

PROJECT DOCUMENT
REFERENCE ONLY

Project Specific Technical Specification

**Transport and Main Roads
PSTS002 V-ITS-S Equipment**

October 2021

Document control sheet

Contact for enquiries and proposed changes

If you have any questions regarding this document or if you have a suggestion for improvements, please contact:

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Version history

Version no.	Owner	Date	Nature of amendment
1.0	Lachlan Gray	29/06/2018	Tender Issue
1.1	David Alderson	27/7/2018	Add lateral Acceleration
1.2	David Alderson and Katharine Mosley	18/3/2019	Various requirement updates as a result of agreed implementation
1.3	David Alderson	06/07/2019	Further implementation updates
2.0	Timothy Liu	05/11/2020	Review and verify various requirement updates
2.1	Nicholas Brook	27/11/2020	Final review
2.3	Jian Qin	29/09/2021	Updated High-Level C-ITS Architecture figure 5.1 and associated text.

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1 Introduction

This Technical Specification defines the supply and commissioning, performance, documentation, training and maintenance requirements for the V-ITS-S and associated equipment.

The V-ITS-S consists of the V-ITS-S Hardware, communication interface, antennae, cabling and any software required to enable correct operation.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

2 Definition of Terms

Table 2-1 – Acronyms

Acronym	Term
ACMA	Australian Communications and Media Authority
ARLW	Advanced Red Light Warning
AS	Australian Standard
ASN.1	Abstract Syntax Notation One
AWS	Amazon Web Services
BoQ	Back of queue
BTP	Basic Transfer Protocol
CA	Cooperative Awareness
CAM	Cooperative awareness message (EU)
CAN	Controller area network
CAVI	Cooperative and Automated Vehicle Initiative
C-ITS	Cooperative intelligent transport systems
C-ITS-F	Central ITS facility
CIT	Component Integration Test
CPU	Central Processing Unit
CSEM	CAVI Safety Evaluation Message
CT	Commissioning Test
DC	Direct Current
DEN	Decentralised environmental notification
DENM	Decentralised environmental notification message (EU)
DSRC	Dedicated short range communications
EEBL	Emergency Electronic Brake Light
EIRP	Equivalent Isotropically Radiated Power
ETSI	European Telecommunications Standards Institute
ETSI EN	European Telecommunications Standards Institute European Norm
ETSI TS	European Telecommunications Standards Institute Technical Standard
FAT	Factory Acceptance Test
FOT	Field operational test
GNSS	Global Navigation Satellite System
HMI	Human machine interface
HSM	Hardware Security Module
IEEE	Institute of Electrical and Electronic Engineers
IF	Interface
IoT	Internet of Things
IP	Ingress Protection
IPv4	Internet protocol version 4
IPv6	Internet protocol version 6
ISO	International Organization for Standardization

Acronym	Term
ISO/TS	International Organization for Standardization Technical Standard
ITS	Intelligent transport systems
IVI	In-vehicle Information
IVS	In vehicle signage
LSB	Least Significant Bit
LxWxH	Length x Width x Height
MAP	Cooperative ITS message, broadcasting geography/topology of intersection
MAPEM	MapData extended Message
MQTT	Message Queuing Telemetry Transport
NTP	Network Time Protocol
NZS	New Zealand Standard
OSI	Open Systems Interconnection
PDU	Packet Data Unit
PSTS	Project Specific Technical Specification
RHW	Road hazard warning
R-ITS-S	Roadside ITS station
RTCM	Radio Technical Commission for Maritime Services
RTK	Real Time Kinematic
RWW	Road Work Warning
SCMS	Security credential management system
SIT	System Integration Test
SIAT	Site Integration Acceptance Test
SPATEM	Signal Phase and Timing Extended Message
SSH	Secure SHell
SSV	Slow/Stopped Vehicle
TAI	International Atomic Time
TCP/IP	Transmission Control Protocol/Internet Protocol
TLS	Transport layer security
TMR	Queensland Department of Transport and Main Roads
TTL	Time to Live
TWVR	Turning Warning for Vulnerable Road User
UPER	Unaligned Packed Encoding Rules
USB	Universal Serial Bus
UTC	Coordinated Universal Time
V-ITS-S	Vehicle ITS station

Table 2-2 – Definitions

Acronym/Term	Term Description
3G/4G	Cellular wireless network provided through a telecommunications company. 3G is the 3rd generation data network, 4G the fourth and LTE stands for Long Term Evolution.
C-ITS event	FOT related term related to tracking C-ITS messages as they are processed by the systems. Events occur on C-ITS-F, C-ITS-S, R-ITS-S and V-ITS-S and include message creation, transmission and receipt, use case triggers, C-ITS message geometry triggers (e.g. start of trace) and HMI message presentations.
C-ITS-F	Back-end C-ITS Facility including C-ITS-S (router and SCMS certificate addition), Maintenance tool, spatial service, integration and messaging engine, data capture system and logging service, and monitoring system.
C-ITS-F data logging service	A service provided by the C-ITS-F that is used to log data mainly for the FOT safety evaluation.

Acronym/Term	Term Description
Control Group	Control Group refers to participants that do not receive the C-ITS intervention (that is, the HMI does not display use case warnings and speed limits), but whose data will still be analysed for the safety evaluation. Participants will be in the Control Group for all or part of their duration in the FOT.
FOT	Field Operational Test – the period when the in-vehicle C-ITS systems are operational and logging data.
HMI Presentation Manager	The HMI Presentation Manager describes an application or process on the V-ITS-S that services all requests and responses to the HMI (single point of control).
ITS-G5	Wireless Radio communications based on 802.11p and defined by ETSI EN 302 663 Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz (5.9GHz) frequency band.
Monitoring system	Sub-system of the C-ITS-F that monitors the operation of the C-ITS system.
Notification	A notification is when applications in the V-ITS-S (for example, use case applications) inform the HMI Presentation Manager about a HMI relevant content.
Participant	Driver who is a consenting participant of the C-ITS Pilot.
Presentation	A presentation is when the HMI Presentation Manager requests control of a HMI display region. Only one presentation per region should be active at a given time. Some presentation requests may also include an audio alert.
Region	Defined area of the HMI display screen for presentation of a message.
Safety Evaluator	C-ITS Pilot actor responsible for delivery of the safety evaluation for the Field Operational Test (FOT).
Use case warning	A warning presented by the HMI when use case applications are triggered.

3 Reference Documents

The requirements of the referenced documents listed in Table 3 below apply to this specification.

Table 3-1 – Referenced documents – External

Document ID	Document Name / Description
AS 1044 (1995)	Radio Disturbance characteristics
AS ISO/IEC 27001 (2015)	Information technology - Security techniques - Information security management systems - Requirements
AS/NZS 60950.1 (2015)	Information technology equipment - Safety General requirements
AS 2578 (2009)	Traffic Signal Controllers
SAE J2945/1_201603	On-Board System Requirements for V2V Safety Communications
ETSI TS 102 687 V1.2.1 (2018-04)	Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part
ETSI TS 103 301 V1.1.1 (2016-11)	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services
ETSI EN 302 665 V1.1.1 (2010-09)	Intelligent Transport Systems (ITS); Communications Architecture
ETSI EN 302 636-4-1 V1.3.1 (2017-08)	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality
ETSI EN 302 636-5-1 V2.1.0 (2017-05)	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol
ETSI EN 302 637-3 V1.2.2(2014-11)	Intelligent Transport Systems (ITS);Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service
ETSI EN 302 637-2 V1.3.2 (2014-11)	Intelligent Transport Systems (ITS);Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service
IEEE 802.11(2016)	Wireless LAN (WLAN) & Mesh Standard

Document ID	Document Name / Description
ISO/IEC 20922:2016	Message Queuing Telemetry Transport MQTT v3.1.1
MRTS01(2017)	Introduction to Technical Specifications
MRTS50 (2017)	Specific Quality System Requirements
ACMA Radio communications (Intelligent Transport Systems) Class Licence 2017	

Table 3-2 – Referenced documents – Internal

Document ID	Document Name / Description
PSTS003	HMI Equipment
PSTS006	Data Entity Catalogue
PSTS007	C-ITS Station Protocol Specification
PSTS008	SCMS Certificate Profile Specification
PSTS011	Emergency Electronic Brake Light
PSTS012	Slow Stopped Vehicle
PSTS013	Advanced Red Light Warning
PSTS014	Turning Warning - Vulnerable Road user
PSTS015	Road Works Warning
PSTS016	Road Hazard Warning
PSTS017	Back of Queue
PSTS018	In Vehicle Speed

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4 Quality System Requirements

Quality system requirements shall be in accordance with this Technical Specification and the requirements of the Contract (including the requirements of MRTS01:2017).

4.1 Testing and Commissioning

Master Test Plans describe the testing and commissioning requirements for the project, examining all project components and interdependencies.

The V-ITS-S is one component within the broader C-ITS implementation and, as such, the any V-ITS-S device shall make provision and consider interoperability within their testing and commissioning procedures for C-ITS deployment.

4.1.1 Testing Methodology

There are three broad stages with which testing focus and activities align:

1. Development stages, as per the V-ITS-S planning, design and development activities,
2. Integration of system components, and
3. Installation and testing of the equipment at off-road and on-road sites.

Integration testing consists of several test cycles in which the entire solution is tested.

The V-ITS-S Vendor shall develop and/or contribute to testing documentation and assist with commissioning on-site. Specific objectives, entry/exit criteria for each phase of testing and test environment requirements and responsibilities are detailed in Master Test Plans.

4.1.2 Testing Activities

The V-ITS-S shall undertake the test types listed in Table 4-1.

Table 4-1 – V-ITS-S Tests

Test Type	Description
Development testing	Incremental testing by Contractor throughout development process – may engage the Principal for verification of requirement achieved
Factory Acceptance Test (FAT)	V-ITS-S functionality against requirements. Other interactions may be emulated, or demonstrable against a suitable test harness – the Principal to approve FAT document, and to witness the FAT as performed by the Contractor
Component Integration Test (CIT) – Bench	Per-unit integration with full system, including interfaces to C-ITS stations, operating on a bench with simulated data but actual functions – Contractor to co-author with others; Principal to approve
System Integration Test (SIT) – Bench	System satisfies C-ITS Specifications, operating end-to-end on a bench with integrated units, actuals functions, and external data sources and outputs – Contractor to co-author with others; Principal to approve
Installation Acceptance Checklists	<p>Installer, Contractor and Principal will collaborate, test and implement a repeatable install procedure for equipment. Installation shall proceed based on successful passing of hold points to-date.</p> <p>An installation acceptance checklist shall be performed for each V-ITS-S/HMI. The installation acceptance checklist shall confirm that each V-ITS-S/HMI functions when installed on site at Mt Cotton (Production stage 1) and at Ipswich (Production stage 2). The installation procedure</p>

Test Type	Description
	<p>verified as a result of these tests shall be utilised for the installation of V-ITS-S/HMI equipment during the commissioning period. – Principal to approve</p> <p>Note that production of the back-end system will be completed with delivery of Production stage 1.</p>
Commissioning Test	A Commissioning test of each installed V-ITS-S/HMI for correct operation and integration, will be performed after physical Installation Acceptance checks have passed and prior to a vehicle becoming part of the C-ITS environment – Principal to approve
Site Integration Acceptance Test (Mt Cotton)	Integration in off-road, real-world environment at Mt Cotton, and testing of all system functions, with a limited rollout of units – Principal to approve
Site Integration Acceptance Test (Ipswich)	Integration in on-road environment at Ipswich, and testing of all system functions, with a larger sample of units rolled out than at Mt Cotton – Principal to approve
Maintenance Tests	Ad hoc testing of fixes prior to being rolled out to operational stations – as needed, and ongoing

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5 System Requirements

5.1 C-ITS Architecture

The V-ITS-S is a component of the broader C-ITS system architecture as shown in Figure 5.1.

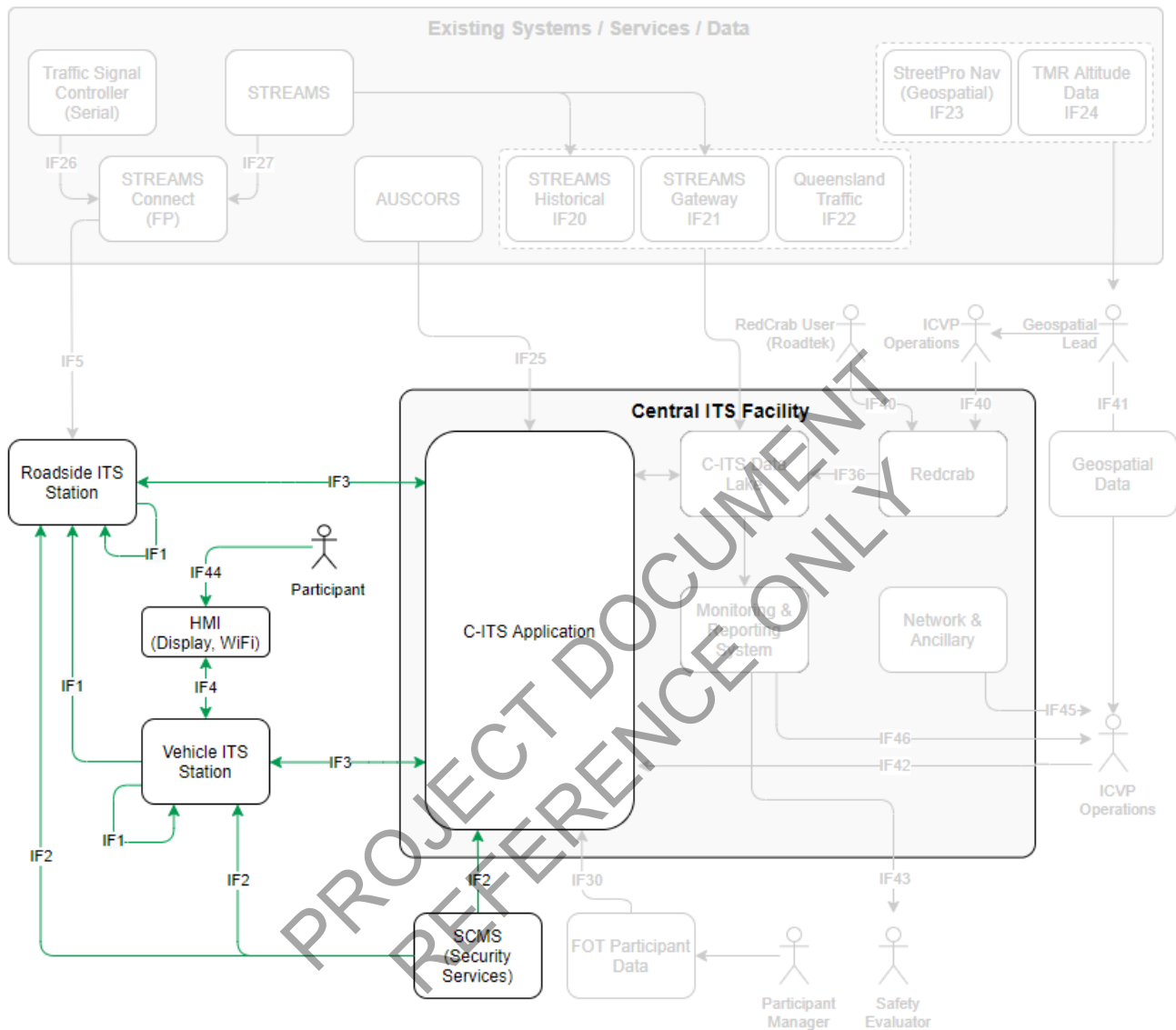


Figure 5.1 – V-ITS-S component in C-ITS architecture

Table 5-1 - C-ITS Pilot system V-ITS-S component interfaces

Interface	Description	Interface Type
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)
Actors		
IF44	Participant → HMI	Human

Note that interface to the vehicle Controller Access Network (CAN) bus has not been outlined as it is assumed to be not available for use by the V-ITS-S equipment for the purposes of this C-ITS.

5.2 V-ITS-S Architecture

The V-ITS-S reference architecture has been adopted from ETSI EN 302 665:2010 and outlines the functionality contained within the V-ITS-S equipment. The architecture follows the principles of the Open Systems Interconnection (OSI) model for layered communication protocols. Figure 5.2 shows how the subsections of this specification apply to the V-ITS-S reference architecture.

The elements contained within the architecture as per ETSI EN 302 665:2010 are summarised below:

- "Access" representing V-ITS-S communication OSI layers 1 and 2 which includes interfaces as defined in Table 5-2 below.
- "Networking & Transport" representing OSI layers 3 and 4 with protocols as described in Table 5-2 below.
- "Facilities" representing OSI layers 5, 6 and 7. This includes facilities required to support communications, operational requirements, applications, management and security functions on the V-ITS-S.
- "Applications" representing the applications required by the V-ITS-S. Refer to Section 6 for further information on required applications.
- "Management" representing management functions required by the V-ITS-S. Refer to Section 7 for further information on required management functions.
- "Security" provides security services to the OSI communication protocol stack, to the security entity and to the management entity. Refer to Section 8 for further information on required security requirements.

Requirement: The V-ITS-S shall implement all functions as defined in the reference architecture presented in Figure 5.2.

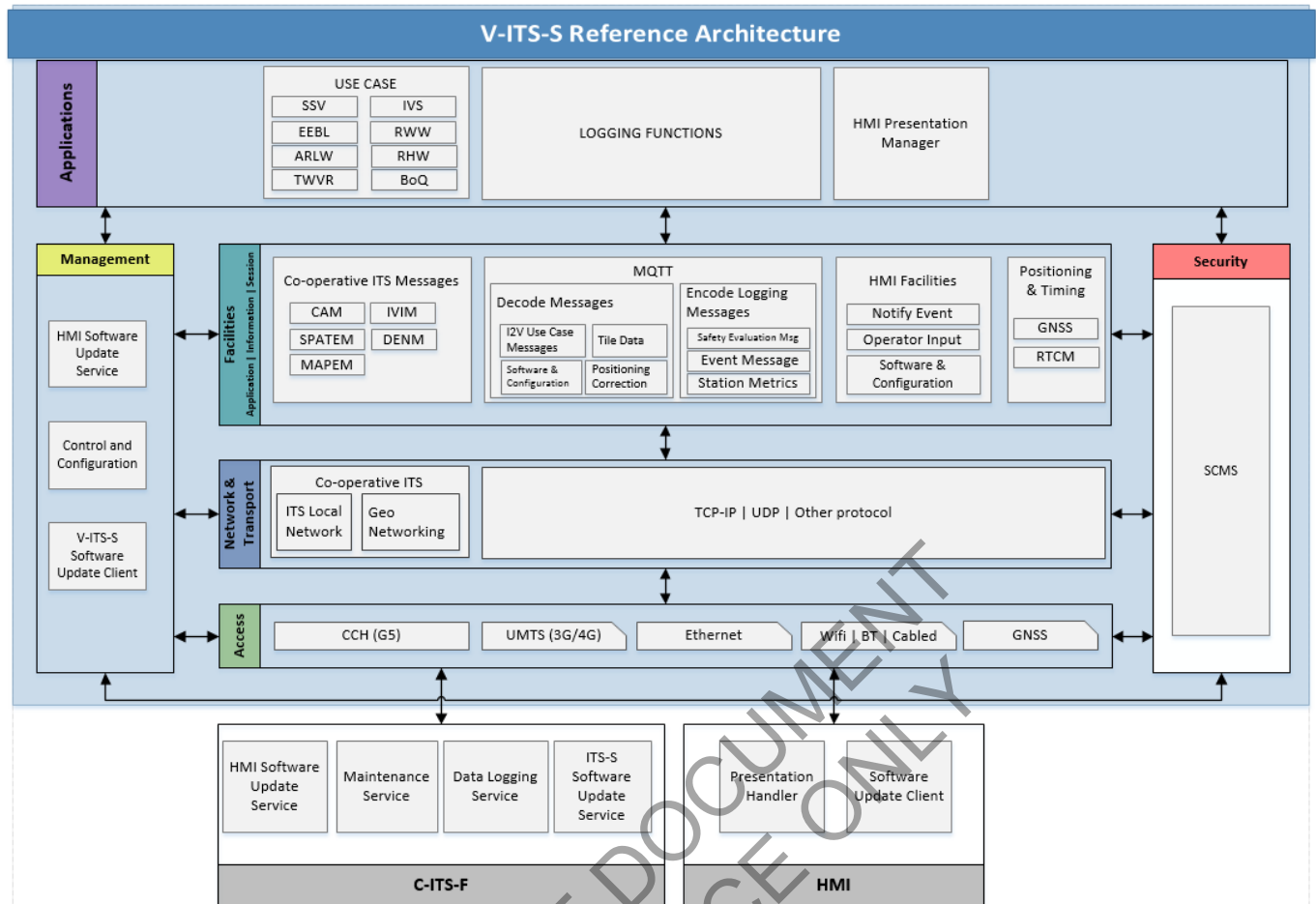


Figure 5.2 – V-ITS-S Reference Architecture (adapted from ETSI EN 302 665:2010)

The interfaces as defined in Figure 5.1 each have requirements for the access, networking, transport and facilities layers.

The interfaces along with the communication methods, networking and transport requirements are listed below in Table 5-2.

Table 5-2 – Communication methods

Interfaces	Access Layer	Networking and Transport Layer	Facilities Layer
V-ITS-S to V-ITS-S (IF1)	ITS-G5 (DSRC)	Geonetworking, BTP	Message Support (section 5.3.1)
V-ITS-S to R-ITS-S (IF1)	ITS-G5(DSRC)	Geonetworking, BTP	Message Support (section 5.3.1)
V-ITS-S to C-ITS-F (IF3)	Cellular 3G/4G (MQTT, HTTPS)	TCP/IP, IPv4	Session and Communication Management (section 5.4.1), Message Support (section 5.4.2)
SCMS to V-ITS-S (IF2)	Cellular 3G/4G (HTTP)	TCP/IP, IPv4	Interface to the security layer

Interfaces	Access Layer	Networking and Transport Layer	Facilities Layer
V-ITS-S to HMI (IF4)	Wireless – WiFi (IEEE 802.11:2016), or equivalent; or cabled connection – Ethernet, USB or equivalent Vendor Specified	Vendor Specified	HMI Support

Requirement: The V-ITS-S shall support the external communication methods, networking and transport protocols and facilities as summarised Table 5-2.

5.3 ITS-G5 Communications (Interface IF1)

The following section details the access, networking, transport and facilities requirements for ITS-G5.

Requirement: ITS-G5 communications shall be 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 shall use the IEEE channel 180 or ITS-G5A control channel.

Requirement: The V-ITS-S transmit power shall be adjustable to a maximum Equivalent Isotropic Radiated Power (EIRP) of 23 dBm/MHz.

Requirement: Geonetworking and BTP shall be used for communications to V-ITS-S and R-ITS-S in accordance with ETSI EN 302 636-5-1:2017 and ETSI EN 302 636-4:2017.

Requirement: All messages between stations using ITS-G5 shall be signed in accordance with the security requirements of Section 8.

Requirement: ITS-G5 communications shall apply Decentralized Congestion Control (DCC) mechanisms in accordance with ETSI TS 102 687:2018.

Requirement: The V-ITS-S shall have system resources for operating with the following minimum performance:

- Transmit a minimum 15 signed ITS-G5 messages per second
- Processing of min. 220 received signed ITS-G5 messages per second

5.3.1 Message Support

Co-operative Awareness Messages (CAM) are typically at variable rates of transmission (1 to 10Hz). While an ongoing C-ITS system would conform to ETSI with regard to transmission frequency, the pilot period will fix CAMs to be transmitted at 10Hz to provide the required data for the research objectives of the pilot's safety evaluation.

Requirement: The V-ITS-S shall provide support for the following message formats as summarised in Table 5-3 below.

Table 5-3 – V-ITS-S supported message types

Message Type	Details
Decentralized Environmental Notification Messages (DENM)	Receive DENMs from other stations and process Create and send DENMs based on trigger conditions In accordance with ETSI EN 302 637-3:2014.
Co-operative Awareness Messages (CAM)	Monitor the V-ITS-S state and create regular CAM messages Receive other station CAMs and process In accordance with ETSI EN 302 637-2:2014. In addition to this a default rate of 10Hz shall be used (<i>camRate</i>). CAMs shall be generated at an accuracy of +/- 10ms of each scheduled CAM generation.
Signal Phase and Timing Extended Message (SPATEM)	Receive SPATEM from R-ITS-S and process in accordance with ETSI TS 103 301:2016
Map Extended Message (MAPEM)	Receive MAPEM from other stations and process in accordance with ETSI TS 103 301:2016

Requirement: The V-ITS-S shall adopt the data element descriptions of the *Data Entity Catalogue PSTS006* which details each of the message types outlined in Table 5-3 including relevance to each use case. If conflicting or competing definitions are identified between the *Data Entity Catalogue PSTS006* and the relevant Standard, the Contractor shall notify the Principal.

5.4 3G/4G (Interface IF2 and IF3)

Requirement: 3G/4G communications shall be provided and be capable of operating on both the Telstra 3G and 4G networks with configurable Access Point Name (APN), username and password. The V-ITS-S shall be capable of simultaneously managing data transfers on multiple 3G/4G ports. For example, access to a maintenance service shall not interfere with the operations of the C-ITS-F in relation to data logging, management and security as defined in sections 6, 7 and 8.

Requirement: TCP/IP, IPv4 shall be used for communications between the C-ITS-F and the V-ITS-S equipment.

5.4.1 Session and Communication Management to C-ITS-F

Requirement: Message Queuing Telemetry Transport (MQTT) publish / subscribe protocol shall be utilised to establish the client / broker connection for communications over 3G/4G between the V-ITS-S and the C-ITS-F. This shall be undertaken in accordance with the *C-ITS Station Protocol Specification PSTS007* and ISO/IEC 20922:2016.

5.4.1.1 Geomessaging (Tile Data)

The C-ITS-F provides geographically specific C-ITS messages to vehicles based on pre-defined geo-tiles using geomessaging. V-ITS-S subscribe to a geo-tile dependant on the current location. As the V-ITS-S moves geographically through tiles, new tiles are subscribed to.

Requirement: The V-ITS-S shall implement the geographic specific messaging facility in accordance with the requirements documented in *C-ITS Station Protocol Specification PSTS007*.

Requirement: The V-ITS-S shall subscribe to any tile within a configurable radius (default 500m) of its current position.

5.4.1.2 Decoding and Encoding Messages

Messages received via MQTT are decoded for use by V-ITS functions. This includes C-ITS messages received from the C-ITS-F, tile data, positioning augmentation, software updates and configuration data. Messages to be sent via MQTT are encoded (for example logging functions as detailed in Section 6.4).

Requirement: The V-ITS-S shall provide the required facilities to decode and encode MQTT messages for use by application, management and security functions of the V-ITS-S in accordance with the *C-ITS Station Protocol Specification PSTS007*.

5.4.2 Message Support

Requirement: The V-ITS-S shall support the following messages and manage the data to and from each topic as summarised in Table 5-4 below. The data of these messages shall be used to enable the operation of the V-ITS-S, HMI and use cases.

Table 5-4 – V-ITS-S supported message types

Message Name	Payload	Relevant ASN	Description
Station Configuration	UPER encoded <i>asn.1 schema</i>	stationConfiguration.asn	Used to deliver station specific configuration information to the V-ITS-S. This message contains configuration information for multiple categories including system, participant and use case.
Station Platform	UPER encoded <i>asn.1 schema</i>	stationPlatformData.asn	Heartbeat message from V-ITSS. Used for session tracking, platform-level events and error logging.
C-ITS Message Event	UPER encoded <i>asn.1 schema</i>	citsMessageEvent.asn	Used to capture information relevant to presentation of C-ITS use case warnings and speed limits on the HMI, including creation and processing of C-ITS messages by use case applications.
Geo Tile Message	UPER encoded <i>asn.1 schema</i>	geoTile.asn	Implements the recursive tile function used to by a vehicle to select the tile appropriate to the vehicle's position.
Safety Evaluation	UPER encoded <i>asn.1 schema</i>	safetyEvaluationData.asn	Captures C-ITS messages transmitted and received by all stations. C-ITS messages includes CAM, DENM, IVIM, MAPEM and SPATEM.
Signed C-ITS Message	TS 103 097 v1.3.1 with TMR modifications. Includes signature and UPER encoded C-ITS message payload	N/A	Publishing of C-ITS driven use case messages (DENM, IVI for V-ITS-S)

Message Name	Payload	Relevant ASN	Description
Position Augmentation	RTCM Standard 10403.3 data	N/A	Augmentation data used for improved positioning accuracy

5.5 HMI Connection (Interface IF4)

Requirement: The V-ITS-S shall support the connection of a HMI to allow information to be presented to the driver of the vehicle.

Requirement: The V-ITS-S shall connect to the HMI through the possible methods outlined in Table 5-2.

5.6 GNSS

5.6.1 Vehicle Positioning

The vehicle positioning facility is required to provide and update the geographical position of the V-ITS-S in real time. GNSS with Real Time Kinematic (RTK) augmentation data is used to achieve appropriate accuracy. In addition to GNSS and augmentation data, the V-ITS-S equipment may utilise any other internal mechanisms to improve accuracy performance, such as inertial augmentation systems.

Requirement: The V-ITS-S positioning shall facilitate 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. The V-ITS-S positioning system shall calculate the V-ITS-S position in real time using GNSS.

Requirement: The V-ITS-S positioning system shall perform 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 as described in the *C-ITS Station Protocol Specification PSTS007*.

Requirement: The V-ITS-S shall allow for positioning augmentation to be disabled. Positioning augmentation shall be controlled by the parameter *positionAugmentation*.

Requirement: The V-ITS-S positioning system shall support positioning requirements for use case applications as outlined in the *Use Case specifications - PSTS011, PSTS012, PSTS013, PSTS014, PSTS015, PSTS016, PSTS017 and PSTS018*.

5.6.2 Timing and Synchronisation

Requirement: V-ITS-S shall be synchronised to Coordinated Universal Time (UTC) using GNSS and shall be accurate to within 10ms.

6 Operational requirements (Applications)

6.1 Use Case Applications

Requirement: The V-ITS-S application layer shall support six (6) use cases. These use cases are:

- Advanced Red Light Warning (ARLW) (detailed in *PSTS013*)
- Turning Warning – Vulnerable Road user (TWVR) (detailed in *PSTS014*)
- Road Works Warning (RWW) (detailed in *PSTS015*)
- Road Hazard Warning (RHW) (detailed in *PSTS016*)
- Back of Queue (BoQ) (detailed in *PSTS017*)
- In Vehicle Speed (IVS) (detailed in *PSTS018*)

Note: Two (2) further use cases were originally scoped within the ICVP for V-ITS-S communication however were removed prior to pilot commencing, these were:

- Emergency Electronic Brake Light (EEBL) (detailed in *PSTS011*)
- Slow Stopped Vehicle (SSV) (detailed in *PSTS012*)

Requirement: The use case applications shall operate independently and allow for the addition and removal of other use cases as requested by the Principal.

6.2 Out-of-Area Mitigation Mode

Legacy Dedicated Short Range Communications (DSRC) systems such as tolling systems can be affected by the operation of ITS-G5 communications (ETSI TS 102 792 V1.2.1). To guarantee avoidance of interference at tolling locations, mitigation mode in the V-ITS-S is used when the vehicle is in the out-of-area tile.

Requirement: If the 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) the V-ITS-S shall remain in the same mode until positioning confidence is regained.

6.3 HMI Presentation Manager

The HMI Presentation Manager is a mechanism for assuring the V-ITS-S is managing and understanding the HMI behaviour. The HMI Presentation Manager describes an application or process on the V-ITS-S that services all requests and responses to the HMI (single point of control).

A notification is when other applications in the V-ITS-S inform the HMI Presentation Manager about a HMI relevant content.

A presentation is when the HMI Presentation Manager requests control of a HMI display region. Only one presentation per region should be active at a given time. All three HMI regions may be active concurrently. Some presentation requests may also include an audio alert.

Requirement: The HMI Presentation Manager shall manage the presentation of content and audio on the HMI (see the *HMI Specification PSTS003* for detailed HMI requirements).

Requirement: The HMI Presentation Manager shall manage simultaneous notifications and presentation requests for:

- Use case warnings (e.g. slow vehicle ahead)
- Speed limits (e.g. static speed signage, roadworks speeds)
- Station status (e.g. 3G/4G connectivity)
- General content (e.g. Start-up, critical failure, software update progress, out-of-area)

Requirement: The HMI Presentation Manager shall monitor and log the HMI behaviour in accordance with section 6.4.

6.3.1 HMI Presentation Keep Alive

After start-up, a driver should always expect to see content presented on the HMI that is relevant to the driver.

Requirement: Each request sent to the HMI shall have a duration. The HMI Presentation Manager shall refresh requests to extend the duration (for example one second).

Requirement: The HMI Presentation Manager will verify that the request continues to be displayed on the HMI by regular polling. Should the HMI indicate that the content is no longer presented or the V-ITS-S fails to receive an acknowledgement for longer than the duration then the HMI Presentation Manager shall raise a system failure.

6.3.2 Driver Participation

Requirement: The HMI will handle participant login independently of the HMI Presentation Manager as this may occur prior to V-ITS-S start-up. The HMI Presentation Manager shall receive and manage the participant selection information from the HMI once connectivity to the HMI has been established. The HMI shall report the participant selection as the selected Participant Code, Non-participant, or Unknown (if no selection is made).

Requirement: The HMI Presentation Manager shall not take control of the HMI until the participant login screens (Login 1 Layout and Login 2 Layout per *HMI Technical Specification PSTS003*) are no longer displayed and participant selection information has been returned by the HMI.

Requirement: For Control Group participants, the HMI Presentation Manager shall request the CONTROL warning identifier be displayed by the HMI (*displayedHmiMessageId* field of the ASN.1). However, use case operation and logging will be the same as for a Treatment participant (as described in Section 6.4 and Figure 6.1).

Requirement: The HMI Presentation Manager shall not request presentation of use case warnings or speed limits if a non-participant is selected.

Requirement: As part of the *Station Configuration*, the V-ITS-S shall inform the HMI of updates to the current list of Participant Codes assigned to the V-ITS-S, as well as participant assignment to the Treatment or Control Groups (via the *hmiEnabled* parameter).

6.3.3 Use Case Warnings

Requirement: 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 (if applicable – refer to Appendix A of *HMI Technical Specification PSTS003*). The relevant use case must have presentation enabled (see *ucArlwPresentationEnabled*, *ucBoqPresentationEnabled*, *uclvsPresentationEnabled*, *ucRhwPresentationEnabled*, *ucRwwPresentationEnabled*, and *ucTwvrPresentationEnabled* in the station configuration message).

6.3.3.1 Prioritisation

When concurrent use case applications create a HMI notification, the HMI Presentation Manager is required to prioritise warnings according to their criticality and urgency.

- Urgency (u) = HIGH (3), MEDIUM (2), LOW (1) based on trigger level from use case notifications (as defined in PSTS011 to PSTS017)
- Criticality (c) = HIGH (3), MEDIUM (2), LOW (1), VERY LOW (0) based on vehicle speed and use case in Table 6-1.

Table 6-1 – Criticality Lookup

Criticality (c)		Vehicle Speed			
		High (e.g. >80km/h)	Medium (e.g. 80>50km/h)	Low (e.g. 50>20km/h)	Very Low (e.g. <20km/h)
Use Case Event Type					
ARLW	Event	3	3	3	3
ARLW	Approach	3	3	3	3
TWVR	Approach	3	3	2	1
RWW	Event	3	2	0	0
RWW	Approach	3	2	0	0
RHW	Approach	2	1	0	0
BoQ	Approach	2	1	0	0

Requirement: If only one use case event type has notifications requested, the HMI Presentation Manager shall present the notification with highest urgency to the HMI immediately.

Requirement: If multiple use case event types have notifications requested, the HMI Presentation Manager shall prioritise HMI notifications based on the following calculation (priority value summarised in Table 6-2).

$$\text{Priority (p)} = \text{Criticality (c)/2} + \text{Urgency (u)/2}$$

Requirement: New notifications:

1. with higher priority get presented immediately
2. with lower priority do not get presented
3. with equal priority but higher criticality get presented immediately
4. with equal priority and equal/lower criticality do not get presented

Requirement: An update in a notification requires a priority/criticality recalculation. The presentation request shall be updated if a higher priority or equal priority with higher criticality notification results.

Table 6-2 – Priority Table

Priority (p)		Vehicle Speed															
		High (e.g. >80km/h)				Medium (e.g. 80>50km/h)				Low (e.g. 50>20km/h)				Very Low (e.g. <20km/h)			
Use Case	Urgency	3	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0
ARLW	Event	3.0	NA	NA	NA	3.0	NA	NA	NA	3.0	NA	NA	NA	3.0	NA	NA	NA
ARLW	Approach	3.0	2.5	2.0	1.5	3.0	2.5	2.0	1.5	3.0	2.5	2.0	1.5	3.0	2.5	2.0	1.5
TWVR	Approach	3.0	2.5	2.0	1.5	3.0	2.5	2.0	1.5	2.5	2.0	1.5	1.0	2.0	1.5	1.0	0.5
EEBL	Approach	3.0	2.5	2.0	1.5	2.5	2.0	1.5	1.0	2.0	1.5	1.0	0.5	1.5	1.0	0.5	0.0
SSV	Approach	3.0	2.5	2.0	1.5	2.5	2.0	1.5	1.0	2.0	1.5	1.0	0.5	1.5	1.0	0.5	0.0
RWW	Event	3.0	NA	NA	NA	2.5	NA	NA	NA	1.5	NA	NA	NA	1.5	NA	NA	NA
RWW	Approach	3.0	2.5	2.0	1.5	2.5	2.0	1.5	1.0	1.5	1.0	0.5	0.0	1.5	1.0	0.5	0.0
RHW	Approach	2.5	2.0	1.5	1.0	2.0	1.5	1.0	0.5	1.5	1.0	0.5	0.0	1.5	1.0	0.5	0.0
BoQ	Approach	2.5	2.0	1.5	1.0	2.0	1.5	1.0	0.5	1.5	1.0	0.5	0.0	1.5	1.0	0.5	0.0

6.3.3.2 Display Hysteresis

Requirement: Notification's with a lifetime shorter than the minimum on time (typically 2 seconds) shall be extended to the minimum on time, unless overridden by a new notification with higher priority.

Requirement: A lower priority notification shall only be requested once all higher priority notifications have ended.

6.3.4 Speed Limits

Requirement: Use case applications with speed information (IVS and RWW) notify the HMI Presentation Manager of a speed limit display with an event identifier and a warning (image/audio) identifier (refer to Appendix A of the *HMI Technical Specification PSTS003*).

Requirement: The HMI Presentation Manager shall prioritise the lowest speed for any concurrent speed notifications.

Requirement: If there is no current speed limit notified by the use case applications, the HMI Presentation Manager shall request the presentation of an unknown speed display (IVS_UNKNOWN) on the HMI (refer to *HMI Technical Specifications PSTS003*).

6.3.5 Station Status

Requirement: The HMI Presentation Manager shall notify the HMI of the current status of the V-ITS-S operation. The V-ITS-S status shall include levels indicating:

- no Time Synchronisation, GNSS – Operational/Failed
- 3G/4G – Operational/Failed
- no RTK fix
- no errors

6.3.6 General Content

6.3.6.1 V-ITS-S System Start-Up

Requirement: The HMI Presentation Manager shall inform the HMI that the system is starting in accordance with section 9.1.

6.3.6.2 V-ITS-S Software Update

Requirement: The HMI Presentation Manager shall inform the HMI that software is being updated and when the update is complete in accordance with section 7.2. During the update, the HMI Presentation Manager shall request the presentation of a software update display (HMI_SYS_UPDATE) on the HMI.

6.3.6.3 Out-of-Area

Requirement: When out-of-area (as described in section 6.2), the HMI Presentation Manager shall request the presentation of an out-of-area display (OUT_OF_AREA) on the HMI.

6.3.6.4 Failures

Requirement: Should the V-ITS-S experience a critical failure (for example, a system update failure), then the HMI Presentation Manager shall request the presentation of a system error display (STATION_ERROR) on the HMI.

6.4 Data Logging

The data logging application monitors the V-ITS-S and HMI and collects data for system performance monitoring and the Field Operational Test (FOT) safety evaluation. This data is sent to the C-ITS-F using MQTT over 3G/4G. The Safety Evaluator will use the data to assess driver behaviour during use case events. The assessment requires that the display and audio warnings provided to the driver can be replayed by the Safety Evaluator in chronological sequence through the logged data. The Safety Evaluator must reliably know the HMI display and audio information provided to driver during use case events.

6.4.1 Data Logging Processing

Figure 6.1 describes the data logging workflow for V-ITS-S.

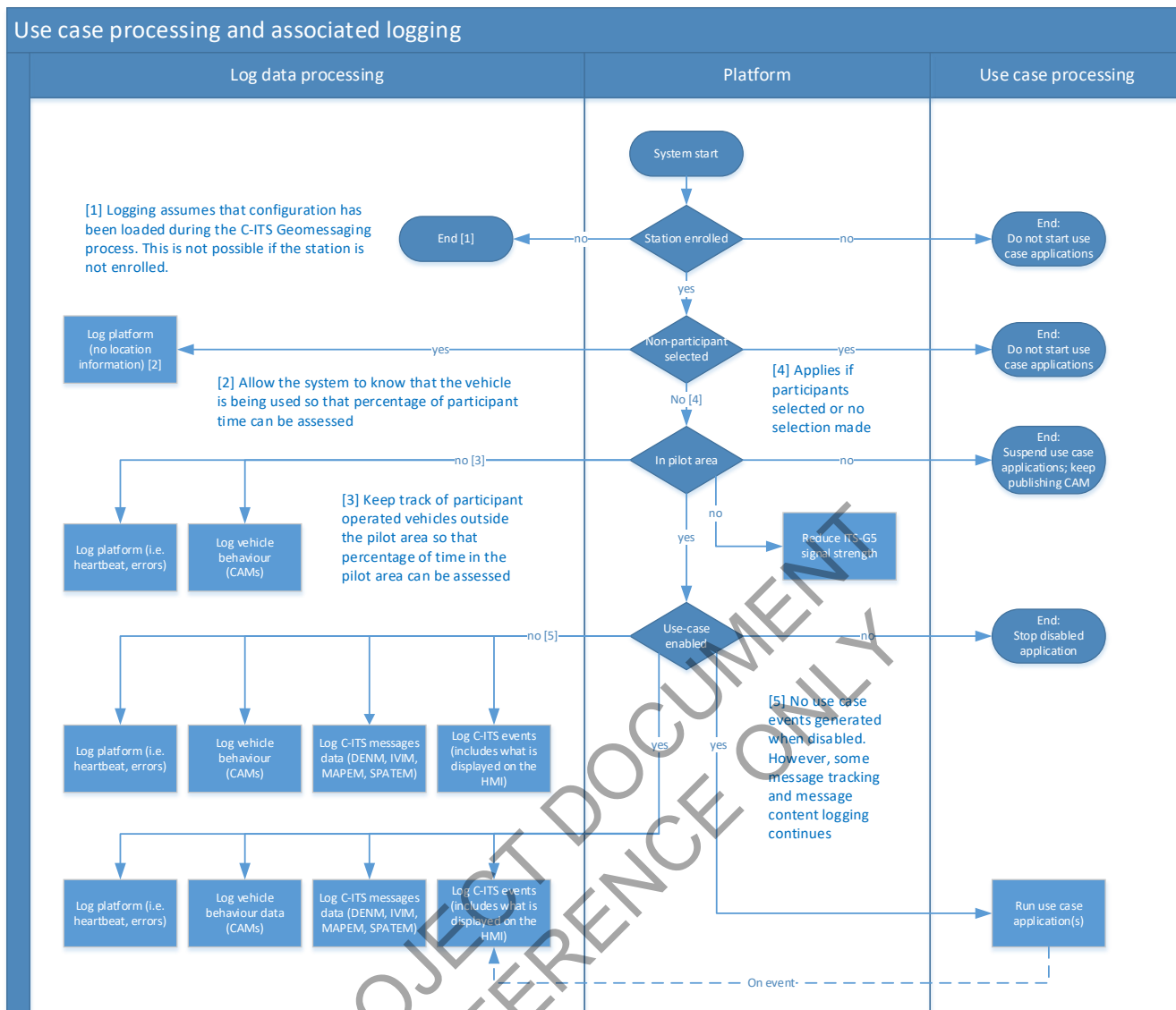


Figure 6.1 – Data logging processing flowchart

Requirement: Data logging shall commence as soon as the V-ITS-S has powered up and initialised and continue as long as the V-ITS-S is turned on.

Requirement: The V-ITS-S shall log *C-ITS Safety Evaluation Messages* as described in *PSTS007 – C-ITS Station Protocol Specification*, and *Data Entity Catalogue PSTS006*.

Requirement: The V-ITS-S shall log *C-ITS Message Event Messages* as described in *PSTS007 – C-ITS Station Protocol Specification*, and *PSTS006 Data Entity Catalogue PSTS006*.

Requirement: The V-ITS-S shall log *C-ITS Station Platform Messages* as described in *PSTS007 – C-ITS Station Protocol Specification*, and *PSTS006 Data Entity Catalogue PSTS006*.

Requirement: The V-ITS-S shall not log *Message Event* data when in an out-of-area tile.

Requirement: The V-ITS-S shall not log *Message Event* and *Safety Evaluation* data when a non-participant is selected. The V-ITS-S shall continue to log *Station Platform Messages* excluding data fields containing location information.

Requirement: *C-ITS Station Platform Messages* and *Message Event* data shall be sent by the V-ITS-S to the C-ITS-F at the rate specified by the parameter *logFrequency* as specified in *Station Configuration Message*. *Safety Evaluation* data shall be sent when reaching one of the log size limits (*csemCamLogLimit*, *csemDenmLogLimit*, *csemIvimLogLimit*, *csemMapemLogLimit*, *csemSpatemLogLimit*) or periodically at *csemLogWatchdogTimeout*.

Requirement: V-ITS-S data logging must not interfere with the transmission and receipt of C-ITS messages via ITS-G5 and 3G/4G.

6.4.2 Data Logging Security

Requirement: Data log messages shall not be signed (as described in section 8), however messages shall be encrypted using TLS as described in as described in the *C-ITS Station Protocol Specification PSTS007*.

6.4.3 Log Data Retention

Requirement: The V-ITS-S shall retain a store of logged data that has not been uploaded to the C-ITS-F logging service for the period specified by the *logMessageRetentionWindow* data element in the *Station Configuration Message*. The stored data shall persist over power cycles. When communication is restored, the V-ITS-S shall send data logs to the C-ITS-F logging service. Logged data shall be retained for *Safety Evaluation*, *Message Event* and *Station Platform* messages.

Requirement: Data logs sent to the C-ITS-F logging service and confirmed shall not be re-uploaded to the C-ITS-F. Any data logs uploaded to the C-ITS-F may be removed from the V-ITS-S (consideration should be given for local diagnostics and testing functions).

6.4.4 Safety Evaluation Data Logging

Safety Evaluation data logging captures C-ITS messages transmitted and received by all stations.

Requirement: V-ITS-S shall capture the receipt and transmission of all C-ITS Safety Evaluation Messages per the logging frequencies described in Table 6-3.

Table 6-3 – C-ITS message logging frequency

Type	Direction	Logging frequency
CAM	Transmitted	At broadcast rate
	Received	At receipt rate
DENM	Transmitted	At broadcast rate
	Received	At receipt rate
IVIM	Received	At receipt rate
MAPEM	Received	At receipt rate
SPATEM	Received	At receipt rate






Requirement: To allow the management of logging bandwidth the collection of message content shall be controlled per C-ITS message type. The control parameters are:

- *camDirection*
- *denmDirection*
- *ivimDirection*
- *mapemDirection*
- *spatemDirection*

Requirement: When data logging is enabled the V-ITS-S shall collect both a count of message type received and transmitted per station and the UPER encoded messages. When data logging is disabled then only a count of message type received and transmitted per station is collected. Data logging shall be controlled for both receipt and transmission.

6.4.4.1 Data Definition

Figure 6.2 describes the overview of the C-ITS Safety Evaluation Message (CSEM). Details are specified in *C-ITS Station Protocol Specification document PSTS007*, and *Data Entity Catalogue PSTS006*. The message structure identifies the following data components:

1.  CSEM PDU container
2.  Message set
3.  Data frame
4.  Sequence of data frame
5.  Data element

Requirement: The *Safety Evaluation* data shall be encoded in accordance with *safetyEvaluation.asn* protocol.

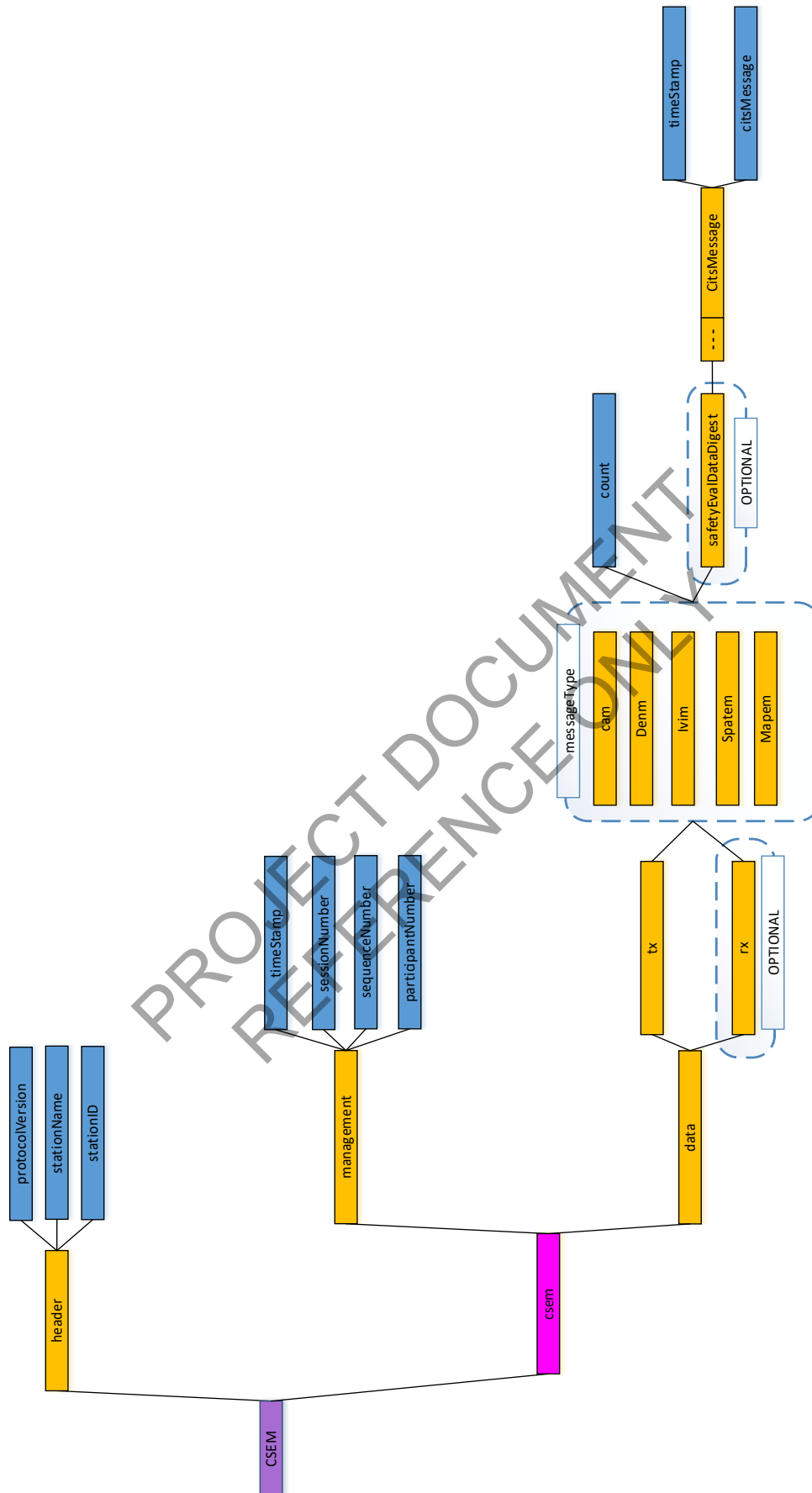


Figure 6.2 – CSEM Structure

6.4.5 Message Event Logging

Message Event data logging is event-driven and captures information relevant to presentation of C-ITS use case warnings and speed limits on the HMI, including creation of C-ITS messages and processing of C-ITS messages by use case applications. Use case events that did not result in a warning being presented on the HMI (the use case notification was lower priority and/or the event was geometrically relevant) are also logged to provide contextual information for the safety evaluator. Message Event data logging should occur for all participants, including Control Group participants, in order for the Safety Evaluator to understand what C-ITS warnings would have been triggered.

All image/ audio presentations on the HMI (including content generated independently by the HMI) will be associated with unique identifiers which will be shared by all system components. This will allow reconstruction of the sequence of warnings/ information presented to the driver. The list of image/ audio identifiers are within the *HMI Specification PSTS003* and the *Use Case Specifications PSTS011-18*.

Requirement: The *Message Event* logging shall capture events relating to the position relevance, notification and presentation of use case warnings and speed limits defined in sections 6.3.3 and 6.3.4. The *Message Event* data captured shall include all information relevant during the event (such as the current images displayed in Regions 1, 2 and 3 of the HMI, if audio was issued, or if there was a Control Group override).

Requirement: The V-ITS-S shall log data in accordance with *Data Entity Catalogue PSTS006* when any of the events in Table 6-4 occur.

Table 6-4 – V-ITS-S C-ITS event logging

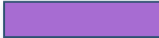




Event	Data Frame	Description
C-ITS message relevance	Relevant	When a C-ITS message with geometric features becomes relevant to the vehicle's position (for example, the vehicle enters a DENM trace).
Use case notification	Notified	When a use case application informs the HMI Presentation Manager about a HMI relevant content.
Use case presentation	Presented	After the HMI Presentation Manager receives acknowledgement that a presentation request has been processed by the HMI.

Requirement: For a use case presentation event, the following minimum parameters shall be logged and passed to the C-ITS-F:

- An identifier for the C-ITS message or messages that caused the use case presentation
- The identifier of the audio/ image file that was requested for presentation by the HMI Presentation Manager (refer to *HMI Equipment Specification PSTS003*)
- The identifier of the audio/ image file that was presented by the HMI (refer to *HMI Equipment Specification PSTS003*)
- Start time of the HMI presentation
- Stop time of the HMI presentation
- Any parameters used to generate the content (e.g. use case event type, priority, speed limit)
- HMI volume value
- HMI brightness value
- Participant attributes (for example, *Participant Code*, *hmiEnabled*)
- Display failure reason (optional).

6.4.5.1 Data Definition

Figure 6.3 describes the overview of the *C-ITS Message Event (CME)*. Details are specified in *C-ITS Station Protocol Specification document PSTS007*, and *Data Entity Catalogue PSTS006*. The message structure identifies the following data components:

1.  CME PDU container
2.  Message set
3.  Data frame
4.  Sequence of data frame
5.  Data element

Requirement: The *C-ITS Message Event* shall be encoded in accordance with *citsmessageEvent.asn* protocol.

PROJECT DOCUMENT
REFERENCE ONLY

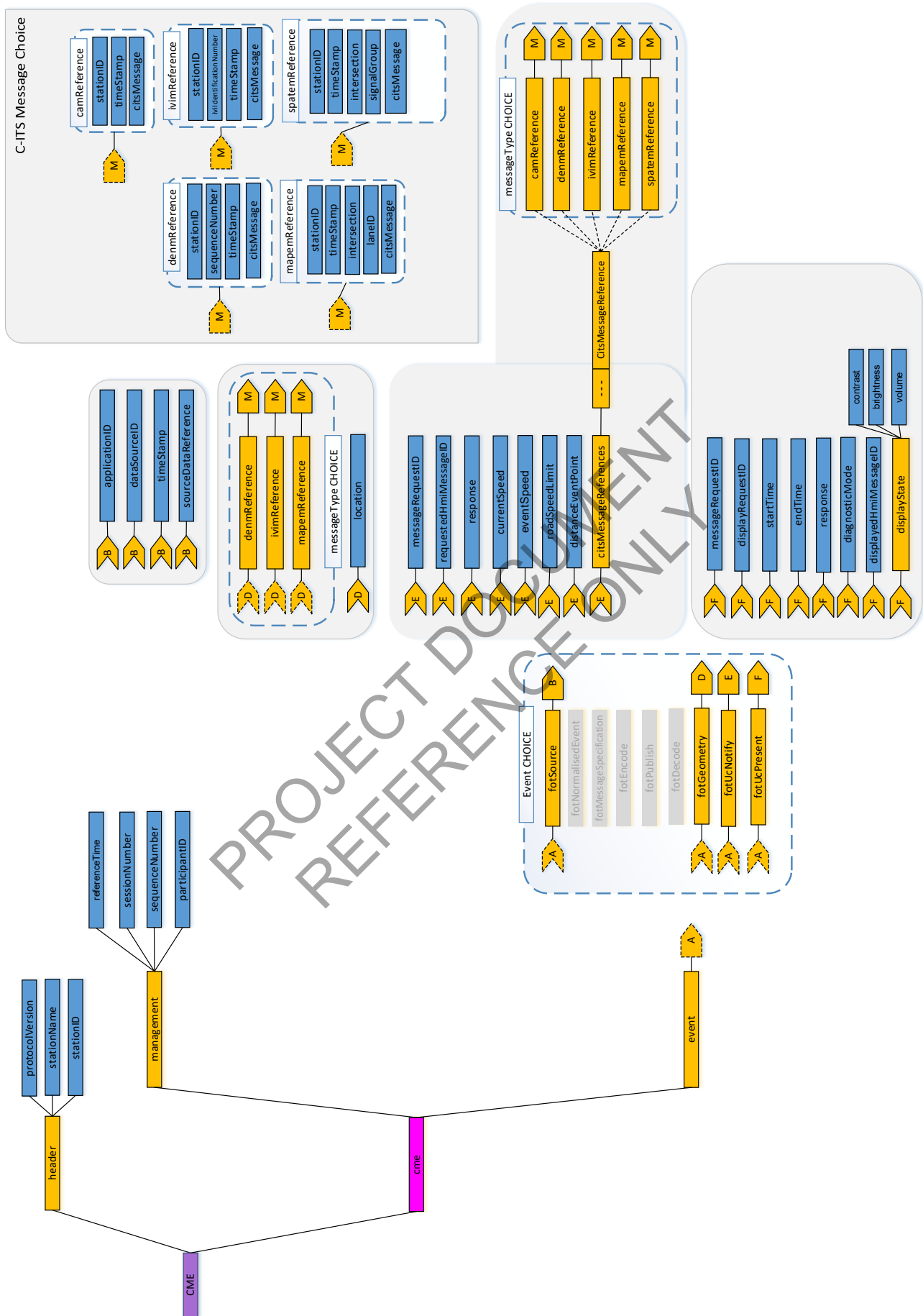


Figure 6.3 – CME Data Structure

6.4.6 Station Platform Data Logging

Station Platform Data is used by the C-ITS-F to monitor the operation of the system.

Requirement: Platform-level data shall include:

- Session monitoring – used to identify a V-ITS-S session and to detect session exceptions
- Platform metrics – monitors station performance
- Platform exception/ error logs – captures the V-ITS-S failures
- HMI metrics – for example, volume value, brightness value, errors, current image/ audio presentation.

6.4.6.1 Session Monitoring

Session monitoring is the measurement of a MQTT session. This will typically align with a vehicle trip (ignition on to ignition off) and therefore the attributes of this data frame include measuring the station availability, complete trip parameters (e.g. distance, time), the path of the vehicle and communications outages.

Requirement: The Platform data shall log MQTT session information (section 5.4.1) and associated vehicle metrics.

6.4.6.2 Platform Metrics

Platform metrics monitor station performance and are used to diagnose and rectify system exceptions so that the collection of data for the safety evaluation remains optimal.

Requirement: The Platform data shall log station platform metrics in accordance with the metrics defined in Table 6-5.

Table 6-5 – Station metrics

Metric	Value	Threshold	Notes
numberProcessingUnits	Count	-	
cpuOneMinuteLoadAverage	Decimal	# cores * 3	Uses the 1-minute average value collected at message generation time
cpuTemperature	Decimal	-	Uses the value collected at message generation time (CPPU temp or board temp)
storageInUse	%	<i>storageThreshold</i>	For all disks or partitions including memory resident storage
gnssHdopErrorCount	Count	<i>dopThreshold</i>	
gnssPdopErrorCount	Count	<i>dopThreshold</i>	
gnssVdopErrorCount	Count	<i>dopThreshold</i>	
gnssSatelliteErrorCount	Count	<i>minNumberOfSatellitesThreshold</i>	
networkInterfaceError	Count	Unavailable	sum of RX and TX interface errors per interface. Always ordered in incrementing interface number. Do not include local loopback
networkIfUnavailableCount	Count	Any	Uses the value collected at message generation time
freePhysicalMemory	%	-	Uses the values collected at message generation time
systemUptime	Minutes	-	Uses the value collected at message generation time
messageSignatureErrorCount	Count	Any	Uses the values collected at message generation time
gnssNoSyncTime	Count	Any	Count maintained and reported at each report interval

Metric	Value	Threshold	Notes
citsMessageDecodeErrorCount	Count	Any	Count maintained and reported at each report interval
ItsNoConnectionTime	Seconds	-	Number of seconds since last connection to the 3G/4G network
radioSignalStrengthIndicator	dB	-	Signal strength of 3G/4G connection reported at the end of each interval

6.4.6.3 Platform Error Logs






Platform error logs capture the failures identified through this specification (e.g. 3G/4G failure, platform metrics warnings) and Contractor-defined errors. This allows fast response time to the diagnosis and rectification of system errors so that data collection for the safety evaluation remains optimal.

Requirement: The error log shall support errors logged by any level of the system (i.e. hardware, platform access, transport and network, facilities, application).

Requirement: The Contractor shall propose a method to be provided by the V-ITS-S to limit the size of these logs (e.g. severity level) so that network bandwidth and data rates are managed.

6.4.6.4 Data Definition

Figure 6.4 describes the overview of the *Station Platform Data*. Details are specified in *C-ITS Station Protocol Specification document PSTS007*, and *Data Entity Catalogue PSTS006*. The message structure identifies the following data components:

1.  CSPM PDU container
2.  Message set
3.  Data frame
4.  Sequence of data frame
5.  Data element

Requirement: The *Station Platform Data* shall be encoded in accordance with *stationPlatformData.asn* protocol.

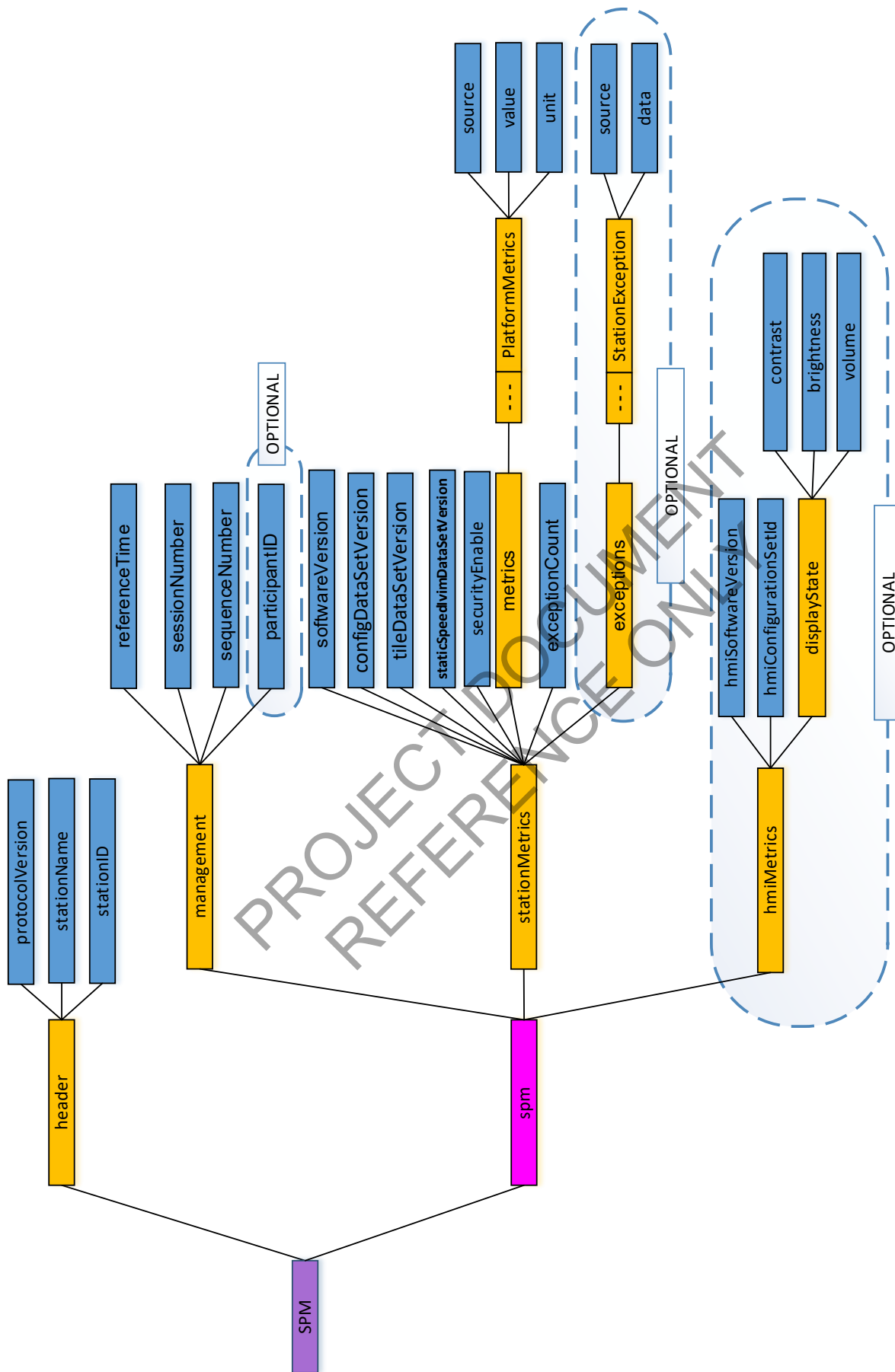


Figure 6.4 – SPM Data Structure

7 V-ITS-S Management

The management entity of the V-ITS-S is shown in the reference architecture as shown in Figure 5.2 and is defined in Section 7 of ETSI EN 302 665:2010.

7.1 Control and Configuration

Key system parameters required are summarised as follows:

- Control of use case applications running on the V-ITS-S – disabling/ enabling of use cases applications.
- Control of use case parameters – changing or modifying parameters within use case applications. Use case parameters are described in the Use Case Specifications PSTS011-18.
- System configuration parameters – system level parameters for system configuration such as system monitoring, data collection and update frequency management.

V-ITS-S configuration is retrieved from the C-ITS-F as specified in the *C-ITS Station Protocol Specification PSTS007*, and *Data Entity Catalogue PSTS006*.

The *Station Configuration Message, stationConfiguration.asn*, forms the protocol specification that describes the configuration message. Key configurable parameters are outlined below. Section 14 contains further information on key configurable parameters and should be referenced for further information.

- C-ITS use case application control
 - Control of in-vehicle systems. See parameter *useCaseEnabled* in Section 14
 - Turning use case processing or presentation on and off. See parameter *useCasePresentationEnabled* in Section 14
- C-ITS use case application configuration as defined in *Use case specifications PSTS011-18*
- C-ITS platform configuration
 - Heartbeat message transmission rate. See parameter *logFrequency* in Section 14.

Requirement: The V-ITS-S shall implement changes contained in control and configuration requests when received and ensure that the platform and application begin using the control and configuration parameters. System or application components may need to be restarted after the receipt of a control and configuration request. This should be undertaken to minimise impacts to participant user experience.

Requirement: The full set of configuration items for V-ITS-S will be sent in one message as described in the *C-ITS Station Protocol Specification PST007* and *Data Entity Catalogue PSTS006*. Each set of configuration parameters for a station will be given a unique identifier. The V-ITS-S shall store this unique identifier so that it can be included in platform-level and use case related messages sent to the C-ITS-F.

Requirement: The V-ITS-S shall subscribe to a configuration topic unique to the station and maintain a subscription. A new configuration set will be published to the station when it makes a subscription. A new configuration may be published by the C-ITS-F at any time during that the station is subscribed.

Requirement: Participants and their attributes (such as assignment to Control Group) shall be remotely configurable and updatable to the V-ITS-S and HMI.

7.2 V-ITS-S Software Update Client

The C-ITS will implement one or more industry-standard package management systems to support the batched update of the following software categories on V-ITS-S and HMI equipment:

- Security updates – to meet information security requirements. These updates are related to the correction of security vulnerabilities
- Use case and other applications – to resolve issues with the operation of applications
- Platform packages.

Requirement: The package management system shall be proposed by the Contractor and approved by the Principal to support software updates of the V-ITS-S and HMI.

Requirement: Packages shall be prepared by V-ITS-S Contractors. Packages shall be applied and become active without user intervention. If a package requires the system configuration to be modified to become active then the configuration change shall be included in the package.

Requirement: The V-ITS-S shall connect to the package management system using the update-system's native process.

Requirement: The download and installation of software updates shall not be impacted by the removal of power during the process.

Requirement: The delivery of software packages shall use 3G/4G with consideration of batching to multiple V-ITS-S with variable vehicle on/off times.

Requirement: Contractors shall size packages so that each package can be delivered within 2 minutes to minimise the likelihood of power-down warnings affecting the update.

7.3 Remote Maintenance

Limited information will be logged in the maintenance portal. This level of information will unlikely allow low-level diagnosis of issues. Contractor specific diagnostic tools are used by accessing the stations remotely using a secure connection (e.g. SSH).

Requirement: The V-ITS-S shall have a facility to allow remote maintenance access. This includes access to information in regards to the station operation, status, communication channels or other relevant system information required for diagnostics.

Requirement: The V-ITS-S remote maintenance facility shall provide information back to the C-ITS-F using 3G/4G in accordance with configuration parameter *loggingLevel* as defined in Section 14.

Requirement: Additional remote maintenance activities shall be undertaken using Contractor-specific tools via secure remote connection via the SSH protocol. This shall include accessing the associated HMI.

7.4 Diagnostic Displays

Contractors may choose to display detailed diagnostic information on the HMI display screen. Should this feature be implemented then the V-ITS-S will return an indication that the HMI is in diagnostic mode. Normal use case processing will continue including presentation requests from the HMI Presentation Manager and data logging, however, the screen will show Contractor-specific diagnostic information.

8 Security

The security entity of the V-ITS-S is shown in the reference architecture as shown in Figure 5.2 and is defined in Section 8 of ETSI EN 302 665:2010. Additional security requirements are defined *C-ITS Station Protocol Specification PST007*.

Only stations installed in the C-ITS are allowed to communicate with other stations. Each station must be verified before being allowed to interact with other ITS stations.

V2V interactions will be managed using processes specified by the *SCMS Certificate Profile Specification PSTS008*.

V2I interactions will be managed using the same security processes. In addition the C-ITS-F will verify that the V-ITS-S is a C-ITS trusted station. For this purposes stations must be enrolled before they can participate in V2I interactions.

Requirement: The V-ITS-S shall facilitate field stations enrolment in accordance with the *SCMS Certificate Policy PSTS008* and *C-ITS Station Protocol Specification PSTS007*.

Requirement: The V-ITS-S shall be capable of enabling or disabling the SCMS security such as signing of messages (*securityEnable* in the *Station Configuration Message*).

Requirement: All station interface messaging to SCMS components shall adhere to ETSI TS 102 941 v1.2.1 using a certificate format as defined in ETSI TS 103 097 v1.3.1. Connection to the SCMS shall comply with *C-ITS Station Protocol Specification PSTS007*.

8.1 Network Security Certificates

Requirement: A SCMS shall be utilised by all C-ITS stations and details are provided in the *C-ITS Station Protocol PSTS007* and *SCMS Certificate Profile Specification PSTS008*.

Requirement: The vehicle station shall encrypt all MQTT traffic using the provided X.509 certificates to establish TLS.

8.2 Station Lifecycle

ETSI TS 102 941 v1.2.1 defines a station lifecycle, however, does not specify the timeframes that this lifecycle will occur over. The following set of requirements specify these timeframes.

8.2.1 Manufacture

Requirement: SCMS network addresses shall be incorporated into the V-ITS-S as provided to the Contractor by the Principal.

Requirement: Public Key Certificates for the Root Certification Authority (Root CA certificate), the Enrolment Authority (EA CA certificate) and the Authentication Authority (AA CA certificate), shall be incorporated into the V-ITS-S as provided to the Contractor by the Principal.

Requirement: The globally unique, canonical identifiers for ITS-S shall be incorporated into the V-ITS-S as provided to the Contractor by the Principal.

Requirement: Permissions within the *SCMS Certificate Profile PSTS008* shall be adhered to.

8.2.2 Enrolment

Requirement: Enrolment shall take place prior to the station being deployed to the field. Enrolment certificates shall be set to expire in 5 years.

8.2.3 Authorisation

Refer to *Station Certificate Profile PSTS008* for station authorisation requirements.

8.2.4 Message Signing and Verification

Requirement: All ETSI defined messages shall be signed at transmit source, and verified on receipt. This shall occur in accordance with the ETSI certificate format ETSI TS 103 097 v1.3.1. Messages that are unsigned or contain an invalid certificate (including an expired certificate) shall be ignored by the station.

8.2.5 Pre-installation Configuration

Requirement: Prior to installation the V-ITS-S shall be configured with required SCMS tickets and the initial connection endpoint.

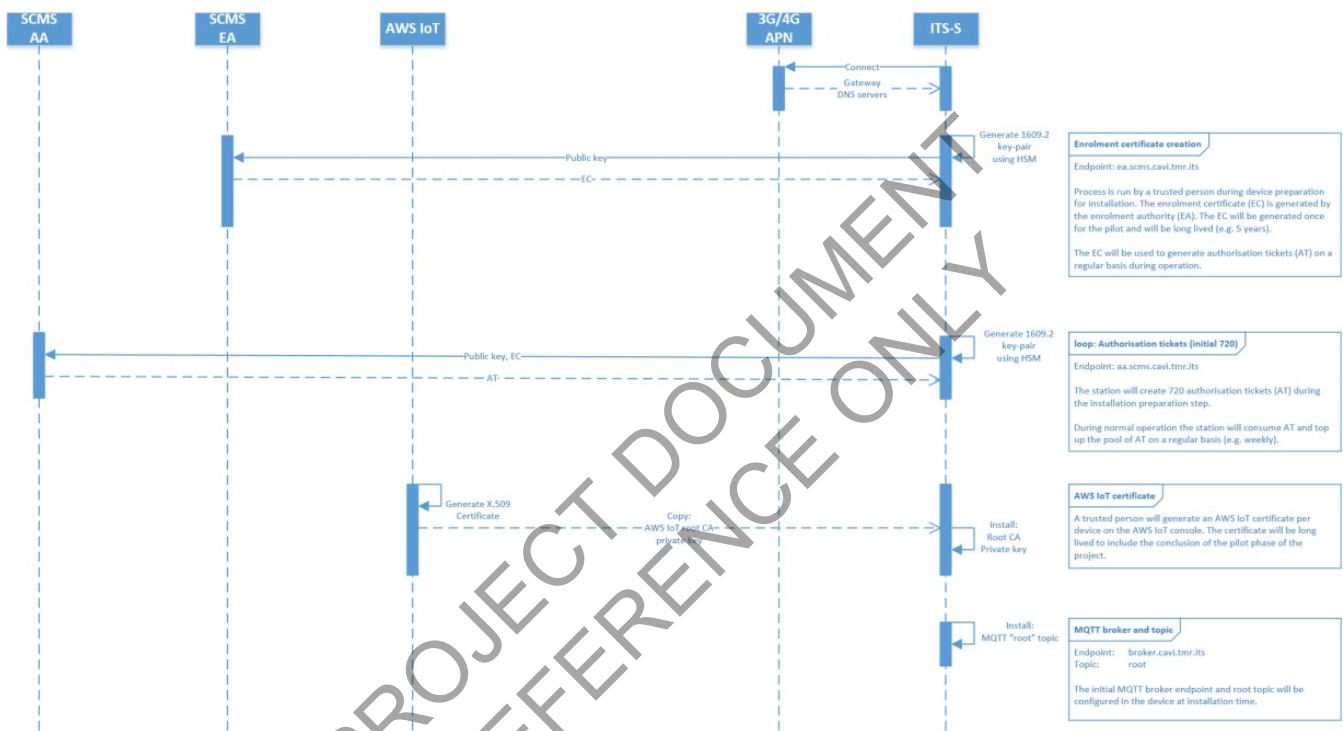


Figure 8.1 – Initialisation process

Requirement: The V-ITS-S shall be connected to the SCMS Enrolment Authority (EA) prior to installation to loading the Enrolment Certificate (EC). The EA is defined by parameter *scmsEA*.

Requirement: The V-ITS-S shall be connected to the SCMS Authorisation Authority (AA) prior to installation to load the Authorisation Ticket (AT) set. The AA is defined by parameter *scmsAA*.

8.3 Device Access Security

Requirement: A hardware security module (HSM) capable of meeting FIPS-2 Level 2 with external tamper evident closure stickers. Shall be provided for securely storing, handling and processing crypto material.

Requirement: Private keys should not be accessible in clear text outside of the HSM.

Requirement: Private keys should not be able to be extracted in any form from the HSM.

Requirement: Each V-ITS-S shall have a unique administrative password approved by the Principal.

Requirement: The password length for administrative credentials shall be a minimum of 12 characters and contain at least one upper-case, one lower, one number and one special character.

Requirement: The V-ITS-S shall run under the principle of reduced surface area such that non-essential services are disabled on the station and that those services that are required are only exposed on the interfaces that they are required to operate on.

Requirement: The V-ITS-S software/firmware development shall follow an applicable best practice security development guideline – such as the OWASP Developer Guide.

Requirement: V-ITS-S design shall incorporate the Australian Signals Directorate's Top 4 Strategies to Mitigate Cyber Security Incidents.

9 Technical Requirements

9.1 System Start-Up

Requirement: The V-ITS-S equipment shall be capable of full operation 3 minutes (at 95% confidence) from a factory start condition. A factory start condition is defined as the unit having no current or stored information in regards to applications, management or security functions required for the V-ITS-S operation.

The V-ITS-S will be de-energised at the end of every trip when the vehicle ignition circuit is switched off or for any other situation where power is removed from the V-ITS-S. The V-ITS-S equipment will be re-energised when the vehicle ignition circuit is switched on.

Requirement: In order to facilitate fast and accurate timing and synchronisation a battery backed real time clock shall be provided in addition to the requirements of Section 5.6.2.

Requirement: The V-ITS-S shall subscribe to the following MQTT topics at the start of each session and whenever a reconnection is made. See *C-ITS Station Protocol Specification PSTS007* for information about topic processing.

- a. *tile/<tileId>/augmentPosition*
- b. *tile/<tileId>/signedCitsMessageVinit/<stationName>*
- c. *tile/<tileId>/signedCitsMessageVupd/<stationName>*
- d. *<stationName>/stationConfiguration.*

9.2 Storage

Requirement: The V-ITS-S shall have non-volatile memory to store all information required to meet the operational and technical requirements.

9.3 Maintenance Communications

Requirement: Additional to the ability to perform remote maintenance as defined in Section 7.3, the V-ITS-S shall be capable of local maintenance and configuration activities via the following communication methods:

- Direct Ethernet connection
- WIFI
- Any other suitable means as proposed by the contractor subject to approval from the Principal

9.4 Control/Diagnostic software

Requirement: The Contractor shall provide the Principal with control and diagnostic software required for the V-ITS-S, HMI and associated equipment.

Requirement: All software shall be licensed on behalf of, and in the name of, the Principal.

9.5 Failure Modes

Requirement: The Contractor and Principal shall agree what constitutes critical failures and minor failures.

Requirement: In the event of critical failures, the V-ITS-S equipment shall:

- Request an error warning display on the HMI.
- Return failures as part of the error log in the *Station Platform Data*. If the failure is an operational and/or telecommunications failure, the V-ITS-S shall continue all background data logging functions for upload back to the C-ITS-F when the interface communication link is re-established.
- Monitor the failure and automatically recover if possible.
- If failure requires a restart, automatically shut down in a safe manner maintaining any stored data.

Requirement: In the event of minor failures, the V-ITS-S equipment shall:

- Continue operating all functions not affected by the failure
- Return failures as part of the error log in the *Station Platform Data*.
- Monitor the failure and automatically recover if possible.
- Request an update of the status bar on the HMI.

9.6 Communications Access

Requirement: The HMI shall provide secure login for any remote or local access communications (for example SSH, FTP, SFTP, SCP)

Requirement: The V-ITS-S privacy related data shall be developed in accordance with, and with due regard to, AS ISO/IEC 27001.

9.7 Radio Performance

Requirement: The V-ITS-S equipment shall provide ITS-G5 communications of a high probability of transmission success over 300 meters line of sight and under vehicle traffic conditions. ITS-G5 communication performance shall be tested and subject to the approval of the Principal.

10 Electrical Requirements

10.1 Connection to Vehicle Battery System

Requirement: All equipment shall operate on a nominal 12V DC voltage capable of withstanding battery output voltage from 11.5V to 30V.

Requirement: Maximum power load of the V-ITS equipment shall be no greater than 50W.

Requirement: The V-ITS-S are powered by a relay activated circuit driven by the ignition circuit of the vehicle. This will energise on start-up of the vehicle and de-energise on switch off of the vehicle. The V-ITS-S shall safely start-up and shut-down. Additional electrical equipment required to manage start-up or shut-down beyond a standard automotive relay shall be provided by the Contractor. The V-ITS-S and all associated equipment (including HMI) shall draw less than 300mW for low power "standby" needs if a direct connection to the vehicle battery is used.

10.2 Electrical Safety

Requirement: All electrical equipment shall be in accordance with Electrical Legislation. The equipment shall not suffer damage if any of the terminations are open circuited, short circuited or disconnected while energised.

Requirement: All V-ITS-S equipment shall comply with the requirements of AS/NZS 60950.1.

Requirement: Telecommunication and radio equipment shall comply with the relevant regulatory requirements and standards of Australian Communications and Media Authority (ACMA).

Requirement: Electromagnetic interference produced by the equipment shall not exceed the limits prescribed in AS 1044:1995 and by the ACMA. Equipment shall be immune to electromagnetic interference from other sources.

11 Mechanical and Physical Requirements

11.1 Environmental Conditions

Requirement: The V-ITS-S and associated equipment shall be capable of continuous, normal operation in the conditions described below:

- installed directly in sunlight (excluding the V-ITS-S itself which is mounted within the vehicle, away from direct sunlight)
- enclosure air temperature between -5°C and 75°C
- ambient ground temperature not exceeding 40°C
- maximum wind conditions and vehicle speeds likely to occur
- Queensland coastal environment with salt deposit densities in the range of 2.0 to 3.0 g/m^2
- a humidity of up to 95% non-condensing
- conditions, both permanent and temporary, that may be unique to the specified location for the trial
- vibrations reasonably expected in the installed location
- IP40 rating for equipment installed inside the vehicle, IP66 for equipment installed external to the vehicle.

Equipment operation shall cause no adverse effect on the vehicle environment in which it is installed. Likewise, Equipment shall not be affected by adverse environmental conditions to be expected.

11.2 V-ITS –S Enclosure

Requirement: The V-ITS-S Enclosure shall satisfy the following minimum requirements:

- Maximum physical Dimensions of 240mmx170mmx55mm (LxWxH)

Alternative dimensions to those stated above will be subject to approval by the Principal

Requirement: The enclosure shall be robust to minimise the risk of physical damage to the equipment.

Requirement: Tamper detection security labels shall be used on potential access points of the enclosure.

11.3 V-ITS-S Antenna

Requirement: The V-ITS-S antennae shall satisfy the following minimum requirements:

- IP 66 for equipment installed external to the vehicle.
- Maximum physical Dimensions of 240 mm x 120 mm x 100 mm (LxWxH)
- Suitable for mounting on the roof of the vehicle via mounting assembly such as a roof rack or similar to be confirmed prior to installation
- The V-ITS-S antenna shall be optimised for the Telstra frequency bands.
- The V-ITS-S antenna shall meet the required specification to support the system requirements as outlined in Section 5 of this document. This includes the requirements for ITS-G5, Cellular 3G/4G and GNSS communications.

Alternative dimensions to those stated above will be subject to approval by the Principal.

11.4 Cabling Requirements

Requirement: Physical interconnections shall be captive, (in the following order of preference):

- manual “click” type (such as retention clips), and
- screw-type.

Requirement: Antenna (ITS-G5, GNSS) cabling shall be optimised (install and performance factors) in length up to a maximum of 5 metres. All other cables shall be capable of normal operation at 10 metres in length, but may also be shortened to a suitable length for installation as agreed between the Supplier and Customer.

12 Installation

The following requirements apply in regards to the installation of the V-ITS-S equipment.

12.1 Initial Configuration

Requirement: The V-ITS-S shall provide for the initial configuration of key parameters, applications, management and security functions of the V-ITS-S. Typical initial configuration activities include but are not limited to:

- Configuration of key configurable parameters relating to applications, use cases, management function, data logging, control, configuration and security functions
- Setting of Unique station ID
- SMCS Bootstrapping
- Pairing of HMI to V-ITS-S
- MQTT service configuration including client, endpoints and global topic.

Requirement: The V-ITS-S shall be configured with an Amazon Web Services (AWS) Internet of Things (IoT) certificate.

12.2 Vehicle Size Configuration

Requirement: The V-ITS-S shall have configurable parameters to define:

- the length of the vehicle
- the width of the vehicle
- X and Y offset adjustment to allow for accurate positioning of the V-ITS-S GNSS antenna.

Requirement: These parameters shall be used when defining the vehicle’s position relative to other vehicles and infrastructure.

13 Performance Requirements

Requirement: The V-ITS-S shall meet the vehicle thresholds defined in Table 13-1.

Table 13-1 – Performance Measures

Requirement	Value	Description
Position Detection Rate	10Hz	The System shall determine the position of the vehicle at a nominal rate of 10 Hertz and the Coordinated Universal Time (UTC) when at that position.
Time Accuracy	1ms	The UTC-conformant output of the reference clock shall be accurate to within 1 millisecond of the UTC reference.

Requirement	Value	Description
		The System shall determine the time at which position is determined, using the UTC-conformant reference.
Data Rate	6Mbps	The System shall transmit CAMs on channel 180 with 10 MHz channel spacing The System shall transmit CAMs using a data rate of 6 Mbps.
CAM Rate Tolerance	10ms	After the first CAM generated after System station startup, the System shall generate each subsequent CAM within +/- 10 ms of its scheduled generation time
Maximum Position Age	150ms	The time represented by the value of GenerationDeltaTime shall be the time from the reference clock at which the vehicle position, velocity, and acceleration data contained in the CAM was determined by the System. In order to ensure the transmitted information is current, the difference between TAI at which the CAM is generated, and the time represented by the value of GenerationDeltaTime shall be less than 150 ms.
Speed Accuracy	1kph	The Speed data shall be accurate to within 1 kph of the actual vehicle speed over 68% of test measurements, under Open Sky Test Conditions
Heading Accuracy	3deg	Heading data shall be accurate to within 3 degrees of the actual vehicle heading over 68% of test measurements when the vehicle speed is greater than 45 kph under Open Sky Test Conditions.
Acceleration Accuracy	0.3m/s ²	longitudinalAcceleration and lateralAcceleration data elements shall be accurate to within 0.3 meters/second ² of the actual vehicle longitudinal acceleration and lateral acceleration, respectively, over 68% of test measurements under Open Sky Test Conditions and flat road test conditions.
Yaw Rate Accuracy	0.5deg/s	The yawRate data element shall be accurate to within 0.5 degrees/second of the actual vehicle yaw rate over 68% of test measurements under Open Sky Test Conditions and flat road test conditions.

14 Key Configurable Parameters

Requirement: The following parameters shall be configurable within the V-ITS-S.

Table 14-1 – Software operation and maintenance parameters

Data Element Identifier	Use (M/O)	Format	Default Value	Description/purpose	Message Tree Reference
citsSoftwareEnabled	M	BOOLEAN	TRUE	Turn off ITS-G5 communications and logging back to C-ITS-F	scm- station
spmExceptionLoggingLevel	M	ENUM: critical(0), error(1), information(2), debug(3)	error(1)	Determines the verbosity of logging returned	scm- station
camDirection	M	BIT STRING {transmit(0),receive(1)}(SIZE(2))	11	BIT STRING 0: Transmit 0 – do not collect CAM content; 1 = collect CAM content; BIT STRING 1: Receive 0 – do not collect CAM content; 1 = collect CAM content	scm- station
denmDirection	M	BIT STRING {transmit(0),receive(1)}(SIZE(2))	11	BIT STRING 0: Transmit 0 – do not collect DENM content; 1 = collect DENM content BIT STRING 1: Receive 0 – do not collect DENM content; 1 = collect DENM content	scm- station
ivimDirection	M	BIT STRING {transmit(0),receive(1)}(SIZE(2))	11	BIT STRING 0: Transmit 0 – do not collect IVI content; 1 = collect IVI content BIT STRING 1: Receive 0 – do not collect IVI content; 1 = collect IVI content <i>Note: V-ITS-S will not typically transmit IVI</i>	scm- station
mapemDirection	M	BIT STRING {transmit(0),receive(1)}(SIZE(2))	11	BIT STRING 0: Transmit 0 – do not collect MAPEM content; 1 = collect MAPEM content BIT STRING 1: Receive 0 – do not collect MAPEM content; 1 = collect MAPEM content	scm- station

Data Element Identifier	Use (M/O)	Format	Default Value	Description/purpose	Message Tree Reference
				<i>Note: V-ITS-S will not typically transmit MAPEM</i>	
spatemDirection	M	BIT STRING {transmit(0),receive(1)}(SIZE(2))	11	BIT STRING 0: Transmit 0 – do not collect SPATEM content; 1 = collect SPATEM content; BIT STRING 1: Receive 0 – do not collect SPATEM content; 1 = collect SPATEM content <i>Note: V-ITS-S will not typically transmit SPATEM</i>	scm- station
storageThreshold	M	INTEGER (50..95)	85	station storage threshold above which an exception is reported	scm- station
dopThreshold	M	INTEGER (1..10)	4	Dilution of Precision (DOP) above which an exception is reported	scm- station
minNumberOfSatellitesThreshold	M	INTEGER (2..5)	4	As indicated in the NMEA GSA string. Required to achieve acceptable positioning accuracy	scm- station
participants	M	SEQUENCE SIZE(1..4)	-	Lists all participants with their identifiers	scm- station
hmiEnabled	M	BOOLEAN	TRUE	Used to override the HMI for control group/baseline participants.	scm- station
presentationTtl	M	INTEGER (1..2500)	2000	Time associated to each message sent to the HMI	scm- station
tileApproachBuffer	M	INTEGER (0..1000)	500	Distance prior to a tile boundary when new tile topics are subscribed to.	scm- station
collectAdr	M	BOOLEAN	FALSE	Additional logging information	scm- station
ucArIwEnabled, ucBoqEnabled, ucEeblEnabled, ucIvsEnabled, ucRhWEnabled, ucRwwEnabled, ucSsvEnabled, ucTwvrEabled	M	All BOOLEAN	TRUE	Turn on the use case application.	scm- station
ucArIwPresentation Enabled, ucBoqPresentation Enabled,	M	All BOOLEAN	TRUE	Allow the use case presentations to display on the HMI (if hmiEnabled is also true)	scm- station

Data Element Identifier	Use (M/O)	Format	Default Value	Description/purpose	Message Tree Reference
ucEebIPresentationEnabled, ucIvsPresentationEnabled, ucRhwPresentationEnabled, ucRwwPresentationEnabled, ucSsvPresentationEnabled, ucTwwrPresentationEabled					
tileSetVersion	M	ParameterVersionNumber	-	Unique identifier for the latest version of the tile set	scm- station
staticSpeedIvimSetVersion	M	ParameterVersionNumber	-	Unique identifier for the latest version of the static speed IVIM set	scm- station
csemCamLogLimit	M	INTEGER (1..600)	150	count of CAMs logged after which a CSEM is generated and logged	scm- station
csemDenmLogLimit	M	INTEGER (1..600)	150	count of DENMs logged after which a CSEM is generated and logged	scm- station
csemIvimLogLimit	M	INTEGER (1..600)	150	count of IVIs logged after which a CSEM is generated and logged	scm- station
csemMapemLogLimit	M	INTEGER (1..600)	150	count of MAPEMs logged after which a CSEM is generated and logged	scm- station
csemSpatemLogLimit	M	INTEGER (1..600)	150	count of SPATEMs logged after which a CSEM is generated and logged	scm- station
vitssSoftwareUpdate	M	HttpEndpoint	-	the location of a new software package	scm- station
vitssSoftwareCurrentVersion	M	IA5String(SIZE(1..32))	-	the version of the software required on the V-ITS-S (trigger to download if not matching)	scm- station
camRate	M	INTEGER(1..10)	10	Rate at which CAMS are produced by the station. Unit: times/seconds	scm- system
logFrequency	M	INTEGER(5..300)	60	Period for R-ITS-S and V-ITS-S to send time-aggregated messages (platform, behavioural, messages) to the C-ITS-F. Used to balance total	scm- system

Data Element Identifier	Use (M/O)	Format	Default Value	Description/purpose	Message Tree Reference
				message throughput and message size Unit: seconds	
csemLogWatchdog Timeout	M	INTEGER(1..1440)	10	if a CSEM has not been sent for this time a CSEM is sent with the current messages and counts	scm- system
logMessageRetentionWindow	M	INTEGER(1..1440)	1440	Period that the stations retain log data not uploaded to the C-ITS-F logging service. Used to allow log data to be uploaded after a 3G/4G communications outage.	scm- system
securityEnable	M	BOOLEAN	TRUE	Used to enable/disable C-ITS message signing.	scm- system
positionAugmentation	M	BOOLEAN	TRUE	Used to enable/disable augmentation provided by the C-ITS-F.	scm- system
scmsEA	M	HttpEndpoint	-	location of the enrolment authority	scm- system
scmsAA	M	HttpEndpoint	-	location of the authorisation authority	scm- system

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