the vendor's bench test quality confirmation. The Pilot team then tested the solution on a test bench and in the field (using the test environment) before accepting and deploying the solution to the pilot environment. The Pilot team will applied the solution using the configuration management tool.

Through the issue management tool, a history of issues resolution process was maintained and tracked for future troubleshooting.

Figure 23.5 – Vehicle station maintenance workflow



23.6 Central station

Monitoring was conducted on a next business day basis by the Pilot team. When further investigation was required the C-ITS-F team also self-monitored per the CFD6. Administration and Maintenance Manual. Issue tickets were generated by the Pilot team, managed by the Test Lead and Change Lead in the issue management tool.

The C-ITS-F team explored the identified issue and provided the Pilot team with a proposed rectification build with relevant release notes and the bench test quality confirmation. The Pilot team then tested the solution on a test bench and in the field (using the test environment) before accepting and deploying the solution to the pilot environment. The C-ITS-F team applied the solution per an agreed schedule with the Test Lead and Change Lead.

Through the issue management tool, a history of issues resolution process was maintained and tracked for future troubleshooting.

23.7 Security Credential Management System

Monitoring of the SCMS Platform was provided by both the Pilot team and the SCMS provider during their respective business hours (as the SCMS provider was based in the USA).

Maintenance was provided by the SCMS provider during USA business hours only (EST) per an agreed schedule with the Test Lead and Change Lead, excepting during a critical event for the pilot (as defined by the Service Level Agreement with the provider).

23.8 Geospatial datasets

Issue tickets related to the geospatial datasets, including the road works application, were generated by the Pilot team. This process was managed by the Test Lead and Change Lead in the issue management tool.

Geospatial datasets were maintained by the relevant Pilot team parties and changes were deployed using the configuration manager per an agreed schedule with the Test Lead.

The road works application was maintained by the road works application vendor in coordination with the C-ITS-F team.

24 References

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