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Project Specific Technical Specification

**Transport and Main Roads
PSTS018 IVS Use Case Specification –
In Vehicle Speed**

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Document control sheet

Contact for enquiries and proposed changes

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Version history

Version no.	Owner	Date	Nature of amendment
1.0	David Alderson	29/06/2018	Tender Issue
1.1	David Alderson	06/07/2019	Updates to match learnings from implementation
1.2	Zinah Tam	27/07/2020	Updated Table 7.1 to match final incorporation of HUET recommendations
2.0	Nicholas Brook	22/01/2021	Final clean up for external sharing, incorporation of actual ICVP deployed specification
2.1	Jian Qin	07/10/2021	System Architecture drawing update

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1 Introduction

The In-Vehicle Speed (IVS) use case specification is intended to provide vendors with details of the Ipswich Connected Vehicle Pilot (ICVP) specific implementation as a guide. It is not prescriptive or expected set of requirements for operation within any future TMR Cooperative ITS eco-systems, as use cases are expected to fall within the remit of original equipment manufacturers (car, application or device manufacturers).

This specification includes:

- Objectives, general operation and applicable scenarios;
- System components and data flows;
- Life cycles;
- High level HMI requirements;
- Data and message examples; and
- Data definitions.

2 Definition of terms

Table 2.1 – Acronyms

Acronym	Term
ASN.1	Abstract Syntax Notation One
C-ITS	Cooperative intelligent transport systems
C-ITS-F	Central ITS facility
FOT	Field operational test
HMI	Human machine interface
I2V	Infrastructure to Vehicle
ISO/TS	International Organization for Standardization Technical Standard
ITS	Intelligent transport systems
ITS-S	ITS station
IVIM	In-vehicle Information Message
IVS	In vehicle signage
PDU	Packet Data Unit
PSTS	Project Specific Technical Specification
R-ITS-S	Roadside ITS station
RTK	Real Time Kinematic
RZ	Relevance zone
SCMS	Security credential management system
TMR	Queensland Department of Transport and Main Roads
TSC	Traffic Signal Controller
UPER	Unaligned Packed Encoding Rules
V-ITS-S	Vehicle ITS station
VMS	Variable Message Sign
XML	eXtensible Markup Language

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.
AUSCORS	Australian Cross Origin Resource Sharing - the way that the NTRIP data is broadcasted by Geoscience Australia.
C-ITS-F	Back-end C-ITS Facility including C-ITS-S, 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 evaluation
FOT	Field Operational Test – the period when the in-vehicle C-ITS systems are operational and logging data
HMI Presentation Manager	Function of the V-ITS-S that arbitrates the information presentation requests to the HMI device
Region	Defined area of the HMI screen for presentation of a message
STREAMS	TMR's integrated ITS operating platform
Use case warning	A warning presented by the HMI when use-case applications are triggered

3 Reference documents

Table 3.1 – Referenced documents – External

Document ID	Document Name / Description
PD CEN ISO/TS 19321:2015*	Intelligent Transport Systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structure
ETSI TS 101 539-3 v1.1.1 (2013-11)	Intelligent Transport Systems (ITS); V2X Applications; Longitudinal Collision Warning (LCRW) application requirements specification

*A newer version has since been released and would need to be considered in future work for this use case.

Table 3.2 – Referenced documents – Internal

Document ID	Document Name / Description
PSTS002	V-ITS-S Equipment
PSTS003	HMI Equipment
PSTS006	Data Entity Catalogue
PSTS007	C-ITS Station Protocol Specification

4 Quality system requirements

4.1 Test Acceptance Criteria

For ICVP the V-ITS-S Vendor demonstrated compliance to this specification in accordance with the test acceptance phases defined in the *V-ITS-S Specification PSTS002*.

For each requirement, the selected test plan/s included criteria that clearly defines how each requirement is met to suitably integrate within the ICVP systems. Test plans at a minimum included; consideration of the primary and alternate scenario equivalents identified in this specification. Some circumstances including testing of other scenarios identified by the V-ITS-S Vendor or Principal as appropriate to prove; device, use case or system implementation.

Sample IVIMs for each type (static, school zone, roadworks and VSL) are provided in the sample data pack in the following encoding formats:

- a. UPER (encoded)
- b. JSON (decoded)
- c. XML

The data pack also contains the ASN.1 value notation that were used for each use case.

5 Overview

The In-Vehicle Speed (IVS) application provides an ongoing HMI representation of regulatory speed limits. IVS will typically be available on all roads within the ICVP area. The provided information is based on the situation, time, date and location. IVS messages will be generated from the following speed information:

- Static speed limits (source: Road Network Model, TMR created)
- School zone speed limit signs (source: School zone calendar, TMR created)
- Variable speed limits (source: STREAMS gateway, Transmax service)
- Roadworks speed limits (source: TMR RedCrab roadworks application)

Note: Roadworks speed limits are covered in more detailed PSTS015 RWW use case specification, however the IVIM components within this specification such as the method, message type and display rules all align with the IVS use case..

The IVS use case does not include:

1. Non-compliance warnings to over speed limit driving
2. Audio alerts for speed limits
3. Approaching speed limits (current relevant speed limits only)
4. General non-speed static road signage and Variable Message Signs (VMS) that form part of the road infrastructure that provide extra information

The above operations exclusions may be considered in the future and the ETSI standards allow for each.

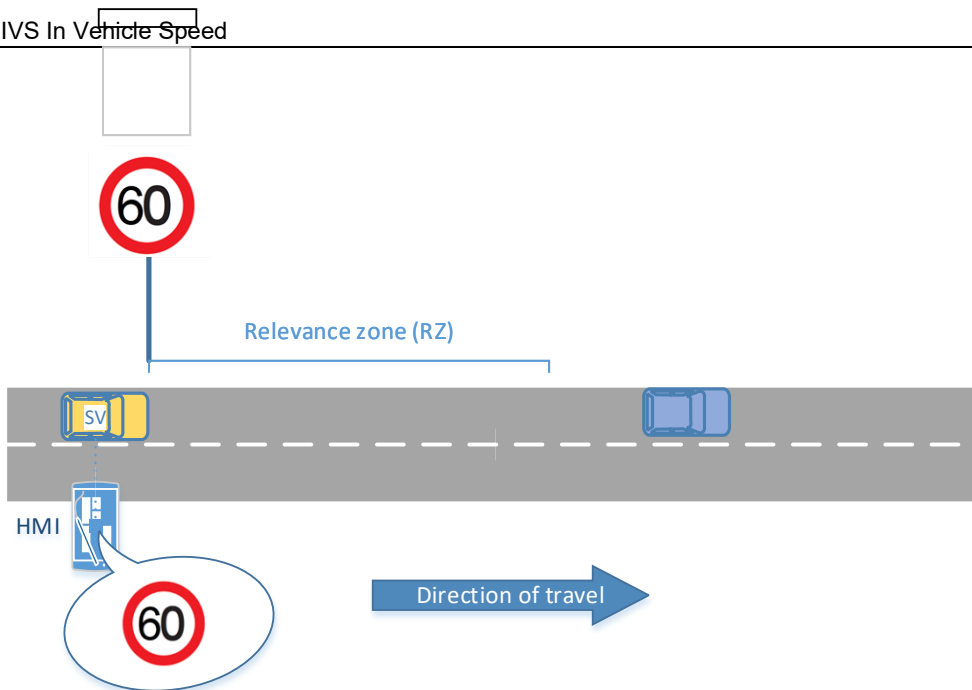


Figure 5.1 – IVS Operation

Requirement: The IVS application shall manage and display speed limit signage.

Requirement: The IVS application shall load and monitor IVIM for the current geo-tile which may contain between 500 and 2,800 IVIM at a given time.

Requirement: The IVS application shall be capable of handling up to 3 relevant and overlapping IVIM simultaneously.

Requirement: The current IVS with the lowest speed shall be prioritised.

5.1.1 Primary Scenario

In the primary scenario, a vehicle drives from one speed zone to a new speed zone. The speed section of the HMI displays 60 in the $RZ_{current}$ area, then 40 in the RZ_{next} area and 60 in the $RZ_{subsequent}$ area.

Note: for simplicity of display the IVIM relevance zones are displayed as polygons on the road segments, however the actual IVIM are line strings with detailed data for number of lanes and lane width that the vehicle uses to determine IVIM relevance to its location.

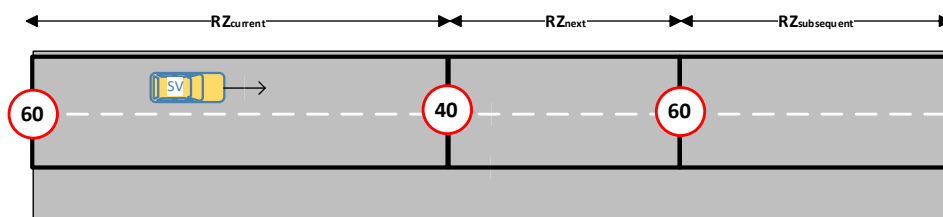
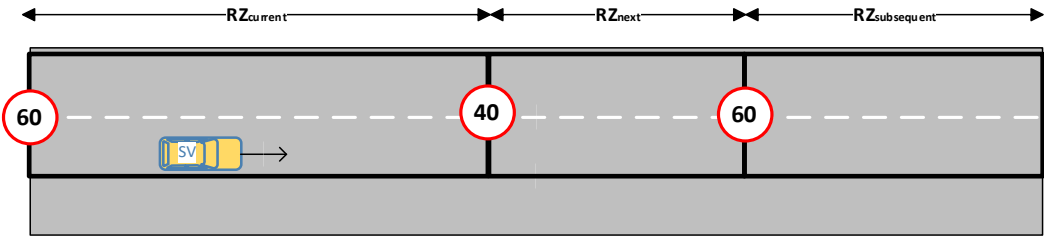
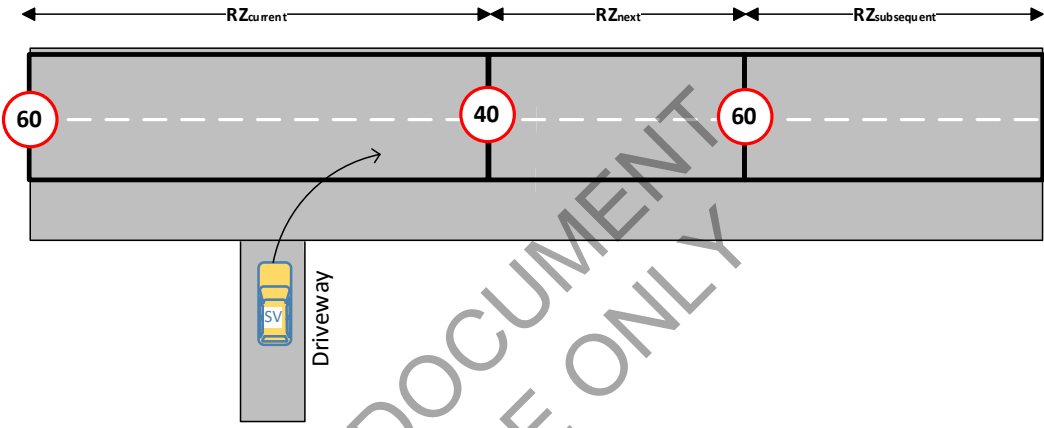
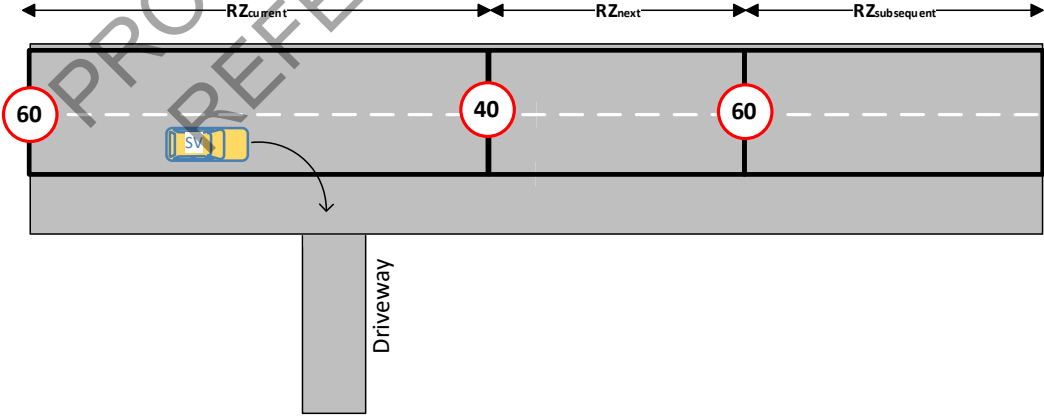


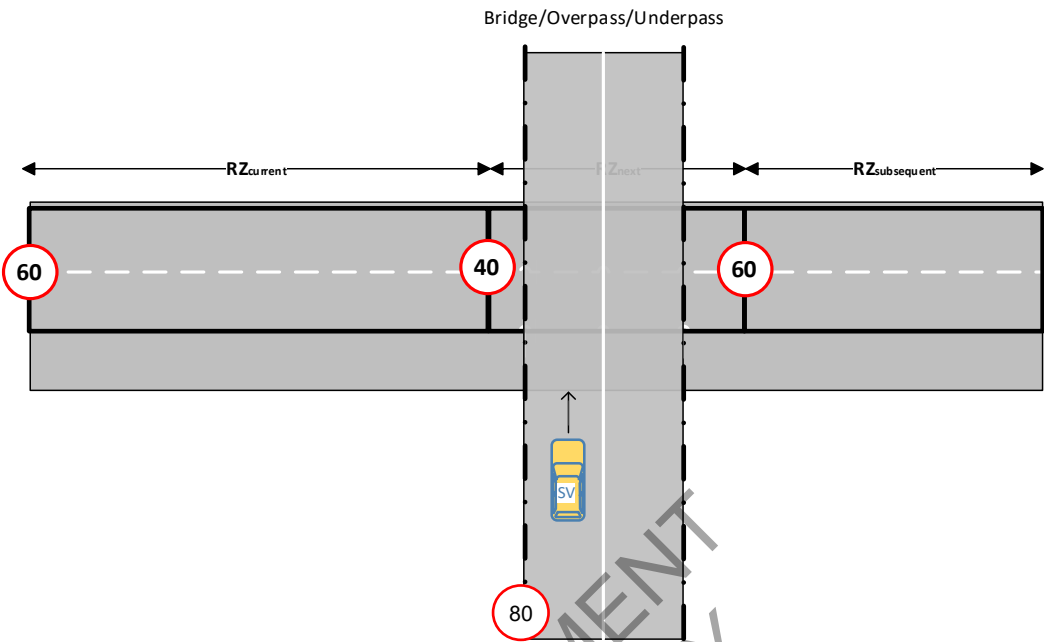
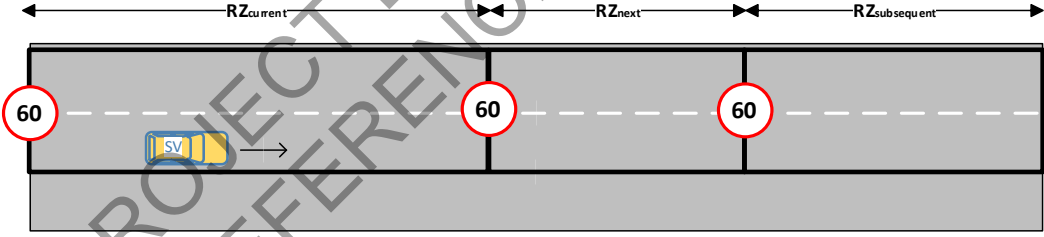
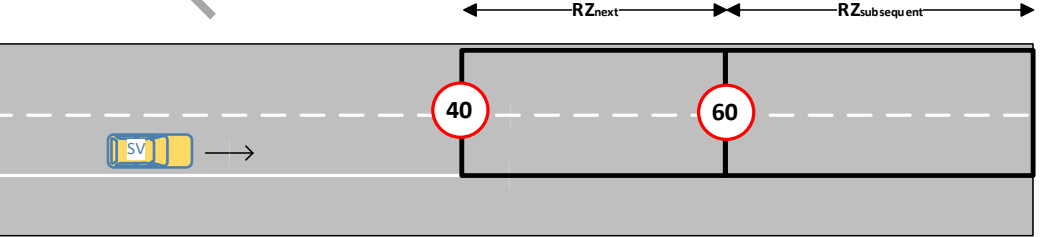
Figure 5.2 – In-Vehicle Speed Scenario

5.1.2 Scenario Equivalents

The following table describes the same primary scenario above but with several variants and the expected outcome.

Table 5.1 – Scenario Equivalents

Variant	Visualisation and Comment
<p>Any lanes that enter the RZ in the direction of travel</p>	 <p>HMI Speed Display: Yes, 60km/h</p>
<p>Vehicles entering the IVS from side roads</p>	 <p>HMI Speed Display: Yes, Blank then once the RZ is crossed and the direction (if applicable) is matched. In the example, 60 is displayed when RZ_{current} is entered</p> <p>Comment: The speed would display on the HMI when the position and direction is established in line with the IVS.</p>
<p>Vehicles leaving the IVS</p>	 <p>HMI Speed Display: Yes, 60km/h but then blank once vehicle leaves IVIM relevance.</p> <p>Comment: If entering a new IVS on the side road, the new speed should be displayed</p>

Variant	Visualisation and Comment
<p>The vehicle is driving on a bridge above the TV (in a different vertical plane)</p>	 <p>HMI Speed Display: Yes, the HMI displays the speed of the IVS on the bridge in this example 80km/h.</p> <p>Comment: This scenario should not display the lower speed on the below carriageway because the vehicle direction and elevation are not within configured tolerances.</p>
<p>New zone but no speed change</p>	 <p>HMI Speed Display: Yes. 60km/h display through all zones with no flicker at changeover.</p>
<p>No zone prior</p>	 <p>HMI Speed Display: Blank display until RZ reached</p> <p>Comment: This will typically of entering the pilot area</p>

5.1.3 IVIM Zones

There are four spatial zones defined in IVIM as shown in Figure 5.3. Due to the constraints of the data sources, it is not possible for the C-ITS-F to provide additional speed information such as speed ahead and advisory speeds. Therefore, only the Relevance Zone (RZ) will be used to display speed.

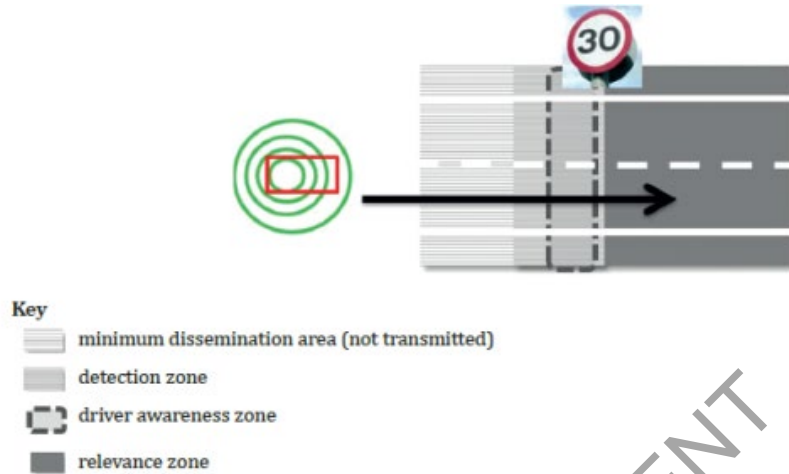


Figure 5.3 - Spatial validity for IVI: Detection and Relevance Zones (ISO/TS 19321:2015)

Requirement: The IVS application shall operate with use of Relevance Zone for speed zone areas and no other zones.

6 System Components

The IVS use case is an I2V application and as a result the primary path is through the input systems (static speed database and STREAMS) to the C-ITS-F and to the V-ITS-S (and HMI).

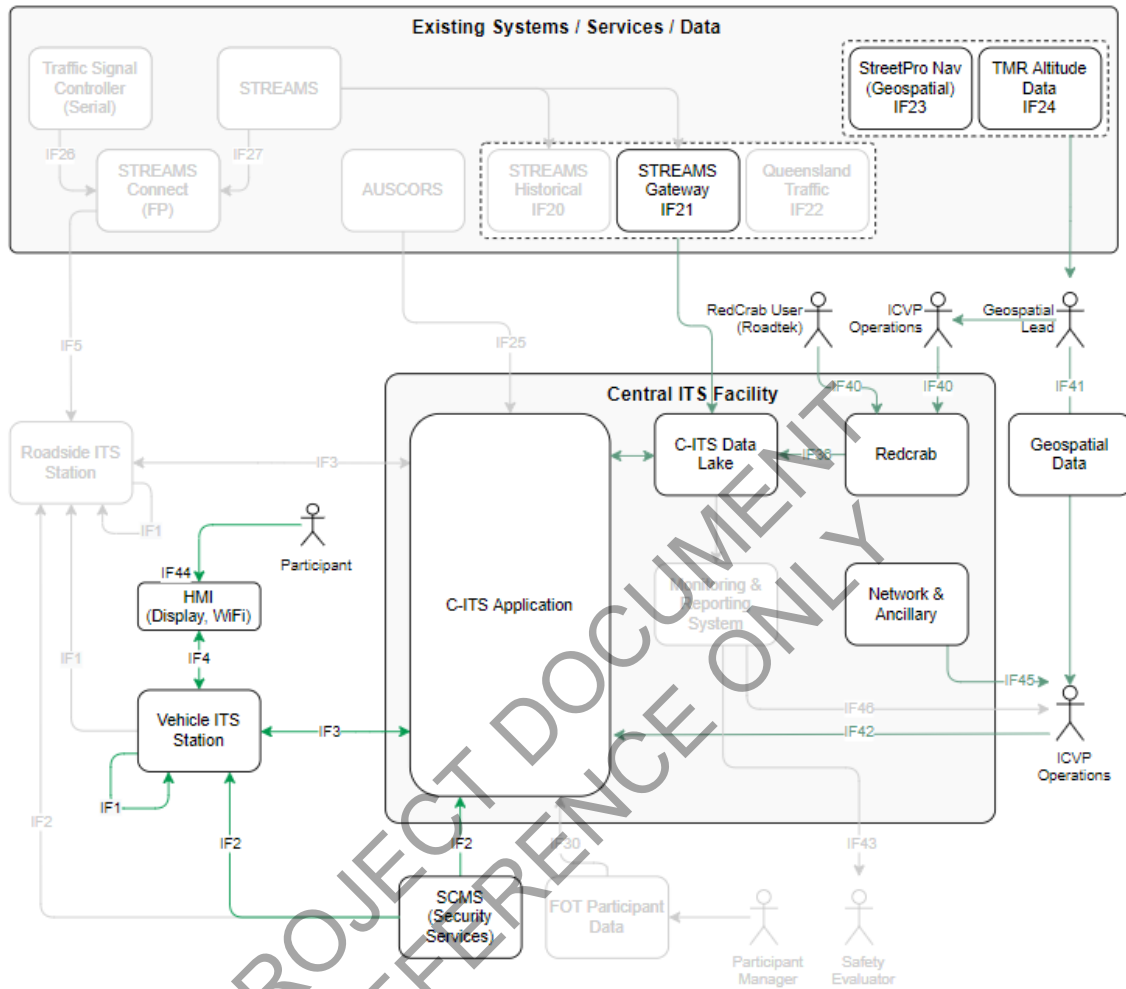


Figure 6.1 – System Architecture

The table below describes the system components that interact for the overall operation of the IVS application.

Table 6.1 – System Component Summary

Component	Role	Description	Detailed component lifecycle
V-ITS-S	Event Processor	The IVS use case application is performed in the V-ITS-S.	The process for managing the IVS use case is defined in section 7.1
HMI	Driver Interface	HMI must be on and able to interact with the V-ITS-S for display and status	HMI Warnings are defined in section 7.2
Static Speed Database	Data Source	Provides business as usual speed limits across roads identified in the C-ITS area	Not applicable. Managed by C-ITS-F
STREAMS	Data Source	Provides current speed limits for variable speed limit sites.	Not applicable. Managed by C-ITS-F
SCMS	Enabler	Provide secure communications	Defined in <i>C-ITS-S Station Protocol Specification PSTS007</i>
C-ITS-F	Enabler and Monitoring	Manages speed limit updates from STREAMS and speed databases (static and internal school zone register) and provides current speed limits to V-ITS-S. Interface for monitoring and use case data logging.	Defined in <i>V-ITS-S Specification PSTS002</i>
AUSCORS	Positioning Augmentation	Provides data to the V-ITS-S through the C-ITS-F that allows greater positioning accuracy for the operation of the use case	Defined in <i>V-ITS-S Specification PSTS002</i>
FOT	Evaluation	Evaluation of use case event log data	Not applicable. Managed by C-ITS-F
RWW Database	Data entry/source	This database is populated through the Red Crab App, the tool to be used for configuration of roadworks site data.	Not applicable. Managed by C-ITS-F

Requirement: The V-ITS-S shall meet the requirements of *V-ITS-S Specification PSTS002* as a basis for enabling the IVS use case operation. Communications between components using 3G/4G are detailed in *V-ITS-S Specification PSTS002* including communications interface, security management, speed message management and protocols to enable the data transfers described in Figure 6.2.

Requirement: The HMI shall meet the requirements of *HMI Specification PSTS003* as a basis for enabling the IVS use case speed updates.

6.1 Typical Process Flow

The process flow for the IVS event is shown in Figure 6.2. This describes the normal process for the event through the relevant system components. The component lifecycles in section 7 describe the detailed creation, management, validation and completion states of the use case (Note: FOT uses an independent process flow to the C-ITS-F and are therefore not included in this use case process flow). The second stage of Figure 6.2 in which the V-ITS-S retrieves speed information from the C-ITS-F shall be managed in accordance with the *C-ITS Protocol PSTS007* where infrequently changing static speed limits have a version check to ensure an update is not required, but dynamic speed limits are retrieved each time.

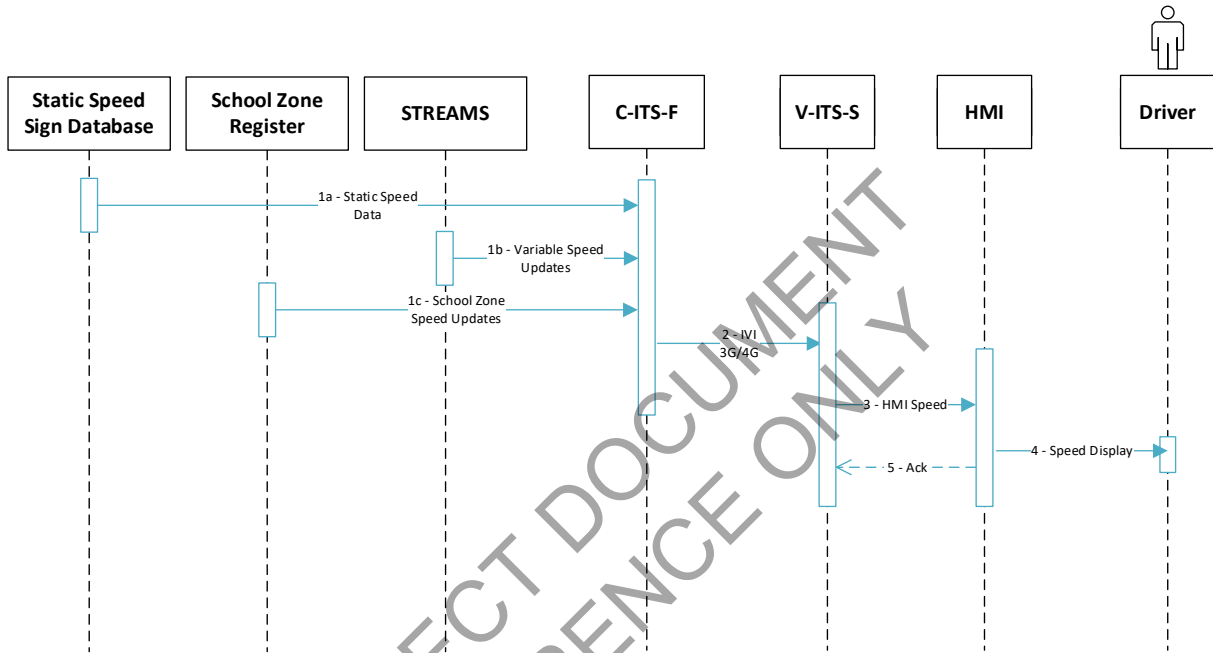


Figure 6.2 – Typical Flow of Data

7 Life Cycles

The IVS event is identified and generated in the V-ITS-S application. Therefore, the event life cycle for this use case matches the V-ITS-S application lifecycle.

7.1 V-ITS-S Application Lifecycle

The following diagram shows a process flow expected from the V-ITS-S to receive IVIM and determine use case behaviour.

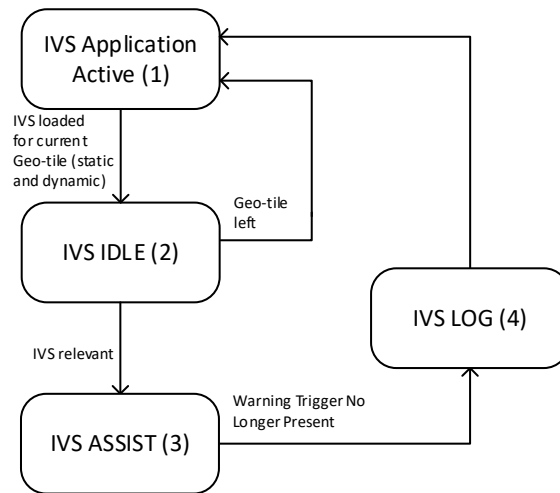


Figure 7.1 – V-ITS-S Lifecycle (modified from ETSI 101 539-03:2013)

Requirement: The V-ITS-S shall apply the lifecycle states and transitions in the use case application (or proven equivalent operation) as defined in Figure 7.1. A critical failure (as defined by the V-ITS-S Vendor) in any state or transition shall cause the application to attempt to restart from state (1) to continue normal operation.

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Requirement: The IVS application shall start up if enabled (see *uclvsEnabled* (State 1) in *V-ITS-S Specification PSTS002* for application enabling and disabling), compare static IVIM versions (updating if required) and request all dynamic IVIM for the current geo-tile from cellular connection to the relevant MQTT topic and maintain a subscription to the message topics (see *C-ITS Station Protocol PSTS007*).

Requirement: The IVS application shall receive and maintain the IVIM for the current geo-tile and update with new IVIM when entering new geo-tiles. IVIM received (see *V-ITS-S Specification PSTS002* for requirements of geo-tile and C-ITS-F data transfer) (Transition 1 to 2)

Requirement: IVS application shall assess current vehicle location against the list of current geo-tile IVIM including neighbouring tiles within a configurable buffer (default 500m). (State 2)

Requirement: If the vehicle leaves the geo-tile (greater than 500m) and therefore the current geo-tile IVIM are outside of the vehicle's driving path the application may discard that list of dynamic geo-tile IVIM. (Transition 2 to 4)

Requirement: The speed limit shall be active if the vehicle location enters the RZ of an IVIM. (Transition 2 to 3)

Requirement: The IVS application shall request the appropriate speed display as defined in section 7.2 to the HMI presentation manager detailed in *V-ITS-S Specification PSTS002*¹. The IVS application shall monitor acknowledgements and the status of the HMI while the speed display request is active. (State 3)

Requirement: The IVIM speed display request shall be cleared if the vehicle location exits the RZ of the IVIM. (Transition 3 to 4)

Requirement: The IVS application shall log event information in accordance with *V-ITS-S Specification PSTS002* and send to C-ITS-F on 3G/4G. (State 4)

Requirement: The IVS application shall confirm the event is logged and event completed. (Transition 4 to 1)

7.2 HMI Speed Display








The HMI speed display provides an informative message to the driver of the current speed limit.





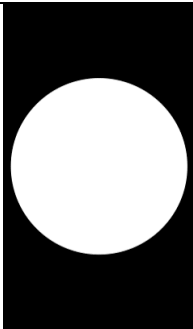
Requirement: The HMI shall display the speed image based on the information presented in Table 7.1. The HMI speed shall display in accordance with *HMI Specification PSTS003*. The speed display requested from the IVS application shall be through the HMI presentation manager (defined in *V-ITS-S Specification PSTS002*).

¹ The HMI presentation manager provides a single point of control for managing, prioritizing and logging all driver alerts including all use case warnings, speed limits and system status.

Requirement: The V-ITS-S and HMI shall allow image configuration updates based on the HMI Speed ID.

Table 7.1 – HMI Speed Display Lookup

HMI Speed ID	IVIM Speed Identifier Field	Image
IVS_10	10	
IVS_20	20	
IVS_30	30	
IVS_40	40	
IVS_50	50	
IVS_60	60	
IVS_70	70	

HMI Speed ID	IVIM Speed Identifier Field	Image
IVS_80	80	
IVS_90	90	
IVS_100	100	
IVS_110	110	
IVS_UNKNOWN	255	

7.3 Continuity

Requirement: IVS shall be capable of being updated dynamically regardless of the vehicle's location being in the RZ or outside of the immediate IVIM region. If the IVS being updated is currently displayed on the HMI, the new speed limit shall automatically be displayed.

Requirement: If a vehicle exits an IVS zone and does not within one (1) second* enter a new IVS zone (or roadworks zone), the HMI speed display shall return to the default state of IVS_UNKNOWN.

*This change was added to reduce flickering and slight difference between IVS dataset locations, positioning and physical sign location.

8 Key Configurable Parameters

Requirement: The following key configurable parameters shall be configurable from the C-ITS-F in accordance with *V-ITS-S Specification PSTS002*. These parameters shall be used through the use case to allow adjustments to the operation and timing.

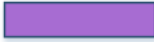





Table 8.1 – Key Configurable Parameters

Reference Clause	Description	Unit	Factory Default	Min	Max	Device(s), systems affected	DENM
7.2	Images per HMI Speed ID	N/A	-	-	-	V-ITS-S	

Note: a value of 0 disables the function associated with the parameter.

9 Data Definitions

The IVIM structure in Figure 9.1 describes the overview of the IVS IVIM structure which is subsequently detailed in data element level in the *Data Entity Catalogue PSTS006*. The message structure identifies the following data components:

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

Requirement: The IVS application shall use IVIM data elements in accordance with the *Data Entity Catalogue PSTS006*.

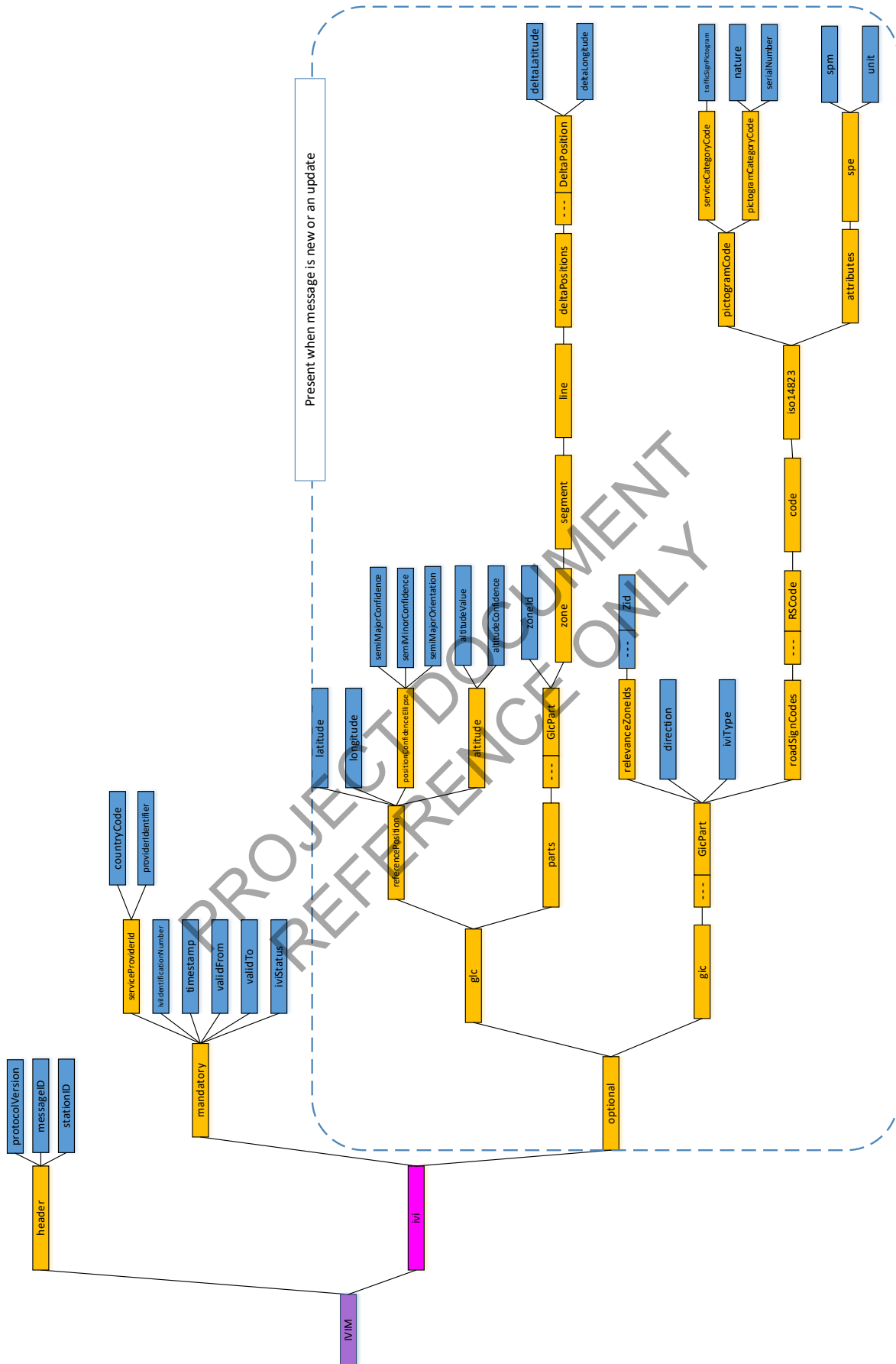


Figure 9.1 – IVS IVIM Message Structure

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