

# Automotive Requirements for the Infrastructure to Vehicle Information (IVI) Service

CAR 2 CAR Communication Consortium



**CAR 2 CAR**  
COMMUNICATION CONSORTIUM

## About the C2C-CC

Enhancing road safety and traffic efficiency by means of Cooperative Intelligent Transport Systems and Services (C-ITS) is the dedicated goal of the CAR 2 CAR Communication Consortium. The industrial driven, non-commercial association was founded in 2002 by vehicle manufacturers affiliated with the idea of cooperative road traffic based on Vehicle-to-Vehicle Communications (V2V) and supported by Vehicle-to-Infrastructure Communications (V2I). The Consortium members represent worldwide major vehicle manufactures, equipment suppliers and research organisations.

Over the years, the CAR 2 CAR Communication Consortium has evolved to be one of the key players in preparing the initial deployment of C-ITS in Europe and the subsequent innovation phases. CAR 2 CAR members focus on wireless V2V communication applications based on ITS-G5 and concentrate all efforts on creating standards to ensure the interoperability of cooperative systems, spanning all vehicle classes across borders and brands. As a key contributor, the CAR 2 CAR Communication Consortium and its members work in close cooperation with the European and international standardisation organisations.

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**Document information**

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**Table 1: Document information**

### Changes since last version

Date	Changes	Edited by	Approved
2021-12-17	<ul style="list-style-type: none"> <li>• Inclusion of the RCC, further detailing of road and zone representation</li> <li>• Introduction of a new clause for preliminary content</li> <li>• Minor improvements</li> </ul>	Release Management	Steering Committee
2021-07-23	<ul style="list-style-type: none"> <li>• Detailing of iviStatus handling</li> <li>• Several improvements of phrasings and figures</li> <li>• Editorial corrections</li> <li>• Renaming of document from:                             <ul style="list-style-type: none"> <li>○ Automotive Requirements for IVIM</li> </ul>                             to                             <ul style="list-style-type: none"> <li>○ Automotive Requirements for the Infrastructure to Vehicle Information (IVI) Service</li> </ul> </li> </ul>	Release Management	Steering Committee
2021-03-12	No changes	Release Management	Steering Committee
2020-12-16	Initial release	Release Management	Steering Committee

**Table 2: Changes since last version**

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## 1 Introduction

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**Other (informational)**

**RS\_ARI\_1**

This document is part of the documentation within the Work Item F0020 'Automotive Requirements for IVIM'. It is the main working document containing identified requirements to the IVIM from an automotive perspective.

It shall serve as an extension to already existing requirements on IVIM in the C-Roads profiles and specifications.

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## 2 Scope

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### Other (informational)

**RS\_ARI\_2**

The present document provides requirements related to the features of a C-ITS station transmitting IVIM to enable interoperability. The requirements in this document are intended as an addition to existing requirements in [ISO 19321], [TS 103 301] and the C-Roads profile.

In this document only, highway use cases were considered, use cases on other road types or in urban areas may need different profiling. Apart from that, the requirements in this document are independent of the specific use case and shall therefore apply to all highway use cases of the In-Vehicle-Signage Service.

Furthermore, the requirements are focused on the functional level, specifications on the lower communication levels are out of scope of this document. Also, for the functional level, these requirements don't claim to be complete.

In some cases, requirements are written in a way which let the implementation open, for example if they refer to very specific implementations which may depend on specific national regulations. Those requirements have to be further detailed by anybody implementing that requirement. Beside these special requirements all other requirements can be further detailed, too.

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### 3 Conventions used

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**Other (informational)**

(RS\_BSP\_152) **RS\_ARI\_3**

Conventions used in this and other C2C-CC specification documents can be found in [C2CCC ConV].



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## 4 Definitions

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**Definition** (RS\_BSP\_193) **RS\_ARI\_9**

'C-ITS time' or 'time base' means the number of elapsed International Atomic Time (TAI) milliseconds since 2004-01-01 00:00:00.000 Coordinated Universal Time (UTC)+0 as defined in [EN 302 636-4-1]. Timestamps as defined in [TS 102 894-2] follow this time format.

**Definition** **RS\_ARI\_10**

The '*station clock*' means a clock representing Cooperative Intelligent Transport Systems (C-ITS) time in a C-ITS station (see RS\_RSP\_006).

**Definition** (RS\_BSP\_429) **RS\_ARI\_11**

Information provided with a '*confidence level*' of 95 % means that the true value is inside the confidence interval or the confidence area for at least 95 % of the data points in a given statistical base.

**Definition** (RS\_BSP\_500) **RS\_ARI\_12**

A '*confidence interval*' is specified by the estimated value plus/minus the confidence value.

**Definition** **RS\_ARI\_13**

An '*instant*' denotes a point on the time axis, often also referred as a 'moment in time' (see also IEC 60050).

**Definition** **RS\_ARI\_15**

The '*relevance area*' (or *relevance zone*) is the area on the road for which the signage information is applicable. Each separate signage information is associated a specific relevance zone. The concept of an IVI relevance zone is the equivalent of an eventHistory used for DENMs.

**Definition** **RS\_ARI\_16**

The '*awareness area*' (or *detection zone*) is the area where drivers have to be informed about upcoming relevant signage information. The concept of an IVI detection zone is the equivalent of a DENM trace.

**Definition** **RS\_ARI\_89**

'*Lane available for regular driving*' refers to all lanes that are an integral part of a highway / motorway segment and which do not assume an implicit, more specific role (such as entry or exit ramps, hard shoulders or emergency lanes).

## 5 Parameter settings

**Table 3: Parameter settings RS\_ARI\_22**

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
<i>pRepetitionInterval</i>	500	ms	Interval for the IVI repetition service	--	--	--
<i>pIdUniquenessRadius</i>	25	km	Radius around the originating station within which the tuple serviceProviderID-IvidentificationNumber shall be unique	--	--	--
<i>pIdReuseBlockingTime</i>	24	H	Minimum blocking time before a previously used IvidentificationNumber may be reused by a service provider			
<i>pRepetitionDuration</i>	5	Min	Duration over which a message shall be repeated	--	--	--
<i>pLongitudinalOffsetSignPosition</i>	3	m	Maximum longitudinal offset to the actual position of the physical sign	--	--	--
<i>pNodeOffset</i>	1	m	Maximum offset between two nodes describing the same geographical position	--	--	--
<i>pMaxNumberOfNodesPerZone</i>	100	--	Maximum number of deltaPositions per segment / zone	--	--	--
<i>pMinDetectionZoneLength</i>	800	m	Minimum length of a detection zone for highway use cases	--	--	--
<i>pMaxDetectionZoneLength</i>	2000	m	Maximum length of a detection zone for highway use cases	--	--	--
<i>pLateralNodeOffset</i>	3	m	Maximum lateral offset to the center of the lane /carriageway for the deltaPositions in polygonalLine and the referencePosition	--	--	--
<i>pLateralNodeOffsetAD</i>	1	m	Maximum lateral offset to the center of the lane /carriageway for the deltaPositions in polygonalLine and the referencePosition if automated driving shall be supported	--	--	--
<i>pLaneAngleDeviation</i>	5	°	Maximum angle between the connection of the node points and the corresponding tangent to the lane centre	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
pMaxPerpendDistLane Centre	10	m	Maximum perpendicular distance between the linear connection of two consecutive lane nodes and the actual centre of the lane	--	--	--

## 6 General understanding of the IVIM

### 6.1 Purpose of the In-Vehicle Signage use cases

The purpose of the In-Vehicle Signage (IVS) is to enable the receiving vehicle to know at any time and condition all the relevant signage information, based on time and location, but also based on characteristics and type of the vehicle. Receivers can filter sign information based on time, geographical and other relevance criteria (e.g. to only show information relevant ahead to the driver).

### 6.2 Purpose of the different containers in IVIM

This clause provides a short introduction to the three most relevant containers in IVIM: Management Container, Geographic Location Container and General IVI Container. See also Figure 1 for a simplified representation of the IVIM.

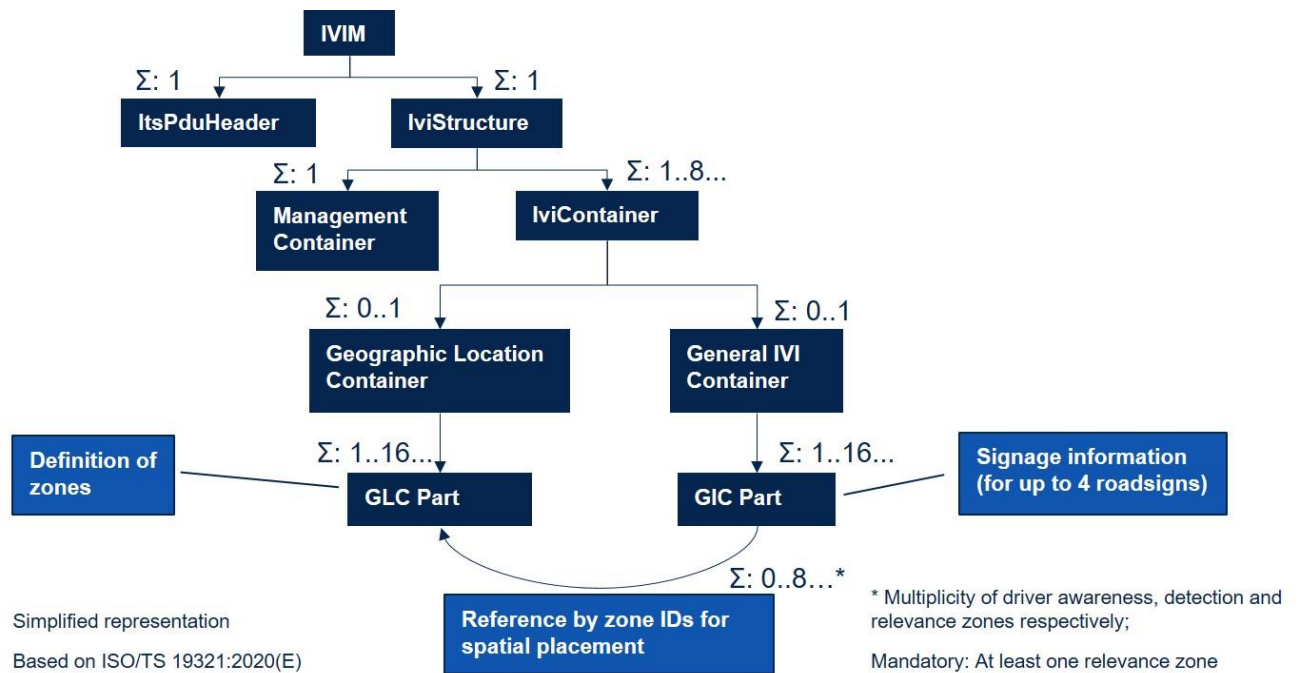


Figure 1: Simplified and shortened representation of IVIM

#### 6.2.1 Management Container

The Management container is mandatory and provides the receiving vehicles with information necessary to handle the entire IVI message, unambiguously identify it (*ServiceProviderId*, *iviIdentificationNumber*) as well as to decide on its further processing and determine the status and time validity of its content (e.g. *iviStatus*, *timestamp*, *validFrom*, *validTo*, etc.)

#### 6.2.2 Geographic Location Container

The Geographic Location Container (Glc) describes essential information for receiving vehicles to understand where and how the information provided in the IVI Application Container applies.

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It is formed by a part which is common to all the parts of the Application Container plus a sequence of *GlcParts* that can be specific to the distinct parts of the application container. *GlcParts* are used to represent detection and relevance zones (following the definitions provided in [C2CCC Glos]). According to C-Roads specifications, at least one detection zone and one relevance zone shall be provided for each IVI message. Each *GlcPart* is described, among others, by a *zoneId* (unambiguously identifying the zone), and a *Zone* (defining the geographical-shape of the zone)

### 6.2.3 General IVI Container

The General IVI Container (*Gic*) provides the signage information to be processed by vehicles. It is a sequence of *GicParts*, each defining a given piece of signage information. This information refers to *Glc* information for its spatial relevance. For this, each *GicPart* contains, among others, *detectionZoneId* and *relevanceZoneId* lists indicating respectively the detection and relevance zones that apply to this *GicPart*. Moreover, each *GicPart* contains the *iviType* (e.g. regulatory info or other kind of info), optionally the *vehicleCharacteristics* (i.e. for which kind of vehicles the info applies) and the specific signage information to communicate (e.g. road sign identifiers *roadSignCodes* or text messages *extraText*, etc.).

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## 7 Requirement specifications

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### 7.1 IVIM Automotive Requirements

#### 7.1.1 Transmission

##### Other (informational)

**RS\_ARI\_14**

The following requirements on IVIM apply in addition to the relevant standards ([TS 103 301 v2.1.1], [ISO/TS 19321:2020]) and the C-Roads documents [C-ITS Message Profiles and Parameters, Release 1.7].

Details:

Tested by:

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##### Requirement

**RS\_ARI\_67**

IVIM shall be repeated with a repetition interval of  $pRepetitionInterval$ .

Details:

Tested by:

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##### Other (informational)

**RS\_ARI\_38**

Signs which indicate the end of a specific or all regulations / restrictions should not be transmitted explicitly as individual signs in an IviStructure. The meaning of these signs is implicitly given through the ending of the relevance zone of corresponding signs.

If transmitted, all requirements given in this document shall apply.

Note: It is recommended not to transmit the aforementioned signs separately. One reason being that the relevance zone of such signs could stretch along several kilometres.

Details:

Tested by:

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#### 7.1.2 IviStructure

##### Requirement

**RS\_ARI\_70**

If the IviStructure corresponds to a physical sign / gantry, it shall provide the legal statement as displayed by the static sign or gantry.

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Note 1: This implies that the IviStructure doesn't need to exactly represent what is depicted on the gantry/sign but needs to provide all information required to represent the regulation as indicated by the gantry/sign.

Note 2: In order to support use cases where there is no physical sign, a corresponding suitable requirement may be defined in the future.

Details:

Tested by:

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**Requirement****RS\_ARI\_17**

An IviStructure having an iviStatus other than 'cancellation' shall contain at least one instance of GeographicLocationContainer.

Details:

Tested by:

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**Requirement****RS\_ARI\_18**

An IviStructure having an iviStatus other than 'cancellation' shall contain at least one instance of GeneralIviContainer.

Details:

Tested by:

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**Requirement****RS\_ARI\_19**

All zones referred to within one GicPart should be contained in one single instance of GeographicLocationContainer within the same IviStructure.

Note: This implies that each IviStructure shall be self-contained.

Note: The requirement is only phrased with 'should' since there might be situations when more than one GLC is needed. One example for such a situation could be, when more than one reference position is needed to comply with all corresponding requirements of this document.

Details:

Tested by:

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**Other (informational)****RS\_ARI\_90**

Service providers should make an effort to reduce the number of different, individual IVI messages transmitted in parallel as far as possible. Rather the mechanisms provided in the IVIM e.g. to reuse zones defined in GLC for different purposes in the GIVs should be utilized. For a better understanding see the two figures below.

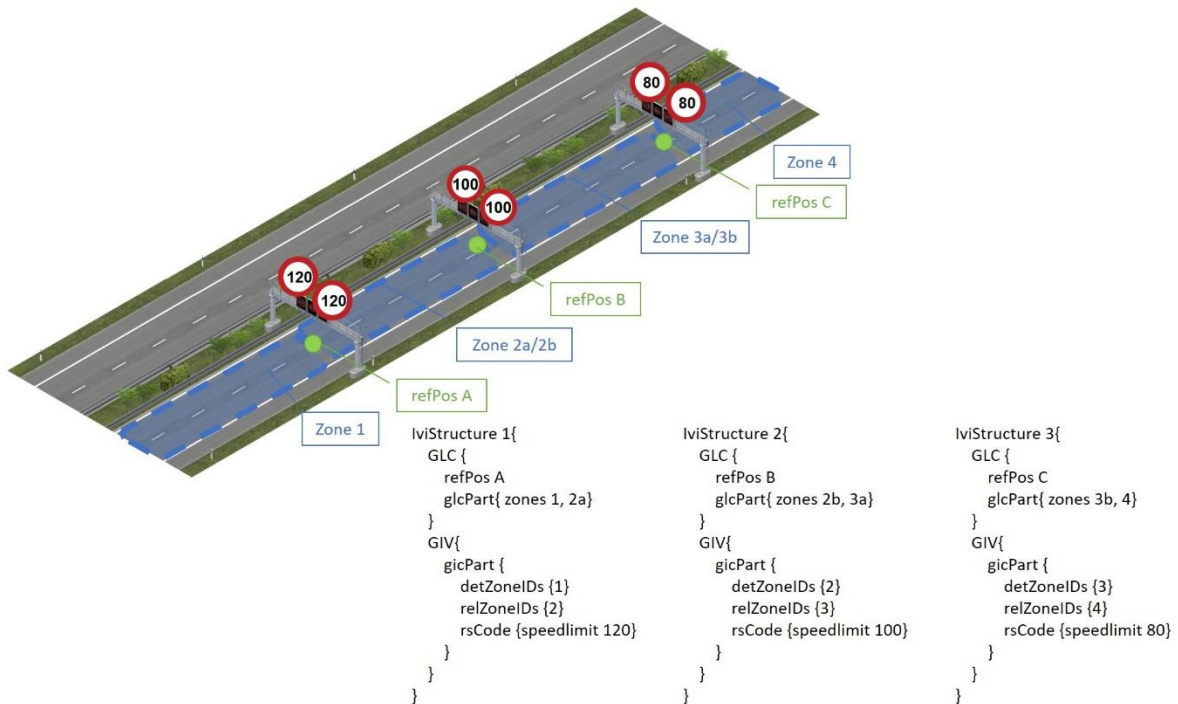


Figure 2: Exemplary implementation for a speed limit cascade with 3 separate IviStructures

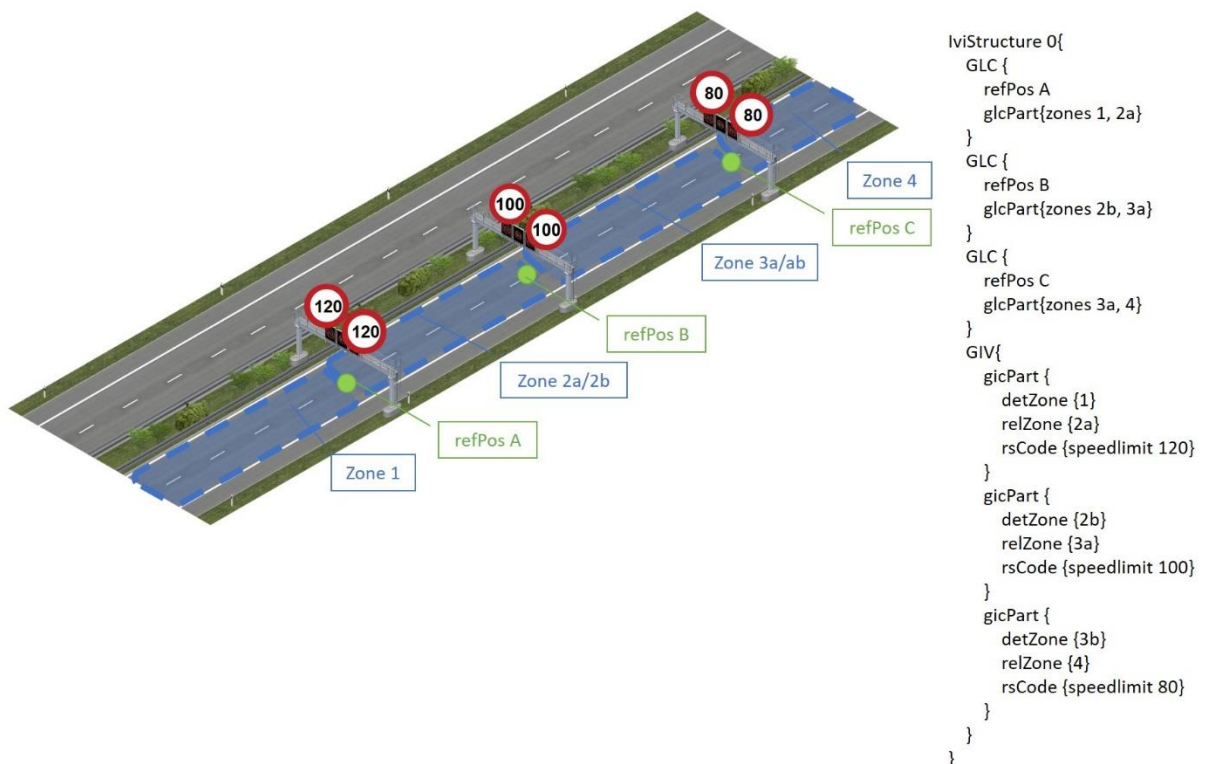


Figure 3: Exemplary, more efficient implementation for the same speed limit cascade with only one IviStructure



Details:

Tested by:

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**Requirement**

**RS\_ARI\_20**

The IviStructure should not contain any instances of LayoutContainer and TextContainer.

Note: If present, these containers may be ignored by receivers. The containers AutomatedVehicleContainer and RoadSurfaceContainer are currently not considered and may therefore also be ignored by receivers.

Details:

Tested by:

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**Requirement**

**RS\_ARI\_21**

If in vehicle information shall or need to be transmitted in separate IVIMs, the following prioritization shall be applied (number one having the highest priority):

- 1) Information applying to the same lane should be contained in a single message.
- 2) Information applying to the same direction of travel should be contained in a single message.
- 3) Information applying to the same local area should be contained in a single message.

Details:

Tested by:

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**Requirement**

**RS\_ARI\_25**

If there are multiple physical signs showing the same information applicable to the same road segment (e.g. one in a distance, one directly at the location of danger), only one IviStructure and GicPart shall be transmitted for all signs.

Details:

Tested by:

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**Requirement**

**RS\_ARI\_52**

At every point in time every combination of RsCode and relevanceZonelds contained in an IviStructure shall be unique for that IviStructure.

Note: This means, that the combination of RsCode and relevance zone shall not be duplicated in in more than one IviStructure at any given point in time. This also excludes a situation as shown in Figure 4.

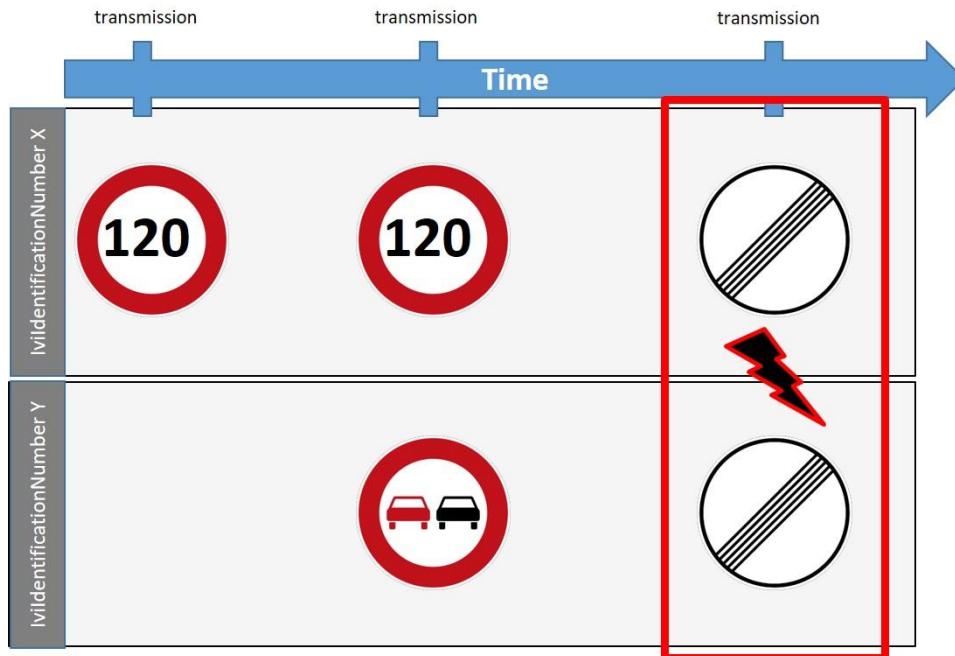


Figure 4: No duplicate information in separate IviStructures, example

Details:

Tested by:

**Requirement**

**RS\_ARI\_53**

All in-vehicle information to be conveyed via IVIM should be transmitted in as few separate IviStructures as possible.

Details:

Tested by:

**Requirement**

**RS\_ARI\_60**

An IviStructure shall contain the RCC to provide information about the total number of lanes where a vehicle can possibly drive in a given direction, including all lanes which the referenced zones represent (i.e. at least all lanes available for regular driving and all lanes for which signage information is provided in that zone).

An exception to this requirement applies, if the road operator has not even information on the total number of lanes available for regular driving. In this case, the RCC and applicableLanes in GicParts shall be omitted in the IviStructure.

---

If this exception is applied, only signs applying to the entire single or unidirectional carriageway shall be transmitted in an IviStructure.

Note: It is recommended to provide information on all lanes of the carriageway (if available, e.g. also hard shoulder).

Details:

Tested by:

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### 7.1.3 ManagementContainer

#### Requirement

**RS\_ARI\_58**

The tuple of ServiceProviderID and IviIdentificationNumber shall be unique at every given point in time within a radius of at least *pIdUniquenessRadius* around the transmitting C-ITS station.

Details:

Tested by:

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#### Requirement

**RS\_ARI\_59**

When a service provider has used an iviIdentificationNumber for an IviStructure, a minimum blocking time of at least *pIdReuseBlockingTime* shall pass before the same iviIdentificationNumber may be used again for another IviStructure with different content by an RSU of the same provider within a distance of *pIdUniquenessRadius*. This does not apply for transitions in the iviStatus of an IviStructure, which use by definition the same iviIdentificationNumber.

Note: To cope for overlaps of the geonet destination areas, the radius is designed to be larger than 2x 10 km and contains another buffer of 5 km, resulting in 25 km radius.

Details:

Tested by:

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#### Requirement

**RS\_ARI\_56**

The timestamp shall be present and set to the time of information generation by the service provider (as defined in [TS 103 301]).

Note: This also holds, if the iviStatus is already set to 'update'. When a new content change occurs, timeStamp shall be set to the point in time of the generation of the new information.

Details:

Tested by:

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**Requirement****RS\_ARI\_62**

The component validFrom shall be present in an IviStructure if the contained information is not yet applicable at the point in time when the message is transmitted.

Details:

Tested by:

**Requirement****RS\_ARI\_63**

The component validFrom shall be omitted in an IviStructure if the contained information is applicable at the point in time when the message is transmitted.

Details:

Tested by:

**Requirement****RS\_ARI\_71**

The component validTo may only be used to indicate the validity duration of the information contained in the IviStructure, if it is ensured that validTo exceeds the actual validity period.

Note 1: This means, that validTo shall not be shorter than the actual validity duration of the information. This prevents, that vehicles travelling in the relevance zone wrongly cancel the information to the driver when validTo times out only because an update of the validTo is not received.

Note 2: Example of a scenario that could benefit from using validTo: Speed limit for purposes of noise reduction over night, e.g. 10 p.m. to 6 a.m. In this scenario the validity duration is deterministic and can be conveyed via validTo thus lifting the need for a separate cancellation message.

Note 3: Example of a scenario where a different usage than specified here can lead to critical situations: The component validTo is set to a time only some minutes in the future and is updated every time before timing out. In such cases vehicles, that have passed the gantry and are already out of the RSU coverage, but yet in the relevance zone, would disable the received IVI road signs upon reaching the validTo time, even if the RSU has updated the validTo and still transmits the road signs.

Details:

Tested by:

**Requirement****RS\_ARI\_37**

If in vehicle information shall or need to be transmitted in separate IVIMs following RS\_ARI\_21 due to message size restrictions, the data element connectedIviStructures shall be present and used to connect at least all messages applying to the same traffic direction.

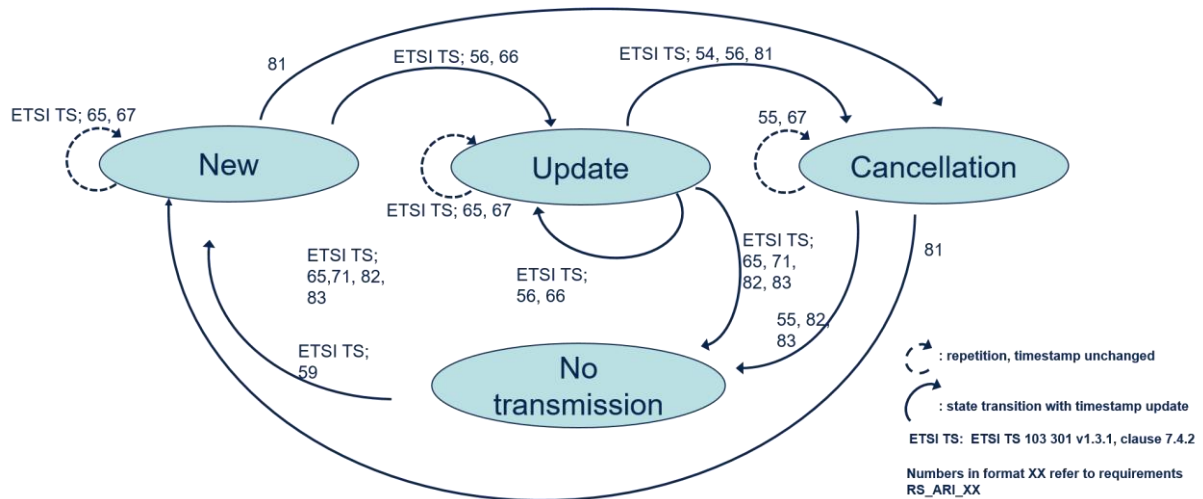
Details:

Tested by:

**Other (informational)**

**RS\_ARI\_64**

For better understanding of the following requirements, Figure 5 provides a state machine for the usage of iviStatus including references to the relevant documents and requirements for the respective state transitions.



**Figure 5: State machine for iviStatus**

Details:

Tested by:

**Requirement**

**RS\_ARI\_65**

An IviStructure with status 'new' or 'update' shall be repeated as long as all information contained remains unchanged or the time value represented by validTo hasn't yet passed in time.

Details:

Tested by:

**Requirement**

**RS\_ARI\_66**

Whenever any signage information changes (meaning any change in the GIVs, TCs or AVCs present in an IviStructure), the IviStructure shall be transmitted with iviStatus 'update'.

Note: For any changes in the geographic information see requirement RS\_ARI\_81.

Details:

Tested by:

**Requirement****RS\_ARI\_81**

Whenever any geographic information changes (meaning any change in the GLCs, MLCs or RCCs present in an IviStructure), the IviStructure shall be transmitted with iviStatus 'cancellation' and a new IviStructure with iviStatus 'new' containing the updated geographic information shall be transmitted.

Note: For any changes in the signage information see requirement RS\_ARI\_66.

Details:

Tested by:

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**Requirement****RS\_ARI\_54**

Whenever all the information given in an IviStructure is not valid any more (i.e. the gantry is switched off and the information isn't shown any more), the IviStructure shall be transmitted with iviStatus 'cancellation'.

Details:

Tested by:

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**Requirement****RS\_ARI\_55**

An IviStructure with status 'cancellation' shall be repeated for *pRepetitionDuration* starting from the point in time of the first transmission of the cancellation IVIM.

Details:

Tested by:

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**Requirement****RS\_ARI\_57**

An IviStructure with status 'cancellation' shall consist of the ManagementContainer only.

Details:

Tested by:

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**Requirement****RS\_ARI\_82**

If the gantry is dark (i.e. if no signage information is available in the R-ITS-S) for longer than *pRepetitionDuration*, no IviStructure shall be transmitted.

Details:

Tested by:

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**Other (informational)****RS\_ARI\_83**

In case of any failure or error in the R-ITS-S, no IviStructure shall be transmitted.

Details:

Tested by:

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**7.1.4 Geographic Location Container****Requirement****RS\_ARI\_30**

If the IviStructure corresponds to a physical sign/gantry, the referencePosition in GLC shall be located in the middle of the carriageway at the position of the sign/gantry. The (longitudinal) offset shall be at most *pLongitudinalOffsetSignPosition*. (See also RS\_ARI\_28 )

Note: In order to support use cases where there is no physical sign, a corresponding suitable requirement may be defined in the future.

Details:

Tested by:

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**Requirement****RS\_ARI\_29**

The referencePosition in GLC shall be located in the middle of the carriageway with a maximum lateral offset to the true middle of the carriageway of *pLateralNodeOffset*.

Details:

Tested by:

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**Requirement****RS\_ARI\_32**

An instance of GLC shall consist of at least two GlcParts.

Note: This ensures that there are at least two zones for representation of detection and relevance zone of information contained in the GeneralIviContainer, respectively.

Details:

Tested by:

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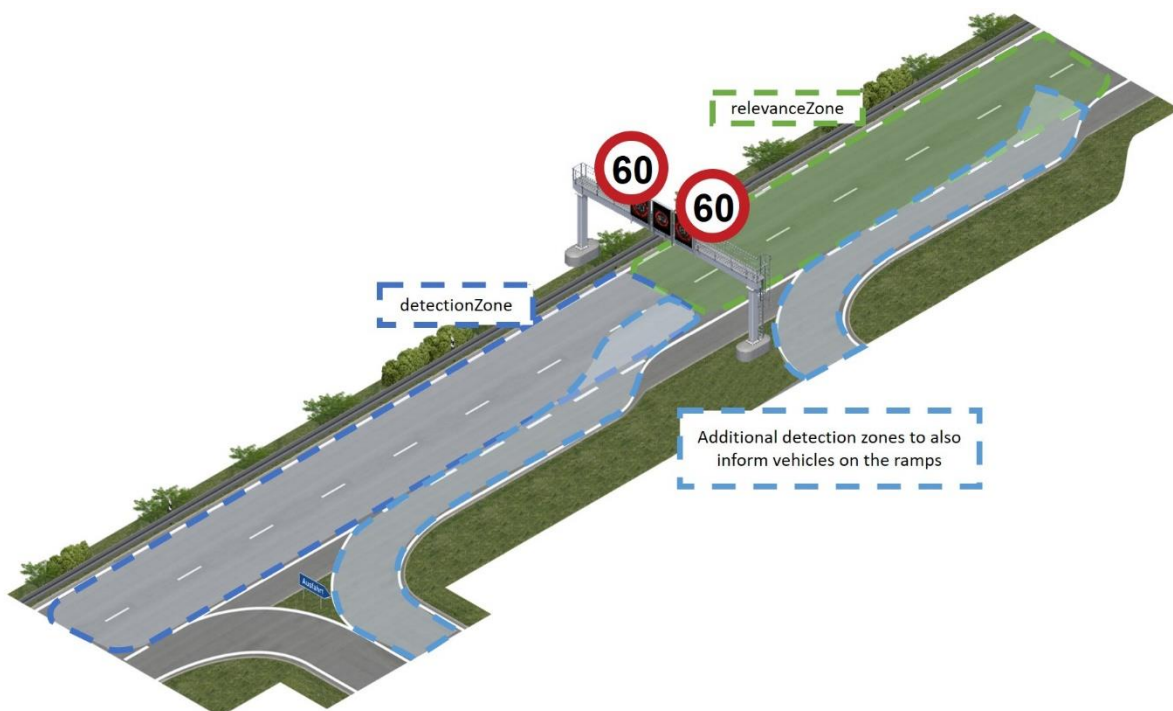
**Other (informational)****RS\_ARI\_91**

If the signage intention of the service provider is to inform vehicles on multiple stretches of road (diverging, converging), then all those stretches shall be represented by corresponding zones in GLC, referenced in GIC as either detection or relevance zone depending on the situation.

Note: This applies in addition to adequate RSU position and geonetworking settings ensuring reception on such stretches of road where the infrastructure wants the vehicle to consider the information.

Note: The decision if, when and how to make use of certain information is still up to the OEM.

Example: If the signage intention of the service provider is to inform vehicles already 2 km ahead, no matter which road / entry ramp they are travelling on, also all concerned entry ramps should be represented by corresponding zones, see the figure below for a better understanding.



**Figure 6: Example, the service provider wants to inform all concerned vehicles about the low speed limit and therefore also provides detection zones on the ramps**

Details:

Tested by:

### 7.1.4.1 Geographic Location Container Part

#### Requirement

RS\_ARI\_31

The zoneld in GlcPart shall be unique throughout the entire IviStructure (i.e. this also applies, if multiple GLCs are used within one IviStructure).



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Note: Uniqueness is only required for the triple serviceProviderID + iviIdentificationNumber + zoneID. Hence, for signage information spread over multiple messages, zoneIDs may be reused.

Details:

Tested by:

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**Requirement****RS\_ARI\_72**

The number of deltaPositions per segment shall be limited to *pMaxNumberOfNodesPerZone*.

Details:

Tested by:

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**Requirement****RS\_ARI\_40**

In all instances of IVI.IviStructure.optional.glc.parts.zone.segment.line in an IviStructure, only either the component deltaPositions or the component deltaPositionsWithAltitude shall be used.

Details:

Tested by:

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**Requirement****RS\_ARI\_61**

The first deltaPosition contained in PolygonalLine shall refer to the reference position given in the corresponding GLC.

Note: See RS\_ARI\_76 for a better understanding.

Details:

Tested by:

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**Requirement****RS\_ARI\_75**

The referencePosition shall not be part of the zone itself. This means that the first deltaPosition in a zone shall describe the first node of the respective zone. If a zone shall begin at the referencePosition, the first deltaPosition shall be set to (0, 0). See RS\_ARI\_74 and RS\_ARI\_76 for further information.

Note: This requirement is in compliance with ISO/TS 19321:2020, where a note explains that the referencePosition of the GLC is not part of the polygonal line.

Note: Not including the reference position to the zones by default becomes even more important when zones are not directly attached to the referencePosition (e.g. when considering ramps).

Details:

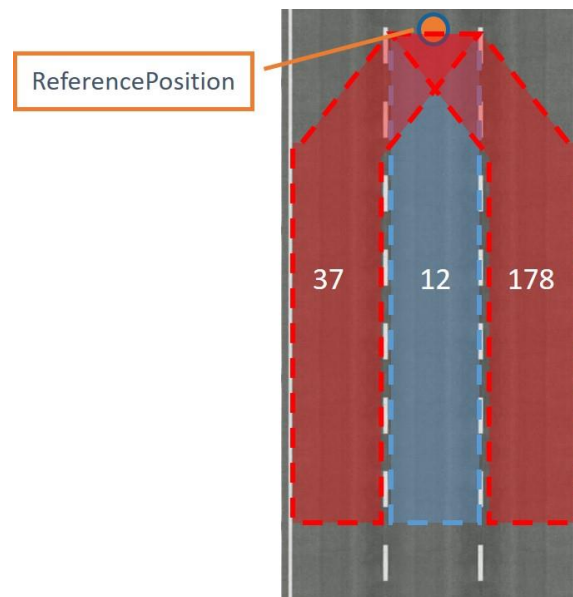
Tested by:

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**Other (informational)**

**RS\_ARI\_76**

The graphic below shows the problematic implications when including the referencePosition in the zone description. For individual zones per lane the inclusion of the reference position would ‘distort’ the zone causing possible problems for interpretation on vehicle side, therefore the first deltaPosition is considered to be the very first node of the zone.



**Figure 7: ‘Distortion’ of zones when including the referencePosition**

Details:

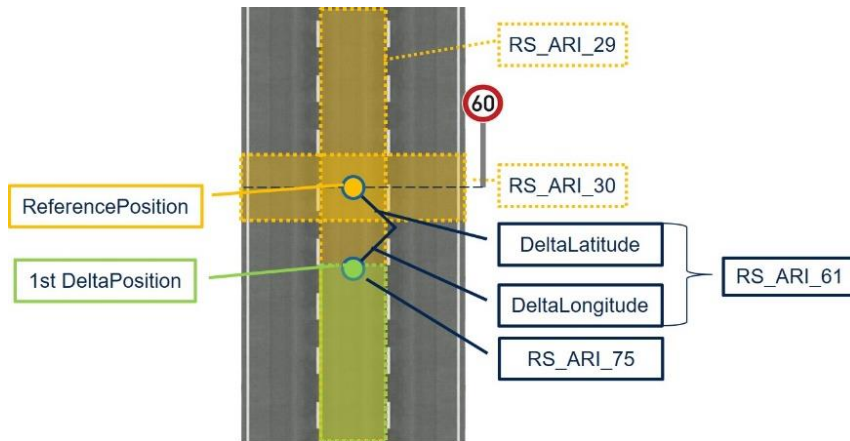
Tested by:

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**Other (informational)**

**RS\_ARI\_74**

Requirements RS\_ARI\_29, RS\_ARI\_30, RS\_ARI\_61 and RS\_ARI\_75 specify polygonal lines in a very generic way in order for them to be applicable to all possible scenarios and settings. The graphic below shows the implications of these requirements on the affected data elements in IVIM.



**Figure 8: Placement of the referencePosition and definition of the first deltaPosition**

Details:

Tested by:

**Requirement**

**RS\_ARI\_42**

The delta positions in PolygonalLine shall be sorted starting from the zone’s extremity that is closest to the reference position in ascending order according to the distance to this extremity along the course of the zone.

Note: That way, zones are always sorted in direction of traffic or against the direction of traffic. See RS\_ARI\_77 for a better understanding.

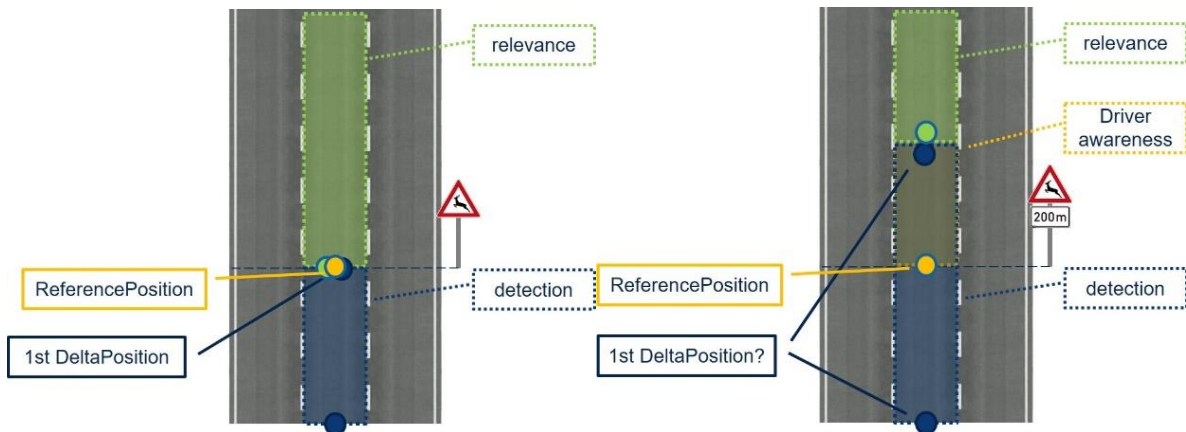
Details:

Tested by:

**Other (informational)**

**RS\_ARI\_77**

Requirements RS\_ARI\_42 is phrased in a very generic way. This is necessary for cases where the referencePosition isn’t located at the borders between the zones but actually in the middle of a zone. This occurs for example, when a driverAwarenessZone is used (for driverAwarenessZone, see RS\_ARI\_26). Without the driverAwarenessZone, the previous requirements make sure that the referencePosition is located at the border between detectionZone and relevanceZone.



Details:

Tested by:

**Requirement**

(RS\_ARSM\_32) RS\_ARI\_46

The absolute lateral offset of node points to the centre of the lane or carriageway shall be less than  $pLateralNodeOffset$ .

Details:

Tested by:

**Requirement**

(RS\_ARSM\_94) RS\_ARI\_47

Let  $\vec{a}$  be the vector representing the linear connection of two delta positions, and  $\vec{p}$  be the vector representing the shortest distance of vector  $\vec{a}$  to the center of the lane/carriageway (that is,  $\vec{p}$  is perpendicular to the tangent of the center line of the lane/carriageway at the foot of the dropped perpendicular).

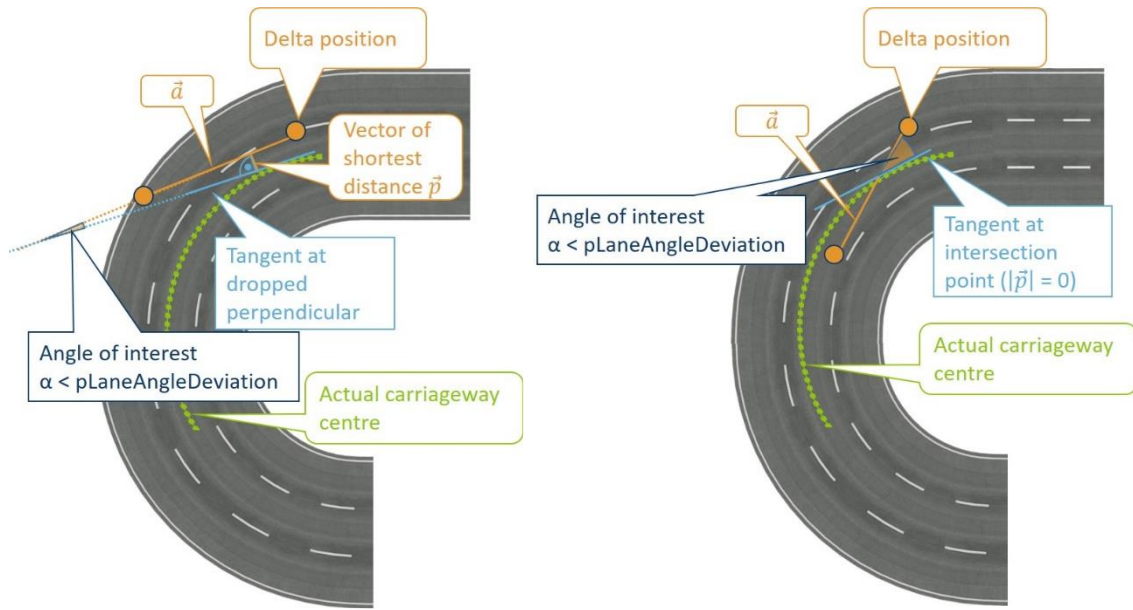
Then for  $|\vec{p}| > 0$  it shall always hold that

$$\cos^{-1} \left( 1 - \frac{\vec{a} \cdot \vec{p}}{|\vec{a}| \cdot |\vec{p}|} \right) \leq pLaneAngleDeviation.$$

For  $|\vec{p}| = 0$  (i.e.  $\vec{a}$  crosses the lane/carriageway centre) the angle  $\alpha$  between  $\vec{a}$  and the tangent to the lane/carriageway centre at the intersection point with the lane centre shall be less than  $pLaneAngleDeviation$ .

Note: In less formal wording this means that the angle between the linear connection of two node points and the corresponding tangent to the lane/carriageway centre shall not be greater than  $pLaneAngleDeviation$ .

Note: See drawings below for a better understanding (exemplary for a polygonalLine describing the centre of the carriageway):



Details:

Tested by:

**Requirement**

(RS\_ARSM\_34) **RS\_ARI\_48**

The perpendicular distance between the linear connection of two delta positions and the centre of the lane/carriageway shall be less than  $pMaxPerpendDistLaneCentre$ .

Details:

Tested by:

**Requirement**

**RS\_ARI\_50**

The data element laneWidth shall be provided if the corresponding zone describes a single lane, and may be used in all other cases.

Note: For a zone containing more than one lane, according to ISO/TS 19321, the laneWidth represents the overall width of the zone.

Details:

Tested by:

**7.1.5 MAP Location Container**

**Requirement**

**RS\_ARI\_37**

The MAP Location Container shall not be used for highway use cases.

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Note: This container may be used at intersections where a MAPEM is transmitted anyway, for such use cases this needs to be profiled explicitly.

Details:

Tested by:

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### 7.1.6 General IVI Container Part

#### Requirement

RS\_ARI\_36

All zonelds present in the components *detectionZonelds*, *driverAwarenessZonelds* and/or *relevanceZonelds* within an instance of *GicPart* shall reference zones which are all described in the same GLC.

Details:

Tested by:

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#### Requirement

RS\_ARI\_23

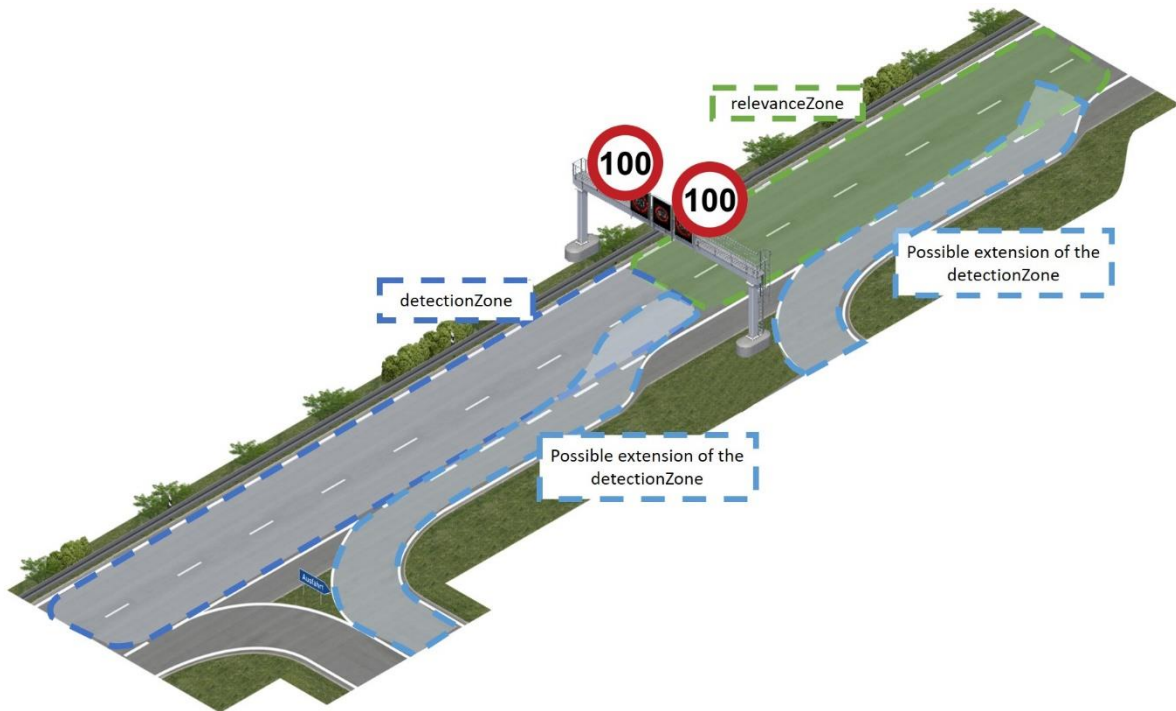
The set of zones referenced within the data element *detectionZonelds* shall be defined in such a way that there is always a concatenation of zones that leads up to a corresponding set of relevance zones. In detail, this means that the first point of each individual zone in the set of zones shall geographically coincide with either:

- a) any point in a corresponding set of physically consecutive relevance zones with a maximum offset of *pNodeOffset* OR with
- b) any point in a set of physically consecutive detection zones which leads up to a corresponding set of physically consecutive relevance zones with a maximum offset of *pNodeOffset*.

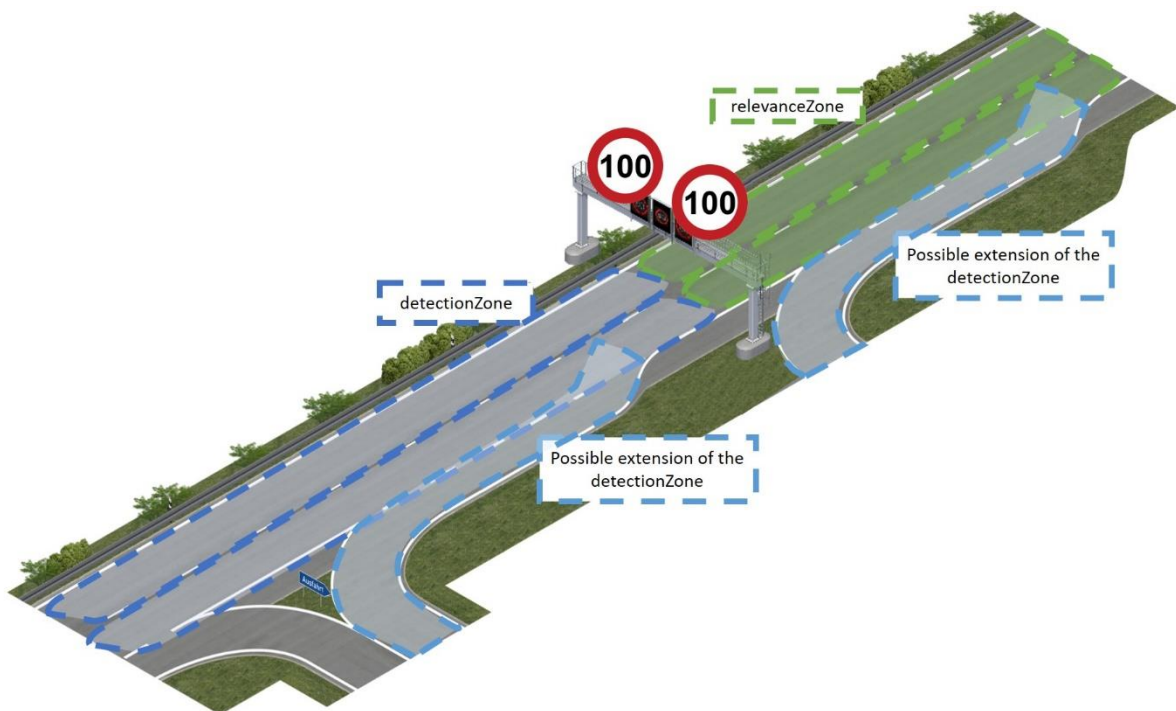
Note: The basic case being that the first point of a set of physically consecutive detection zones coincides with the first point of the corresponding set of relevance zones (i.e. the physically consecutive detection zones lead up to the start of the relevance zone)

Note: In some cases, entry ramps on highways may merge into the highway in the middle of a relevance or detection zone, in these cases, the corresponding detection zone on the ramp may lead up to a suitable entry point of the relevance or detection zone.

Note: For a better understanding see the graphics below.



**Figure 9: Example, detectionZones leading up to the beginning of the relevanceZone or to another suitable entry point to the relevanceZone**



**Figure 10: Example, detectionZone on the first ramp leading up to a suitable entry point to another detectionZone**

Details:

Tested by:

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**Requirement****RS\_ARI\_51**

Each set of physically consecutive zones referenced by the data element `detectionZonelds` in a `GicPart` shall have an accumulated length of at least *pMinDetectionZoneLength*.

Details:

Tested by:

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**Requirement****RS\_ARI\_79**

The set of consecutive zones referenced by the data element `detectionZonelds` in `GicPart` shall cover a distance of at most *pMaxDetectionZoneLength*.

Details:

Tested by:

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**Requirement****RS\_ARI\_80**

The set of zones referenced by the data element `detectionZonelds` in `GicPart` shall be completely contained in the destination area defined in the `GeoNet` header.

Details:

Tested by:

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**Requirement****RS\_ARI\_26**

An instance of `driverAwarenessZonelds` shall be present in all `GicParts` which refer to a physical sign that is located before the start of the relevance zone.

Details:

Tested by:

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**Requirement****RS\_ARI\_27**

The driver awareness zone in a `GicPart` (i.e. the combination of all zones referred to in the instance of *driverAwarenessZonelds*) shall represent the complete area between the location of the physical sign and the start of the relevance zone, if the sign's applicability doesn't start at the position of the sign but in a certain distance.



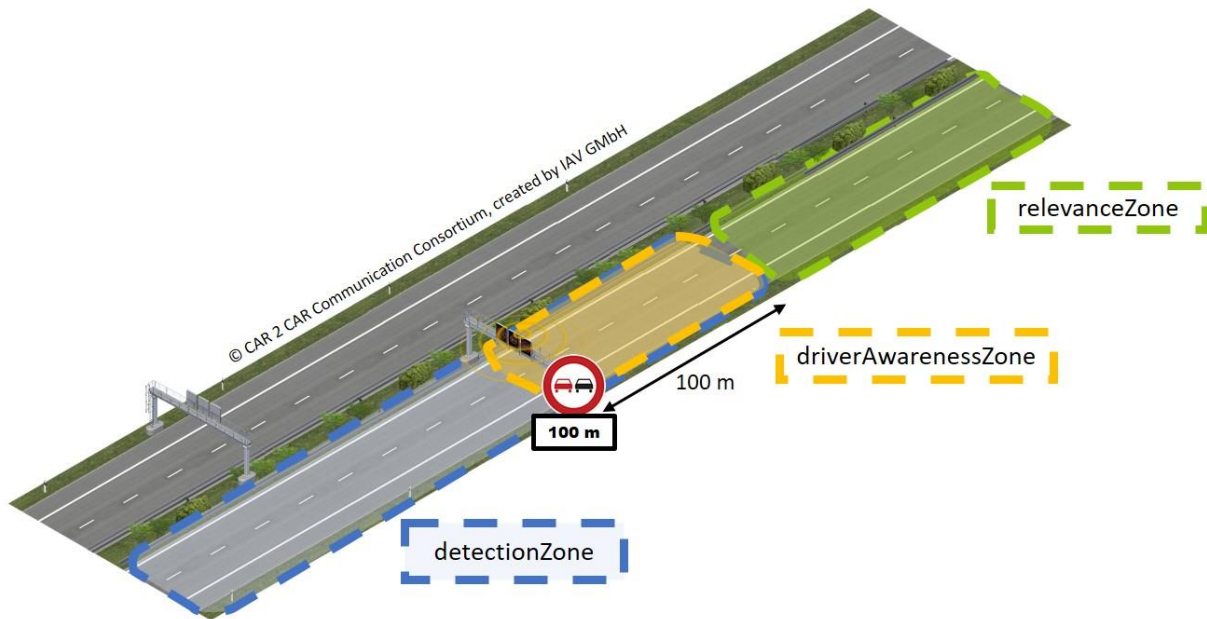


Figure 11: Example: overtaking ban applicable in a distance - e.g. due to a situation on the road

Details:

Tested by:

**Requirement**

**RS\_ARI\_24**

If defined, a driver awareness zone shall be part of the detection zone (i.e. geographically contained within the detection zone).

Details:

Tested by:

**Requirement**

**RS\_ARI\_35**

In every instance of GicPart the data element *relevanceZoneIds* shall be present and refer to a nonempty set of zones described in a GLC.

Details:

Tested by:

**Requirement**

**RS\_ARI\_43**

For each set of physically consecutive zones (along the path of the road segment) referenced in *relevanceZoneIds* in an instance of GicPart, there shall be a corresponding set of physically consecutive zones referenced in *detectionZoneIds*, which fulfils requirement RS\_ARI\_23 .

Details:

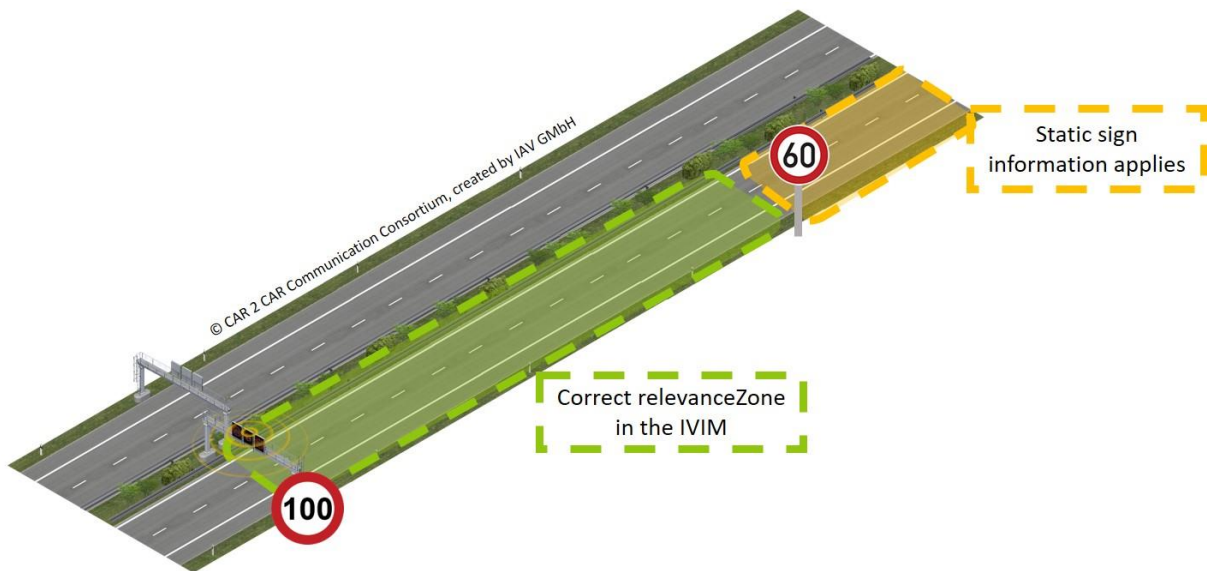
Tested by:

**Requirement**

**RS\_ARI\_33**

The *relevanceZone* in a GicPart (i.e. the combination of all zones referred to in the instance of *relevanceZoneIds*) shall represent the complete road segment where the traffic rules according to the sign described in GicPart are applicable.

Note: If the *relevanceZone* ends and no further signs are transmitted via IVIMs, this means, that from the last point of the *relevanceZone* downstream, the previous road sign transmitted via IVIM doesn't apply any more. Figure 12 shows an example of a correct implementation, Figure 13 shows a possible receiver interpretation in case of a faulty implementation in the same situation.



**Figure 12: Example of a correct implementation of relevanceZone**

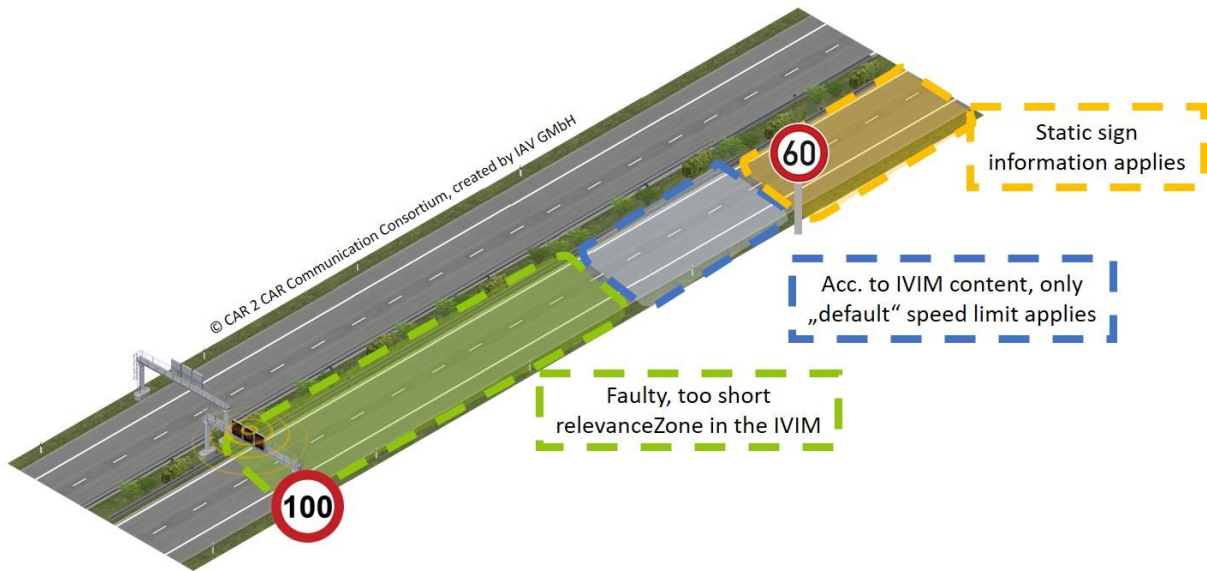


Figure 13: Possible receiver interpretation in case of a faulty implementation

Details:

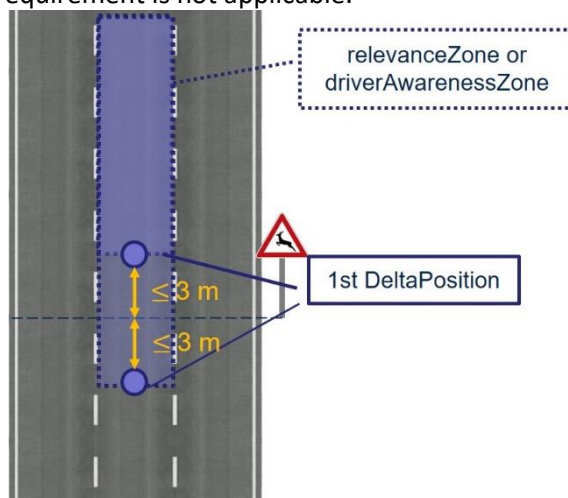
Tested by:

**Requirement**

**RS\_ARI\_28**

The longitudinal position w.r.t. the carriageway of the first node of the set of zones referenced by *relevanceZoneIds* (or by *driverAwarenessZoneIds*, if used), shall coincide with the longitudinal position of the physical sign (if applicable), with a maximum offset of *pLongitudinalOffsetSignPosition* if the traffic rule according to the sign is applicable starting from the position of the sign.

Note: In this case ‘if applicable’ means, if there is a physical sign present. In case of virtual signage without physical sign this requirement is not applicable.



Details:

Tested by:

**Requirement**

**RS\_ARI\_44**

The data element *direction* shall be present in every instance of GicPart in an IviStructure.

Details:

Tested by:

**Requirement**

**RS\_ARI\_68**

The component *iviType* shall be set in accordance with the service categories as defined in ISO 14823. The following mapping shall be used:

<b>iviType</b>	<b>Service category</b>
0 (immediateDangerWarningMessages)	11 (Warning), 31 (ambient road condition), 32 (road condition)
1 (regulatoryMessages)	12 (regulatory)
2 (trafficRelatedInformationMessages)	13 (guide)
3 (pollutionMessages)	n/a
4 (noTrafficRelatedInformationMessages)	21 (public facilities)

Details:

Tested by:

**Requirement**

**RS\_ARI\_73**

RSCodes that apply to multiple lanes shall occur only once in an IviStructure (i.e. in only one single GicPart) with indication of the concerned lanes in the component *applicableLanes* as specified in RS\_ARI\_86.

Note: This implies that it is not allowed to repeat the same road sign in separate GicParts, each of them associated to only one *applicableLane*. It serves the purpose of data minimization.

Details:

Tested by:

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### 7.1.7 Road Configuration Container Part

**Requirement****RS\_ARI\_87**

On highways and motorways, the lanes present in the RCC shall be assigned one of the laneTypes 'traffic (0)', 'acceleration (3)', 'deceleration (4)' or 'emergency (18)' in accordance with the laneType definitions in ISO 19321.

Details:

Tested by:

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**Requirement****RS\_ARI\_88**

In the RCC, the laneType shall be set to 'traffic' for all lanes available for regular driving.

Details:

Tested by:

## 7.2 Further, preliminary items

**Other (informational)****RS\_ARI\_84**

This clause contains preliminary items. As such all items in this clause are work in progress and included for documentation purposes only. They are not part of the finalized requirements!

They have already been discussed in quite some detail and have reached a quite concrete state. Nevertheless, they are not yet ready for full inclusion into the profile as full requirements since there are complex and in-detail open questions still to be clarified.

For every one of the listed preliminary items the open issues are roughly indicated in a note.

**Other (informational, preliminary)****(RS\_ARSM\_31) RS\_ARI\_45**

The polygonal line describing the zone shall be centred laterally among the regular driving lanes of that zone.

Note: With the information on the total number of lanes (RS\_ARI\_60) and the zone width (if provided), the receiver then can create the box describing the zone.

Note: This is for now just a preliminary phrasing. The final phrasing requires more in-detail consideration for different setups of carriageways/roadways (e.g. with or without physical separation, kinds of physical separation). In addition, there exist different understandings and meanings for the term 'carriageway' which need to be clarified. Taking also automated driving into

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account, the road design for automated driving doesn't yet exist and the relevant regulatory aspects to be taken into consideration are still under discussion.

Details:

Tested by:

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**Other (informational, preliminary)**

**RS\_ARI\_85**

To describe a zone, the component segment shall be used. It shall represent all lanes where a vehicle can possibly drive in a given direction in addition to those for which signage information is given in the GIC.

Note: This is for now just a preliminary phrasing. The final phrasing requires more in-detail consideration for different setups of carriageways/roadways (e.g. with or without physical separation, kinds of physical separation). In addition, there exist different understandings and meanings for the term 'carriageway' which need to be clarified. Taking also automated driving into account, the road design for automated driving doesn't yet exist and the relevant regulatory aspects to be taken into consideration are still under discussion. In addition, the current phrasing links the representation of lanes to the zone being used as relevance zone, which is not ideal. The final phrasing should be decided upon in combination with RS\_ARI\_60.

Details:

Tested by:

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**Other (informational, preliminary)**

**RS\_ARI\_86**

The component applicableLanes in a GicPart shall be present if the corresponding RsCode(s) apply only to a subset of all lanes represented by the set of relevance zones to which the GicPart applies (see also RS\_ARI\_85).

If the RsCode(s) apply at least to all lanes represented by the set of relevance zones, the component may be absent.

Note: This corresponds to the C-Roads requirement on usage of the component 'applicableLanes'.

Note: This requirement is preliminary for now since it needs to be defined and finalized in the context of RS\_ARI\_45 and detailed definitions of different setups of carriageways.

Details:

Tested by:

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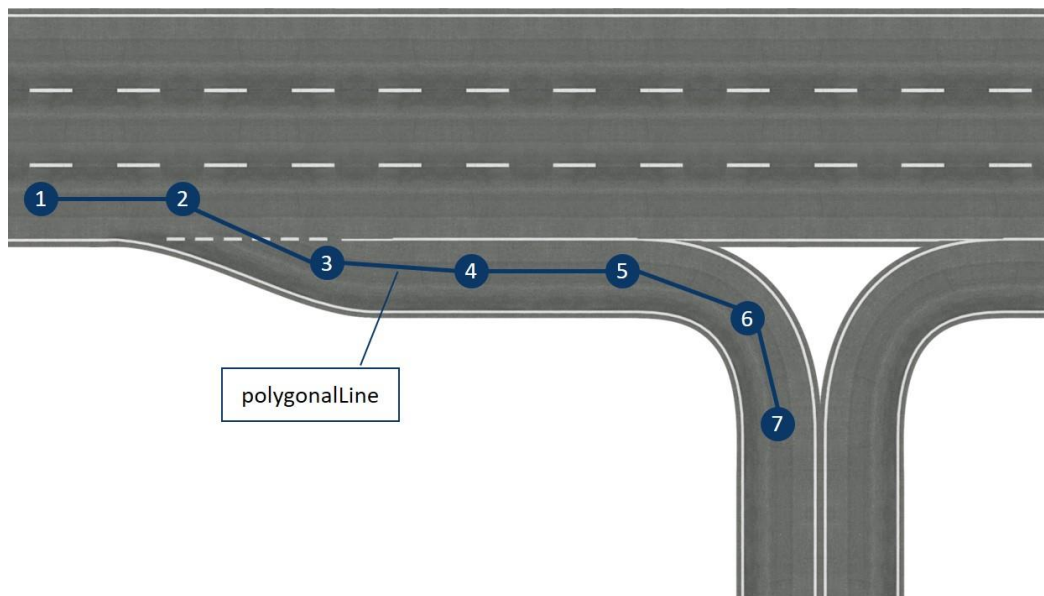
## 7.3 Open questions and subjects

### 7.3.1 Usage of zoneHeading

According to current C-Roads specifications, the usage of zoneHeading in GlcPart is mandatory (see [C-ITS Message Profiles and Parameters, Release 1.7], Table 10).

The profile defines it as ‘Effective direction of applicability of the sign at the Reference Position, indicating the traffic direction’. C2C-CC’s understanding is, that this information shall be given through ‘direction’ in GIC.

Furthermore, it is not clear, how this value will be determined and how it is defined – will it be the heading between the ‘first’ two nodes of the zone? What is the intended added value of this information? E.g. we are not sure if the enabling of a differentiation between the zones on a highway and the zones on a ramp would work in all situations (see figure below).



**Figure 14: Motorway exit ramp; heading of the first two nodes wouldn't differ from the heading of zones on the motorway (representation simplified to ease understanding)**

Some clarification in the specifications is needed for us to understand how to make use of the data element.

## 8 Annex

This annex contains a table for IVIM showing which data elements are mandatory according to the standard (CEN/ISO), this document and the C-Roads profile in Release 1.7.

Legend:

- The number of '+' in the column 'Layer' and the shading of the row represents the layer / level of the corresponding data element within the message.
- '-': This data element is not mentioned in the respective document.
- 'O': This data element is optional.
- 'M': This data element is mandatory.
- 'O/M': This data element is mandatory only under certain conditions which are defined in the respective document.
- 'C': This data element is an option within a 'Choice'.
- 'NU': (C-Roads specific) This data element is not used in C-Roads.
- 'F': The respective document forbids the usage of this data element.
- 'O/F': This data element is forbidden under certain conditions which are defined in the respective document.
- 'O/F/M': This data element is mandatory only under certain conditions and forbidden under other conditions which are defined in the respective document.
- (p): The corresponding requirement for this data element is for now only preliminary

### 8.1 IVIM mandatory and optional data elements

Layer	Data element / data field in and IviStructure	ISO 19321	C2C-CC (this document)	C-Roads (Release 1.7)	Combined
+	managementContainer	M	-	M	M
++	serviceProviderId	M	M	M	M
++	iviIdentificationNumber	M	M	M	M
++	timeStamp	O	M	M	M
++	validFrom	O	O/F/M	O	O/F/M
++	validTo	O	O/F	M	O/F
++	connectedIviStructures	O	O/M	NU	O/M
++	iviStatus	M	M	M	M
++	connectedDenms	O	-	-	O
+	iviContainers (sequence of IviContainer)	O	O/M	M	M



Layer	Data element / data field in and IviStructure	ISO 19321	C2C-CC (this document)	C-Roads (Release 1.7)	Combine d
++	geographicLocationContainer	C	O/M	M	O/M
+++	referencePosition	M	M	M	M
++++	latitude	M	-	-	M
++++	longitude	M	-	-	M
++++	positionConfidenceEllipse	M	-	-	M
++++	altitude	M	-	-	M
+++	referencePositionTime	O	-	NU	
+++	referencePositionHeading	O	-	NU	
+++	referencePositionSpeed	O	-	NU	
+++	parts (sequence of GlcParts)	M	M	M	M
++++	zoneId	M	M	M	M
++++	laneNumber	O	-	O/M	O/M
++++	zoneExtension	O	-	NU	
++++	zoneHeading	O	-	M	M
++++	zone	O	M	M	M
+++++	segment	C	M(p)	M	M
++++++	line	M	M	M	M
+++++++	deltaPosition	C	C	M	M
+++++++	deltaPositionsWithAltitude	C	C	?	?
+++++++	absolutePositions	C	F	F	F
+++++++	absolutePositionsWithAltitude	C	F	F	F
+++++++	laneWidth	O	O/M	O/M	O/M
+++++	area	C	-	F	F
+++++	...				
+++++	computedSegment	C	-	F	F
+++++	...				

Layer	Data element / data field in and IviStructure	ISO 19321	C2C-CC (this document)	C-Roads (Release 1.7)	Combine d
++	generallviContainer (sequence of GicParts)	C	O/M	C/M	O/M
+++	detectionZonelds	O	M	M	M
+++	Its-Rrid	O	-	NU	
+++	relevanceZonelds	O	M	M	M
+++	direction	O	M	M	M
+++	driverAwarenessZonelds	O	O/M	NU	O/M
+++	minimumAwarenessTime	O	-	NU	
+++	applicableLanes	O	O/M(p)	O/M	O/M
+++	iviType	M	M	M	M
+++	iviPurpose	O	-	NU	
+++	laneStatus	O	-	O	O
+++	vehicleCharacteristics	O	-	O	O
++++	...				
+++	driverCharacteristics	O	-	NU	
+++	layoutId	O	-	NU	
+++	preStoredlayoutId	O	-	NU	
+++	roadSignCodes (sequence of RSCode	M	M	M	M
++++	layoutComponentId	O	-	O	O
++++	code	M	-	M	M
+++++	viennaConvention	C	-	F	F
++++++	...				
+++++	iso14823	C	-	M	M
++++++	...				
+++++	itisCodes	C	-	F	F
++++++	...				

Layer	Data element / data field in and IviStructure	ISO 19321	C2C-CC (this document)	C-Roads (Release 1.7)	Combine d
+++++	anyCatalogue	C	-	F	F
+++++	...				
+++	extraText (sequence of Text)	O	-	O	O
++++	layoutComponentId	O	-	M* (due to error in previous ISO version)	O*
++++	language	M	-	-	M
++++	textContent	M	-	-	M
++	roadConfigurationContainer (sequence of rccParts)	C	M	NU	M/NU
+++	relevanceZoneIds	M	M	M	M
+++	roadType	M	M	M	M
+++	laneConfiguration (sequence of laneInformation)	M	M	M	
++++	laneNumber	M	M	M	M
++++	direction	M	M	M	M
++++	validity	O	-	-	O
++++	laneType	M	M	M	M
++++	laneTypeQualifier	O	-	-	O
++++	laneStatus	M	M	M	M
++++	laneWidth	O	-	-	-
++++	...				
++	textContainer	C	F	NU	
+++	...				
++	layoutContainer	C	F	NU	
+++	...				

Layer	Data element / data field in and IviStructure	ISO 19321	C2C-CC (this document)	C-Roads (Release 1.7)	Combined
++	automatedVehicleContainer	C	-	NU	
+++	...				
++	mapLocationContainer	C	F	NU	
+++	...				
++	roadSurfaceContainer	C	-	NU	
+++	...				