SWP 2.1 Use Cases

In-Vehicle Information
WP 2 – System Definition
Version: 03.50

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Overview of changes

No.	Version	Status	Date	Type of Change
1	01.00	Released	2014-11-20	First Release
2	02.00	Released	2015-03-12	Second Release
3	03.00	Released	2015-07-15	Third Release
4	03.10	Released	2015-10-28	Third Release – Update
5	03.50	Released	2016-04-29	Third Release – Second Update
6	03.60	Released	2016-07-29	Third Release – Third Updated

Table 1: Document History

Reference to the status- and version administration:

Status:

In progress — the document is currently in editing mode

Released — the document has been checked and released by quality assurance, it can only be modified if the version number is updated.

Versions:

Takes place in two stages. Released documents receive the next higher integral version number.

00.01, 00.02 etc. — Not released versions, with the status in progress

01, 02, etc. — Released version with the status released

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1 Document Information

1.1 Purpose of this document

This document describes the use case and provides a functional description for the “In-Vehicle Information” (IVI) service, one of the Day 1 use cases to be implemented in Austria in general and in ECo-AT in particular. The use case definition essentially serves three purposes during the course of this project:

1. It creates a common understanding of all project partners in ECo-AT regarding the objectives, the functional elements and the general course of activities and interactions in the particular use case.
2. It is the basis for further, more detailed specifications of the applications, data and components needed to implement this use case in ECo-AT, in SWP 2.1 and beyond.
3. It is the basis for communication with the other Corridor partners in DE and NL in order to come to harmonized Corridor-wide specifications.

The ECo-AT IVI use case is based on the Amsterdam Group Functional Description Paper [AG IVI] for the same application. Note that references to specifications have to be versioned, i.e. aligning the documents will mean updating this document to refer to any potentially updated AG paper. Furthermore, the essential content form the AG paper is physically copied and quoted here in order to keep the document self-contained and to avoid semantic errors in the alignment and iterative amendment process.

In addition to the basic AG description, any ECo-AT specific choices / profiles and additional specifications are added in this document in order to provide all necessary information required for a full deployment specification in ECo-AT.

1.2 Definitions, Terms and Abbreviations

Abbreviation / Term	Definition
2G/3G/4G	Different generations of cellular communication systems, offering digital communication links for data exchange – typical systems assigned to these generations in Europe are GSM/GPRS, UMTS and LTE
AG	Amsterdam Group – co-operation of C2C-CC, CEDR, ASECAP & POLIS for European roll-out of Cooperative ITS
C-ITS	Cooperative ITS – C-ITS is a *“subset of overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems”* (ISO/TR 17465-1)
CORBA	Common Object Request Broker Architecture
DENM	Decentralized Environmental Notification Message

Abbreviation / Term	Definition
I2V	Infrastructure-to-Vehicle – describes the directional information flow from infrastructure communication point R-ITS-S towards passing vehicles (V-ITS-S)
ITS	Intelligent Transport Systems – systems that use information and communication technology to improve transport systems
IVI	In-Vehicle Information
IVS	In-Vehicle Signage
MAP	Message to convey local, detailed network topology in specific areas, as specified in ISO/PDTS 19091
VISP / DDS	VISP / DDS, ASFINAG's central traffic data hub
R-ITS-S	Roadside ITS station (as of [ETSI 302 665]), mobile on vehicle or fixed at roadside
RWW	Road Works Warning – Day 1 I2V use case where a R-ITS-S delivers information about downstream road works to V-ITS-S
TLS	Technische Lieferbedingungen für Streckenstationen [TLS] – the technical delivery conditions for route stations (TLS) serve as a standard for establishing traffic control systems on highways.
VDS	Variable Direction Sign
V-ITS-S	Vehicle ITS station (as of [ETSI 302 665]), i.e. on-board unit for C-ITS
VMIS	Verkehrsmanagement- und Informationssystem, ASFINAGs TLS based traffic management and information system
VMS	Variable Message Sign – electronic traffic sign with dynamic content that may include textual as well as graphical elements
VTP	Variable Text Panel

Table 2: Definitions, Terms and Abbreviations

1.3 References

All references in this document can be found in the master table of references available in the "Eco-AT_SWP2.3_MasterTableOfReferences_v03.60.pdf" document.

2 Functional Description

Traditional fixed road signs are positioned by the road to inform drivers about applicable regulations, to warn them about dangers or to provide them with other general information – this can be considered as *roadside signage* information. Beyond such fixed signage, newer technologies today allow for more accurate, dynamic presentation of roadside signage information depending on the actual road and environmental conditions using *variable or dynamic message signs*. With the advent of Cooperative Intelligent Transport Systems (C-ITS) it will now become possible to provide more focused and timely guidance to drivers themselves as well as driver assistance systems via digital radio communication from infrastructure to vehicle (I2V). This technology will allow for a continuous presentation of the content of roadside signage information in the vehicle rather than only during the short moments its takes for a vehicle to pass traditional road signs. Direct in-vehicle presentation of roadside signage information – called *In-Vehicle Signage* – facilitates the provision of information to specific classes or characteristics of vehicles. It also allows a finer granularity in the definition of affected road sections than stationary, traditional fixed plate signs and use of variable/dynamic road signs. Delivering the In-Vehicle Signage service to road users can improve road safety and support traffic management.

2.1 Scope

2.1.1 Distinction between IVI and IVS

In-Vehicle Information (IVI) denotes a data structure that is required by different ITS services to convey information into the vehicle. One of these services is *In-Vehicle Signage* (IVS) which provides static as well as dynamic road sign and message sign information. ECo-AT (in all its releases) will focus on the In-Vehicle Signage (IVS) subset of IVI. IVS contains information about not only conventional road signs, but also variable message signs being used on motorways.

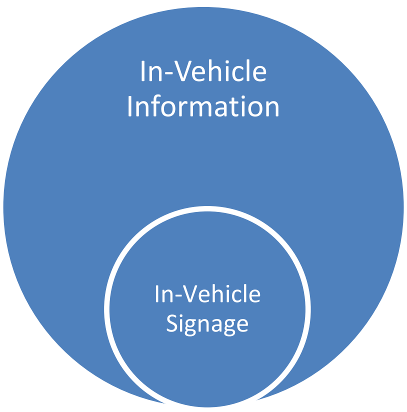

Figure 1: Distinction between IVI and IVS

2.1.2 IVI encoding

In-Vehicle Information (IVI) cannot be adequately conveyed with currently published C-ITS message standards like DENM. Although DENM has been used successfully as a temporary workaround for IVI in some demonstrations in the past, the operational roll-out of IVI requires a new standard. This standard is ISO/TS 19321 - *Dictionary of in-vehicle information (IVI) data structures* [ISO 19321], developed jointly by CEN and ISO and published in early 2015. It specifies the In-Vehicle Information data structures that are required by different ITS services for exchanging IVI information between ITS Stations. ISO/TS 17425 – *Data exchange specification for in-vehicle presentation of external road and traffic related data*, another possible standard for IVI encoding, was not published or stable enough to be considered for ECo-AT at the time this decision had to be made. It is still unpublished as of Release 3.5 of ECo-AT.

2.1.3 Definition of In-Vehicle Signage (IVS)

The focus of this document is the In-Vehicle Signage (IVS) service which provides information about all kinds of road traffic signs by means of Infrastructure2Vehicle (I2V) communication. This document addresses those elements of IVI that will be deployed on Day 1. It therefore covers the information that is currently being communicated by means of (conventional) road signs for both, mandatory and advisory policies.

For the purpose of this document two categories of road signs are considered

- Static road signs
- Electronic road signs
    - Variable message signs
    - Variable text panels
    - Variable direction signs

2.1.4 Expected benefits

The purpose of IVI is to enable the driver and the vehicle to have at any time access to all relevant (from a road operator's perspective, road operator authorized) information, based on time and location, but also based on characteristics and type of the vehicle. The information can be processed by driver assistance systems in the vehicle or it can be presented to the driver, either automatically (warnings based on certain triggers) or on request, when asked for (driver wants to check something).

Sign information will be filtered according to geographical relevance and other relevance criteria, e.g. only information relevant ahead should be processed or presented to the driver. This basically concerns regulatory information for the specific type of road user (type of vehicle).

The service improves the awareness of road users by giving them access to all relevant information (for that type of vehicle) at the right time and location (and not only at a specific location/point on the road).

Filtering/priority setting should be done to prevent overload of information to the end user. Another added value is that the information can be transmitted in a language independent way.

Expected benefits are:

1. Less accidents and increased road safety because of
    a. Decreased chance of traffic signs not being noticed
    b. Improved understanding of difficult contextual signs (some signs are not self-explanatory in the short moment drivers can see them)
    c. Increased awareness level of drivers on road regulations
2. Smoother traffic and less congestions / improved traffic efficiency

2.2 General Structure of IVI

It is important to note that each different sign has a specific *policy* or *regime*. Transferring this to IVI makes it immediately apparent that not every physical sign is relevant for every vehicle. For example a width restriction is only applicable for trucks and special types of large vehicles.

We can define relevant signs according to the Vienna convention categorization on road signs and signals, see also ANNEX A: Vienna convention categorization signs examples.

- A Danger warning signs
- B Priority signs
- C Prohibitory or restrictive signs
- D Mandatory signs
- E Special Regulation Signs
- F Information, facilities, or service signs
- G Direction, position, or indication sign
- H Additional panels

Important Note: Road operators provide *information*, the decision on how this information is processed is the choice of the application designer, i.e. OEMs or service providers, and may differ from one application/device/vehicle to the other.

It is important to note that the “traditional” fixed road signs alongside the roads are mostly regulatory signs (of course there are also fixed advisory signs) and should in the Day 1 application of In-Vehicle Information always have the highest priority. Nevertheless, information presented by means of In-Vehicle Information is not legally binding (at least in Day 1).

Although the scope of this Use Case is rather clear, there are still some open issues and questions. ANNEX B: Assumptions for in-Vehicle Information provides an overview of these issues and which assumptions have been made to address them.

2.3 Definition of relevance and awareness area

The subsequent chapters will make use of the terms relevance area and awareness area which are therefore defined as following:

The **relevance area** concerns the area for which the sign / measure is applicable. Although the relevance area is fixed for each separate sign / measure, it can vary depending on time and specific location. (red part in Figure 2)

The **awareness area** for traditional road-signs covers the area from which the sign can be visually observed. (yellow part in Figure 2) A very well know limitation here concerns the weather conditions. In bad weather conditions the driver might notice the road-signs (too) late in order to act adequately. In-Vehicle Information has the strong advantage that it is not dependent on the weather conditions. This means that the driver can be informed in time at any moment, even taking into account his speed and the specific situation and characteristics of the vehicle, thus effectively increasing the awareness area.

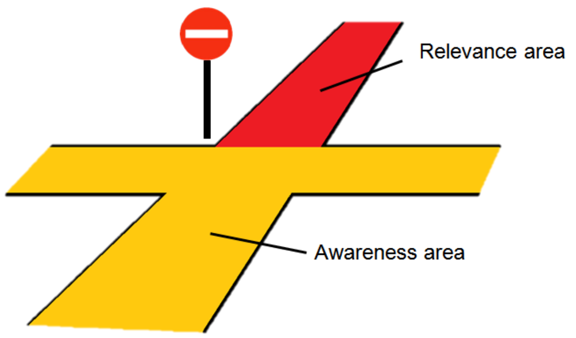

Figure 2: Difference between relevance and awareness area

2.4 IVI Viewpoints

The following chapters describe the use of IVI from a functional viewpoint, first from a user's perspective and later from the road operator's perspective. The Use Case itself is then specified based on different scenarios as examples how the service eventually works.

2.5 IVI from User's Perspective

For in-Vehicle Information from the user's point of view, there are different use cases, both for highway (inter urban) and urban / rural roads. This distinction is made because of the different levels of detail of Information and policies active in the two application environments. On the highway for instance, the speed limit is one of the most important signs presented. But in an urban area parking policies and priority signs are also relevant. Priority signs are obviously more present in urban areas and often a lot of signs are very close to each other. Hence, a user clearly has very different experiences in the two application environments. From a road operator's perspective, this distinction is not made, as described in the next subchapter.

In terms of complexity (more information at the same time requires more performance from the technical system), the Use Case highway / inter-urban is a Day 1 application, and the urban area / rural road could be seen as a Day 2 deployment. This document will focus on the highway / inter-urban Use Case for Day 1.

This approach matches the release plans of ECo-AT, spreading the Use Cases over different releases:

Day 1	Static Signs	Dynamic Signs
Release 1		
Release 2		Electronic road signs (highway / inter-urban)
Release 3 **Release 4**	~~Static road signs (highway / inter-urban) *~~	Electronic road signs (highway / inter-urban)

Table 3: Release Plan for IVI in ECo-AT / Day 1

Day 2	Static Signs	Dynamic Signs
	Static road signs (highway / inter-urban) Static road signs (urban / rural)	Electronic road signs (highway / inter-urban) Electronic road signs (urban / rural)

Table 4: Plans for IVI on Day 2

* Support for Static road signs was initially planned for Release 3 of ECo-AT. Due to technical constraints in the underlying source data, support for Static road signs was dropped in ECo-AT as of Release 3.5. The reasons for that decision are described in Chapter 4.3.

2.5.1 Functional description of IVI from the user's perspective

A vehicle approaches an area governed by a traffic sign (e.g. speed limit zone) and receives an In-Vehicle information message (IVI message) via ITS G5 / DSRC / 802.11p. The processing of the sign information (e.g. presentation to the driver via the HMI) has to be performed in due time (time, distance and speed), sufficient for reacting in time to adapt e.g. the speed accordingly, and in all cases not later than the sign becoming valid. This use case does not address the different HMI types and possibilities to present the information (visual, speech, etc.). This aspect is in the responsibility of the OEMs (of course respecting safety regulations) and might be personalized according to the special needs of the driver. The HMI possibilities shown in Figure 3 and other places are just illustrative examples.

Figure 3: Example IVS from user's perspective

2.6 IVI from Road Operator's Perspective

Road operators can use in-Vehicle Information to convey road information and regulation to the drivers. This can be done by the use of Roadside ITS Stations (R-ITS-S), which broadcast this information to the passing vehicles. To get a better understanding of the needs of the road operators in the case of In-Vehicle Information, three use cases have been identified:

- Standalone R-ITS-S

- R-ITS-S as part of a dynamic stand-alone system
- R-ITS-S as part of a dynamic network, controlled on-line by the road operator

The three scenarios cover (all) the different systems available to road operators today. The most relevant scenario for ECo-AT will be the third, which corresponds to the way ASFINAG operates electronic signage.

Standalone units can be used to convey regulation for a particular area to the drivers. This can be for instance the maximum allowed speed in that area or an area which is forbidden to enter. The second scenario is used for dynamic systems that operate autonomously, for instance dynamic speed regulations by means of a motorway control system during fog and congestion. The third scenario is the use of R-ITS-Ss as part of a network that can be controlled directly by the road operator via a Traffic Control Centre (TCC). The different modes of operation are of course not necessarily tied to different sign types.

It is not necessary to have an R-ITS-S for each single sign, one R-ITS-S can cover a whole area and "transmit" details of multiple road signs (see Figure 4). This might require the R-ITS-S to be connected to a TCC. In a stand-alone solution, the R-ITS-S will transmit only the local information – but does not require any connection with the TCC. Both solutions have advantages / disadvantages. It is up to the road operator which implementation to choose.

Different road signs have different types of regimes and policies. Example: one R-ITS-S can send out information about the speed limit, but also alert about the oncoming railway crossing and also about the parking prohibition along the roadside. This creates a more network oriented approach.

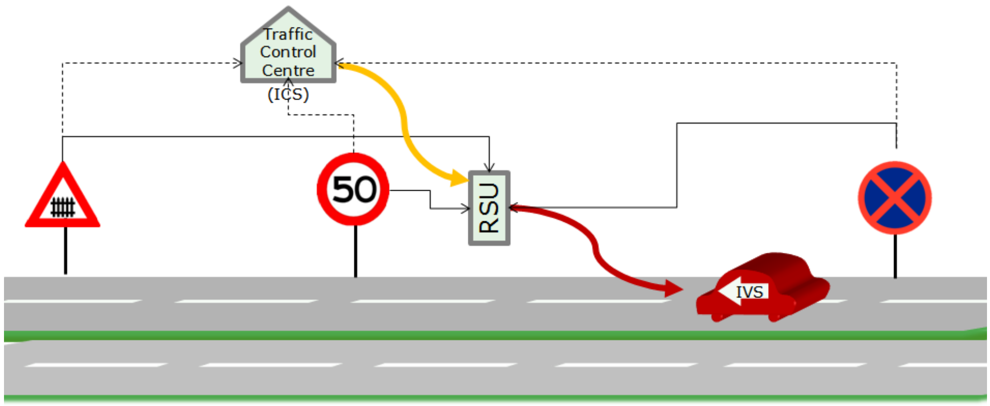

Figure 4: Not every sign needs to have an R-ITS-S

2.6.1 Standalone R-ITS-S

A road operator wants to set a maximum speed limit on a highway. He therefore places an R-ITS-S next to the road on which the speed limit is in effect (it is also possible to transmit speed information of the whole network) which relays the information about the upcoming speed limit (static, this R-ITS-S is not connected to the downstream signs).

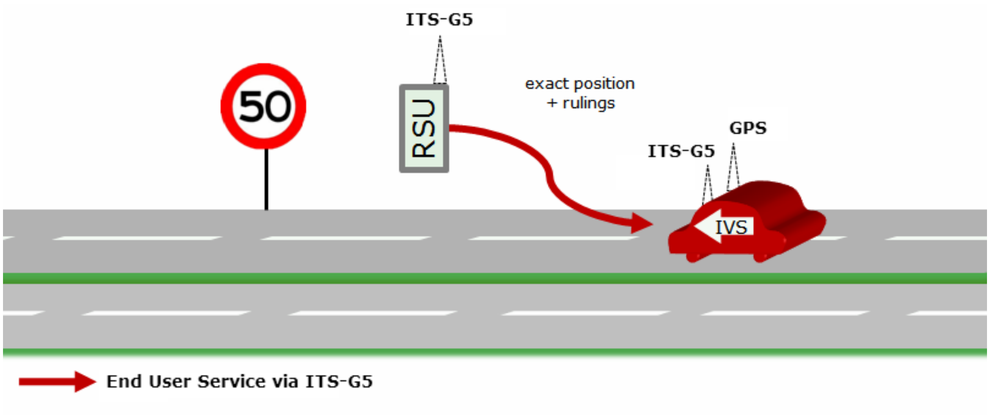

Figure 5: Standalone R-ITS-S

2.6.2 R-ITS-S which are part of a dynamic stand-alone system

Road operators can use autonomous systems to detect incidents which require warnings and lower speeds on the road. Fog-, accident and congestion warning are examples of these incidents. These systems can contain a weather station, roadside units combined with variable message signs, loop detectors with sub-centers or video based incident detection. When an incident (via automatic incident detection / AID) is detected, the system automatically lowers the maximum speed limit by means of matrix signs above the road (like in Figure 6). In case of In-Vehicle Information this maximum speed which overrules the previous, regular maximum speed is transmitted via R-ITS-S to the vehicles.

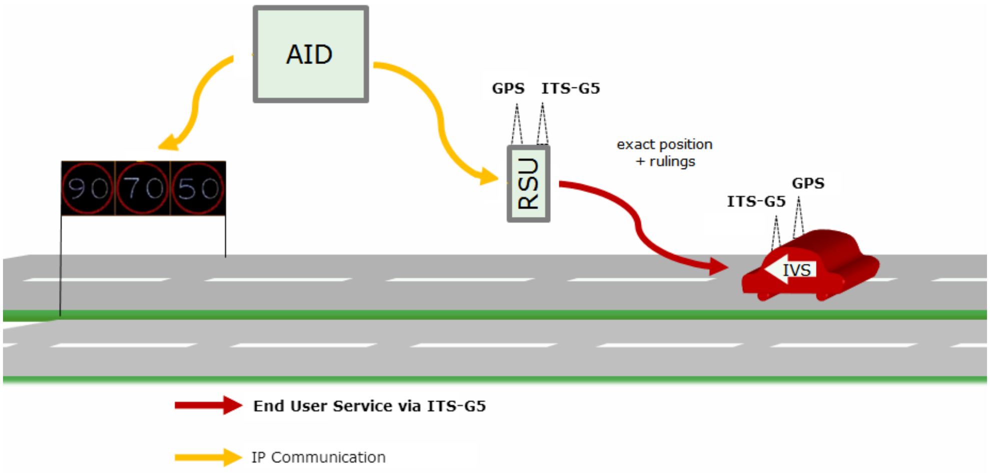

Figure 6: Road side units which are part of a dynamic stand-alone system

2.6.3 R-ITS-S which are part of a dynamic network (centrally controlled via TCC)

In the third use case the R-ITS-S transmitting traffic regulation in an area can directly be controlled by the road operator in the TCC. So the road operator can change traffic regulations on demand and in real-time. This enables dynamic influence on drivers' behavior. This will be the most relevant scenario for ECo-AT, as it corresponds to the way ASFINAG operates electronic signage.

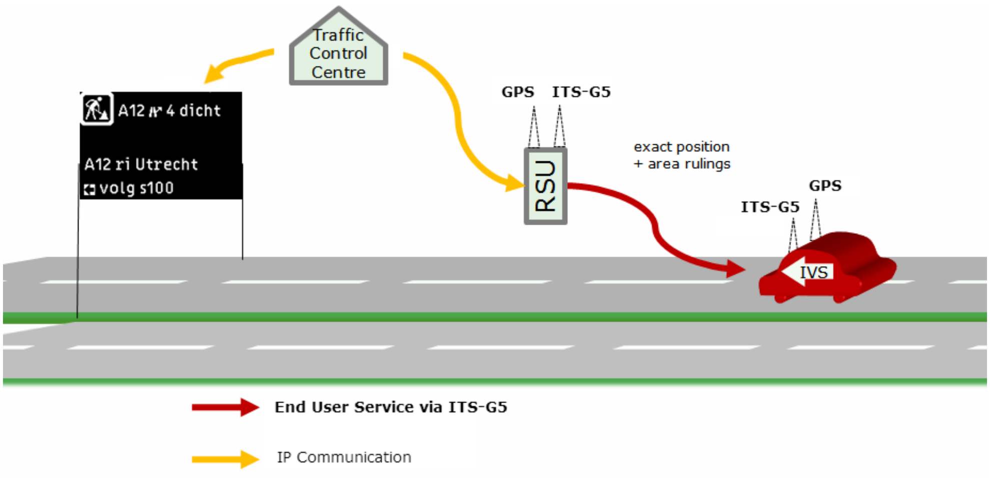

Figure 7: Road side units which are part of a dynamic network

2.7 IVI information requirements

The In-Vehicle Information service should provide the following data and information. Note: the message sets contain both, the information on the sign itself but also additional, contextual information.

At least the following information needs to be sent by the R-ITS-S:

- Signage (identification / code)
  - Type of signage (danger, priority, prohibitory, mandatory etc.);
  - Identification of signage (e.g. against a catalogue);
  - Content (e.g. max. 100 km/h);
  - Time validity;
  - Message Priority;
  - Message type (informative or mandatory);
  - Vehicle classification.
- Coverage
  - Ideally road and direction of relevance, at least the exact position of the signs
  - Minimum area and direction of awareness expressed as waypoints on the approach to which the vehicle can match its own trajectory (traces)

Also some concrete physical information need to be defined and set:

- The mounting point where the R-ITS-S is installed, having direct impact on where and when the information will be transmitted from the R-ITS-S, taking into account the awareness and relevance areas.
- Additional information (e.g. messages only relevant further away) should be transmitted at the same location as the “relevant” information. Due to capacity restrictions on the transmission channel, additional information may however not be sent out at all.

In-Vehicle presentation of information:

Although it is stated earlier that the HMI is under responsibility of the OEMs, road operators expect that the information is presented to the driver at least at the same time as the traditional road signs can be observed by the drivers.

OEM perspective (desired input)

Tables and picture libraries need to be provided to OEMs/service providers, preferably by or under control of the competent road authorities.

- Identifiers of the signs and identifiers of countries
- Service available to download respective image(s) (if not yet in database)
- Description of meaning of signs in different languages also available for download

Content for the use case

It is the aim that all information displayed via conventional signs along the road network are made available via cooperative ITS to the on board units of the users like

- variable message signs
- dynamic speed limits
- static signs
- additional pictograms
- predefined and/or free text messages
- messages about advised route

3 Status Quo

3.1 Legal environment in Austria

There is legislation as well as guidelines and regulations concerning road signs and sign posting in Austria. The Use Case In-Vehicle Signage (IVS) must obey all requirements provided by these documents.

3.1.1 Legislation: Straßenverkehrsordnung (StVO)

Road signs in Austria are regulated by law in the "Straßenverkehrsordnung (StVO)". The current edition of this law is published by the Legal Information System of the Republic of Austria via https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011336.

3.1.2 Guidelines and Regulations: RVS

Furthermore, the RVS ("Richtlinien und Vorschriften für das Straßenwesen") stipulates guidelines and regulations for sign posting and road signs on streets with public traffic in Austria. There a different guidelines / regulations for highway / inter-urban and rural / urban areas:

- Highway / Inter-urban areas
  - RVS 05.02.13 Beschilderung und Wegweisung auf Autobahnen
- Rural / Urban areas
  - RVS 05.02.12 Beschilderung und Wegweisung im untergeordneten Straßennetz

RVS can be directly obtained by the publisher, „Forschungsgesellschaft Straße – Schiene – Verkehr" (FSV).

Road signs are generally placed on the right side next to the road or above the road. Sometimes signs are also placed on both sides, in some exceptional cases signs are only placed on the left (particularly town signs).

3.1.3 Vienna Convention

Despite an apparent general uniformity and harmonization, European traffic signs show some relevant differences between countries. Nevertheless, most European countries refer to the Vienna Convention on Road Signs and Signals, available here: http://www.unece.org/fileadmin/DAM/trans/conventn/signalse.pdf

Recognizing that international uniformity of road signs, signals and symbols and of road markings is necessary in order to facilitate international road traffic and to increase road safety, the Vienna Convention was agreed upon by the United Nations Economic and Social Council at its Conference on Road Traffic in Vienna and came into force 6 June 1978. It is a multilateral agreement designed to increase road safety and aid international road traffic by standardizing the signing system for road traffic (road signs, traffic lights and road markings) in use internationally. This conference also produced the Vienna Convention on Road Traffic, which complements this legislation by standardizing international traffic laws.

In article 2 the convention classifies all road signs into a number of categories (A - H):

- A Danger warning signs
- B Priority signs
- C Prohibitory or restrictive signs
- D Mandatory signs
- F Information, facilities, or service signs
- G Direction, position, or indication sign
- H Additional panels

The convention then specifies precisely colours, sizes and shapes for each of these classes of signs. Sign examples are listed in *ANNEX A: Vienna convention categorization examples*.

3.2 Existing signage on Austrian highways

Road signage in Austria consists of static signage (road sign plates) and dynamic signage (electronic variable message signs), both in highway/ inter-urban and in rural / urban areas. A Use Case regarding In-Vehicle Signage is complex and has to address a variety of data with a large number of parameters.

The focus of ECo-AT on Day 1 will be on electronic and static signage in highway/ inter-urban areas.

ASFINAG currently operates approx. 800 locations of dynamic signage with approximately 6000 display options. Data about static signage is collected in a central database for static road signs.

The following sections are based on the planning manuals for the ASFINAG traffic control system, which can be downloaded at http://www.asfinag.net/Home/PlaPB. Relevant documents can be found in the *“800.551 Verkehrsbeeinflussungsanlagen (VBA)”* category. Please refer to the documents *“PlaPB 800.551.1000 Technische Richtlinie”* [ASF VBA TECHGUIDE] and *“PlaPB 800.551.2000 Technische Spezifikation”* [ASF VBA TECHSPEC] for further details.

3.2.1 Variable Message Signs (VMS)

The cross-section signage mounted centrally overhead consists of centre-lane mounted VMS signs (A) with an additional information sign below (AC) and an intermediate VMS (B), also with an additional sign below (BC).

All possible signs that VMS are currently able to display are listed in *ANNEX C: Sign Catalogue for ASFINAG VMS / VTP*, based on the current specification in the planning manuals for the ASFINAG traffic control system (*“PlaPB 800.551.2000 Technische Spezifikation”)* [ASF VBA TECHSPEC].

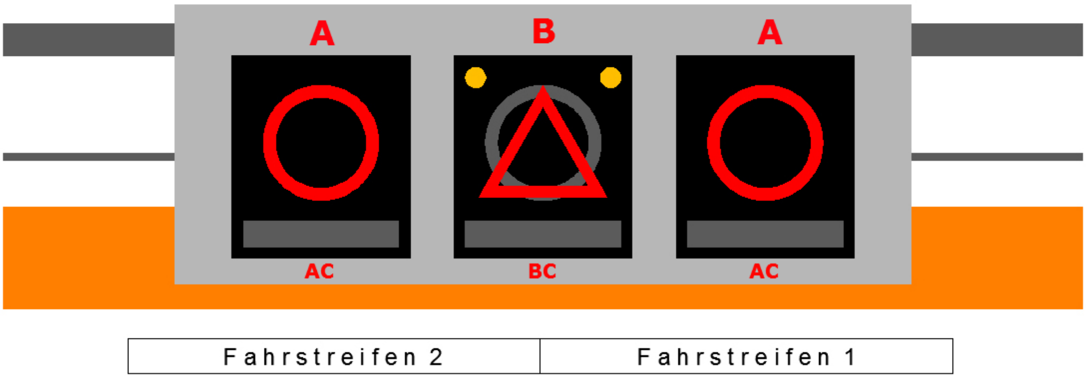

Figure 8: Variable Message Sign (VMS) covering two lanes

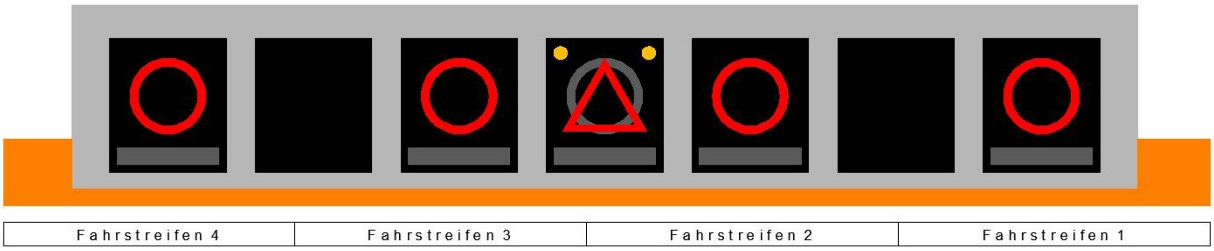

Figure 9: Variable Message Sign (VMS) covering four lanes

Data availability and limitations

- Real-time data for VMS is basically available via TLS, but there is no standard interface or format to provide it for time-critical, external applications like IVI. Latency may be significant and all interfaces have to be checked for suitability regarding the In-Vehicle Signage Use Case.
- All data is related to the before-mentioned cross-sections. If a sign of 80km/h is shown, it means that the sign is valid from the point where it is shown up until the next VMS gantry or static road sign in driving direction. The geographical validity of the sign, both the starting and the end point, are not part of the information available over the interfaces per se, although a start point can be derived in most cases. Connected information e.g. a velocity across several VMS is not available.

3.2.2 Variable Text Panels (VTP)

Variable Text Panels are changeable signs based on LED technology on which information about particular events can be presented for road users in the form of free text, accompanied by at least one pictogram.

There are two forms of VTPs on the ASFINAG network:

1. Variable Text Panel (Wechseltextanzeige - WTA)

   WTAs consist of three lines of (free) text and one VMS to display a road sign or a pictogram

2. Fully graphical Variable Text Panel (Wechseltextanzeige - WTA-V)

   WTA-Vs are – from a technical viewpoint - freely programmable information panels with individually addressable pixels. Any form of text and/or pictures can be presented. On a logical level, however, they are currently used the same way as VTP and therefore are treated the same way in this document.

All signs (and text) VTP are currently able to display are listed in *ANNEX C: Sign Catalogue for ASFINAG VMS / VTP*, based on the current specification in the planning manuals for the ASFINAG traffic control system (*"PlaPB 800.551.2000 Technische Spezifikation")* [ASF VBA TECHSPEC].

Figure 10: Variable Text Panel (VTP)

Data availability and limitations

- Real-time data for VTP is basically available via TLS, but there is no standard interface or format to provide it for time-critical, external applications like IVI. Latency may be significant and all interfaces have to be checked for suitability regarding the In-Vehicle Signage Use Case.
- All data is related to the before-mentioned cross-sections. Any regulatory information shown is valid from the point where it is shown up until the next VMS gantry or static road sign in driving direction. The geographical validity of the sign, both the starting and the end point, are not part of the information available over the interfaces per se, although a start point can be derived in most cases. Connected information over several VMS or VTP installations is not possible
- Free text information presented on VTP is not available in an encoded, language independent way. It is only available as plain text (in German) via the existing interfaces.

3.2.3 Variable Direction Signs (VDS)

Variable direction signs (see Figure 11) are signs that can display pre-defined scenarios on otherwise conventional road sign plates by rotation of three or four prism bars. The movement of the prism is controlled by a motor.

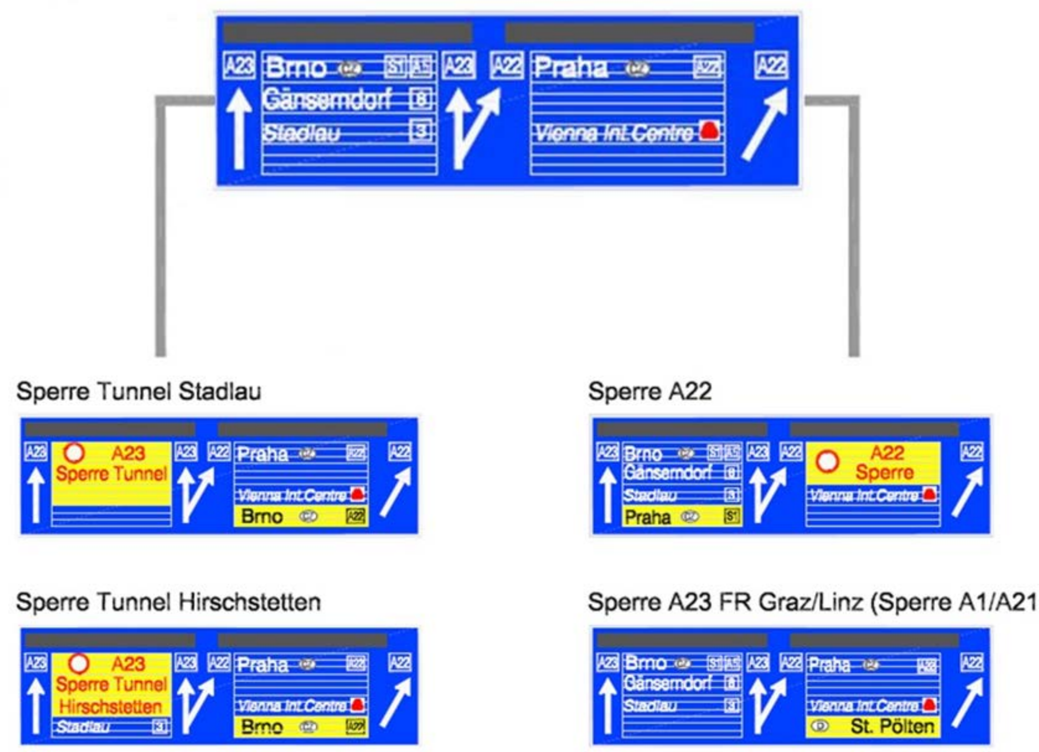

Figure 11: Variable Direction Signs (VDS)

Data availability and limitations

- Real-time data for VDS is basically available via TLS, but there is no standard interface or format to provide it for time-critical, external applications like IVI. Latency may be significant and all interfaces have to be checked for suitability regarding the In-Vehicle Signage Use Case.
- The representation of VDS is however difficult because the data available at the TCC only considers the changing part of the sign plate which is rather useless as traffic information on its own. In some cases, the whole picture of the sign would be available for data transfer, in others, only the changed parts. Even with the whole picture present, a meaningful representation in the vehicle by just showing the picture of the sign would be doubtful. A textual interpretation of the current state of the sign, which would be the most meaningful data content, is currently only available on paper and not yet integrated into the TCC systems.

3.2.4 Static Road Signs

Static Road Signs are actual sign plates placed on the side of the road.

ASFINAG has internally set up a database of traffic signs (VZDB). In 2010 the motorway network was inspected and the data of static road signs were collected. These collected data contain speed limit signs, no-passing signs and "general ban on motorized traffic" signs on the main driving lanes.

Data availability and limitations

- Information on static signs is generally available (see VZDB above), but needs to be checked for completeness and being up-to-date.
- Static speed information will also be fully available in the Austrian national Graph Integration Platform (GIP) in the future.

3.3 Standardization

During the "Testfeld Telematik" project, a first IVS Use Case had been developed, encoded in TPEG and also in a provisional DENM message by using 8 unused bytes of the DENM. Even at that point, it was clear that the DENM could be used for Roadworks Warning but was not sufficient for IVI / IVS. Standardization of a proper IVI / IVS standard was therefore needed. ECo-AT has settled on ISO/TS 19321 – *Dictionary of in-vehicle information (IVI) data structures* because it provides all the required functionality and was available in the necessary timeframe. ISO/TS 17425 – *Data exchange specification for in-vehicle presentation of external road and traffic related data* would have been another option, but was further behind in its development and not stable enough for the use in ECo-AT.

3.3.1 ISO/TS 19321 - Dictionary of in-vehicle information (IVI) data structures

A suitable IVI message format was developed in "ISO/TS 19321 - Dictionary of in-vehicle information (IVI) data structures" [ISO 19321]. The development of this standard was actively supported by ASFINAG and other ECo-AT / Corridor partners. The standard was published early 2015. It will be used in ECo-AT for the mapping of IVI / IVS, possibly also for aspects of (long-term) RWW.

ISO/TS 19321 supports mandatory and advisory road signage as well as applications like contextual speeds and road works warnings. In-Vehicle Information can be send by an ITS Station (generally the R-ITS-S) and either corresponds to physical road signs such as static or variable road signs, correspond to virtual signs or correspond to road works. IVI does not include identification of road events (except for road works) as already provided by DENM. It provides a toolbox of information elements for IVI and aims at being an enabling standard. It does not specify which information is necessary for a certain service but it supports those IVI information elements that may be necessary to be transmitted to a receiving ITS-S to carry out a certain service. Usage of the IVI elements depends on the specific context and application of IVI for a specific service, and usage is established as mandatory or optional only for messaging purposes, not for application purposes. The IVI Structure is intended to be profiled to fulfil the requirements of a specific service.

The IVI Structure itself is specified as a general, extensible data structure. It is split into structures called containers. Transmitted information includes In-Vehicle Information (IVI) such as contextual speed, road works warnings, vehicle restrictions, lane restrictions, road hazards warnings, location-based services, re-routing, etc. The information in the containers is organized in sub-structures called data frames and data elements which are described in terms of content and syntax.

The data structures themselves are specified as communications agnostic. The technical specification does not provide the communication protocols, but it provides scenarios for usage of the data structure, e.g. in case of real time, short-range communications.

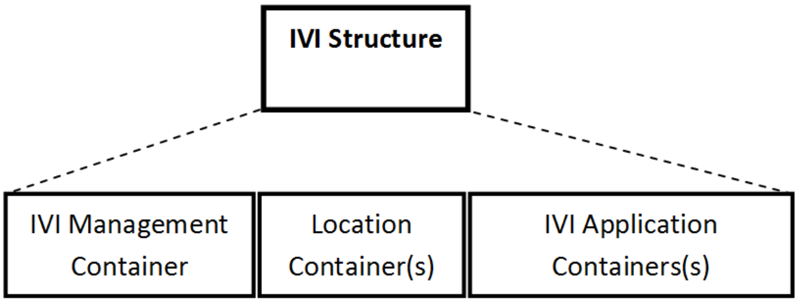

Figure 12: IVI Structure

In-Vehicle Information (IVI) includes In-Vehicle Signage (IVS), distinguishing Simple IVS (sign plates and simple VMS) and Complex IVS (Complex VMS, VTP, VDS), as well as construction sites and track information. The exact definitions of Simple and Complex IVS are currently being revised.

The IVI Structure is intended to be encapsulated in a message with the appropriate ITS Common Header, similar to a DENM message.

The IVI Structure shall contain a Management Container. The information in the IVI Management Container is applicable to the entire IVI Structure. This Container is mandatory and provides a receiving ITS-S with enough information to handle the IVI Structure and decide on its further processing.

The IVI Structure may contain one or more Location Container(s). The Location Container describes the essential information for applications in the receiving ITS-S: to understand how to apply the information provided by the IVI Application Containers. Location Containers may carry information relevant for different Application Containers, or carry the same content but expressed in different forms. This enables a receiving ITS-S to choose the most appropriate, supported location referencing system.

The IVI Structure may contain one or more Application Container(s). The IVI Application Container provides IVI information for use by an application. Application information is self-contained and refers to location information for its spatial validity. Application information of the same type shall not refer to overlapping Reference Zones. An Application Container may optionally provide information about the minimum awareness time; that is, the minimum time that the IVI should be available before the vehicle enters the Relevance Zone.

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This *MinimumAwarenessTime* information can be used by the receiving ITS-S to determine the appropriate Driver Awareness Zone.

3.3.2 ISO/TS 14823 - Graphic data dictionary for pre-trip and in-trip information dissemination systems

For the presentation of IVI / IVS, a corresponding common catalogue of road and information signs to refer to is needed, otherwise each application and/or country would need its own national / proprietary catalogue. The IVI standard (ISO/TS 19321) refers to the sign catalogue established by "ISO/TS 14823 - *Graphic data dictionary for pre-trip and in-trip information dissemination systems* [ISO 14823]. This standard presents a system of standardized codes for existing signs and pictograms used to deliver traffic and traveler information (TTI). The current version of the standard is mainly focused on static road signs and is missing signs relevant for dynamic signage (VMS). ISO/TS 14832 is therefore insufficient for IVI / IVS at the moment, but is planned to be the definitive reference in the future. Therefore, additional signs from all countries will be added and it is also planned to make the whole catalogue electronically editable. See: http://standards.iso.org/iso/ts/14823/ for the latest version (work in progress). This has been agreed upon between the committees in charge of ISO TS 19321 and ISO TS 14823.

4 Analysis of Data Availability for the IVI / IVS Use Case

The following chapter will analyze the data sources for Static and Dynamic Signage available to ECo-AT to cover the IVI Use Case. It will detail current solutions, identify further work to be done and list potential problems. Key parameters (especially latency) of all data sources and interfaces will be tested and analyzed to determine their suitability for the IVI use case in ECo-AT.

4.1 Data availability for Static Signage

ASFINAG has internally set up a database of traffic signs (VZDB). Starting in 2010, the motorway network is regularly inspected and the data of static road signs is collected. These collected data sets contain speed limit signs, no-passing signs and “general ban on motorized traffic” signs on the main driving lanes.

The dataset consists of

- Type of road sign (with exact STVO number and textual description)
- Additional signs (plates below the signs)
- Location (GPS coordinates, motorway kilometer, area of validity, direction of motorway)
- Current status (e.g. active/inactive)
- Speed limit (in case of a speed limit sign)
- Picture of the road sign in actual environment

If there is a change on the motorway network, both maintenance and traffic management personnel act together to incorporate these changes into VZDB and keep it current.

In the future, Static Signage should also be fully available in the Austrian national Graph Integration Platform (GIP), which then could be used as a source. VZDB already has interfaces to GIP for that purpose.

4.2 Data Availability for Dynamic Signage

There are three different data sources available delivering the current state of Dynamic Signage throughout the ASFINAG network:

4.2.1 Scenario 1: Default VMIS

This is the default scenario for gathering data from dynamic signage. All VMS on the ASFINAG network are based on the TLS (Technische Lieferbedingungen für Streckenstationen) standard published by the German Federal Highway Research Institute, which defines the architecture and design for traffic control systems. The whole system is called VMIS (Verkehrsmanagement- und Informationssystem), which translates into Traffic Management and Information System.

Data from VMS passes through all elements of the TLS architecture (from VMS / VTP / VDS via various intermediate systems: Streckenstationen (SST), Kommunikationsrechner Inselbus (KRI), Unterzentralen (UZ) up to the Verkehrsrechenzentrale (VRZ) (which is the main part of the overall Traffic Control Centre (TCC)), where it is stored in a database. From there, it is processed for further transfer to different subsystems. One of the older systems was KexEA, which provided the data regularly via FTP, but generates significant latency by doing so. VMIS-DÜ is a newer system which synchronizes data elements (via DB triggers) to a corresponding database in VISP / DDS, ASFINAG's central traffic data hub. From there, it is processed, converted into various formats and ready to be retrieved over different interfaces.

Problems with the old KexEA system triggered both the new VMIS-DÜ system and the development of Scenario 2 described in the next section.

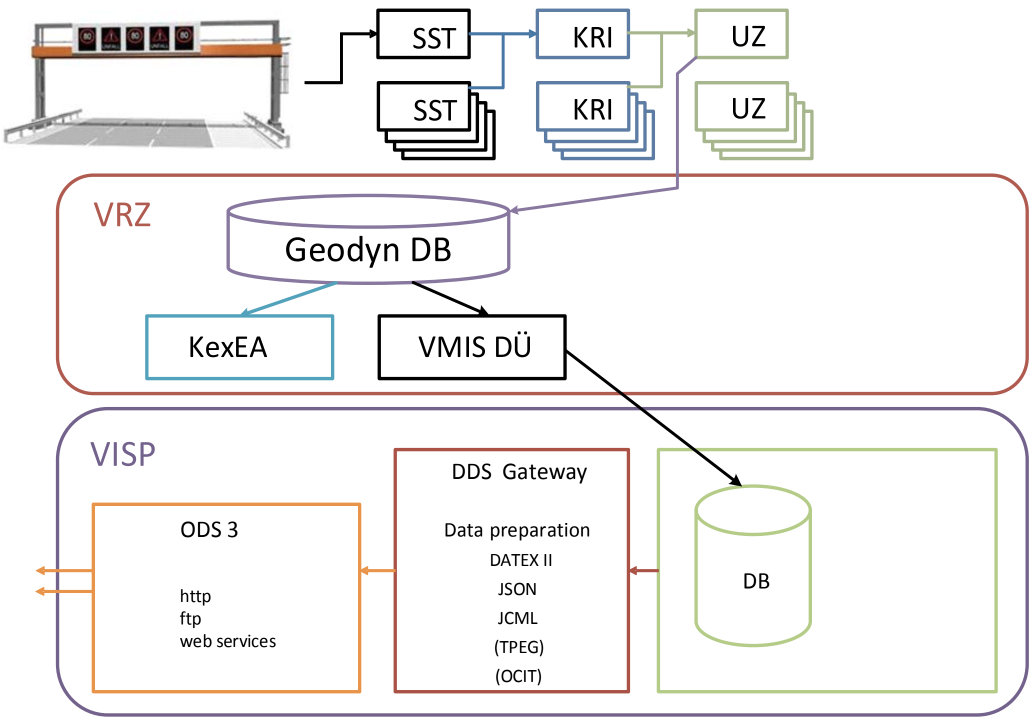


Figure 13: Scenario 1: Default VMIS using VMIS-DÜ

4.2.2 Scenario 2: Direct TLS Connection

For the use of IVS information in "Testfeld Telematik", the default VMIS scenario (using KexEA) was showing unacceptable latency. To fulfil the needs of IVS in the Testfeld, a new system (TLS Manager) was established. It bypasses large parts of the TLS architecture and the VRZ completely by accessing the command stations (KRI) responsible for the VMS directly. The switching and acknowledgement commands can be directly received at that location and are immediately stored in a local database and regularly synchronized with the databases of VISP / DDS, ASFINAG's central traffic data hub. This solution proved to be faster and less susceptible to latency problems than the VMIS scenario, but, from an architectural point of view, it is a workaround, not fully integrated in the normal operation scenarios.

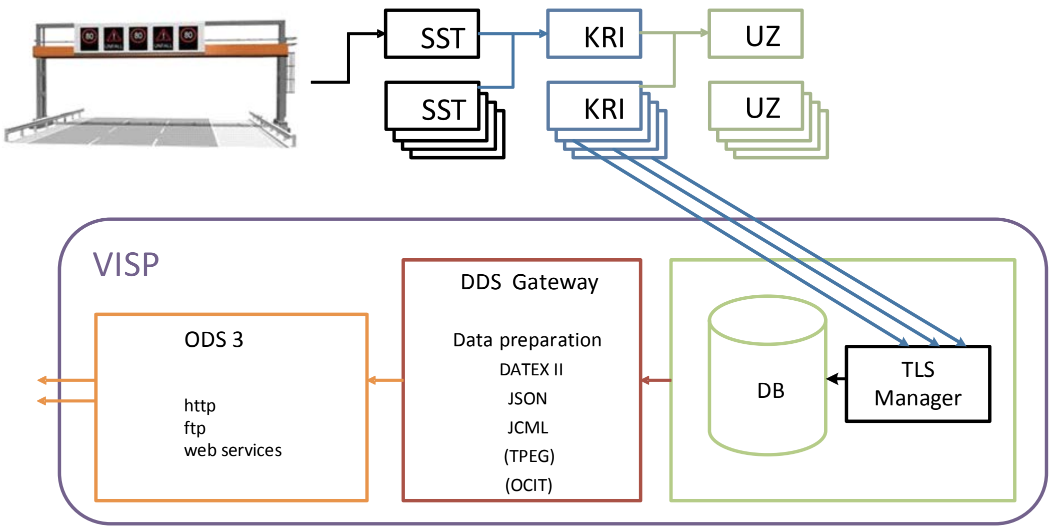


Figure 14: Scenario 2: Direct TLS Connection

4.2.3 Scenario 3: CORBA

ASFINAG has recently started to regionalize the operation of their traffic control system, away from an omnipresent TCC towards regional control at various points. These regional control points should also be able to operate both their traffic control and their tunnel systems with the same operating procedures. To facilitate these aims, a new CORBA based access to the TLS architecture (KRI, UZ) had to be established. CORBA (Common Object Request Broker Architecture) is a standard to facilitate the communication of systems that are deployed on diverse platforms. CORBA enables collaboration between systems on different operating systems, programming languages, and computing hardware.

The retrieval of VMS states directly from the TLS architecture via direct connections to the UZ using this CORBA interface was a key requirement and was recently implemented. The system is also able to visualize the sign states of individual signs and whole VMS gantries as shown in Figure 15.

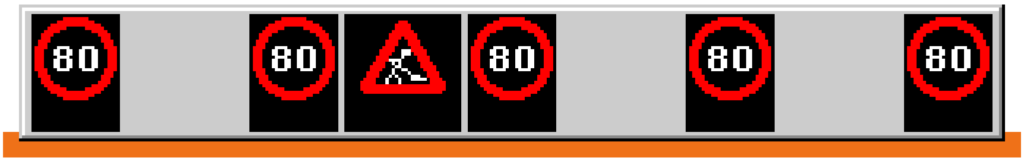


Figure 15: Output of the CORBA test system, visualizing a VMS gantry on A23

The CORBA interface is delivering the data regularly to VISP / DDS, ASFINAG's central traffic data hub and is – other than the TLS Manager in the previous solution – fully integrated in the normal operation scenarios.

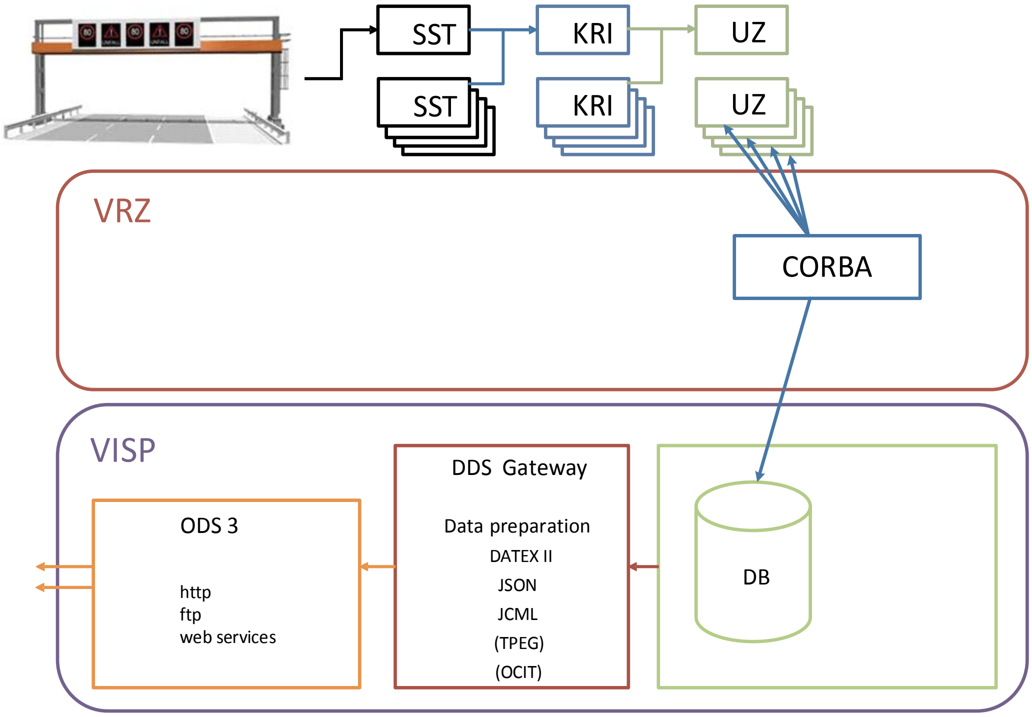


Figure 16: Scenario 3: CORBA

4.3 Analysis of data sources for Static Signage

Data from the database of traffic signs (VZDB) introduced in Chapter 4.1 is readily available via VISP / DDS, ASFINAG's central traffic data hub and could be provided in parallel, using the same data structures and data elements as Dynamic Signage. The main problem is, that there is currently no fusion / consolidation of Static and Dynamic Signage on the data level in VISP / DDS. Dynamic Signage may, at any time, contradict Static Signage, resulting in e.g. two conflicting speed limits for similar stretches of the motorway network. The convenient and obvious concept, that any Electronic Signage always has priority over Static Signage is not fully applicable as well, because geographic validity zones of Static Signage may differ from their static counterparts. This would mean that parts of the road stretch indicated by some Static Signage would still be affected by the static information (e.g. a speed limit) even if there was contradicting and potentially higher priority Electronic Signage information (e.g. a higher / lower speed limit) available for all other parts of it. Either the TCC (on the level of VISP / DDS) or the C-ITS system would have to do a complex consolidation of both Static and Electronic Signage in order to guarantee that only valid and not contradicting IVI / IVS information in sent out via C-ITS. Because of these restrictions, support for Static Signage was dropped from the ECo-AT IVI Use Case as of Release 3.5.

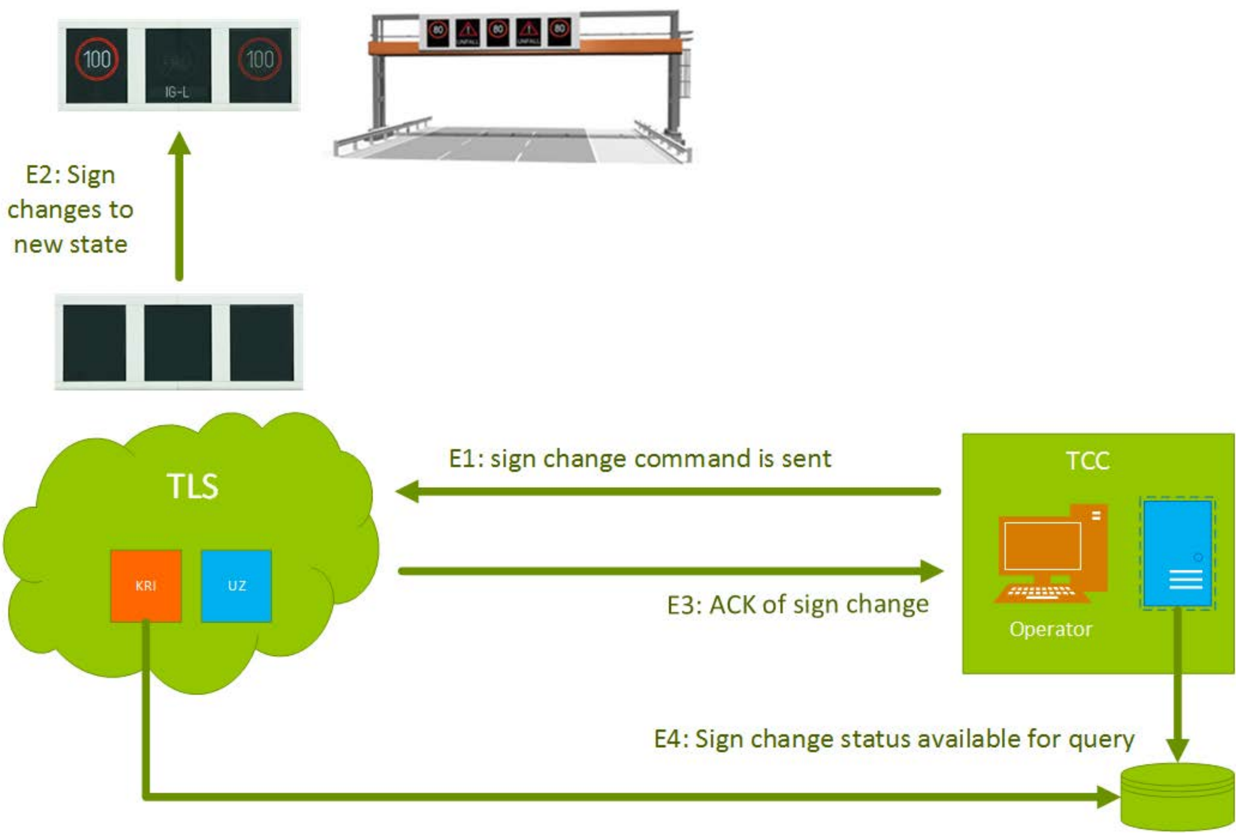


Figure 17: Procedure and relevant Events for electronic sign Change in a TLS based system

4.4 Analysis of data sources for Dynamic Signage

To put an analysis of data sources in the proper context, the procedure of changing the state of an electronic road sign has to be explained and the events that are significant in regard to data availability have to be identified. Figure 17 visualizes this process: when dynamic signage is changed, the operator in the TCC sends out a change command (E1), which is relayed along the TLS-architecture based systems directly to the sign. The sign then changes to the new state (E2) and sends an acknowledgement of the state change (E3) back (again, via the TLS system) to the TCC and the operator. The new state also needs to be provided for query / retrieval by other systems (E4), either by delivering the change information via TCC or by directly accessing TLS subsystems along the way.

The process of changing the state of electronic signage is therefore no real-time event. All the events in this process have inherent latency due to their architecture and the legacy systems involved and while some sources of delay can be circumvented, a certain system latency between the visible sign change on the road and the availability of the sign change via data systems has to be accepted.

In the (default VMIS based) implementation of the TLS-based electronic signage

- the time between events E1 and E2, from the time the operator sends the sign change command until the moment the sign actually changes, is around 5-10 seconds
- the time between events E1 and E3, from the time the operator sends the sign change command until the TCC and the operator receives the acknowledgement of the sign change, is roughly 20-25 seconds
- the time until event E4 is reached and a new sign state is available to be queried by other data systems (like ECo-AT) varies between 25 and 95 seconds, depending on subsystem used for monitoring the state change.

4.4.1 Scenario 1: Default VMIS

The VMIS-DÜ system used in this scenario is operated and monitored directly in the VMIS system of the TCC. It synchronizes data elements to a corresponding database in VISP / DDS, ASFINAG's central traffic data hub. Latency tests have shown good performance under normal circumstances, from E1 (sign change command sent) to E4 (new sign state available for query) it took 20 seconds at average, which is basically the same time it takes from event E1 to event E3 (acknowledgement of sign change received in the TCC / by the operator), introducing no additional latency in the data provision: when the TCC is aware of the change, the data is available. The problem with VMIS-DÜ is that there is only one data distribution process not designed for real-time operation and the dynamic signage information is only a small part of the data distributed. Latency can therefore multiply in an unpredictable fashion, depending on the amount of data to be distributed at any time. Tests have shown sporadic latencies of several minutes, sometimes the whole process is locked and gets restarted automatically by the monitoring system, resulting in a 20 minute gap in data availability. Furthermore, the data distributed by VMIS-DÜ is not the complete set of information available in dynamic signage. The additional signs (AC, BC) used by VMS signs and VTP signs in general are not available because of restrictions in the underlying data source. The latency issues could potentially be addressed by introducing an additional distribution instance solely responsible for dynamic signage information, the data availability problem will need further analysis. For the use in ECo-AT however, using other scenarios will have priority.

4.4.2 Scenario 2: Direct TLS Connection

As mentioned in chapter 4.2.2, the TLS Manager used in this scenario was introduced to provide better IVS data performance and latency compared to existing systems during the “Testfeld Telematik” project. It achieved that goal by bypassing large parts of the TLS architecture and the VRZ completely and accessing the command stations (KRI) responsible for the VMS directly. While this is a sound approach that (unlike VMIS-DÜ in Scenario 1) guarantees data completeness and reduces latency in the events steps E3 and E4, it is not fully integrated in the normal operation scenarios of both VMIS and VISP / DDS, ASFINAG’s central traffic data hub. During implementation, it was planned to write all sign states and acknowledgements, including all errors, directly and continuously into to VISP / DDS systems by using triggers. The approach failed due to massive parallel write operations on selected master tables of the VISP / DDS database, generating access problems and deadlocks. The current architecture and table design of VISP / DDS was not compatible with the approach of the TLS manager and therefore, a time delay was introduced and information was bulk inserted every 60 seconds instead of carrying out every transaction individually when it occurs. Latency tests clearly display this additional delay as it takes between 60 and 90 seconds from E1 (sign change command sent) to E4 (new sign state available for query) when using TLS Manager. Additional development effort and changes in the VISP / DDS systems would be needed to allow TLS Manager real-time write access. Evaluation of such an upgrade has confirmed that the architecture and the concepts of TLS Manager, being a stand-alone solution developed for a specific purpose, are quite different from existing core systems. Any upgrade would require many additional efforts in order to tackle topics like system integration and maintenance. It was therefore decided to concentrate on the already better integrated and supported CORBA interface and only employ TLS Manager as a possible backup solution.

4.4.3 Scenario 3: CORBA

The CORBA interface has the aim to enable regional control points for the traffic control system by directly accessing TLS architecture (KRI, UZ). It is able to directly access and also change the state of all dynamic signage used by ASFINAG, also including tunnels, which are proprietary system and not part of the TLS architecture. The interface provides notifications, thus relaying only changed data. A JDBC based interface for time critical data is available. The CORBA interfaces thus constantly relays any VMS changes into VISP / DDS, ASFINAG’s central traffic data hub, in real time. Latency tests have shown excellent performance of the CORBA interface: only seconds (3-6 on average) after a sign visibly changes to a new state (E2), query / retrieval of its new status is available to other systems (E4) via VISP / DDS. This is significantly faster than all the other solutions and even faster than operators of the (default VMIS) TLS-based system usually get the acknowledgement of the sign change (E3) in their systems. CORBA was therefore chosen to be the best possible data source for the In-Vehicle Signage Use Case in ECo-AT.

5 Profile of IVI ISO/TS 19321 for ECo-AT

5.1 Introduction

In the sections below, the requirements to the IVI Structure and containers are stated from the perspective of the In-Vehicle Signage Service of ECo-AT, which are therefore more specific than the general IVI requirements. This includes specific "Mandatory / Optional / Absent" (M/O/A) requirements for all components. For the definitions of the data element and data frames refer to ISO/TS 19321 [ISO 19321].

5.2 IVI Structure

The IVI structure for In-Vehicle Signage Service in ECo-AT shall contain:

- The IVI Management Container
- One Geographic Location Container
- One General IVI Application Container

5.2.1 IVI Management Container

Table 5: IVI Management Container

Component	Data Element	Nr	M/O/A[a]	Additional requirements
serviceProviderId	Provider	1	M	
iviIdentificationNumber	IviIdentificationNumber	1	M	
timestamp	TimestampIts	1	M	
validFrom	TimestampIts	1	O	Present if known by the service
validTo	TimestampIts	1	M	
connectedIviStructures	IviIdentificationNumber	1..8	A	
iviStatus	IviStatus	1	M	

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container.*

5.2.2 Geographic Location Container

The Geographic Location Container shall consist of:

- the common content and
- 1 part describing the detection zone,
- and one or more (consecutive) relevance zone(s) described either as:
    - 1 part describing the entire carriageway as a relevance zone, or
    - n parts describing the n lanes of the carriageway as single distinct parts of the entire relevance zone, if IVI are lane specific and if lane specific location information is available.

Table 6: Geographic Location Container - Common Location Container content

Component	Data Element	Nr	M/O/A[a]	Additional requirements
referencePosition	ReferencePosition	1	M	Position of the start of the Relevance Zone, measured at the transversal centre of the carriageway
referencePositionTime	TimestampIts	1	A	
referencePositionHeading	Heading	1	A	
referencePositionSpeed	Speed	1	A	

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container.*

Table 7: Geographic Location Container - Location Container Part (n parts)

Component	Data Element	Nr	M/O/A[a]	Additional requirements
zoneId	Zid	1	M	Value 1 for Detection Zone, Value 2…n for Relevance Zone(s)
laneNumber	LanePosition	1	O	Mandatory if single lanes are described.
zoneExtension	INTEGER (0..255)	1	A	
zoneHeading	HeadingValue	1	A	
zone	Zone		M	
Zone	Segment	1	M	
line	PolygonalLine	1	M	
PolygonalLine	DeltaPosition	1..32	M	Measured at the transversal centre of the carriageway or of the lane
laneWidth	LaneWidth	1	O	Mandatory if single lanes are described.

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container.*

5.2.3 General IVI Application Container

The sending ITS-S shall define the information associated to the In-Vehicle Signage Service in one or more General IVI Container Parts. If lane-specific information is supported, as many container parts as different lane-specific information shall be used, plus optionally one part for information applicable to the entire carriageway.

Table 8: General IVI Application Container – container part

Component	Data Element	Nr	M/O/A[a]	Additional requirements
detectionZoneIds	Zid	1	M	Value 1

`its-Rrid`	`VarLengthNumber`	1	A	Pointer to the regulatory region definition and to the regulations in place in general, e.g. those valid for those vehicles to which the contextual speeds does not apply (e.g. trucks)
`relevanceZoneIds`	`Zid`	1..8	M	Value 2…n; the information may apply to one or more consecutive relevance zones.
`direction`	`Direction`	1	M	
`driver AwarenessZoneIds`	`Zid`	1..8	A	How to address awareness is up to the receiving ITS-S.
`minimumAwarenessTime`	`INTEGER (0..255)`	1	O	To be provided as a guideline for the receiving ITS-S
`applicableLanes`	`LanePosition`	1..8	O	All lanes to which the IVI, and/or lane status applies. To be used only if IVI or lane status information is lane specific.
`iviType`	`IviType`	1	M	Values in accordance to the information transmitted
`iviPurpose`	`IviPurpose`	1	A	
`laneStatus`	`LaneStatus`	1	O	Status of the lane(s) if different from "open"
`vehicleCharacteristics`	`CompleteVehicleCharacteristics`	1	O	To be provided if IVI is applicable to specific types of vehicles only
`tractor`	`TractorCharacteristics`	1	A	
`equalTo`	`VehicleCharacteristicsFixValues`	1..4	A	
`notEqualTo`	`VehicleCharacteristicsFixValues`	1..4	A	
`ranges`	`VehicleCharacteristicsRanges`	1..4	A	
`trailer`	`TrailerCharacteristics`	1..3	A	
`equalTo`	`VehicleCharacteristicsFixValues`	1..4	A	
`notEqualTo`	`VehicleCharacteristicsFixValues`	1..4	A	
`ranges`	`VehicleCharacteristicsRanges`	1..4	A	
`train`	`TrainCharacteristics`	1	C.1	C.1: mandatory IF `vehicleCharacteristics` component present
`equalTo`	`SEQUENCE OF`	2	C.2	C.2: mandatory for classes: *Trucks / Lorries > 3.5 tons* *Trucks / Lorries > 7.5 tons* otherwise absent
`VehicleCharacteristicsFixValues`	`CHOICE`	1	M	

				euVehicleCategoryCode			CHOICE	1	M	
					EuVehicleCategoryN		ENUMERATED	1	M	Value: n2
			VehicleCharacteristicsFixValues				CHOICE	1	M	
				euVehicleCategoryCode			CHOICE	1	M	
					EuVehicleCategoryN		ENUMERATED	1	M	Value: n3
		notEqualTo					VehicleCharacteristicsFixValues	1..4	A	
		ranges					SEQUENCE OF	1	C.3	C.3: mandatory for classes: *Vehicles > 3.5 tons* *Vehicles > 7.5 tons* *Trucks / Lorries > 7.5 tons* Otherwise absent
			VehicleCharacteristicsRanges				SEQUENCE	1	M	
				comparisonOperator			ComparisonOperator	1	M	Value: 0 (greater than)
				limits			CHOICE	1	M	
					vehicleWeightLimits		SEQUENCE	1	M	
						vehicleMaxLadenWeight Int2	INTEGER(0..65535)	1	M	Not used
						vehicleTrainMaximumWeight	INTEGER(0..65535)	1	M	Value: 350 or 750 (10 Kg units)
						vehicleWeightUnladen	INTEGER(0..65535)	1	M	Not used
driverCharacteristics							DriverCharacteristics	-	A	
layoutId								-	A	
preStoredLayoutId								-	A	
roadSignCode							RSCode	1..2	M	List of Road Sign codes using the ISO TS 14823 coding (see examples)
extraText							Text	1..4	O	Include limited text relevant for the service, optionally in different languages.

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

5.3 IVI Dissemination and Format

The IVI service shall be operated in accordance to ETSI TS 103 301 [ETSI 103 301] using the short range communication dissemination parameters. [ETSI 103 301] describes facilities layer protocols and communication requirements for infrastructure services. Infrastructure services are application support facilities provided by the facility layer that construct, manage and process messages distributed from infrastructure to vehicles based on payload received from the application. The infrastructure services specified in this document support I2V applications in order to achieve communication interoperability, and may be implemented in parallel services in an ITS-S. In the scope of the present standard, the infrastructure services include the In-Vehicle-Information (IVI) message carrying the IVI payload specified by ISO/TS 19321 and therefore supports the IVI / IVS use case and profile used in ECo-AT.

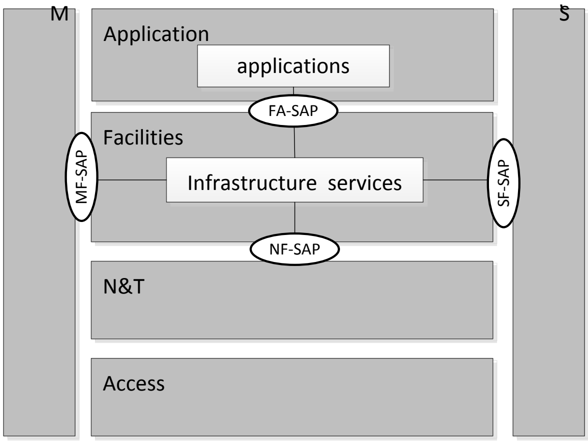


Figure 18: Infrastructure services within the ITS-S architecture

5.4 Coding of Variable Message Sign (VMS)

The tables below display the encoding of the `roadSignCode` and `extraText` components, including values for the following VMS example:

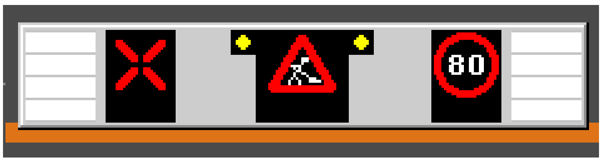


Figure 19: VMS example

Note: the code values are as currently assigned in http://standards.iso.org/iso/ts/14823/.

Table 9: Road Sign Code and Extra Text for Lane 1 of the VMS example

Component	Data Element	Nr	M/O/A [a]	Example Value
roadSignCode	RSCode	1..4	M	Road Sign code for lane 1
layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode	SEQUENCE	1	M	
countryCode	OCTET STRING	-	A	
serviceCategoryCode	CHOICE	1	M	
trafficSignPictogram	ENUMERATED	1	M	Example - Value: 12 regulatory
pictogramCategoryCode	SEQUENCE	1	M	
nature	INTEGER (0..9)	1	M	Example - Value: 5
serialNumber	INTEGER (0..99)	1	M	Example - Value: 57 Maximum Speed Limit
attributes	ISO14823Attributes	1	M	
ISO14823Attributes	SPE	1	M	
spm	INTEGER (0..250)	1	M	Example - Value: 80
mns	INTEGER (0..250)	1	A	
unit	RSCUnit	1	M	Example - Value: Km/h
extraText	Text	1..4	O	Example – no text

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

Table 10: Road Sign Code and Extra Text for all lanes of the VMS example

Component	Data Element	Nr	M/O/A [a]	Example Value
roadSignCode	RSCode	1..4	M	Road Sign code for all lanes
layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode	SEQUENCE	1	M	
countryCode	OCTET STRING	-	A	
serviceCategoryCode	CHOICE	1	M	
trafficSignPictogram	ENUMERATED	1	M	Example - Value: 11 danger warning
pictogramCategoryCode	SEQUENCE	1	M	
nature	INTEGER (0..9)	1	M	Example - Value: 3
serialNumber	INTEGER (0..99)	1	M	Example - Value: 48 Road Works

extraText	Text	1..4	O	Example – no text

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

Table 11: Road Sign Code and Extra Text for lane 2 of the VMS example

Component	Data Element	Nr	M/O/A [a]	Example Value
roadSignCode	RSCode	1..4	M	Road Sign code for lane 2
layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode	SEQUENCE	1	M	
countryCode	OCTET STRING	-	A	
serviceCategoryCode	CHOICE	1	M	
trafficSignPictogram	ENUMERATED	1	M	Example - Value: 13 Informative
pictogramCategoryCode	SEQUENCE	1	M	
nature	INTEGER (0..9)	1	M	Example - Value: 7
serialNumber	INTEGER (0..99)	1	M	Example - Value: 68 Lane Closed
extraText	Text	1..4	O	Example – no text

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

5.5 Coding of Variable Text Panel (VTP)

The table below displays the encoding of the `roadSignCode` and `extraText` components, including values for the following VTP example:

Figure 20: VTP example

Table 12: Road Sign Code for the VTP example

Component	Data Element	Nr	M/O/A [a]	Example Value
roadSignCode	RSCode	1..4	M	Road Sign code for all lanes

layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode	SEQUENCE	1	M	
countryCode	OCTET STRING	-	A	
serviceCategoryCode	CHOICE	1	M	
trafficSignPictogram	ENUMERATED	1	M	Example - Value: 11 Danger Warning
pictogramCategoryCode	SEQUENCE	1	M	
nature	INTEGER (0..9)	1	M	Example - Value: 2
serialNumber	INTEGER (0..99)	1	M	Example - Value: 54 Slippery Road
extraText	Text	1..4	O	Example – three elements of text, in German language, one for each row

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

5.6 Coding of Variable Direction Sign (VDS)

The table below displays the encoding of the `roadSignCode` and `extraText` components, including values for the following VDS example:

The basic sign is the following:

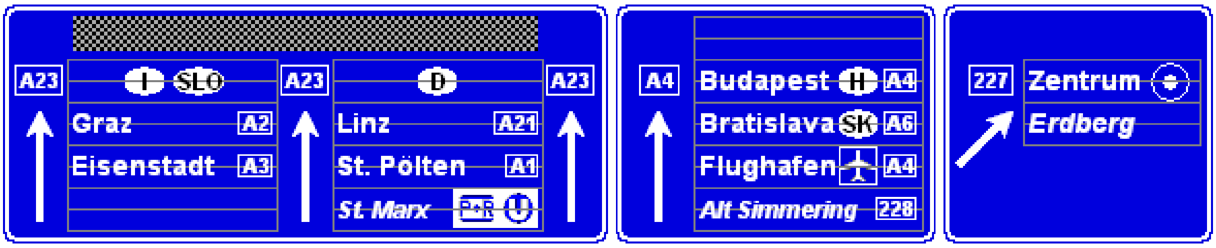


Figure 21: VDS example (basic sign)

Note: in this example only the variable parts (in yellow) of the variable message signs are coded for transmission to the vehicle using ISO/TS 19321:

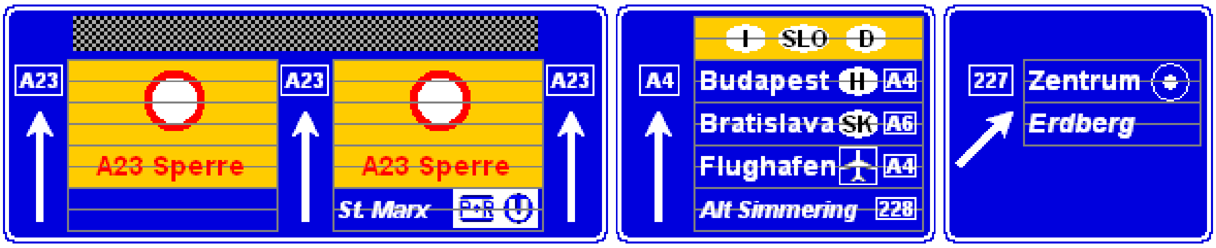


Figure 22: VDS example (altered sign)

The first table covers the Road Sign Code for lane two, the second table the Road Sign Code for lanes three and four.

Table 13: Road Sign Code and Extra Text for lane 2 of the VDS example

Component	Data Element	Nr	M/O/A[a]	Example Value
roadSignCode	RSCode	1..4	M	
layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode	SEQUENCE	1	M	
countryCode	SEQUENCE	-	A	
serviceCategoryCode	OCTET STRING	1	M	Example - Value: 13 informative
pictogramCategoryCode	CHOICE	1	M	Example - Value: 169 "Advance signs showing the expressway with place name"
attributes	ISO14823Attributes	1	M	
ISO14823Attributes	SPE	1	M	
dcj	INTEGER (1..128)	1	M	Value 9 for straight ahead
dcr	INTEGER (1..128)	-	A	
tpl	INTEGER (1..128)	-	A	
ioList	DDD_IO	1..8	M	1 instance.
drn	INTEGER(0..7)	1	M	Value 4 for straight ahead direction
dp	DestinationPlace	1..4	M	3 instances
depType	DDD_DEP	1	M	Value 5 for Country
depRSCode	ISO14823Code	-	A	
depBlob	OCTET STRING	-	A	
plnId	INTEGER (1..999)	1	O	Any Id
plnText	UTF8String	1	M	"I"
depType	DDD_DEP	1	M	Value 5 for Country
depRSCode	ISO14823Code	1	M	
depBlob	OCTET STRING	-	A	
plnId	INTEGER (1..999)	1	O	Any Id
plnText	UTF8String	1	M	"SLO"
depType	DDD_DEP	1	M	Value 5 for Country
depRSCode	ISO14823Code	1	M	
depBlob	OCTET STRING	-	A	
plnId	INTEGER (1..999)	1	O	Any Id
plnText	UTF8String	1	M	"D"
dr	DestinationRoad	1..4	A	

rne	INTEGER (1..999)	-	A	
stnId	INTEGER (1..999)	1	M	Any Id
stnText	UTF8String	1	M	"A4"
dcp	DistanceOrDuration	-	A	
ddp	DistanceOrDuration	-	A	
extraText	Text	1..4	O	Example – no text

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

Table 14: Road Sign Code and Extra Text for lanes 3 and 4 of the VDS example

Component	Data Element	Nr	M/O/A [a]	Example Value
roadSignCode	RSCode	1..4	M	
layoutComponentId	-	-	A	
code	ISO14823Code	1	M	
pictogramCode		1	M	
countryCode	SEQUENCE	-	A	
serviceCategoryCode	OCTET STRING	1	M	Example - Value: 13 informative
pictogramCategoryCode	CHOICE	1	M	Example - Value: 169 "Advance signs showing the expressway with place name"
attributes	ISO14823Attributes	1	M	
ISO14823Attributes	SPE	1	M	
dcj	INTEGER (1..128)	1	M	Value 9 for straight ahead
dcr	INTEGER (1..128)	-	A	
tpl	INTEGER (1..128)	-	A	
ioList	DDD_IO	1..8	M	1 instance.
drn	INTEGER(0..7)	1	M	Value 4 for straight ahead direction
dp	DestinationPlace	1..4	M	1 instance
depType	DDD_DEP	1	M	Value 0 for None
depRSCode	ISO14823Code	1	M	
pictogramCode		1	M	
countryCode	OCTET STRING	1	A	
serviceCategoryCode	CHOICE	1	M	

								trafficSignPictogram	ENUMARATED	1	M	Example - Value: 12 regulatory
							pictogramCategoryCode		SEQUENCE	1	M	
								nature	INTEGER (1..9)	1	M	Example - Value: 2
								serialNumber	INTEGER (1..99)	1	M	Example - Value: 35 "Closed to all vehicles in both directions"
						depBlob			OCTET STRING	-	A	
						plnId			INTEGER (1..999)	1	O	Any Id
						plnText			UTF8String	1	M	"Sperre A23"
					dr				DestinationRoad	-	A	
					rne				INTEGER (1..999)	-	A	
					stnId				INTEGER (1..999)	1	M	Any Id
					stnText				UTF8String	1	M	"A23"
					dcp				DistanceOrDuration	-	A	
					ddp				DistanceOrDuration	-	A	
extraText									Text	1..4	O	Example – no text

[a] *Mandatory (M) shall be included in the container. Optional (O) may be included in the container. Absent (A) shall not be included in the container*

6 Data Element Description

The following chapter describes the relevant data elements of the IVI structure, determines the source for the provision of the data elements and comments on the interpretation and default values for each data element.

6.1 IVI Structure

The IVI structure for In-Vehicle Signage Service in ECo-AT shall at least contain:

- The IVI Management Container
- One Geographic Location Container
- One General IVI Application Container

Message content encoding will occur in the General IVI Application container within the RoadSignCode and the ExtraText containers / data elements, using ISO/TS 14823 codes.

6.1.1 IVI Management Container

Table 15: IVI message data elements – IVI management container

Data element	IVI Container	M/O	Source	Comment
serviceProviderId	Management	M	C-ITS-S	serviceProviderID consists of data elements “countryCode” and “providerIdentifier”. countryCode is a bitstring that will be set to the decimal value of 40 (bitstring 0000101000) for Austria according to ISO-3166-1. providerIdentifier will be set to “10000” for all ECo-AT based IVI messages.

				Together with iviIdentificationNumber, this is the unique identifier for messages for the receiving V-ITS-S.
iviIdentificationNumber	Management	M	C-ITS-S based on TCC information	Identifier of the IVI Structure, as assigned by the C-ITS based on information from the TCC in DATEX II. The TCC identifies information objects using the ID of the cross-sections used in dynamic and static signage (each cross-section can contain several information objects) but supplements this information with a unique identification number that can be used for this data element and thus makes the IVI message unique and traceable throughout the ECo-AT communication chain.
timestamp	Management	M	C-ITS-S based on TCC information	Timestamp of the generation or last change of information content at the C-ITS-S (based on information incoming from TCC).
validFrom	Management	O	C-ITS-S	Start time of the validity period of the message. Default is absent, will not be provided.
validTo	Management	M	C-ITS-S	Start time of the validity period of the message. Will be provided by the C-ITS-S as part of the message management of IVI messages.
iviStatus	Management	M	C-ITS-S	Supported Status are: new, update. It is not intended to use iviStatus cancellation or negation. C-ITS-S generates this information based on the changes of information from TCC:

				• Change from "empty" VMS publication to "meaningful" (not empty) VMS publication: status new • Change from “meaningful” VMS publication to next “meaningful” VMS publication: status update • Change from “meaningful” VMS publication to “empty” VMS publication: no C-ITS-S message generation

6.1.2 Geographic Location Container

The Geographic Location Container shall consist of:

- the common content and
- 1 part describing the detection zone,
- and one or more (consecutive) relevance zone(s) described either as:
    - 1 part describing the entire carriageway as a relevance zone, or
    - n parts describing the n lanes of the carriageway as single distinct parts of the entire relevance zone, if IVI are lane specific and if lane specific location information is available.

Table 16: IVI message data elements – geographic location container – common location container

Data element	IVI Container	M/O	Source	Comment
referencePosition	Common Location	M	TCC	Position of the start of the Relevance Zone, measured at the transversal centre of the carriageway. Altitude will not be available.

Table 17: IVI message data elements – geographic location container – location container part

Component	IVI Container	M/O	Source	Comment
zoneId	Location Container	M	C-ITS-S	Value 1 for Detection Zone, Value 2…n for Relevance Zone(s)
laneNumber	Location Container	O	TCC	Mandatory if single lanes are described in this location container. Default is absent (no lane information)
zone	Location Container	M		
Zone	Location Container	M		
line	Location Container	M		
PolygonalLine	Location Container	M	TCC	The reference zone position and extension is based on information provided by the TCC

					The detection zone position and extension is based on information provided by the TCC
	laneWidth	Location Container	O	TCC	Mandatory if single lanes are described. Default is absent (no lane information)

6.1.3 General IVI Application Container

The sending ITS-S shall define the information associated to the In-Vehicle Signage Service in one or more General IVI Container Parts. If lane-specific information is supported, as many container parts as different lane-specific information shall be used, plus optionally one part for information applicable to the entire carriageway.

Table 18: IVI message data elements – general IVI application container

Data element	IVI Container	M/O	Source	Comment
detectionZoneIds	Application	M	C-ITS-S	Value 1
relevanceZoneIds	Application	M	C-ITS-S	Value 2…n; the information may apply to one or more consecutive relevance zones.
direction	Application	M	C-ITS-S	Fixed to: sameDirection
minimumAwarenessTime	Application	O	TCC	To be provided as a guideline for the receiving ITS-S, Default is absent.
applicableLanes	Application	O	TCC	All lanes to which the IVI, and/or lane status applies. To be used only if IVI or lane status information is lane specific.
iviType	Application	M	TCC	Values in accordance to the information transmitted, e.g. “1” for Regulatory Messages

laneStatus	Application	O	TCC	Status of the lane(s) if different from "open"
vehicleCharacteristics	Application	O	C-ITS-S based on TCC information	To be provided if IVI is applicable to specific types of vehicles only
train	Application	C.1		C.1: mandatory if vehicleCharacteristics component present
equalTo	Application	C.2		C.2: mandatory for classes: *Trucks / Lorries > 3.5 tons* *Trucks / Lorries > 7.5 tons* otherwise absent
VehicleCharacteristicsFixValues	Application	M		
euVehicleCategoryCode	Application	M		
EuVehicleCategory	Application	M	C-ITS-S	Value: n2
VehicleCharacteristicsFixValues	Application	M		
euVehicleCategoryCode	Application	M		
EuVehicleCategoryN	Application	M	C-ITS-S	Value: n3
ranges	Application	C.3		C.3: mandatory for classes: *Vehicles > 3.5 tons* *Vehicles > 7.5 tons*

				Trucks / Lorries > 7.5 tons Otherwise absent
VehicleCharacteristicsRanges	Application	M		
comparisonOperator	Application	M		Value: 0 (greater than)
limits	Application	M		
vehicleWeightLimits	Application	M		
vehicleMaxLadenWeight	Application	M	C-ITS-S	Not used
vehicleTrainMaximumWeight	Application	M	C-ITS-S	Value: 350 or 750 (10 Kg units)
vehicleWeightUnladen	Application	M	C-ITS-S	Not used
roadSignCode	Application	M	C-ITS-S based on TCC information in TLS format	Ordered list of Road Sign codes using the ISO TS 14823 coding (see examples) corresponding to the signs displayed on the road by Asfinag
extraText	Application	O	TCC information	List of text lines associated to the ordered list of road sign codes corresponding to the text displayed on the road by Asfinag.

6.1.4 RoadSignCode in the IVI Application Container

Table 19: IVI message data elements – RoadSignCode in the IVI application container

Component	IVI Container	M/O	Source	Comment
roadSignCode	RoadSignCode	M		
code	RoadSignCode	M		
pictogramCode	RoadSignCode	M		
serviceCategoryCode	RoadSignCode	M		Example - Value: 13 informative
pictogramCategoryCode	RoadSignCode	M		Example - Value: 169 "Advance signs showing the expressway with place name"
nature	RoadSignCode	M	C-ITS-S	Example - Value: 4
serialNumber	RoadSignCode	M	C-ITS-S	Example - Value: 31 Maximum Speed Limit
attributes	RoadSignCode	M		
ISO14823Attributes	RoadSignCode	M		
dcj	RoadSignCode	M	C-ITS-S	Example - Value 9 for straight ahead
ioList	RoadSignCode	M		1 instance.
drn	RoadSignCode	M	C-ITS-S	Example - Value 4 for straight ahead direction
dp	RoadSignCode	M		3 instances
depType	RoadSignCode	M	C-ITS-S	Example - Value 5 for Country
plnId	RoadSignCode	O	C-ITS-S	Any Id

						plnText	RoadSignCode	M	C-ITS-S	Example - "I"
						depType	RoadSignCode	M	C-ITS-S	Example - Value 5 for Country
						depRSCode	RoadSignCode	M	C-ITS-S	
						plnId	RoadSignCode	O	C-ITS-S	Any Id
						plnText	RoadSignCode	M	C-ITS-S	Example - "SLO"
						depType	RoadSignCode	M	C-ITS-S	Example - Value 5 for Country
						depRSCode	RoadSignCode	M	C-ITS-S	
						plnId	RoadSignCode	O	C-ITS-S	Any Id
						plnText	RoadSignCode	M	C-ITS-S	Example - "D"
					stnId		RoadSignCode	M	C-ITS-S	Any Id
					stnText		RoadSignCode	M	C-ITS-S	Example - "A4"
extraText							RoadSignCode	O	C-ITS-S	Example – no text

7 Scenarios

Each use case can be broken down into so called "scenarios". A scenario is s a sequence of events within the C-ITS system that forms a mode of operation for the use case. Each use case contains at least one scenario, but can of course also consist of multiple scenarios, covering different ways of operation possible for the underlying C-ITS system. In regard to the "In-Vehicle Information" use case, the following scenarios are covered:

7.1 Sending signage information from the TCC to the vehicles

Signage information from the traffic information system in the TCC is sent to the C-ITS-S over IF1 using DATEX II. In the C-ITS-S, a mapping from the DATEX II content to the IVI target format is performed and corresponding IVI messages are created. They are forwarded to geographically relevant R-ITS-S (using IF3) and sent out via ITS-G5 (IF4) at these locations. Vehicles driving through the coverage area of such an R-ITS-S receive these IVI messages.

8 IVI Location Encoding

The geographic validity of Electronic Signage on the highway / inter-urban network starts at the sign gantry displaying the electronic signs itself and ends at the beginning of the next sign gantry, as depicted in Figure 23. Static Signage is either based on the same principles or simply has explicit start and endpoints and therefore will not be addressed individually in this document.

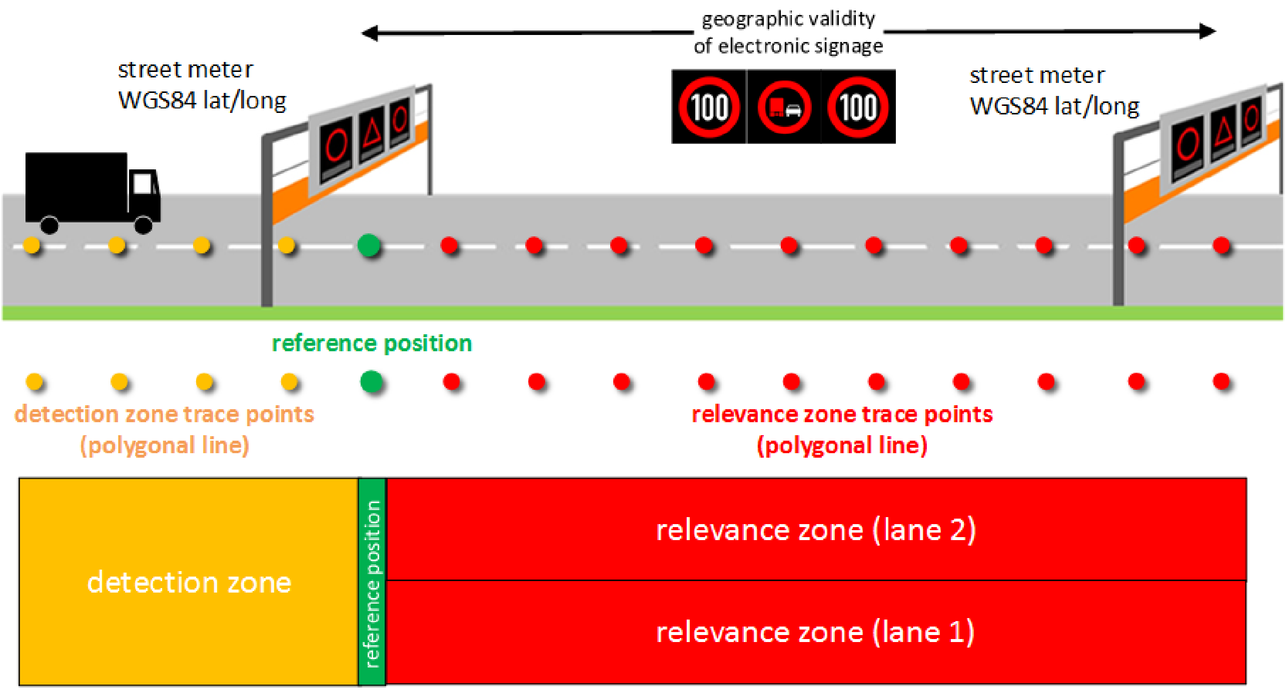


Figure 23: IVI Location Encoding

The middle of the carriageway at the exact position of the sign gantry is then used as the **reference position** of the IVI message depicting the content of the electronic signage.

In approach to this reference position, a **detection zone** is provided as a polygonal line of WGS84 latitude / longitude coordinates, resulting in several detection zone trace points.

The **relevance zone** covers the area where the IVI message is applicable, again using a polygonal line of WGS84 latitude / longitude coordinates, resulting in multiple relevance zone trace points, starting at the reference position and ending at the reference position of the next sign gantry. Relevance zones can either be specified for the whole direction of traffic / carriageway or further narrowed down into lane specific relevance zones.

ASFINAG location encoding is primarily based on street meter values. Several projections onto geographical map databases allow for the automated retrieval of WGS84 latitude / longitude coordinates for every street meter value. WGS84 coordinates needed for the reference point and the trace points that make up the polygonal lines for both detection zone as well as relevance zone(s) can therefore be provided directly by the TCC when passing Electronic Signage data to the C-ITS-S.

Until Release 2 (March 2015), available automated projections at the TCC were based on older systems and requirements, which only covered whole carriageways and did not guarantee a positioning in the middle of the carriageway under all circumstances. Since Release 3, a better, more precise projection based on GIP (Austria’s Graph Integration Platform) is available.

9 IVI Validity

The validity of an IVI message has two aspects: the first on is the **geographical validity**, described in the previous chapter 7. The IVI message contains a number of geographical points and out of these points, the ones depicting the relevance zone of the IVI message create the geographical validity of the IVI message. The second one is the **temporal validity**: each IVI message sent out by ECo-AT has a timestamp of creation and additional information, how long the message can be considered valid (validTo). This temporal validity is kept rather short by design in ECo-AT, mostly because changes in electronic signage information are unpredictable but also to avoid “false positives” – messages that appear valid while the affected VMS sign has changed in reality – during Day 1 of C-ITS when ITS station penetration will be low.

In the ECo-AT set up, a short temporary validity can however lead to the problem that IVI messages may time out, reach the end of their temporal validity, while the vehicle is still in the geographical validity of the message. Figure 24 illustrates this problem. A VMS Gantry sends out an IVI message with short temporal validity (20 seconds) which geographically concerns the next VMS gantry in driving direction. The temporal validity of the message decreases while the vehicle drives towards this next gantry and into the geographical validity of the message. The message then times out while still being valid geographically, there is a gap between geographical and temporal validity of the message.

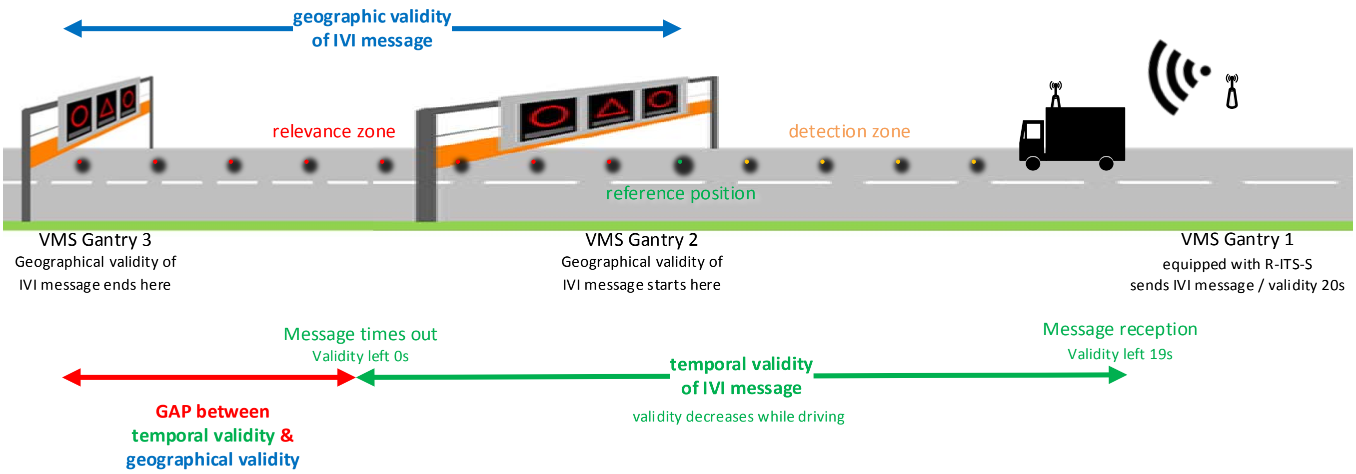


Figure 24: Validity of an IVI message

In such a case, it would be the expectation of ECo-AT that vehicles continue to show a geographically valid message, even if the temporal validity has ended. Of course, this should only be applicable if the vehicle has entered the geographical validity while temporal validity was still given and there was no update of the message while driving: Only a vehicle that has entered the relevance zone of the IVI message with enough remaining validity should continue to show the message if validity expires while still in the relevance zone.

10 Full IVI Message Example

This chapter includes a complete IVI message example, including all location information, based on an existing VMS gantry (AQ_A04_2_006,120) on the Austrian A4 near Vienna.

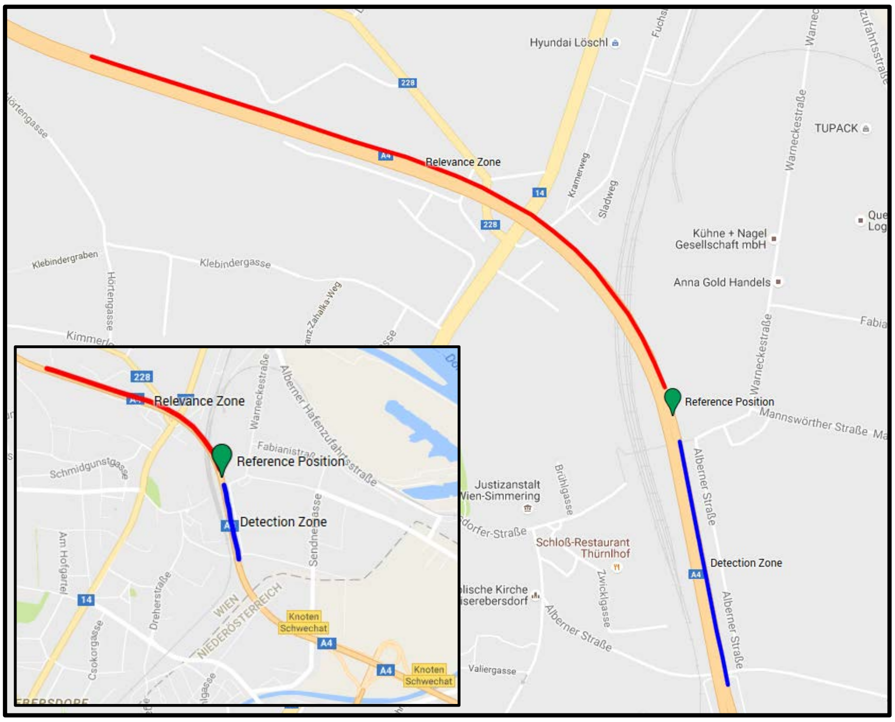


Figure 25: Location information for the IVI message example

The location was specifically chosen due to the curvature of its relevance zone. There are two driving lanes and the hard shoulder on the carriageway facing in the direction of Vienna. The VMS gantry has one VMS for each of the driving lanes and an additional VMS for the entire carriageway. The example will be based on a common setting in this area, displaying 100 km/h for both driving lanes and a restriction on overtaking for trucks exceeding 7.5t, as displayed on Figure 26.

Figure 26: VMS „AQ_A04_2_006,120" on the A4 near Vienna as seen from the ASFINAG video system

The geographic validity of this VMS gantry starts at the sign gantry displaying the electronic signs itself at KM 6.1 of the A4 and ends at the beginning of the next sign gantry at KM 4.8. Location Points necessary for the definition of the reference position, as well as the detection and relevance zone, are provided by the TCC by mapping KM positions to WGS84 latitude / longitude values. Points are 50 meters apart from the next point. There are 10 detection zone points (from KM 6.6 to 6.1), the reference position (at km 6.1) and 26 relevance zone points (from KM 6.2 to 4.8). Distances between points can be freely selected in the TCC, the current distance of 50 meters was chosen as default value for the example. Until Release 2 (March 2015), available automated projections at the TCC were based on older systems and requirements, which only covered whole carriageways and did not guarantee a positioning in the middle of the carriageway under all circumstances. Since Release 3 (July 2015), a better, more precise projection based on GIP (Austria's Graph Integration Platform) is available. Due to currently available location quality, the example is not lane specific, the 100 km/h restriction is encoded for the whole carriageway.

Within the IVI message, the points of the polygonal lines are – in accordance to the standard – depicted as a "sequence of delta points with respect to the previous position, with latitude and longitude, as coded by the data element DeltaPosition". DeltaPositions are derived from the TCC / DATEX II provided location points according to the approach given in Figure 27. Note that the reference position is not part of the polygonal line but still part of both the relevance zone and the detection zone.

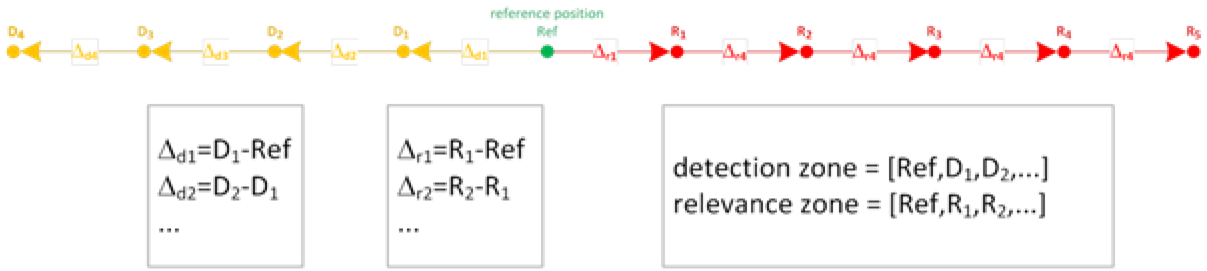


Figure 27: Calculation of DeltaPositions for relevance zone and detection zone respectively

The full example is printed below:

```
ETSI TC-ITS (IVI)
    IVI
        header
            protocolVersion: currentVersion (1)
            messageID: ivi (6)
            stationID: 1010002
        ivi
            mandatory
                serviceProviderId
                    countryCode: 40
                    providerIdentifier: 10000
                iviIdentificationNumber: 1
                timeStamp: 395408270955
```

```
        validTo: 395408290955
        iviStatus: new (0)
    optional
        Item 0
            IviContainer: glc (0)
                glc
                    referencePosition
                        latitude: 481607933
                        longitude: 164772129
                        positionConfidenceEllipse
                            semiMajorConfidence: unavailable (4095)
                            semiMinorConfidence: unavailable (4095)
                            semiMajorOrientation: unavailable (3601)
                        altitude
                            altitudeValue: unavailable (800001)
                            altitudeConfidence: unavailable (15)
                    parts
                        Item 0
                            GlcPart
                                zoneId: 1
                                zone: segment (0)
                                    segment
                                        line: deltaPositions (0)
                                            deltaPositions
                                                Item 0
                                                    DeltaPosition
                                                        deltaLatitude: -4311
                                                        deltaLongitude: 1717
                                                Item 1
                                                    DeltaPosition
                                                        deltaLatitude: -4422
                                                        deltaLongitude: 1335
                                                Item 2
                                                    DeltaPosition
                                                        deltaLatitude: -4428
                                                        deltaLongitude: 1278
                                                Item 3
                                                    DeltaPosition
                                                        deltaLatitude: -4425
                                                        deltaLongitude: 1297
                                                Item 4
                                                    DeltaPosition
                                                        deltaLatitude: -4425
                                                        deltaLongitude: 1278
                                                Item 5
                                                    DeltaPosition
                                                        deltaLatitude: -4387
                                                        deltaLongitude: 1297
                                                Item 6
                                                    DeltaPosition
                                                        deltaLatitude: -4435
                                                        deltaLongitude: 1269
```

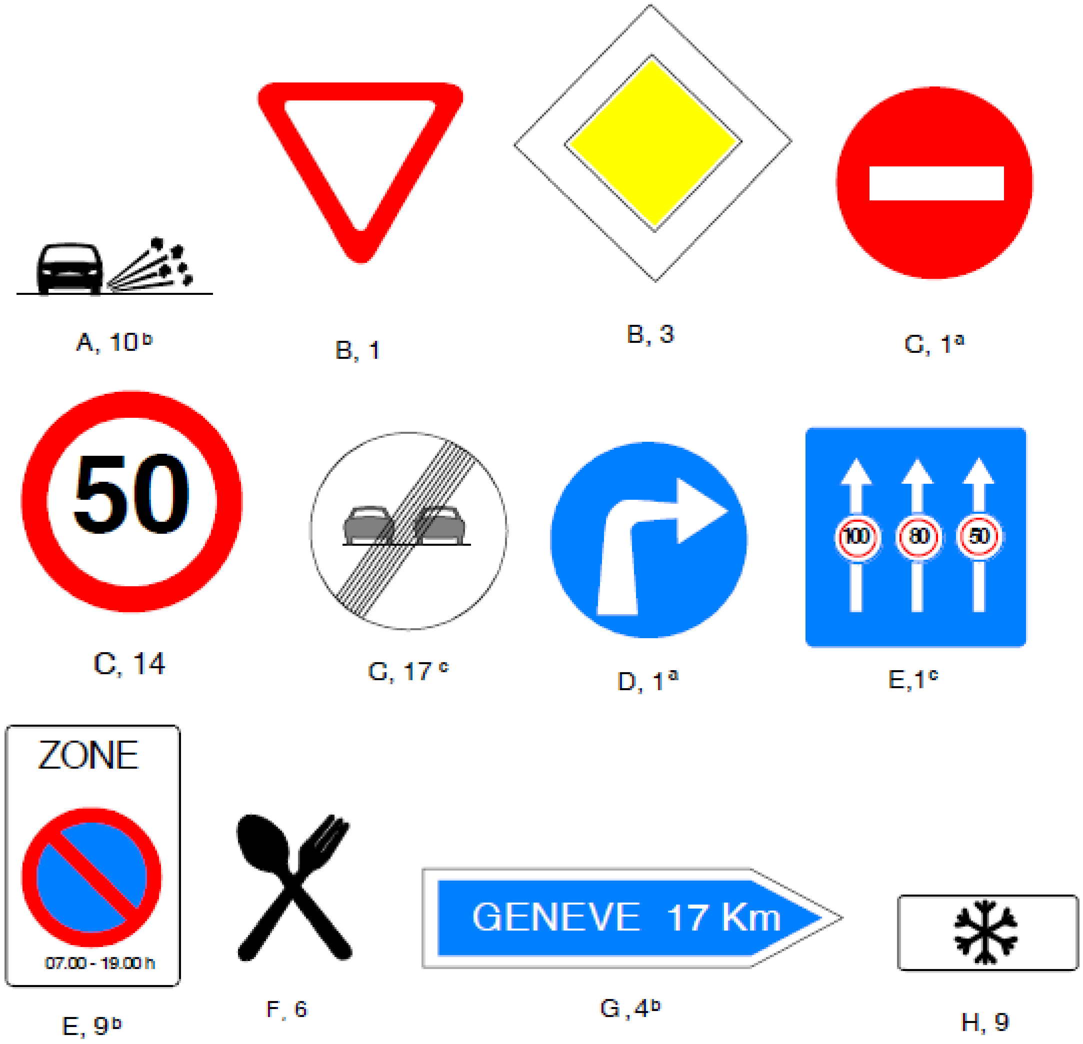
```
                                        Item 7
                                            DeltaPosition
                                                deltaLatitude: -4400
                                                deltaLongitude: 1300
                                        Item 8
                                            DeltaPosition
                                                deltaLatitude: -4500
                                                deltaLongitude: 1417
                                        Item 9
                                            DeltaPosition
                                                deltaLatitude: -4441
                                                deltaLongitude: 1483
                Item 1
                    GlcPart
                        zoneId: 2
                        zone: segment (0)
                            segment
                                line: deltaPositions (0)
                                    deltaPositions
                                        Item 0
                                            DeltaPosition
                                                deltaLatitude: 4501
                                                deltaLongitude: -1793
                                        Item 1
                                            DeltaPosition
                                                deltaLatitude: 4066
                                                deltaLongitude: -2651
                                        Item 2
                                            DeltaPosition
                                                deltaLatitude: 4100
                                                deltaLongitude: -2918
                                        Item 3
                                            DeltaPosition
                                                deltaLatitude: 3851
                                                deltaLongitude: -3567
                                        Item 4
                                            DeltaPosition
                                                deltaLatitude: 3649
                                                deltaLongitude: -3948
                                        Item 5
                                            DeltaPosition
                                                deltaLatitude: 3560
                                                deltaLongitude: -4273
                                        Item 6
                                            DeltaPosition
                                                deltaLatitude: 3281
                                                deltaLongitude: -4692
                                        Item 7
                                            DeltaPosition
                                                deltaLatitude: 2959
                                                deltaLongitude: -5321
                                        Item 8
```

```
                        DeltaPosition
                            deltaLatitude: 2725
                            deltaLongitude: -5379
                    Item 9
                        DeltaPosition
                            deltaLatitude: 2275
                            deltaLongitude: -5817
                    Item 10
                        DeltaPosition
                            deltaLatitude: 2226
                            deltaLongitude: -6047
                    Item 11
                        DeltaPosition
                            deltaLatitude: 1831
                            deltaLongitude: -6256
                    Item 12
                        DeltaPosition
                            deltaLatitude: 1643
                            deltaLongitude: -6237
                    Item 13
                        DeltaPosition
                            deltaLatitude: 1562
                            deltaLongitude: -6370
                    Item 14
                        DeltaPosition
                            deltaLatitude: 1259
                            deltaLongitude: -6485
                    Item 15
                        DeltaPosition
                            deltaLatitude: 1279
                            deltaLongitude: -6447
                    Item 16
                        DeltaPosition
                            deltaLatitude: 1429
                            deltaLongitude: -6409
                    Item 17
                        DeltaPosition
                            deltaLatitude: 1450
                            deltaLongitude: -6351
                    Item 18
                        DeltaPosition
                            deltaLatitude: 1421
                            deltaLongitude: -6447
                    Item 19
                        DeltaPosition
                            deltaLatitude: 1400
                            deltaLongitude: -6409
                    Item 20
                        DeltaPosition
                            deltaLatitude: 1375
                            deltaLongitude: -6485
                    Item 21
```

```
                                                            DeltaPosition
                                                                deltaLatitude: 1373
                                                                deltaLongitude: -6485
                                                        Item 22
                                                            DeltaPosition
                                                                deltaLatitude: 1352
                                                                deltaLongitude: -6390
                                                        Item 23
                                                            DeltaPosition
                                                                deltaLatitude: 1300
                                                                deltaLongitude: -6332
                                                        Item 24
                                                            DeltaPosition
                                                                deltaLatitude: 1400
                                                                deltaLongitude: -6351
                                                        Item 25
                                                            DeltaPosition
                                                                deltaLatitude: 1365
                                                                deltaLongitude: -6352
                Item 1
                    IviContainer: gic (1)
                        gic
                            Item 0
                                GicPart
                                    detectionZoneIds
                                        Item 0
                                            Zid: 1
                                    relevanceZoneIds
                                        Item 0
                                            Zid: 2
                                    direction: sameDirection (0)
                                    applicableLanes
                                        Item 0
                                            LanePosition: outermostDrivingLane (1)
                                        Item 1
                                            LanePosition: secondLaneFromOutside (2)
                                    iviType: regulatoryMessages (1)
                                    roadSignCodes
                                        Item 0
                                            RSCode
                                                code: iso14823 (1)
                                                    iso14823
                                                        pictogramCode
                                                            serviceCategoryCode: trafficSignPictogram (0)
                                                                trafficSignPictogram: regulatory (1)
                                                            pictogramCategoryCode
                                                                nature: 5
                                                                serialNumber: 57
                                                        attributes
                                                            Item 0
                                                                ISO14823Attributes item: spe (4)
                                                                    spe
```

```
                                        spm: 100
                                        unit: kmperh (0)
            Item 1
                GicPart
                    detectionZoneIds
                        Item 0
                            Zid: 1
                    relevanceZoneIds
                        Item 0
                            Zid: 2
                    direction: sameDirection (0)
                    applicableLanes
                        Item 0
                            LanePosition: outermostDrivingLane (1)
                        Item 1
                            LanePosition: secondLaneFromOutside (2)
                    iviType: regulatoryMessages (1)
                    vehicleCharacteristics
                        Item 0
                            CompleteVehicleCharacteristics
                                train
                                    equalTo
                                        Item 0
                                            VehicleCharacteristicsFixValues: euVehicleCategoryCode (1)
                                                euVehicleCategoryCode: euVehicleCategoryN (2)
                                                    euVehicleCategoryN: n2 (1)
                                        Item 1
                                            VehicleCharacteristicsFixValues: euVehicleCategoryCode (1)
                                                euVehicleCategoryCode: euVehicleCategoryN (2)
                                                    euVehicleCategoryN: n3 (2)
                                    ranges
                                        Item 0
                                            VehicleCharacteristicsRanges
                                                comparisonOperator: greaterThan (0)
                                                limits: vehicleWeightLimits (2)
                                                    vehicleWeightLimits
                                                        vehicleMaxLadenWeight: 0
                                                        vehicleTrainMaximumWeight: 750
                                                        vehicleWeightUnladen: 0
                    roadSignCodes
                        Item 0
                            RSCode
                                code: iso14823 (1)
                                    iso14823
                                        pictogramCode
                                            serviceCategoryCode: trafficSignPictogram (0)
                                                trafficSignPictogram: regulatory (1)
                                            pictogramCategoryCode
                                                nature: 5
                                                serialNumber: 44
```

11 ANNEX A: Vienna convention categorization signs examples



- A Danger warning signs
- B Priority signs
- C Prohibitory or restrictive signs
- D Mandatory signs
- E Special regulation signs
- F Information, facilities, or service signs
- G Direction, position, or indication sign
- H Additional panels

12 ANNEX B: Assumptions for in-Vehicle Information

Process related assumptions:

1. **Day-one vs day-two applications**: *Although the main focus in day-one applications is on motorways, the urban applications should already be considered in order to include specific requirements directly from the start.*

2. **Mandatory vs optional information:** *Road authorities must decide for which information / signs it is urgent to send them into the vehicle (push) and which information is optional (pull).*

Content related assumptions:

3. **The information presented by means of I2V is not legally binding**: *Information should be handled as "convenience information" and presented accordingly to the driver, as currently done within navigation systems. Before using the system/service the driver should be asked to confirm that he is aware that the road signs on the road are legally binding, whatever the in-car systems says. This applies also for possible errors translations of messages and signs.*

4. **Implicit information:** *Day 1 application In-Vehicle Information will be limited to the signs (static/ dynamic) and not to general regulation which should be known by drivers as part of the driving education. This will be handled in Day 2 applications.*

5. **Information can be vehicle category specific (e.g. no passing for truck)**

6. **Different signs at the same moment:** *More than one message can be valid at a specific moment in a specific area. Messages will be prioritized.*

7. **Safety and relevant information vs contextual information**: *Active "rules and conditions" are of highest urgency and will be provided urgently for instant presentation (push). Contextual/ informative information can be provided on request (pull).*

8. **V2V:** *V2V for In-Vehicle Signage will not be considered in the Day 1 deployment. This means that each vehicle must receive the message directly from the R-ITS-S.*

9. **Standards for current message sets:** *The functional description for In-Vehicle Information will be based on the use of In-Vehicle Information Message (IVI).*

10. **OEM perspective/ language issue:** *The driver gets information presented by signs familiar to him and in his own language.*

13 ANNEX C: Sign Catalogue for ASFINAG VMS / VTP

The following sections are excerpts of the (German language) planning manuals for the ASFINAG traffic control system (*"PlaPB 800.551.2000 Technische Spezifikation")* [ASF VBA TECHSPEC]. They represent the sign catalogue that VMS and VTP are able to display.

13.1 Variable Message Signs (VMS)

13.1.1 WVZ A

Dauerlichtzeichen nach StVO rote gekreuzte Schrägbalken

Dauerlichtzeichen nach StVO gelb blinkender links/rechts nach unten gerichteter Schrägpfeil

Dauerlichtzeichen nach StVO grüner, senkrecht nach unten weisender Pfeil

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „40"

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „60"

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „80"

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „100"

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „110"

§ 52.10a StVO Zulässige Höchstgeschwindigkeit „120"

Aufhebung der Geschwindigkeitsbegrenzungen

Allgemeine Aufhebung

13.1.2 WVZ B

 § 50.16 StVO Andere Gefahren (TLS- Code 1)

 § 50.10 StVO Schleudergefahr (TLS- Code 4)

 § 50.9 StVO Baustelle (TLS- Code 8)

 § 52.4a StVO Überholen verboten

 § 52.4b StVO Ende des Überholverbotes

 § 52.4c StVO Überholverbot für Kfz über 3,5 t

 § 52.4d StVO Ende des Überholverbotes für Kfz über 3,5 t

 § 52.11 StVO Ende Überholverbot/Geschwindigkeitsbegrenzung

 Staupiktogramm (entspricht dem Z 124 der deutschen StVO) (TLS- Code 9)

 Schnee- oder Eisglätte (TLS- Code 3)

 § 50.15 Vorankündigung eines Lichtzeichens (TLS- Code 12)

 § 52/7a Fahrverbot für Lastkraftfahrzeuge

 § 50/10a Seitenwind

Für die Ankündigung von Betriebszuständen, die eine Abweichung von der freien Fahrt ankündigen, sind im WVZ B zwei Blinker vorzusehen Die Abweichung ist durch abwechselndes gelb blinken anzuzeigen.

13.1.3 WVZ BC

- Grundstellung (keine Anzeige)
- Entfernungsangaben ohne Pfeile - z.B. für Rampen: nach 500m, 1000m, 1500m (1 km, 1,5 km)
- Entfernungsangaben mit Pfeil - können bei einem Abstand der Anzeigequerschnitte von mehr als 1.000 m die Länge bis zum nächsten Anzeigequerschnitt anzeigen, wenn es die Verkehrssicherheit erfordert: 500m, 1000m, 1500m, 2000m, 2500m (1 km, 1,5 km, 2 km, 2,5km) Länge
- 7,5 t
- 3,5 t
- STAUGEFAHR
- UNFALL
- Accident
- NEBEL
- Fog
- SICHT
- Low visibility
- NÄSSE
- ÖLSPUR
- GLÄTTE
- Slippery road
- ABSTAND
- PANNE
- Breakdown
- KONTROLLE
- Control
- TUNNELSPERRE
- Tunnel closed
- GEISTERFAHRER
- IG – L
- SEITENWIND
- Crosswind
- UMLEITUNG
- GLÄTTEGEFAHR
- STAU
- Congestion
- WINTERDIENST

- LKW-SPERRE
- SPERRE

Die Darstellung hat jeweils zentriert zu erfolgen.

13.1.4 WVZ AC

Prinzipiell sind im frei programmierbaren WVZ AC sämtliche Pixelbilder in Analogie zum WVZ BC zu hinterlegen.

13.2 Variable Text Panels (VTP)

13.2.1 Grafikteil

§ 50.16 StVO Andere Gefahren (TLS- Code 1)

§ 50.10 StVO Schleudergefahr (TLS- Code 4)

§ 50.9 StVO Baustelle (TLS- Code 8)

Staupiktogramm (entspricht dem Z 124 der deutschen StVO) (TLS- Code 9)

Schnee- oder Eisglätte (TLS- Code 3)

§ 50.15 Vorankündigung eines Lichtzeichens (TLS- Code 12)

§ 52.22 Schneeketten vorgeschrieben (TLS- Code 208)

TLS- Code 250

TLS- Code 251

TLS- Code 215: LKW-Stellplatzinfo

TLS- Code 216: P + R

TLS- Code 217: Stadion

Je Informationstafel sind 10 „Dummy“ Bildinhalte zu definieren, welche in späterer Folge mit neuen Inhalten bespielt werden.

13.2.2 Textteil

- Anordnung des Textes (mind. 3 Zeilen) im rechten Bereich der Anzeige
- Es sind mindestens 22 Zeichen pro Zeile vorzusehen, wobei die Anforderungen der ÖNORM EN 12966-1 an Zeichenabstände eingehalten werden müssen.
- In den drei Textzeilen wird eine beliebige textliche Verkehrsinformation, bzw. -anweisung und -warnung dargestellt. Es ist folgendes festgelegtes Anzeigeschema vorgesehen:

Verkehrs-zeichen	Sachstand
	Ort
	Effekt