



# **C-ITS SERVICE AND USE CASE DEFINITIONS**

**SIGNALISED INTERSECTIONS (SI)  
[C-ROADS SUD05]**

**VERSION 3.0.0**

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# Introduction

The document ‘Service and Use Case Descriptions 01 Intro Document’ [C-Roads SUD01] explains the structure of the service and use case descriptions harmonized in C-Roads. Also, it gives an overview of all harmonized service and use cases and in which document they are described. Each service and its use cases are described in a separate chapter in a separate document. Together, these documents form the integral deliverable of the service and use case descriptions.

All References (in square brackets) refer to the global reference document [WG2 REF], which is part of the whole set of documents of a specific C-Roads release.

## 5. Signalised Intersections (SI)

### 5.1 SI: Service introduction

Service introduction	
Summary	This service will provide information to drivers and vehicle data to traffic light controllers for a safe and efficient approach and crossing of signalised intersections. The implementation of the infrastructure-based intersection use cases will increase the safety and efficiency of traffic flow and minimise environmental pollution at signalised intersections.
Background	Intersections can be complex traffic environments where traffic flow can be affected negatively by various traffic aspects. Additionally, intersections are also areas with higher risks of accidents, because of conflicting traffic streams. Also, emissions are higher due to stops and acceleration. For these reasons C-ITS services that allow a smooth passing of one or more intersections with a constant speed for a large number of drivers decrease negative effects of urban traffic.
Objective	More attentive driving while approaching and passing an intersection by providing in-vehicle information, speed advice and priority to designated vehicles (e.g. public transport, emergency vehicles, heavy goods vehicles, etc.), resulting in better energy efficiency and increased road safety.
Expected benefits	Enhanced safety for emergency vehicles as conflicting traffic streams can be stopped and drivers can cross the road with less risk.
Use cases	<ul style="list-style-type: none"> <li>○ Signal Phase and Timing Information (SI – SPTI)</li> <li>○ Green Light Optimal Speed Advisory (SI – GLOSA)</li> <li>○ Imminent Signal Violation Warning (SI – ISVW)</li> <li>○ Traffic Light Prioritisation (SI – TLP)</li> <li>○ Emergency Vehicle Priority (SI – EVP)</li> <li>○ Toll Station Crossing (SI – TSC)</li> </ul>

## 5.2 SI: Use Cases

### 5.2.1 SI – Signal Phase and Timing Information (SI-SPTI)

Type of road network	Intersections
Type of vehicle (receiver)	All
Use case introduction	
Summary	In this use case, drivers approaching and passing signalised intersections are provided with information about the current signal phase as well as upcoming phase(s) and the moment these are expected to start and end.
Background	Intersections cause delays and stops, which have a negative effect on environmental pollution and traffic safety. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights can be provided to drivers to optimise their driving speed and to eliminate inefficiencies.
Objective	Enabling drivers to adapt their driving behaviour to the time they have left until the next traffic signal phase in order to minimise sudden stops, deceleration, and acceleration (delay), resulting in better safety, throughput and sustainability.
Desired behaviour	Drivers can adapt their speed while approaching a signalised intersection or they can turn off their engine when stopping before a red phase.
Expected benefits	The expected benefits are increased awareness of traffic lights and their phase changes, and more efficient and effective driving behaviour while approaching or waiting at signalised intersections with fewer stops, reducing emissions, anger and aggressiveness and increasing safety.
Use case description	
Situation	A V2X-equipped vehicle approaches an I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights, as well as a road topology for the intersection ahead, periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> Defines policy and traffic light infrastructure (i.e., traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology).</li> <li>○ <b>Road operator:</b> Ensures coordination of signalised intersections and provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> </ul>

	<ul style="list-style-type: none"> <li>○ <b>Service provider:</b> Disseminates signal phase and timing information to drivers.</li> <li>○ <b>Drivers:</b> Receive signal phase and timing information and adapt their driving behaviour according to this information.</li> </ul>
Use case scenario	<p><u>Case 1: Vehicle approaches a green traffic light</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current green phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to red information and uses that to determine its trajectory towards the intersection.</li> </ul> <p><u>Case 2: Vehicle approaches a red traffic light</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current red phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location, velocity, and speed limit receives the messages and extracts the relevant time to green information and uses that to determine its trajectory towards the intersection.</li> </ul> <p><u>Case 3: Vehicle is stopped at red traffic light</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current red phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle extracts the relevant time to green information.</li> </ul>
Intended Presentation/Alert principle	<p>The signal phase and timing information needs to be provided to the drivers on an HMI early enough and should be moderately intrusive. The notification could be, for example, a traffic light symbol, countdown timer, sand glass, alert to turn off the engine or an alert to prepare for green. The presentation of signal phase and timing through the HMI should be done in a way that discourages drivers from increasing their speed beyond the speed limit or to depart before the start of the green phase. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints / dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high quality information.</li> <li>○ The signal phase state as indicated by the physical signal heads shall always outweigh the information provided in the vehicle.</li> <li>○ Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle</li> </ul>

	information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.
Link to other use cases	This use case is the basis for SI-GLOSA.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>The SPATEM and MAPEM messages for SI – SPTI are profiled in chapter 4.2.3 of [C-Roads MP].</li> <li>The data frame ‘speeds’ is not used in this use case.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>serviceType = SI-SPTI</li> <li>messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document “C-ITS Test Plan” [C-Roads_TP].</p>



## 5.2.2 SI – Green Light Optimal Speed Advisory (SI-GLOSA)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, drivers will be provided with speed advice information for a safe and efficient approach and crossing of signalised intersections.
Background	Intersections cause delays and stops, which have a negative effect on environmental pollution and traffic safety. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights as well as speed advisory can be provided to drivers to optimise their driving speed and to eliminate inefficiencies.
Objective	Calculating a speed advice for one or multiple intersections, enabling drivers to adapt their approaching speed and to pass one or more signalised intersections safely, sustainably, and in an energy efficient manner (e.g. by minimizing stops, acceleration and deceleration).
Desired behaviour	Drivers can adapt their speed according to the speed advice while approaching, stopping and/or passing a signalised intersection or driving through a sequence of signalised intersections.
Expected benefits	The expected benefit is a smoother driving behaviour while approaching and passing a sequence of signalised intersections, which reduces stops, reduces emissions and increases safety.
<b>Use case description</b>	
Situation	<p><u>Single intersection:</u></p> <ul style="list-style-type: none"> <li>○ A V2X-equipped vehicle approaches a single I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead periodically and in real-time.</li> </ul> <p><u>Sequence of intersections:</u></p> <ul style="list-style-type: none"> <li>• A V2X-equipped vehicle approaches a sequence of I2V-enabled signalised intersections, which transmit the current phase state and predicted timing of the traffic lights and road topology for the intersection(s) ahead periodically and in real-time.</li> </ul>
Logic of transmission	I2V

Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> Defines policy and traffic light infrastructure (i.e., traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology).</li> <li>○ <b>Road operator:</b> Ensures coordination of signalised intersections and provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> <li>○ <b>Service provider:</b> Calculates speed advice and disseminates this information to drivers.</li> <li>○ <b>Drivers:</b> Receive speed advisory information and adapt their driving behaviour according to this information.</li> </ul>
Use case scenario	<p><u>Scenario 1a: Vehicle calculates speed advice</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection transmits the current phase state and timing of upcoming phase changes of the traffic lights periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates the optimal speed advice for approaching the intersection.</li> </ul> <p><u>Scenario 1b: Infrastructure calculates speed advice</u></p> <ul style="list-style-type: none"> <li>○ The I2V-enabled signalised intersection calculates and transmits advisory speed information for multiple road segments of the approach of the intersection periodically and in real-time. The V2X-equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the optimal speed advice for approaching the intersection.</li> </ul> <p><u>Scenario 2: Green wave speed advice</u></p> <ul style="list-style-type: none"> <li>○ A sequence of I2V-enabled traffic light-controlled, synchronised intersections transmit a pre-defined/planned green wave speed advice. The V2X-equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and extracts the green wave speed advice for passing the intersections.</li> </ul>
Intended Presentation/Alert principle	<p>The speed advice information needs to be provided to the drivers through an HMI early enough, shall be moderately intrusive, and could be a speed value, a speed range, a driving indication like slow down, or something else. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints / dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high quality speed advisory.</li> <li>○ The signal phase state as indicated by the physical signal heads always outweigh the information provided in the vehicle.</li> <li>○ Traffic conditions, e.g., queues or traffic jams, affect the validity of speed advice information and therefore shall be considered.</li> </ul>

	<ul style="list-style-type: none"> <li>○ A speed advice shall never exceed the legal speed limit.</li> <li>○ Public Transport Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	Based on SI-SPTI
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SPATEM and MAPEM messages for SI-SPTI are profiled in chapter 4.2.3 of [C-Roads MP].</li> <li>○ For this use case: <ul style="list-style-type: none"> <li>○ MAPData / intersections / intersectionGeometry / speedLimits (when available), SPAT / intersections / intersectionState / states / state-time-speed / MovementEvent / timing and SPAT / intersections / intersectionState / states / maneuverAssistList / ConnectionManeuverAssist / queueLength (when available) are key information to deliver a good speed advisory.</li> </ul> </li> <li>○ For scenarios 1b and 2, speeds is mandatory, as are the AdvisorySpeed data elements type, speed, confidence, distance.</li> <li>○ The data frame speeds is not used in scenario 1a.</li> <li>○ The data element type of AdvisorySpeed must be set to greenwave (1) for scenario 2 and set to ecoDrive (2) for scenarios 1b.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p>

Test and validation requirements	<ul style="list-style-type: none"> <li>○ serviceType = SI-GLOSA</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p> <p>The document “C-ITS Cross-Border Testing and Validation Concept” [C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document “C-ITS Test Plan” [C-Roads_TP].</p>
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### 5.2.3 SI – Imminent Signal Violation Warning (SI-ISVW)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, drivers approaching signalised intersections will be provided with imminent signal violation warnings.
Background	Signalised intersections can be complex traffic environments, and occasionally drivers do not stop for a red traffic light, intentionally or unintentionally. At signalised intersections, actual and/or predicted information on the phases and timing of traffic lights, as well as imminent signal violation warnings, can be presented to drivers to increase their awareness of red traffic lights and avoid red light violation.
Objective	Reducing the likelihood and severity of collisions and injuries at signalised intersections by warning the drivers of potential violations of a red intersection signal.
Desired behaviour	Drivers react to the imminent red light violation warning, stopping their vehicle in time to avoid red light violation or reducing their speed to minimise the impact of the red-light violation.
Expected benefits	The primary expected benefits are increased awareness of signal phases and their timing, less red-light violations and thereby less collisions at signalised intersections.
<b>Use case description</b>	
Situation	A V2X-equipped vehicle approaches an I2V-enabled signalised intersection, which transmits the current phase state and predicted timing of the traffic lights and road topology for the intersection ahead periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Road authority:</b> Defines policy and traffic light infrastructure (i.e. traffic light controller able to transmit current phase state and predicted timing of the traffic lights and road topology).</li> <li>○ <b>Road operator:</b> Provides access to signal phase and timing data.</li> <li>○ <b>Data provider:</b> Processes the signal phase and timing data.</li> <li>○ <b>Service provider:</b> Disseminates imminent red light violation warnings to drivers.</li> <li>○ <b>Drivers:</b> Receive imminent red light violation warning and adapts their driving behaviour according to this information.</li> </ul>
Use case scenario	The I2V-enabled signalised intersection transmits the current phase state and

	timing of upcoming phase changes of the traffic lights periodically and in real time. The V2X-equipped vehicle approaching the intersection, aware of its own location and velocity, receives the messages and calculates if red light violation is imminent.
Intended Presentation/Alert principle	The imminent red light violation warning needs to be provided to the drivers through an HMI early enough and shall be intrusive (e.g., supported acoustically). The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.
Functional constraints / dependencies	<ul style="list-style-type: none"> <li>○ Current signal phase state and timing of upcoming phase changes from the signalised intersection shall be sufficiently accurate and reliable to ensure high-quality red-light violation warnings.</li> <li>○ The time critical nature of this use case requires for a sufficiently low latency system implementation.</li> <li>○ The signal phase state as indicated by the physical signal heads always outweigh the information provided in the vehicle.</li> <li>○ Public Transport Prioritisation affects the validity of signal phase and timing information, thereby could negatively affect user acceptance.</li> <li>○ If red light violation is inevitable, another use case comes in play which ensures that other drivers are warned of the presence of a red-light violator at the signalised intersection.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	Based on SI-SPTI.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ SPATEM and MAPEM messages for SI-ISVW are profiled in chapter 4.2.3 of [C-Roads MP].</li> <li>○ The data frame 'speeds' is not used in this use case.</li> <li>○ One consistent SPATEM/MAPEM message per intersection shall be distributed for this use case</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology	For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.

requirements: ITS-G5	For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>○ serviceType = SI-ISVW</li> <li>○ messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document “C-ITS Test Plan” [C-Roads_TP].</p>

## 5.2.4 SI – Traffic Light Prioritisation (SI-TLP)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	In this use case, designated vehicles (e.g., public transport, heavy goods vehicles, etc.) are given priority over individual vehicles at signalised intersections to ensure on-time transportation schedules (e.g. bus, tram) and/or minimise emissions.
Background	To assure punctual transportation and minimise emissions, a prioritisation system for designated vehicles at signalised intersections is necessary. The prioritisation system will also make the use of public transport more comfortable and attractive to the public.
Objective	Interaction between designated vehicles and traffic light controllers (either local or central) to reduce the delay of designated vehicles at signalised intersections, thereby improve the efficiency of vehicle operations.
Desired behaviour	Designated vehicles (e.g., buses, trams, trucks) drive through an intersection without stopping at a red light or having to wait for green light and cross the intersection without any delays.
Expected benefits	<ul style="list-style-type: none"> <li>○ Minimum delay for designated vehicles at signalised intersections.</li> <li>○ Less emissions from designated vehicles.</li> <li>○ Improved punctuality due to reduced disturbance on branch lines.</li> <li>○ Increased attractiveness of public transport due to improved comfort.</li> <li>○ Improved efficiency of vehicle operations (e.g., same service quality with less vehicles or higher frequency with equivalent fleet).</li> <li>○ Improved choice of suppliers for fleet operators or public authorities due to standardised V2X solution for designated vehicle prioritisation systems.</li> </ul>
<b>Use case description</b>	
Situation	A V2X-equipped priority eligible vehicle approaches a signalised intersection which is equipped with a prioritisation system.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Priority eligible vehicle:</b> Transmits the priority request, receives priority status information and benefits from the priority.</li> <li>○ <b>Road authority:</b> Sets the priority policy.</li> <li>○ <b>Road operator:</b> Processes the priority request and implements the priority</li> </ul>



	<p>policy.</p> <ul style="list-style-type: none"> <li>○ <b>Fleet operator:</b> Determines if the designated vehicle is in time or delayed.</li> </ul>
Use case scenario	<p>The designated vehicle transmits a prioritisation request. The prioritisation system processes the request and either accepts (e.g., if the vehicle is behind schedule and/or eligible to get priority) or rejects (e.g., if other priorities are granted) the request, then gives feedback to the designated vehicle. If the request is accepted the vehicle gets "green light" with minimum delay at the stop line (e.g., by shortening "red phases" and extending "green phases"). After the vehicle has successfully driven through the intersection, the traffic light controller switches back to normal operation.</p>
Intended Presentation/Alert principle	<p>The driver of the designated vehicle receives information about the prioritisation status on an in-vehicle display, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, information on whether the request is accepted or rejected. In addition, time to green information may be presented to the driver. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints / dependencies	<ul style="list-style-type: none"> <li>○ The stationID of the vehicle shall not change during the processing of a prioritisation request.</li> <li>○ Authentication and authorisation of designated priority vehicles shall be ensured.</li> <li>○ Policy on vehicle prioritisation shall be defined, e.g., the level of priority, which vehicles and/or lines the priority applies to, the locations in which priority is available, etc.</li> <li>○ The priority request shall be provided in time to allow the prioritisation system to react on the request.</li> <li>○ Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	none
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SSEM and SREM messages for SI-TLP are profiled in chapter 4.2.4 of [C-Roads MP].</li> <li>○ As inBoundLane the data element 'connection' must be provided.</li> <li>○ As part of RequestorType the 'role' emergency (6) is reserved for Emergency vehicle Priority (SI-EVP).</li> </ul>
Security and data protection	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p>

requirements	An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SSEM/SREM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>• serviceType = SI-TLP</li> <li>• messageType = SSEM or SREM</li> </ul> <p>Geographic area (Quadtree) for SSEM/SREM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>

Test and validation requirements	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document “C-ITS Test Plan” [C-Roads_TP].</p>
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## 5.2.5 SI – Emergency Vehicle Priority (SI-EVP)

Type of road network	Intersections
Type of vehicle (receiver)	All
<b>Use case introduction</b>	
Summary	This use case will actively contribute to the phase control of a signalised intersection to aid the passage of an emergency vehicle (EV). It will also provide the prioritisation status to other users approaching and passing signalised intersections.
Background	Traffic light prioritisation for eVs can be distinctly different from normal traffic light prioritisation. Depending on intersection geometry, lanes other than those that the EV intends to use may be cleared, offering the EV an easier approach to and passage through the intersection. Moreover, drivers of other vehicles are often not aware that they can pass through a red light if an emergency vehicle (with sirens and light bar enabled) is approaching and there is no other way to clear a path. This results in drivers blocking the path of the emergency vehicle until the light turns green.
Objective	Interaction between eVs and traffic light controller(s) (either local or central) to reduce the time taken for eVs to cross signalised intersections and increase the safety of these crossings.
Desired behaviour	The traffic light control adapts its signal phases to give priority to the EV, allowing it to pass the signalised intersection safely and with minimum delay. The EV driver responds to the information on the prioritisation status (e.g., active and accepted) and if needed adjusts the EV path to the lane which will be cleared by the traffic light controller.
Expected benefits	Primarily expected benefits are a shorter travel time for EVs and a lower risk of collision. An additional benefit is the increased flexibility to alter the priority lane/signal and use different routes.
<b>Use case description</b>	
Situation	A V2X-equipped EV approaches an I2V-enabled signalised intersection that is serviced by an EV prioritisation system. The EV transmits the current position and the certified right of a prioritised passing at the intersection ahead periodically and in real-time.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ <b>Emergency vehicle:</b> Transmits the priority request, receives information about the priority status and gets prioritised passing at</li> </ul>

	<p>the intersection.</p> <ul style="list-style-type: none"> <li>○ <b>Road operator:</b> Processes the priority request and implements the priority policy at the signalised intersection.</li> <li>○ <b>Road authority:</b> Defines policy and traffic light infrastructure (i.e., assigns authorisation and acceptance of certification for EV prioritisation).</li> </ul>
Use case scenario	<p>The V2X-equipped vehicle approaching the intersection, sends the current position and the operational state periodically and in real-time. The I2V-enabled signalised intersection receives the prioritisation request and checks its validity. Depending on the position, the direction of travel, and the distance to the intersection, the traffic light phases are controlled so that conflicting traffic streams are stopped first, then taking into account minimum inter green times, all or selected lanes of the ingress approach of the EV get a green light and are cleared. Based on the prioritisation status information, the EV passes the intersection using the cleared lane(s). After detecting that the EV has successfully passed the intersection, the intersection control switches back to normal operation (i.e., starting with green light for conflicting lanes with high traffic).</p>
Intended Presentation/Alert principle	<p>The driver of the EV receives on an in-vehicle display information about the prioritisation status, early enough and in a moderately intrusive manner (at the vehicle manufacturer's and/or service provider's decision). For example, information on whether the request is accepted or rejected and what lane(s) will be cleared. A combination with the signal phase and timing service can give additional comfort. The HMI presentation sequence is at the vehicle manufacturer's and/or service provider's own responsibility.</p>
Functional constraints / dependencies	<ul style="list-style-type: none"> <li>○ The stationID of the emergency vehicle shall not change during processing of a prioritisation request.</li> <li>○ Authentication and authorisation of emergency vehicles shall be ensured.</li> <li>○ Policy on emergency prioritisation shall be defined, e.g., the level of priority, what locations, which lanes to clear, etc.</li> <li>○ The priority request shall be provided in time to allow the prioritisation system to react on the request.</li> <li>○ Traffic Light Prioritisation affects the validity of Green Light Optimal Speed Advisory, thereby could negatively affect user acceptance.</li> <li>○ How the information is presented to the drivers is not part of the service description. It is left to the provider of the in-vehicle information system with HMI how information is presented. Information might e.g., be translated to the preferred language of the driver.</li> </ul>
Link to other use cases	<p>This use case could simultaneously be implemented with the HLN-EPVA use case</p>

Interoperability Requirements	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SREM and SSEM message for SI-EVP are profiled in chapter 4.2.4 of [C-Roads MP].</li> <li>○ As inBoundLane the data element 'approach' must be provided.</li> <li>○ As part of RequestorType the 'role' must be set to emergency (6).</li> <li>○ As part of RequestorDescription, the data elements routeName, transitStatus and transitSchedule are not used in this use case.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>
Communication technology requirements: IP based	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SREM/SSEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>• serviceType = SI-EVP</li> <li>• messageType = SREM or SSEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterised by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
Test and validation requirements	<p>The document "C-ITS Cross-Border Testing and Validation Concept" [C-Roads_TV] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document "C-ITS Test Plan" [C-Roads_TP].</p>

## 5.2.6 SI – Toll Station Crossing (SI-TSC)

Type of road network	Motorways with a toll station with traffic lights and barriers
Type of vehicle	Automated vehicles (AVs)
<b>Use case introduction</b>	
Summary	After an automated driving system aims for a specific lane at a toll station with traffic lights, the road operator sends information about the topology of the road and the status of the traffic light and the barrier.
Background	In the development of automated vehicles, the automated passing of a toll station is a potential difficult hurdle to take. Once the vehicle has dealt with the choice of the lane, it needs to know the precise configuration of it and the state of both the traffic light and the barrier in order to cross the toll station safely. The information received in C-ITS is a complement to the on-board sensors, which may not be sufficient to deal with this complex situation.
Objective	The objective is to provide to the vehicle information about: <ul style="list-style-type: none"> <li>○ The topology of the road to safely drive towards the appropriate lane;</li> <li>○ The state of the traffic light and the barrier so that it can understand better the situation and determine whether it is allowed and safe to pass the toll gate or not.</li> </ul>
Desired behaviour	The automated driving system must take in consideration the topology information to drive safely towards the appropriate lane. It must then make the appropriate decision, e.g. slow down to a stop, remain stopped, start and pass the gate at the appropriate speed, or e.g. adjust speed and pass the gate at the appropriate speed.  Its decisions depend on both the information it receives through connectivity and the information it gets from its sensors, including the detection of obstacles that could prevent it from crossing other lanes or passing the gate.
Expected benefits	<ul style="list-style-type: none"> <li>○ Enhancement of capability to cross a toll station in automated mode, potentially less transitions of control.</li> <li>○ Enhanced traffic safety.</li> <li>○ Fluidity and comfort of the braking and acceleration going through the toll barrier.</li> </ul>
<b>Use case description</b>	
Situation	The automated vehicle is approaching the toll barrier knowing which lane it should go to and is able to proceed to the payment.
Logic of transmission	I2V
Actors and relations	<ul style="list-style-type: none"> <li>○ Road operator: the sender is the TCC or the Toll Management Center.</li> </ul>

Scenario	<ul style="list-style-type: none"> <li>○ Automated vehicle: end-user of the service.</li> </ul> <ol style="list-style-type: none"> <li>1. The automated vehicle approaches a toll station that has traffic lights and barriers, knowing which lane it wants to go to.</li> <li>2. The road operator sends the topology of the road upstream and downstream the barrier.</li> <li>3. The automated driving system adapts the trajectory and speed considering the received information and the intended lane.</li> <li>4. The road operator sends information about the status of the barriers (closed or open) and the traffic lights (green or red).</li> <li>5. The vehicle receives the information and processes it. The automated driving system makes the appropriate decision: slow down to a stop, remain stopped, start and pass the gate at the appropriate speed or adjust speed and pass the gate at the appropriate speed.</li> <li>6. The automated driving system adapts the trajectory and speed considering the received topology information and the intended direction to leave the toll station.</li> </ol>
Display / alert principle	The information may be displayed through the HMI, it is the manufacturer's choice to do so.
Functional Constraints / dependencies	<ul style="list-style-type: none"> <li>○ The automated driving system needs to know which toll gate it is concerned by.</li> <li>○ The cartography of the road configuration needs to be predefined and updated often enough by the road operator.</li> <li>○ Source of information: database of the road operator, up to date, holding the static and dynamic characteristics of the toll station</li> <li>○ The communication of this message will have to deal with network constraints. Latency must be short enough to let the automated driving system react in time</li> <li>○ Dependencies with the use case specifying "Toll Station Approaching". The IVI message specified in that use case should be technically specified and developed using the same lane configuration as the one used in the present use case.</li> </ul>
Link to other use cases	This use case is strongly linked to NG-TSA (Navigation Guidance - Toll Station Approaching) use case. These two use cases should work successively.
<b>Interoperability Requirements</b>	
Message profile requirements	<ul style="list-style-type: none"> <li>○ The SPATEM and MAPEM messages for SI-TSC are profiled in chapter 4.2.3 of [C-Roads MP].</li> </ul> <p>Regarding the MAPEM profile used for this use case:</p> <ul style="list-style-type: none"> <li>○ A toll station is an intersection topography so the DF intersections is used, and roadSegments is not used. In addition, every direction at the tolling station shall be encoded in a dedicated intersection and the numbering of the lanes (DE laneID) shall match the numbering in the IVI message sent at the same toll station when there is one (see Toll station approaching use case).</li> <li>○ The refPoint should be located at the centre of the toll station.</li> </ul>



	<ul style="list-style-type: none"> <li>○ LaneSet shall contain one ingress (lane upstream the barrier) and one egress lane (lane downstream the barrier) for each barrier. Thus, the number of lanes in laneSet shall include at least twice the number of toll lanes. It can also include the lanes and road boundaries, i.e. some types of lane objects used to separate traffic lanes, by using laneType "laneAttributes-Barrier".</li> <li>○ NodeList shall start at the toll barrier and end where the toll lanes merge to the motorway lanes for both ingress and egress lanes.</li> <li>○ Attributes are set to: <ul style="list-style-type: none"> <li>○ Indicate merging nodes at the end of tolling lanes in both ingress and egress direction,</li> <li>○ Enable/Disable lane changes at the approach of the tolling barrier.</li> </ul> </li> <li>○ dWidth should be used for nodes where physical road markings is present. It should not be used when no road marking exists.</li> <li>○ signalGroup is mandatory for this use case.</li> </ul> <p>Regarding the SPATEM profile used for this use case:</p> <ul style="list-style-type: none"> <li>○ The broadcast communication of this message will have to deal with network constraints. Latency must be short enough to let the automated driving system react in time.</li> <li>○ Possible values for eventState are: <ul style="list-style-type: none"> <li>○ Unavailable (0) if there is a problem for providing information,</li> <li>○ Stop-And-Remain (3) when the traffic light is red and the barrier down (crossing forbidden),</li> <li>○ Pre-Movement (4) when the traffic light is green and the barrier down (crossing forbidden),</li> <li>○ Permissive-Movement-Allowed (5) when the traffic light is red and the barrier up (crossing conditioned),</li> <li>○ Protected-Movement-Allowed (6) when the traffic light is green and the barrier up (crossing authorized).</li> </ul> </li> <li>○ minEndTime shall be set to 36001 when the end time of the current phase is unknown, which is usually the case for toll barriers traffic lights.</li> <li>○ maxEndTime, likelyTime, confidence and nextTime data elements are not used.</li> <li>○ Data frame speeds is not used.</li> </ul>
Security and data protection requirements	<p>Security requirements and specifications of certificates are described in [C-ITS Security Requirements and Specifications].</p> <p>An overall introduction to the common European trust model is described in [C-ITS Security and Governance] which is referring to the relevant ETSI standards for certificates and PKI management as the underlying technical basis.</p> <p><i>NOTE: The definition of relevant SSPs will be added in a later release.</i></p>
Communication technology requirements: ITS-G5	<p>For ITS-G5 based implementations of use cases where roadside stations are used, the requirements of [C-Roads RSP] shall apply.</p> <p>For ITS-G5 based implementations of use cases where mobile stations are used, the requirements of C-Roads, [C-Roads MSP] shall apply.</p>

<p>Communication technology requirements: IP-Based</p>	<p>For IP based implementations of use cases shared using backend communication, the requirements of [C-ITS IP Based Interface Profile] shall apply.</p> <p>For use cases based on SPATEM/MAPEM messages the AMQP filtering tables specified in chapter 3.3 of [C-ITS IP Based Interface Profile] shall apply:</p> <ul style="list-style-type: none"> <li>• serviceType = SI-TSC</li> <li>• messageType = SPATEM or MAPEM</li> </ul> <p>Geographic area (Quadtree) for SPATEM/MAPEM message, see appendix A of [C-ITS IP Based Interface Profile]:</p> <p>The event is characterized by its referencePosition, detectionZone(s), relevanceZone(s) and DestinationArea. These fields draw a geographic area and C-ITS actors shall publish in a set of tiles corresponding to the maximum set of tiles containing all the geographic indication mentioned.</p> <p>Please be aware that the exact details of the specification are defined in chapter 3.3 of [C-ITS IP Based Interface Profile].</p>
<p>Test and validation requirements</p>	<p>The document “C-ITS Cross-Border Testing and Validation Concept” [C-Roads_TVC] contains the generic applicable framework and process for interoperability testing.</p> <p>The applicable message and service generic and use case specific test cases are listed in the document “C-ITS Test Plan” [C-Roads_TP].</p>