Traffic Management Services
VARIABLE SPEED LIMITS

Deployment Guideline

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EasyWay is a trans-european project co-financed by the European Commission (DG MOVE)

www.easyway-its.eu

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Preamble

EasyWay is a cooperation of road authorities and road operators from 27 European countries that have teamed up to unlock the benefits of cooperation and harmonisation in the deployment of Intelligent Transport Systems (ITS) on Europe's major road network. ITS as a technology is a known contributor to sustainable mobility in terms of improved safety, efficiency and reduced environmental impact. Nevertheless, fragmented deployment on a national level will fail to deliver seamless European services and will not contribute to a coherent European Transport network. The European Member States have consequently launched the EasyWay project together with the European Commission as a platform to harmonise their ITS deployments.

This document has been drafted by EasyWay as part of the set of documents containing the 2012 version of the EasyWay Deployment Guidelines (DG 2012). These guidelines have been developed by EasyWay experts and practitioners. They have undergone a thorough review by international domain experts in an intense peer review exercise and they have been validated by the participating Member State Partners of EasyWay in an extensive formal Member State consultation process, which finally led to their adoption as basis for all deployment activities in future EasyWay phases.

EasyWay as a project is not a standardisation body, nor does it have any power to legally constrain the Member State in their national deployment activities. It is therefore crucial to understand that these documents are neither technical standards, nor are they specifications as they would be required for such cases, e.g. as currently developed by the European Commission as their part of the implementation of the ITS Directive 2010/40/EU. But since a certain level of strictness in compliance is required to achieve the intended goal of the EasyWay Deployment Guidelines – harmonisation and interoperability in Europe – the guideline documents are written in a way that clearly defines criteria that deployments have to fulfil in order to claim overall compliance with the guideline.

Although not legally binding in any sense, compliance may be required for the eligibility of deployments in future ITS road projects co-funded by the European Commission. Deviation from compliance requirements may nevertheless be unavoidable in some cases and well justified. It is therefore expected that compliance statements may contain an explanation that justifies deviation in such cases. This is known as the "comply or explain" principle.

Although not standards themselves, the EasyWay DG2012 Deployment Guidelines in some cases do mention – and sometimes require – the use of such standards. This is the case in particular regarding the use of the CEN/TS 16157 series of technical specifications for data exchange ("DATEX II"). Although standardised data exchange interfaces are a powerful tool towards harmonised services in Europe, it must be understood that real world deployments have to fit into existing – and sometimes extensive – infrastructures and investment in these infrastructures must be protected. It is therefore important to note that the use of DATEX II mentioned below as a MUST is referred to implementation of "new" data exchange systems and not the utilisation of the existing ones, unless these latter affect harmonisation of deployments or interoperability of services.

Service at a glance

SERVICE DEFINITION

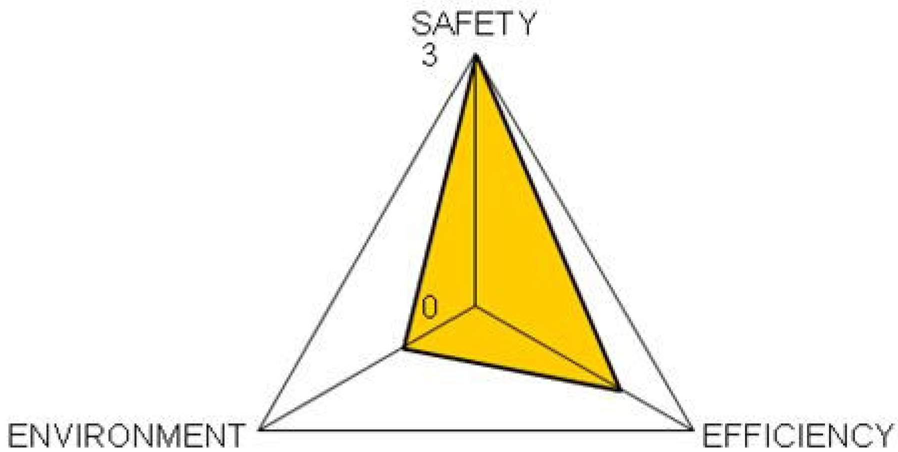
Variable speed limits (VSL) use variable speed signs, mandatory or advisory, as **a means to help drivers to travel at an appropriate speed considering the prevailing traffic or weather conditions**, in some cases supported by Speed Enforcement (SE), which mostly uses cameras to identify speeding vehicles and/or drivers.

SERVICE OBJECTIVE

The common main objective of VSL is to support drivers in travelling at a safe speed or to improve traffic fluency. In some cases these systems are also used to mitigate environmental effects, such as pollution or noise.

In most cases, the displayed speed limit should correspond to the conditions the drivers encounter, and therefore will be experienced as relevant. The drivers are then more likely to adhere to the speed limits. This will result in better safety, better mobility, smoother traffic, increased comfort and a reduced impact on the environment. However, there are cases when circumstances call for a reduced speed limit for which the reason is not obvious to the drivers, i.e. environmental reasons, problems downstream like incidents or work zones.

SERVICE BENEFIT RADAR



EUROPEAN DIMENSION

The European dimension is to achieve a coordinated roll-out around Europe on the road sections where it is most beneficial, i.e. where it has a very clear effect on the main EasyWay objectives and the benefits exceed the costs. The European road network is characterized in many areas – and not only in the surrounding areas of large cities and metropolitan regions - by high traffic volumes with frequent speed breakdowns during peak hours as well as traffic obstructions due to bad weather conditions or incidents. The application of traffic controlling measures with an emphasis on variable speed limits is an efficient means to increase traffic safety and to use the available route capacities optimally.

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List of abbreviations

TERN	Trans-European road network
VSL	Variable speed limits
SE	Speed enforcement
TMC	Traffic management centre
TCC	Traffic control centre
VMS	Variable message sign (road sign, text sign or combined)
FR<#>	Functional requirement <number>
OR<#>	Organisational requirement <number>
TR<#>	Technical requirement <number>
CL&FR<#>	Look and feel requirement <number>
LoSR<#>	Level of service requirement <number>

1 Introduction

1.1 The concept of the EasyWay Deployment Guidelines

1.1.1 Preliminary note

This document is one of a set of documents for the EasyWay project, a project for Europe-wide ITS deployment on main TERN corridors undertaken by national road authorities and operators with associated partners including the automotive industry, telecom operators and public transport stakeholders. It sets clear targets, identifies the set of necessary European ITS services to deploy (Traveller Information, Traffic Management and Freight and Logistic Services) and is an efficient platform that allows the European mobility stakeholders to achieve a coordinated and combined deployment of these pan-European services.

EasyWay started in 2007 and has since established a huge body of knowledge and a consensus for the harmonised deployment of these ITS services. This knowledge has been captured in documents providing guidance on service deployment - the EasyWay Deployment Guidelines.

The first iteration of the Deployment Guidelines mainly captured best practice. This strongly supported service deployment within EasyWay by:

- making EasyWay partners in deployment aware of experiences made in other European deployment programmes.
- helping to avoid making errors others had already made
- reducing risk and facilitating efficient deployment by highlighting important and critical issues to consider

Meanwhile, this best practice has already successfully contributed to ITS deployments across Europe. It is now possible to take the logical next step and actually start recommending those elements of service deployment that have proven their contribution to both the success of the local deployment, as well as the European added value of harmonised deployment for seamless and interoperable services.

1.1.2 Applying Deployment Guidelines – the “comply or explain” principle

The step from descriptive best practice towards clear recommendations is reflected in the document structure used for this generation of the Deployment Guidelines. Apart from introduction and the annexes that cover specific additional material, the Deployment Guidelines consist of two main sections:

Part A – this part covers the recommendations and requirements that are proven to contribute to successful deployment and have been agreed by the EasyWay partners as elements that should be part of all deployments of this particular service within the scope of EasyWay. Thus, the content of this section is prescriptive by nature. EasyWay partners are expected to ensure that their deployments are compliant with the specifications in this section. Wherever concrete circumstances in a project do not allow these recommendations to be followed fully, EasyWay partners are expected to provide a substantial explanation for the need for this deviation. This concept is known as the “comply or explain” principle.

Part B – this part offers an opportunity to provide more valuable but less prescriptive information. Supplementary information may be contained including – but not limited to – regional/national examples of deployment and business model aspects like stakeholder involvement or cost/benefit analysis results.

1.1.3 Use of Language in Part A

It is essential for every prescriptive document to provide specifications in a well-defined and unambiguous language. There are various definitions that clarify the use of particular words (such as those listed below) within their prescriptive texts.

For the purpose of the EasyWay Deployment Guidelines, the well-established provisions of the RFC 2119 (http://www.ietf.org/rfc/rfc2119.txt, see (1)) are used, which is used to specify the basic Internet standards:

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

An overview of the keywords, their meaning and the possible answers in the context of part A provides the following table. In general the keywords in brackets are possible, but their use is not recommended in order to avoid confusion which may arise as a consequence of different common linguistic usage of the terms in the different EU member states.

Requirement wording	Meaning in RFC 2119	Meaning in EasyWay	Possible checklist answers
MUST (REQUIRED, SHALL)	the definition is an absolute requirement	there may exist insurmountable reasons to not fulfill (e.g. legal regulations…)	**fulfilled: yes** or **Fulfilled: no - explanation of insurmountable reasons**
MUST NOT (SHALL NOT)	the definition is an absolute prohibition		
SHOULD (RECOMMENDED)	there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.	The Definition is very close to a "MUST", "MUST NOT" Meaning in EasyWay conform to RFC 2119	**fulfilled: yes** or **Fulfilled: no - with explanation**
SHOULD NOT (NOT RECOMMENDED)	there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label		
MAY (OPTIONAL)	The item is truly optional. One deployment may choose to include the item because of particular local circumstances or because it is felt to deliver a special added value	Meaning in EasyWay conform to RFC 2119	**fulfilled: yes - with explanation** or **Fulfilled: no**

Table 1: Part A - requirement wording

Note: the capitalisation of these keywords that is frequently used in IT standards is not recommended for EasyWay Deployment Guidelines.

The use of this 'requirements language' allows the direct transfer of the requirements stated in part A to a compliance checklist.

The following paragraph gives an example for a functional requirement:

Functional requirement:

- **FR2:** Data and information collected by both automatically and non-technical sources must be based upon both a consistent geographic reference model and a time validity model, which both **must** be part of data description.

Beneath "Requirement" a new semantic element "Advice" is proposed for part A, which has not the character of a hard requirement but of a "recommendation" and hence must not be listed in the compliance checklist. "Advice" is not immediately related to the three pillars of ITS-service harmonization (Interoperability, Common look & feel, Quality criteria) but to "inner features" of an ITS-service. Nevertheless such an element delivers a European added value and hence should be addressed by the deployment guidelines.

The notation for using the advice element in the text is as follows:

Organisational advice:

- Clear definitions of organisational aspects are a crucial precondition for the successful implementation of a "Forecast and real-time event information service" and should be documented and accepted of all involved parties/partners in form of a Common partner arrangement/MoU - Memorandum of understanding, which establishes the details of co-operation.

1.2 ITS-Service Profile

1.2.1 ITS-Service Strategy

1.2.1.1 General Service Description

Variable speed limits (VSL), use Variable Message Signs (VMS) to display speed limits (mandatory or advisory), that are adapted to the particular road and/or traffic conditions.

In some cases VSL is supported by Speed Enforcement (SE), which mostly uses cameras to identify speeding vehicles and/or drivers.

Speed enforcement (SE) covers violations of speed limits either on a spot or over a defined section of the road, also called section control. Depending on the strategy, mobile and/or stationary speed enforcement is used.

1.2.1.2 What is the Vision?

The main purpose of VSL is to help drivers to travel at an appropriate speed considering the prevailing traffic or weather conditions. Sensitive road segments, like tunnels, are often subject to VSL deployment for safety reasons. VSL can also be used to mitigate negative effects for society in general, like pollution or noise and to increase throughput. The use of VSL for environmental purposes is small today, but an increase is expected.

1.2.1.3 What is the Mission?

Regulating the speed limits so that the objectives of the specific deployments are met.

Harmonisation of traffic flow

Harmonization algorithms determine the optimal speed depending on the traffic volume on the main carriageway to avoid flow breakdowns and to increase throughput.

Speed control dependent on rain, slippery roads or visibility

In the case of heavy rain, slippery roads due to ice or snow or limited visibility it is recommended to adjust the speed limits to the surface conditions and/or stopping sight distance.

Environmental criteria

Speed control could be used to mitigate the negative environmental effects of traffic, like pollution or noise, which has been proved in evaluations (see examples in annex). Reduction of the allowed speed and smoother traffic flow can help to achieve the directive on air quality in populated areas.

User acceptance is a key factor to achieve the desired results. If the drivers understand the reasons for the displayed speed limits and experience them as relevant, they are more motivated to observe them.

Other applications

VSL can also be used for example at bus stops, bridges subject to strong winds, intersections and in order to help protecting vulnerable road users. The service can also increase traffic safety by alerting and slowing down traffic approaching road works and incidents.

1.2.1.4 EasyWay harmonization focus

The main focus of this guideline is to use consistent signposting for variable speed limits, thus making it easier for drivers to understand both the valid speed limit and the reasons behind them.

A second main focus is to harmonise functionality, so that the "feel" is consistent. The aim is to achieve a consistent driver perception of VSL systems.

Furthermore, sharing information on the benefits and effects of VSL can promote deployment of the service and thus make it more accessible for drivers.

1.2.1.5 Distinctiveness from other ITS-services

In practice, VSL is often an integrated part in a larger traffic management system, especially on motorways. These systems are often referred to as 'Motorway Control Systems', MCS.

Relevant complementary information, which is not the content of this Deployment Guideline and will be covered by other DGs, is:

- Hard shoulder running, where VSL is an important ingredient (TMS-DG04).
- Dynamic lane management, where lane signals and VSL often share hardware (TMS-DG01).
- VSL may be combined with other variable road signs, like warning signs (for example fog, road works or queue) or prohibitory signs (i.e. HGV overtaking ban TMS-DG06).
- VSL are sometimes also combined with other types of VMS, like text displays for warning and/or informative messages and route guidance signs (prism or LED technology) (VMS-DG01).
- Ramp metering systems may co-operate with VSL (TMS-DG03).
- Speed limit information (TIS-DG04).

VSL may be complemented by Speed Enforcement (SE). The effects of both systems may be increased by combining them. You may enforce the normal (not reduced) speeds, decreased speeds or all signposted speeds. It is recommended to enforce at least the reduced speeds in order to achieve the desired effects. When combining VSL and SE it is especially important to display relevant speed limits and communicate the reasons for reduced speeds in order to maintain the confidence of the public. It is also paramount that the VSL and SE systems co-operate in a reliable way, so that the enforced speed limits correspond to the speed limits displayed by the VSL systems.

1.2.2 Contribution to EasyWay Objectives

1.2.2.1 Service radar

The common main objective of VSL is both to support drivers in travelling at a safe speed and to improve traffic fluency. In some cases speed limits are also used to mitigate environmental effects, such as pollution or noise.

In most cases, the displayed speed limit should correspond to the conditions the drivers encounter, and therefore will be experienced as relevant and thus the acceptance is increased. This will result in better safety, better mobility, smoother traffic, increased comfort and reduced impact on the environment. However, there are cases when circumstances call for a reduced speed limit where the reason is not obvious to the drivers, i.e. environmental reasons, problems downstream like incidents or work zones.

VSL evaluation objectives, methodologies and methods of data collection differ from country to country. The figure below, Figure 1, shows a basic graphical relationship between VSL and the EasyWay objectives. Safety and network efficiency are the main benefits of the service.

The graph below provides a quantification of the added value of “Variable speed limits” services regarding the three main objectives of EasyWay which are: safety, efficiency and environment. The applied scales for the service radars are based on expert view and not on specific scientific analysis.

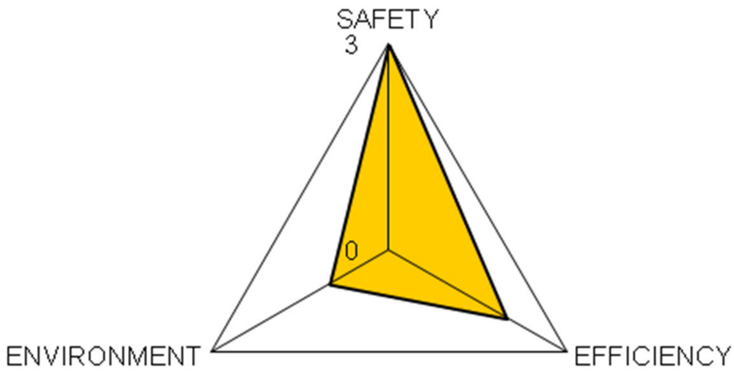

Figure 1: Variable speed limit objectives

1.2.2.2 Safety

The deployment of speed control offers the opportunity to optimize traffic safety depending on capacity and weather conditions. Traffic-related and/or weather-related speed control reduces the risk of congestion and accidents. The impact analysis of existing facilities confirms the positive effect on traffic safety.

VSL on motorways are expected to reduce accidents in the interval 15-40% or even up to about 60% during periods with heavy traffic loads (Bundesministerium für Verkehr, Bau- und Wohnungswesen, Heft 787, 2000), dependent on factors like traffic flow, congestion duration and severity, and speed limit without active VSL.

VSL at intersections have very different effects due to the situation, traffic flows, etc, but if locations are chosen wisely, a decrease in personal injuries and fatalities in the range of 15-40% can be expected (Results from Swedish trials with VSL, Swedish Road Administration, 2008).

VSL used in foggy conditions is proved to reduce accidents by up to 80% when used in combination with other Traffic Management measures like Dynamic Route Information Panels (Bundesministerium für Verkehr, Bau- und Wohnungswesen, Heft 787, 2000).

1.2.2.3 Environmental impact

VSL systems on motorways positively affect the flow of traffic and reduce traffic-related congestion and accidents (and the consequence of further congestion development). Improving the free flow of traffic reduces noise and pollutant emissions (emissions reduced by between 2 % and 8 % depending on the individual pollutant considered with VSL on the M25 in UK). VSL can also be used for environmental purposes, with a reduced speed limit to mitigate noise and emissions when there is no congestion.

VSL at intersections have negligible effects on the environment.

1.2.2.4 Network efficiency

Demand-oriented speed control improves the flow of traffic in the complete network area concerned. The duration of congestion, and thus the loss in operational costs and time costs, is considerably reduced as the existing section capacity is optimally used. For motorways, traffic flow and throughput can be increased by up to about 15%. Another effect is a more even flow, which has a positive effect on both traffic safety and throughput. For example, on the French A7 motorway, individual speed variability has decreased from 7 km/h to 2 km/h with VSL.

1.2.3 Current status of deployment

VSL solutions have been implemented and tested in more or less all European countries. The implementations vary from small tests to broader large scale implementations. The purpose of VSL use is different from case to case. The general overall purpose is for safety reasons, to decrease speed and accidents, and to harmonize the traffic flow for increased throughput. VSL is mainly used on motorways but also on other roads like trunk roads. The systems are mainly automatic but supervised by a Traffic Control Centre (TCC) or Traffic Management Centre (TMC).

1.2.4 European Dimension

The European dimension is to achieve a coordinated roll-out across Europe on the road sections where it is most beneficial, i.e. where it has very clear effect on the main EasyWay objectives and the benefits exceed the costs. The European road network is characterized in many areas – and not only in the surrounding areas of large cities and metropolitan regions - by high traffic volumes with frequent flow breakdowns during peak hours as well as traffic obstructions due to bad weather conditions or incidents. The application of traffic controlling measures with an emphasis on variable speed limits is an efficient means to increase traffic safety and to use the available route capacities optimally.

Harmonisation relating to VSL should focus on interoperability with other services and end-user acceptance through a common look & feel of VSL systems across Europe.

2 Part A: Harmonization Requirements

2.1 Service Definition

Variable speed limits (VSL) use variable speed signs, mandatory or advisory, as **a means to help drivers to travel at an appropriate speed considering the prevailing traffic or weather conditions**, in some cases supported by Speed Enforcement (SE), which mostly uses cameras to identify speeding vehicles and/or drivers.

2.2 Functional Requirements

2.2.1 Functional architecture

The following figure shows the typical functional architecture of a VSL system. Red arrows show possible interfaces to other services.

Functional requirement:

- **FR1:** Functional decomposition and the provision of standardised interfaces **should** be carried out to ensure interoperability in cases where the service is carried out by more than one organisation (and is in any case recommended to be prepared for an easy functional decomposition, as could be the case in the future). Control and algorithms may be done through local (roadside) or central systems.

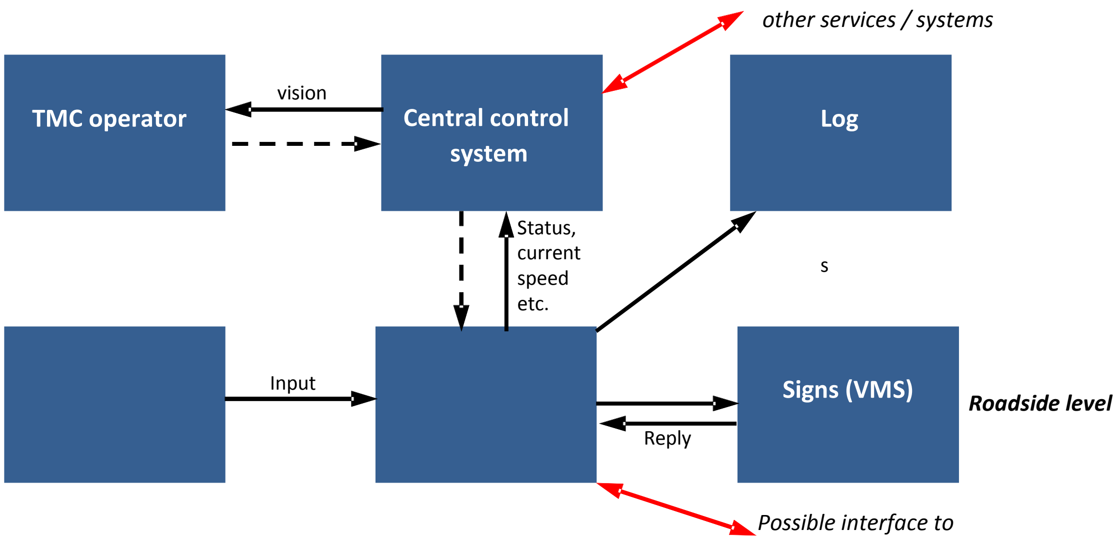

Figure 2: Typical functional architecture

2.2.2 Functional decomposition[1] and interfaces

Functional requirements per sub-function:

- **FR2**: Sensors **must** be adapted to the service and give input to the control system. Exceptions: For systems using clock and/or calendar control, sensors are replaced by the system clock. For manually controlled systems at road works, sensors are usually replaced by a keypad (local control unit) or similar. Note: Systems may include both manual and automatic functions as well as several types of sensors. This requires well defined hierarchical rules and priorities.
- **FR3:** Automatic and semi-automatic systems **should** contain models and algorithms that calculate the speed limit and transmit it to the signs. These models and algorithms can be implemented in a central control system or at the roadside.
- **FR4:** The signs **must** display the speed limit that the control system has requested and functionality **must** be monitored continuously by on duty staff.
- **FR5:** If VSL systems interact with other services like hard shoulder running, dynamic lane management or HGV overtaking ban (or adjacent VSL systems), interfaces **may** be found either at roadsides or in central control systems. In practice, this can often be internal interfaces in the same system.

Functional advice:

- Signs should report to the control system if message activation was successful or not and possible error messages.
- Traffic Management Centre Operators should be trained in supervising the system. Exception: Some local VSL systems operate independently and need no supervision regarding current signposted speed limits.
- TMC operators should be able to control the system manually and override automatic operation.
- The central control system should have the ability to supervise and control the system.
- VSL systems should have a log that stores data about signposted speed limits, error messages, etc. This is used for maintenance and legal purposes and is required in some countries.
- The control algorithms should result in speed limits that are relevant to achieve the desired effects and observance by the drivers. Exception: It is sometimes necessary to display speed limits that are not obviously relevant to the drivers for example environmental reasons or to maximise throughput.
- The algorithms should be constructed in an appropriate and stable way. The request for quick enough responses when safety critical circumstances occur needs to be balanced against unnecessary switching of the speed limits.
- Automatic control should be used whenever possible.
- Manual control should be used to control the system, for instance in the case of road works or accidents. You may also consider the option of using a semi-automatic mode where you set the maximum speed limit manually but let the system vary the displayed speed limit up to this threshold. This can be especially useful for long road works.
- When a greater decrease of the speed limit is needed, this should be performed through gradual reduction, 20-40 km/h dependent on operating environments, context, speed and road topology (note: 20 km/h reduction between two gantries is common practice on motorways). The reason for this is that otherwise you could end up with heavy breaking vehicles, which in its turn could cause rear-end collisions.
- When a VSL system is used to decrease the risk of rear-end collisions due to congestion, detector spacing should be adequate to the function. Spacing in the range of 500-2500 m is recommended in this case.

[1]The ITS service is "distributed" over more than one administration (cross-border, cross-regional) for operation, i.e. different road operators and other parties are involved, providing "logical sub-functions". Between the distributed functions, interoperability must be guaranteed by properly specified interfaces.

- Detector data updating frequency should be adapted to the required response times. For instance, a normal updating frequency for traffic data is between 20 seconds and one minute.
- The systems should have predefined handling of situations like power failure, disruptions in communications and other functional problems to avoid functional inconsistencies in the service. System parameters and error states should be disseminated in real time to on duty staff.
- When VSL is supplemented by speed enforcement, the monitoring technology used by private as well as public road operators, which generates evidence of speeding, must meet the national legal requirements.
- End-user acceptance

  A general rule to achieve a good understanding and observance of VSL is that the speed limits should be relevant. This sets the requirements for data collection and control principles. It is relatively easy for the driver to understand that the speed limit is reduced when there is congestion or bad weather, but it is more difficult to communicate speed reductions due to, for example, environmental reasons. Therefore, road authorities may consider including a pictogram or a warning sign showing the reason for the displayed speed limit, or as a third choice, having additional text on the signs. However, the legislation in some countries does not allow additional text to speed limit signs (like Sweden).
- It is also important to verify that VSL systems operate correctly and show relevant speeds according to the conditions. This means that much effort should be put into quality control and maintenance. Speed reductions for long stretches should be avoided, unless necessary because of extended problems. Data quality from sensor systems is also paramount for reliable operation, correct speed limits and user acceptance. Aspects that need to be considered are completeness, availability, veracity and accuracy.
- The responsible organisation should establish a good cooperation with the police and good communication with the public for the reasons and benefits of VSL. This is a key to success and encourages a positive attitude from drivers.

2.3 Organisational Requirements

Organisational advice:

- VSL systems should generally be monitored by a Traffic Management Centre. This need is less prominent for automatic systems with only spot coverage.
- Road operators (Public and/or private) are responsible for planning, development and operation of the systems for variable speed limits. The corresponding guidelines, regulations and consultant papers should to be taken into account.
- .When VSL systems are designed, deployed and trimmed for operation, the decided objectives for implementations should always be in focus.
- VSL is mostly a concern of the Road operators (road authorities and motorway companies and its subsidiaries). However these stakeholders may also be considered:
  - Municipalities and cities: At boundaries between state and municipal roads or when these systems influence traffic flow on municipal roads. Municipalities and cities may also implement VSL on their own networks.
  - Public transport authorities and operators: When these systems influence accessibility and schedules for public transport. It is also possible to consider priority for public transport in separate lanes in conjunction with VSL.
  - The Police: To enforce the speed limits for better compliance by road users. The police are generally an important partner when speed limits are enforced using automatic speed enforcement systems. Depending on national regulations, the police may also need to accept VSL projects formally.
- A cost-benefit analysis, as well as an analysis of the achieved effects in relation to the objectives, should be carried out when new VSL systems are deployed, unless similar projects already have been thoroughly evaluated. For suggestions about evaluation, see part B section 3.3.

2.4 Technical Requirements

2.4.1 ICT Infrastructure requirements

No specific requirements or advice.

2.4.2 Standards and Agreements: Existing and Required

2.4.2.1 DATEX II-Profiles

Technical requirement:

- **TR1:** Discontinuous signs (i.e. LED) **should** follow the European standard EN 12966-1 or their national counterparts. Continuous signs (retro-reflective, i.e. prism signs) **should** follow the European standard EN 12899-1 or their national counterparts where applicable.

Note: The standards allow several levels of performance to be selected due to i.e. the environment where the signs are used.

DATEX II Profile

One of the major deliverables of the DATEX II specifications is to offer a toolbox for applying one of the most common IT technologies for data definition, the Unified Modelling Language (UML, ISO/IEC 19501:2005).

In the case that road operators have to exchange data requiring interoperability between two or more different organisations, they are required to enable their system to use DATEX II (see TR4). What makes this so important is that providing one such formal data definition for each service supported by all implementations in EasyWay ensures technical interoperability (“Plug & Play”) because interfaces generated from the same data definition are sure to be able to process the exchanged data.

This integration of the DATEX II profile in the deployment guideline provide a solid dimension in terms of service standardisation and harmonisation, this also guarantees the information exchange among traffic managers and the wide dissemination of traffic information and traffic management services thanks to the facilities for providing standardised DATEX II publications to service providers. Sub-schemas for VSL can be found on the DATEX II website by following this link. www.datex2.eu/easyway/profiles/tms-dg02_2012.xsd

TR2: The Speed control / Speed limit service is characterized by the following elements:

- o the location of the speed limit
- o the length affected by the measure
- o when necessary, the type of vehicle concerned by the speed limit.

These elements and the speed limit itself **must** be described in the DATEX II Model as follows:

<u>Location</u>

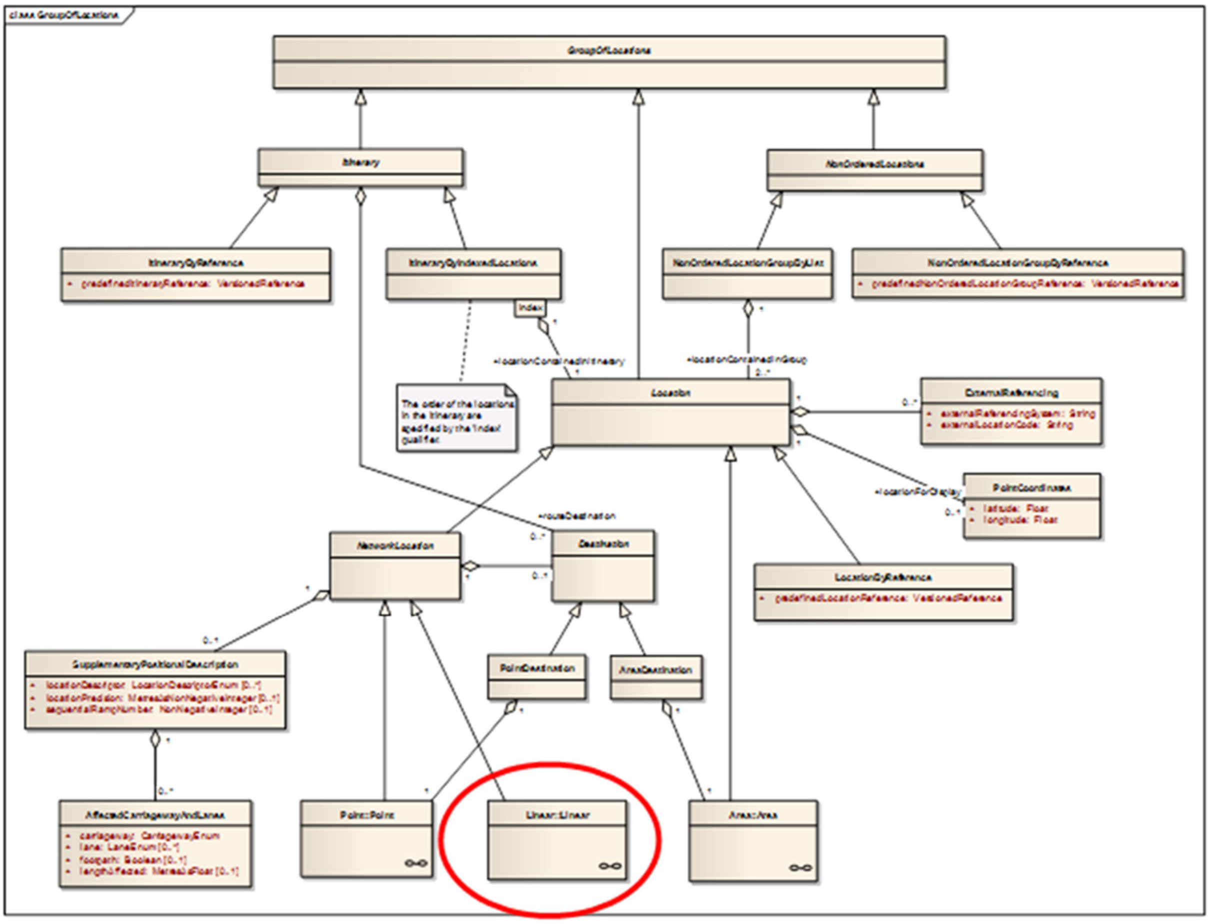

Figure 3: DATEX II profile: Location

The DATEX II model offers various possibilities for describing location but for this service location referencing can be restricted to linear locations. The SupplementaryPositionalDescription feature is needed to specify the length of the measure.

Length

Description about the length of the Speed limit service has to be specified with the attribute **lengthAffected.**

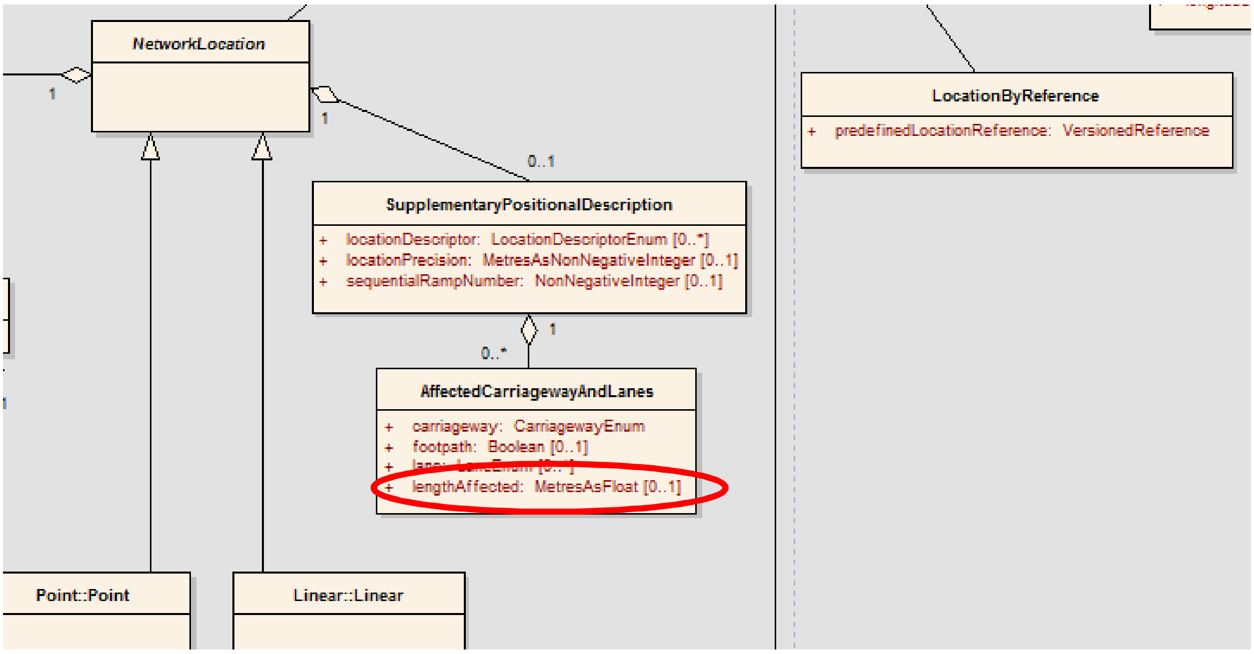

Figure 4: DATEX II profile: Length

Type of vehicle

In some case the Speed Limit only concerns specific vehicles (lorries for example), in such a case restriction of measures for particular types of vehicles need to be described in the **VehicleCharacteristics** class. In this class select the type of vehicle concerned.

- **TR3:** The following figure presents a selection for lorry. Additional detail can be outlined (for example tonnage of the concerned vehicles **must** be specified in **GrossWeightCharacteristic**)

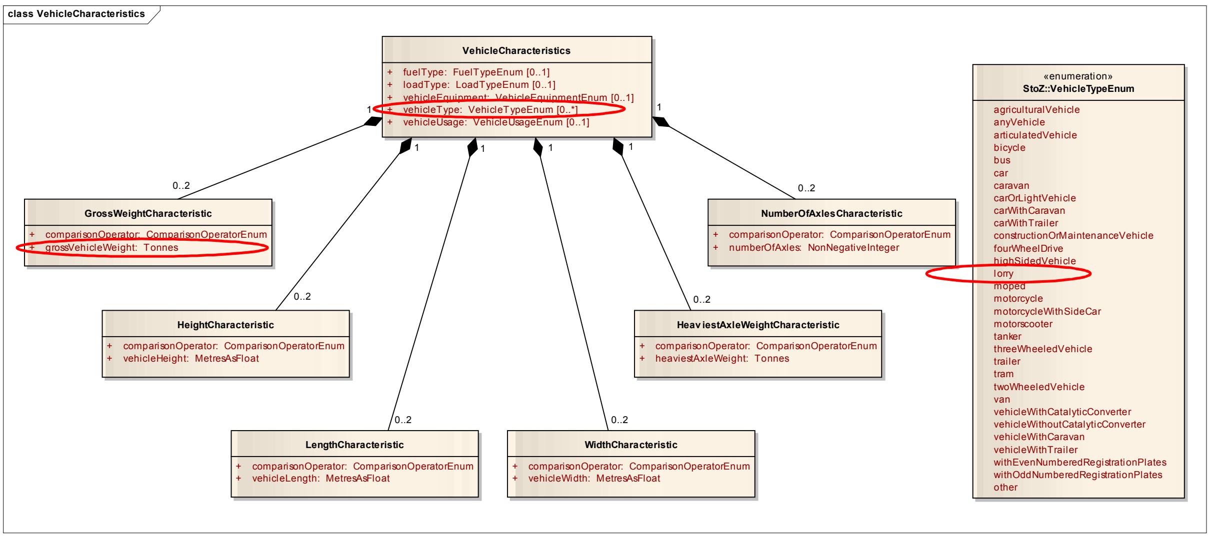

Figure 5: DATEX II profile: Type of vehicle

Speed Control – Speed limit

The mapping of information related to Speed control/Limit service into the DATEX II level A is easy. DATEX II has a dedicated class for this type of information called **SpeedManagement**. In this class, select the attribute speedRestrictionInOperation in the SpeedManagementTypeEnum.

- **TR4:** In the case that road operators have to exchange data requiring interoperability between two or more different organisations, they **must** enable their system to use DATEX II. This class is a specialisation of the **SituationRecord** class, hence the information regarding Speed limit shall be published via a **SituationPublication**.

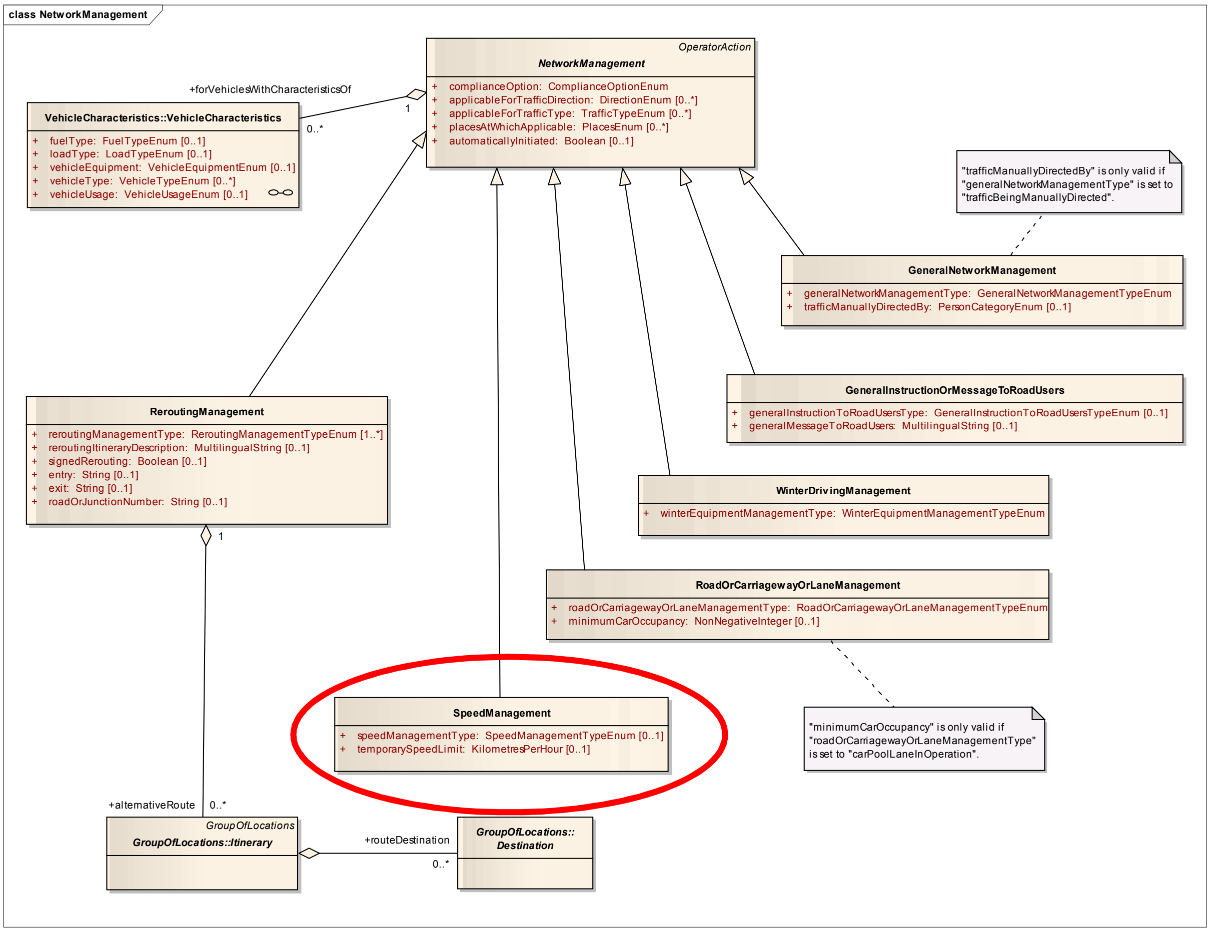

Figure 6: DATEX II profile: Variable speed limits

2.4.2.2 Need for Additional Specifications

None

2.5 Common Look & Feel

Common look & feel requirements:

- **CL&FR1:** Mandatory variable speed limits **should** be displayed in one of the following ways:
  - o Discontinuous signs: White, off-white or yellow figures on a black background enclosed by a red ring. Discontinuous VMS can also be used without colour inversion if national regulations allow or require this.
  - o Continuous signs: Sign surface similar to fixed mandatory speed signs according to national regulations.

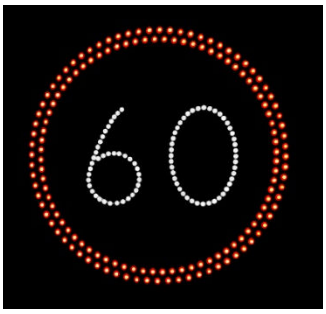

Figure 7: Example of a mandatory VSL sign

Reference to the Vienna convention: Sign C14.

- **CL&FR2:** Advisory dynamic speed signs **should** be displayed in one of the following ways:
  - o Discontinuous signs: White, off-white or yellow figures on a black background. The sign can have a white rectangular border, but no red ring. Discontinuous VMS can also be used without colour inversion if national regulations allow or require this.
  - o Continuous signs: Sign surface similar to fixed advisory speed signs according to national regulations.

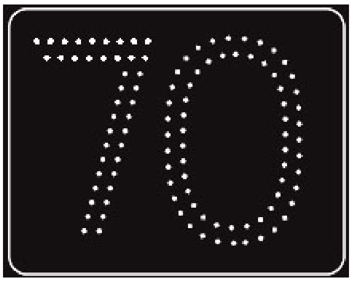

Figure 8: Example of an advisory VSL sign

- **CL&FR3:** Yellow flashing lights **may** be added to increase visibility. In Motorway Control Systems yellow flashing lights **may** be used to alert the driver that he/she enters a section with a lower speed limit.
- **CL&FR4:** Supplementary information **may** be added, e.g. the reason for a reduced speed limit. There is a greater need for this when it is difficult for the drivers to understand the reason.
- **CL&FR5:** Signs **should** be located either above the carriageway or on the verge of the road. If signs are located on the verge, there **should** be signs on the right hand side of the road with possible supplementary signs to the left (opposite for countries where you drive on the left). If there is more than one lane in the direction of travel, it is recommended to have signs on both sides.
- **CL&FR6:** If signs are mounted above the carriageway, you **may** have one speed limit sign above each lane or a single speed limit sign integrated in a larger VMS which is valid for all lanes.

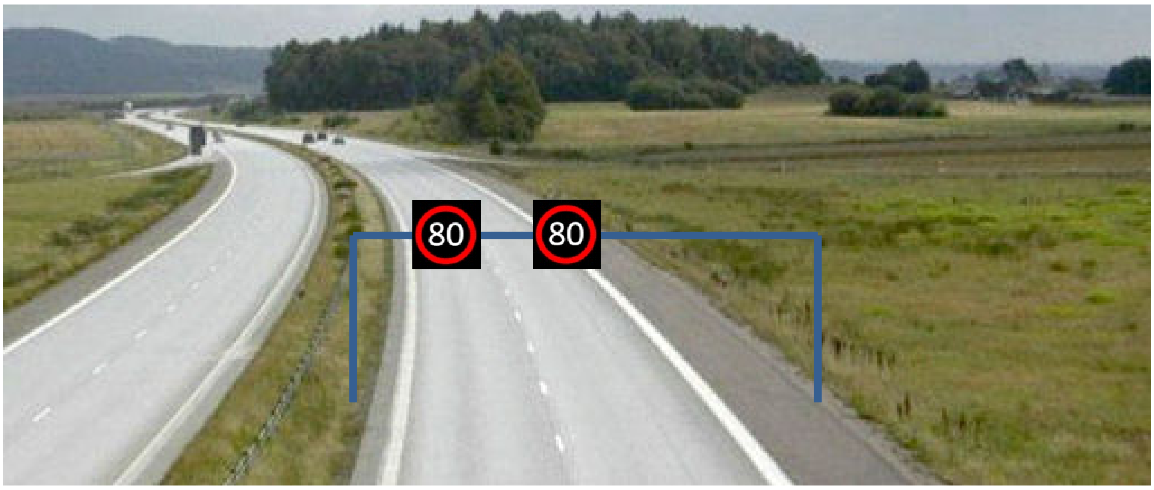

Figure 9: Portal mounted VSL signs on motorway, one sign above each lane according to CL&FR5

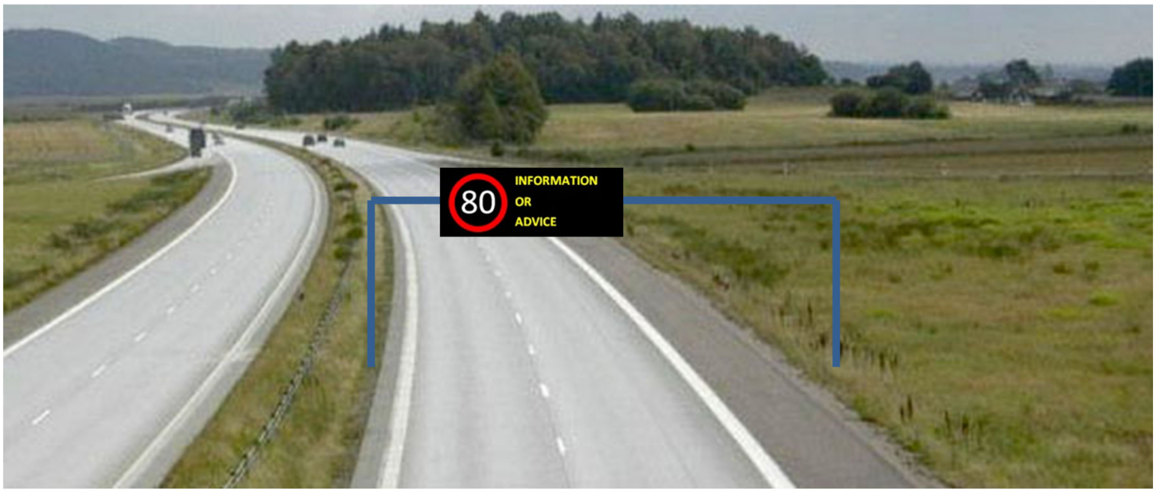

Figure 10: Portal mounted VSL signs on motorway, one speed limit sign integrated in VMS according to CL&FR5

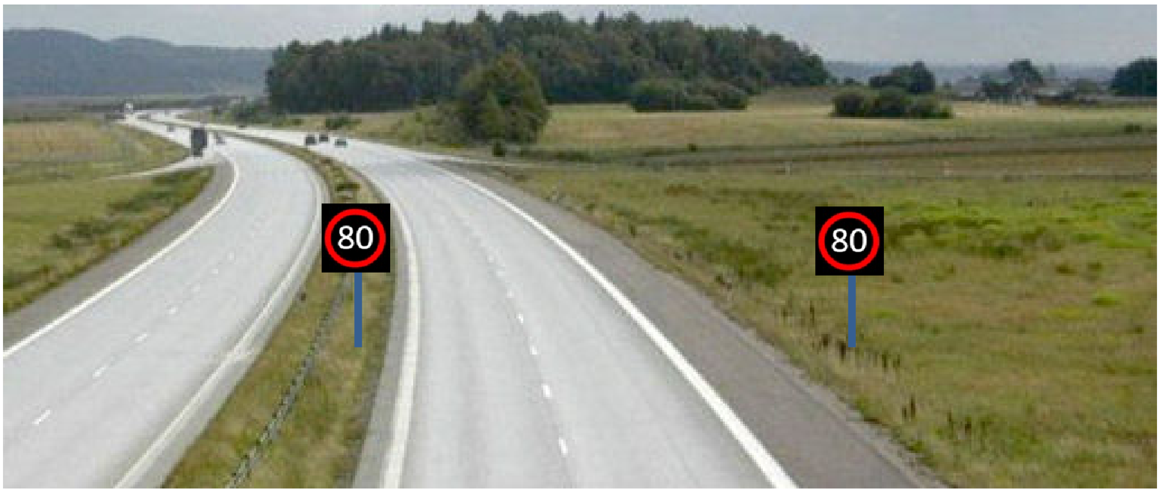

Figure 11: Side mounted VSL signs on motorway according to CL&FR6

- **CL&FR7:** Speed limits **should** be repeated at least after every entry slip road, and the distance **should** not exceed 10 km on long stretches or according to national guidelines and operating context.

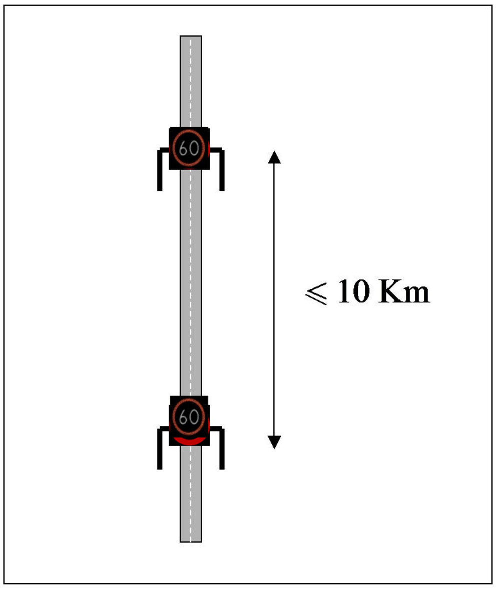

Figure 12: Repeated signposting on long stretches

- **CL&FR8:** It **should** be obvious to the drivers when a section with VSL ends and what the valid speed limit is after that. Normally this is done using fixed speed limit signs.

Common look & feel advice:

- Fixed and variable speed limit signs must never be placed in a way that drivers can doubt which speed limit is valid. This means that fixed and variable speed limit signs should not be placed at the same cross section. Legislation differs between member states. Adaption to national regulations is therefore necessary.
- Signs mounted above each lane may display different speeds on different lanes, but only in limited cases and after proper testing and evaluation. In these situations, it is recommended that the greatest difference in speeds between adjacent lanes does not exceed 20 km/h. This requires that the algorithms make separate calculations for each lane, but at the same time maintain consistent messages to the drivers both laterally and longitudinally.
- Side mounted VMS may remain in operation also when single lanes are closed. On the contrary, portal mounted VMS over closed lanes may be switched off, unless they are used in a motorway control system where a red cross is displayed.
- If there is free speed after the regulated section, the "speed limit end" sign may be used (Vienna convention sign C 17).

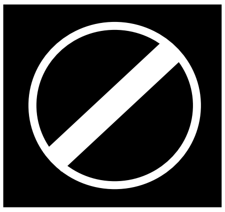

Figure 13: Example of a variable speed limit ends sign as VMS

Note: In some countries this sign also means that other prohibitions end, like overtaking ban. This has to be taken into account when sign C17 is used.

- Speed limit signs may be active only when a reduced speed limit is set. In other cases they may be blank. In some circumstances this makes it easier for the drivers to notice conditions that require a lower speed.
- It is common that VSL is integrated in motorway control systems, where the speed limit signs are mounted above the carriageway. In these cases VSL may be combined with, e.g. lane control and warning signs. The requirements and advice regarding VSL in this guideline are still applicable, but need to be combined with requirements and advice from other guidelines like TMS-DG01 (Dynamic Lane Management) and TMS-DG05 (Incident warning and Incident Management).

2.6 Level of Service Definition

2.6.1 Preliminary remark

The scope of EasyWay is to provide Core European Services to the European road users. These services are harmonized in content and functionality, but also in their availability: The road users shall be able to expect certain services on offer in a specific road environment. In order to provide a basis for the harmonization process EasyWay needs a tool to define such environments in an agreed manner. This tool is the Operating Environments – a set of pre-defined road environments combining physical layout of the road and network typology with traffic characteristics.

In essence, EasyWay has agreed on a set of 18 pre-defined Operating Environments (OE) where each OE is a combination of three criteria:

- Physical characteristics – Motorways, other 3/4 lane roads or 2-lane roads
- Network typology – Corridor, Network, Link or Critical spot
- Traffic characteristics – Traffic flow and road safety situations (with optional additions)

For more information and details, visit http://www.easyway-its.eu/document-center/document/open/490/ and download the Guidance for Classifying the EasyWay Network into OE ver 1.0.

2.6.2 Level of Service Criteria

Levels of Service table: Variable Speed Limits			
Core Criteria	**A**	**B**	**C**
Coverage	Spot coverage	Section coverage	Total corridor coverage (on critical sections along the corridor)
Level of coordination	No or limited coordination with other systems on section	Coordination with other TM measures for section control	
Monitoring / control	Manual monitoring	Clock and/or calendar control	Specific sensors monitoring

Table 2: Level of Service

Coverage

A – spot coverage: The VSL system covers only a short stretch of road where specific conditions prevail, for example. hazardous intersection.

B – Section coverage: The VSL system covers a longer stretch of road, but does not cover an entire corridor. A corridor in this case is the total road from one important point to another, e.g. between two cities.

C – Total corridor coverage: The VSL system covers an entire corridor as described above.

Level of coordination

A – No or limited coordination with other systems on a section. The VSL system does not operate in a coordinated way with other Traffic Management measures like hard shoulder running or lane signals.

B – Coordination with other TM measures for section control: The VSL system is coordinated with other measures, often integrated in a Motorway Control System.

Monitoring and control

A – Manual monitoring: Traffic Management staff change the speed limit manually when there is a need. The operators can either discover the problem through a CCTV system or get information from partners, like the police and rescue services.

B – Clock and/or calendar control: The speed limit is set automatically due to time of day and/or year. This option is most suited for situations where you have daily or seasonal recurring problems.

C- Specific sensors monitoring: Automatic control with sensors which detect the situation that calls for a reduced speed limit. This is generally the best solution, since it is not dependent on manual supervision and the displayed speed limit is in most conditions seen as relevant by the drivers.

2.6.3 Level of Service Criteria related to Operating Environment

<u>Level of service requirement:</u>

- **LoSR1**: In the case that pre-deployment surveys / evaluations provide the necessary evidence to proceed with the deployment of the ITS-service "Variable speed limits", the minimum and optimum LoS should respect the following Level of Service to Operating Environment mapping table.

Note: The Level of Service to Operating Environment mapping table is not an outcome of a specific scientific analysis but an expert view output.

VARIABLE SPEED LIMITS Criteria for the Levels of Service [reference TMS - DG02]			EasyWay OPERATING ENVIRONMENT																	
			C1	**T1**	**T2**	**T3**	**T4**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**S1**	**S2**	**N1**	**N2**	**P1**
Coverage	C	Total corridor coverage (on critical sections along the corridor)															O		O	
	B	Section coverage	O		O	O	O			O	O			O	O	O	M	O	M	O
	A	Spot coverage	M						O				O							
	/	*No coverage*		NA	M	M	M	NA	M	M	M	NA	M	M	M	M		M		M
Level of Coordination	B	Coordination with other TM measures for section control				O	O			O	O			O	O	O	O	O	O	O
	A	No or limited coordination with other systems on section	OM		O	M	M		O				O				M		M	
	/	*Service Unavailable*		NA	M			NA	M	M	M	NA	M	M	M	M		M		M
Monitoring / Control	C	Specific sensors monitoring	O		O	O	O			O	O			O	O	O	O		O	O
	B	Clock and/or calendar control							O				O					O		
	A	Manual monitoring	M			M	M										M		M	
	/	*Service unavailable*		NA	M			NA	M	M	M	NA	M	M	M	M		M		M

Table 3: Level of Service to Operating Environment mapping table

OE	Explanation
C1	critical spots, local flow-related traffic impact and/or potential safety concerns
T1	motorway (link), no flow-related traffic impact and no major safety concerns
T2	motorway (link), no flow-related traffic impact, potential safety concerns
T3	motorway (link), seasonal or daily flow-related traffic impact, no major safety concerns
T4	motorway (link), seasonal or daily flow-related traffic impact, potential safety concerns
R1	two-lane road (link), no flow-related traffic impact, no major safety concerns
R2	two-lane road (link), no flow-related traffic impact, potential safety concerns
R3	two-lane road (link), seasonal or daily flow-related traffic impact, no major safety concerns
R4	two-lane road (link), seasonal or daily flow-related traffic impact, potential safety concerns
R5	three-/four-lane road (link), no flow related traffic impact, no major safety concerns
R6	three-/four-lane road (link), no flow related traffic impact, potential safety concerns
R7	three-/four-lane road (link), seasonal or daily flow related traffic impact, no major safety concerns
R8	three-/four-lane road (link), seasonal or daily flow related traffic impact, potential safety concerns
S1	motorway corridor or network, at most seasonal flow-related impact, possibly safety concerns
S2	motorway corridor or network, daily flow-related traffic impact, possibly safety concerns
N1	road corridor or network, at most seasonal flow-related traffic impact, possibly safety concerns
N2	road corridor or network, daily flow-related traffic impact, possibly safety concerns
P1	peri-urban motorway or road interfacing urban environment, possibly safety concerns

OE type	Number	Flow-related traffic impact				Potential safety concerns	
		NO	SEASONAL	DAILY		NO	YES
Critical spots							
C	1		X	X	and/or		X
Motorway links							
T	1	X			and	X	
	2	X			and		X
	3		X	X	and	X	
	4		X	X	and		X
Road links							
R	1	X			and	X	
	2	X			and		X
2	3		X	X	and	X	
lanes	4		X	X	and		X
R	5	X			and	X	
	6	X			and		X
3 or 4	7		X	X	and	X	
lanes	8		X	X	and		X
Motorway corridor or network							
S	1		X		and		(X)
	2			X	and		(X)
Road corridor or network							
N	1		X		and		(X)
	2			X	and		(X)
Peri-urban motorway or road							
P	1				and		(X)

Table 4: Legend - EasyWay Operating Environments for Core European ITS Services.

3 Part B: Supplementary Information

EasyWay Deployment Guidelines are twofold:

- *Part A elaborates on the content of the ITS service addressed, including the entire deployment framework including Requirements and Levels of Services.*
- *Part B is an appendix of educational content. Its objective is to illustrate part A with examples and feedback from deployments in the field.*

This lively chapter is subject to continuous development and update. It consists in a database of national practices and experiences which, as cross-fertilisation material, can benefit any road operator in Europe.

Bearing in mind the cyclic nature of the elaboration of EasyWay Deployment Guidelines, one can assume that the first edition of the 2012 Guidelines will not yet include users' experience on its content. Forthcoming ITS deployments based on part A of this Deployment Guideline will generate feedback which will in-turn be integrated into the next revised version of part B.

3.1 Current Best Practice

3.1.1 Description of generic VSL implementations

VSL on motorways

On motorways, VSL is mostly used to harmonise traffic flow and thus increase throughput and safety. Environmental reasons could also be a main goal.

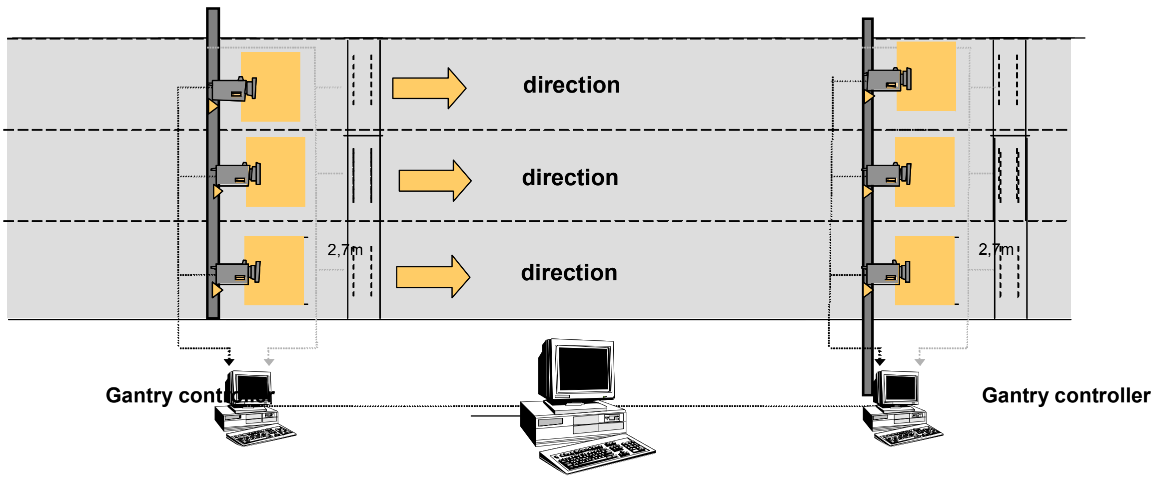

Figure 14: VSL on motorways

- Input: Traffic sensors, typically speed and traffic flow. The sensors are usually placed at each sign gantry. Inductive loops and microwave are commonly used technologies. Also video, laser, light barriers and piezoelectric sensors are used.
- Control: Often automatic based on sensor data. Manual override is used mainly in case of accidents or road works or, in wintertime, warnings concerning slippery and snowy roads. The algorithms should be designed both for increased throughput and safety ("queue warning function").

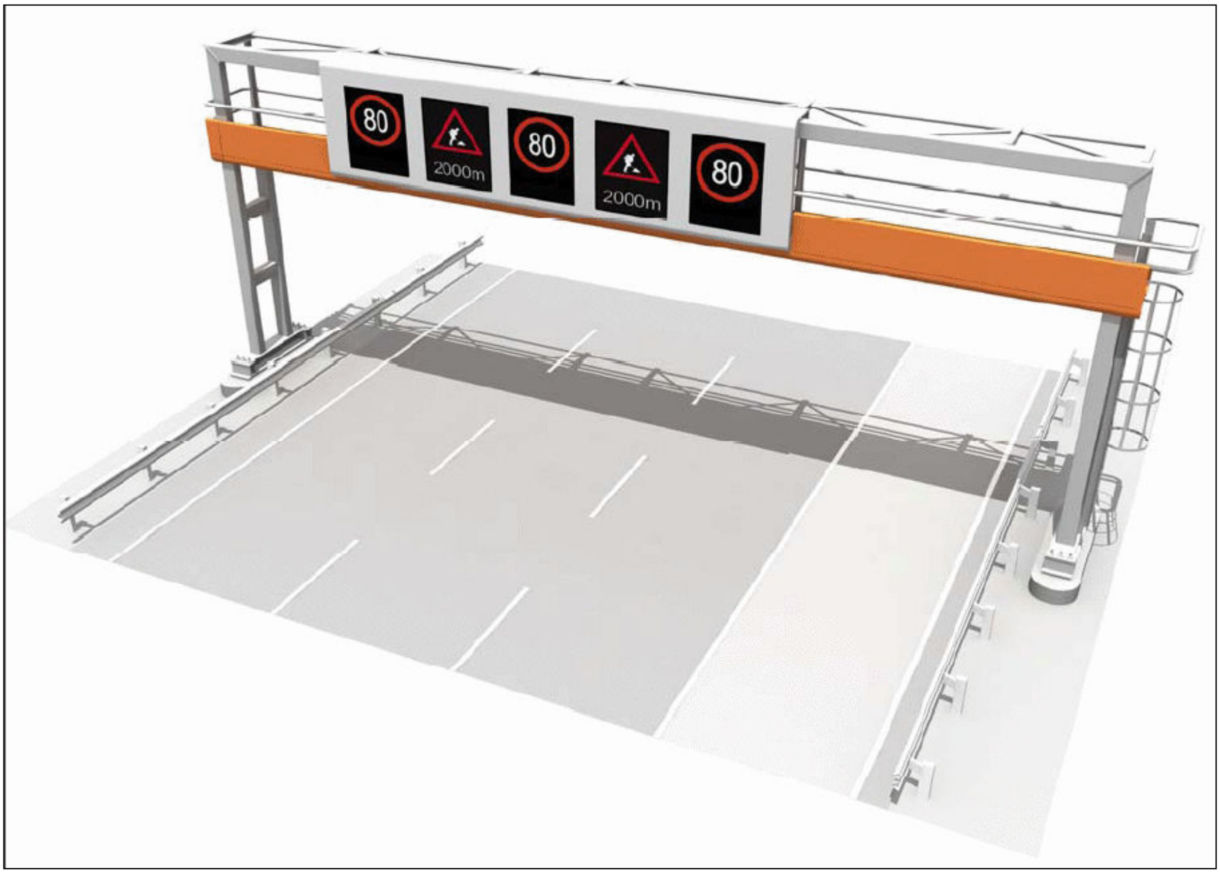

Figure 15: Example of an Austrian line control system with variable speed limits and warning signs on a common gantry

Weather controlled VSL

Weather controlled VSL has the aim to help drivers travelling at a safe speed according to the prevailing weather and road surface conditions.

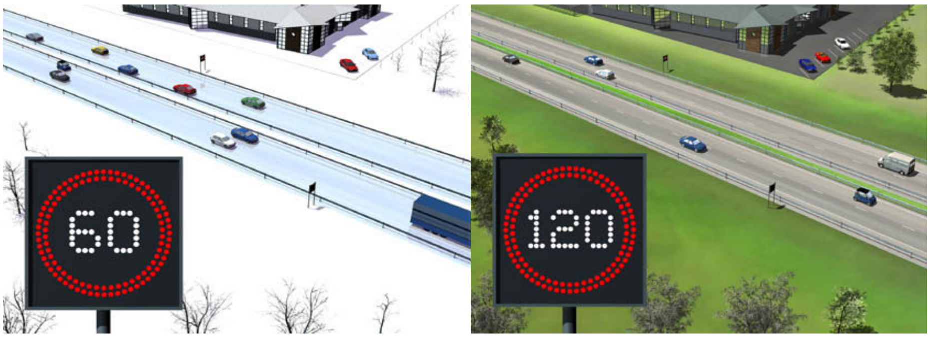

Figure 16: Weather controlled VSL

- Input: Weather and road surface conditions. Many different types of sensors are used and in some cases combined with weather forecasts. Example of sensors:

  o Air temperature, air humidity/dew point, road surface temperature

  o Wind, speed and direction

  o Visibility

o Freezing point of liquid on the road

o Road surface status (i.e. dry, wet, ice, snow; thickness may be included)

o Precipitation intensity

- Control: Can be automatic, manual or a combination. Results show that automatic control should be used as much as possible, but with supervision from TMC operators. Much effort needs to be put into design of the weather control model and its algorithms. Note: National legislations may prevent road operators from using automatic weather controlled VSL.

Note: Environmentally controlled VSL systems operate in a similar way, but with different detectors and control models.

VSL at intersections

VSL can be used at intersections to improve safety when conflicting traffic occur. The speed reduction has a safety effect in itself, but drivers are also alerted by the system, and are therefore more observant when driving through the intersection.

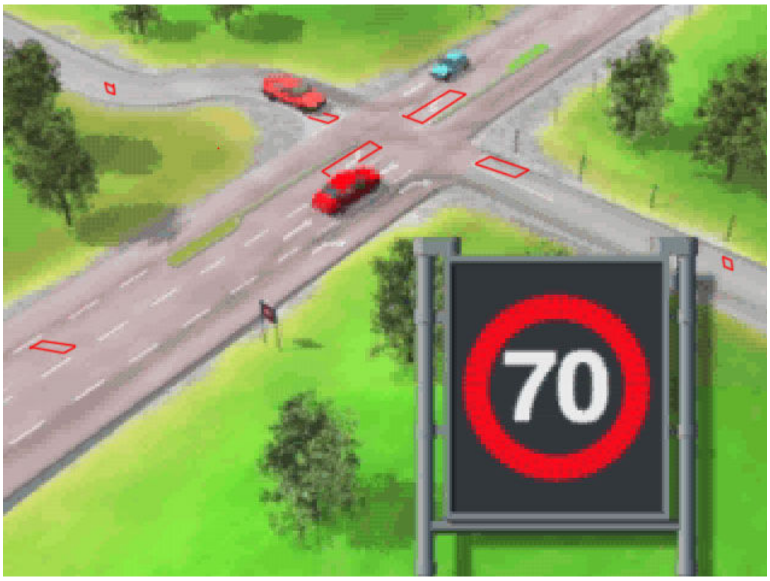

Figure 17: VSL at intersections

- Input: Detectors for vehicle passage and presence. Passage detectors are used to activate the system, when vehicles approach the intersection. Presence detectors keep the system active when vehicles wait at the intersection. Detectors can be placed both on incoming secondary roads and the left turning lane (when driving on the right) on the primary road (see example in the figure above).
- Control: Autonomous operation. Reduced speeds are displayed on the primary road when vehicles approach the intersection from the secondary roads and also when vehicles are present in the left turning lane on the primary road. In the latter case, reduced speed needs to be displayed only in the opposite direction. Manual override is often possible in case of accidents or road works.

Detection and data analysis

The basis for most variable speed limit systems is the detection of the current traffic conditions as well as the weather and road conditions through suitable sensors. A distinction has to be made between the detection systems that are embedded in the road surface and as the so-called “contactless” systems (i.e. microwave). The collected data are normally combined and analyzed in the local control stations or the sub-centres.

Some advanced motorway control systems make predictions of the future traffic flow. Many systems also have prioritisation as well as horizontal and vertical comparison of display sites taking place to avoid conflicting, illegal or traffic-hazardous display combinations. Illegal display combinations can in addition be locked-up in the signs on site. This enables a reasonable and continuous display consecution for the road user.

3.1.2 Required ICT infrastructure

These are the basic needs for communication infrastructure:

- Detectors to Roadside control system or central control system
- Roadside or central control system to VMS
- Roadside control system (if applicable) to TMC (Central control system and Log database)

Communication infrastructure can be based on cables, fibre-optics or wireless solutions.

The components in road side equipment have to be of the correct environmental class to cope with the environmental conditions. For maintenance reasons, it is an advantage if the components of the systems are easy to reach and replace.

3.1.3 List of applicable standards

The following existing standards have been identified. Due to existing national regulations, use of proprietary systems etc., other standards are used among the member states.

Variable message traffic signs (discontinuous)

- EN 12966-1 Road vertical signs - Variable message traffic signs - Part 1: Product standard
- EN 12966-2 Road vertical signs — Variable message traffic signs — Part 2: Initial type testing
- EN 12966-3 Road vertical signs —Variable message traffic signs — Part 3: Factory production control

Fixed traffic signs

- EN 12899-1:2007 Fixed, vertical road traffic signs – Fixed signs. This standard can be partly used for continuous (retro-reflective) variable signs, like prism signs.

3.2 Examples of deployment

3.2.1 Example Sweden

GENERAL INFORMATION	
Name of service/project	Variable speed limits at intersections
Name of operator/organisation	Swedish Transport Administration
Web link	http://www.trafikverket.se/Privat/Resan-och-trafiken/Din-resa/Hastighetsgranser-pa-vag/Variabla-hastigheter/
Contacts	Bjarne Holmgren, Van Thai
Other	
Applicable Deployment Guideline	TMS DG02 Variable Speed Limits

GEOGRAPHICAL ASPECTS	
Country	Sweden
Region of implementation	Skåne
Networks concerned	National trunk roads
Deployment indicators	1 Number of kilometers

SERVICE DESCRIPTION	
Problem(s) addressed / Objectives	☐Reduction of congestion ☒Increase of safety ☐Reduction of environmental damage (%) ☐Other:
ITS service description	The speed limit is reduced when conflicting traffic occur. This is when vehicles enter the main road from the secondary road and when there are left turning vehicles on the main road. The system use loop detectors (passage) to activate the system on calculated distances from the point of conflict and other loop detectors (presence) to keep the system active where vehicles are waiting. Then there is a delay after the passage detectors are inactivated. The system has been in operation since 2004.
Service requirements	☒Functional requirements ☐Organisational requirements ☒Technical requirements ☒Look & Feel for the end user

	☐ Level of Service criteria
Requirements specifications	The system was implemented as a part of a national trial of variable speed limits. Specifications for tender request were written by experts from the Swedish Road Administration and consultants. The European standard 12966 was used for requirements on the VMS.

IMPLEMENTATION ASPECTS	
Duration (start, end)	Start: 3/1/2004 End:11/30/2004
Lessons learnt / factor of success	Technical Loop detectors were designed improperly, thus motorcycles, tractors and other vehicles giving low magnetic impulses were missed. The detectors had to be replaced. Legal Swedish laws did not (and still don't) allow variable speed limits. A special national trial regulation was established. A local traffic regulation was also needed, based on the trial regulation, which is still in force.
Impacts assessment / results	We got different results at different intersections depending on the design, traffic conditions and traffic volumes on main roads and secondary roads. General conclusions are that variable speed limits at intersections can be an efficient tool to increase traffic safety. The best effects occur when the daily traffic volume on the main road is roughly 10 000 vehicles and the volume on the secondary roads are about 20-40% of that on the main road. A benefits-cost ratio of 3.0 was reached at the best intersection. Effects on accessibility, travel times and the environment are negligible.

REFERENCES	
Documentation available on the project	Title: Evaluations at intersections Contact: http://publikationswebbutik.vv.se/shopping/ShowItem____2700.aspx Language: English ☐ EW/TEMPO evaluation

ILLUSTRATIONS

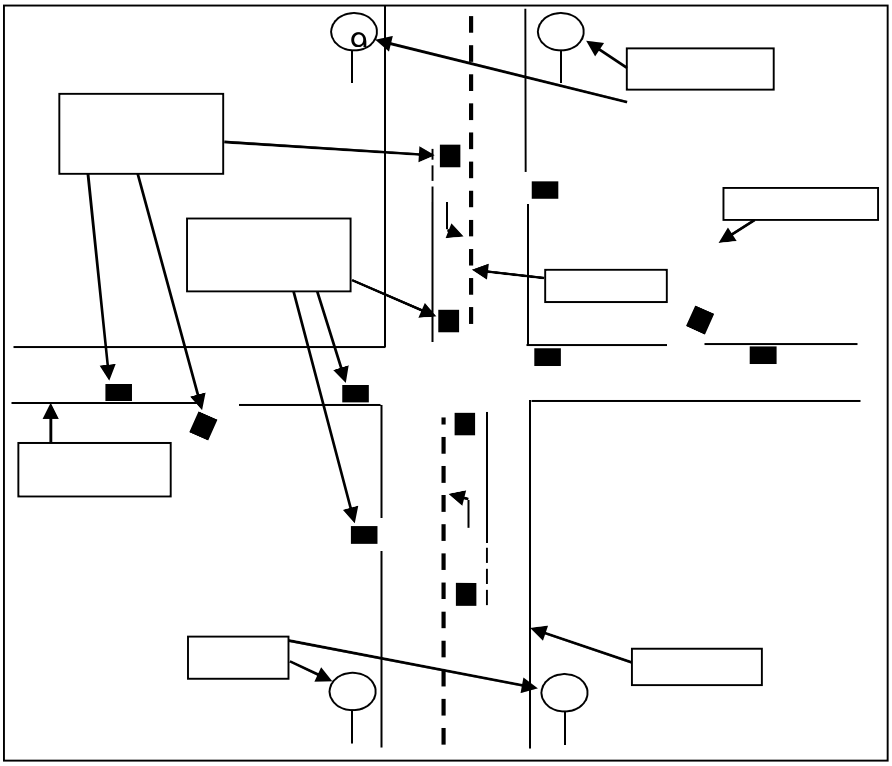

Figure 18: Layout of VSL at intersection "Lemmeströ" in Sweden

Figure 19: VSL at intersection "Fogdarp" in Sweden

3.2.2 Example Denmark

GENERAL INFORMATION	
Name of service/project	Variable Speed Limits om Motorring 3
Name of operator/organisation	Vejdirektoratet
Web link	www.trafikken.dk
Contacts	Lene Mårtensson, lemaa@vd.dk
Other	
Applicable Deployment Guideline	TMS DG02 Speed Control

GEOGRAPHICAL ASPECTS	
Country	Denmark
Region of implementation	Copenhagen
Networks concerned	Motorway
Deployment indicators	14 Number of kilometers

SERVICE DESCRIPTION	
Problem(s) addressed / Objectives	☒Reduction of congestion ☒Increase of safety ☐Reduction of environmental damage (%) ☐Other:
ITS service description	On Motoring 3 around Copenhagen there is a motorway control system with following key applications • Traffic detector system • Variable speed limits (via variable speed signs, mandatory) • Real time traffic information provided by VMS, e.g. incident warnings and travel times • Video surveillance • Web applications The Motorway control system was originally implemented as part of a large construction work in connection with the extension of the motorway from 2 to 3 lanes. The control system is still in use after the opening of the wider motorway
Service requirements	☐Functional requirements ☐Organisational requirements

	☐Technical requirements ☐Look & Feel for the end user ☐Level of Service criteria
Requirements specifications	The ITS system has been in operation since 2005 and was implemented before the Deployment Guideline 2010

IMPLEMENTATION ASPECTS	
Duration (start, end)	Start: 4/1/2005 End:
Lessons learnt / factor of success	Technical See below Institutional/organisational Legal Financial
Impacts assessment / results	Driving Speeds Investigations regarding travelling speeds have shown that the speed signs and variable message signs have led to a slight decrease in travelling speeds, the magnitude of which depends on what is shown on the variable signs (both speed limits and others) and the traffic conditions at hand. Gaps between vehicles The traffic management system in general causes the drivers to drive more closely to each other at speeds between 80 km/hour and 100 km/hour. Outside of this speed interval the time gaps have generally increased. Accident statistics The construction works did not lead to an increase in the number of traffic accidents taking place on the M3. This was one of the primary success criteria for the traffic management system. The safety impact of the Motorway Control System has not been evaluated after the opening of the wider motorway.

REFERENCES	
Documentation available on the project	Title: Impacts of Traffic Management on Motorring 3, VIKING, 2007-04-03 Contact: Language: Danish – with English summary ☒ EW/TEMPO evaluation

ILLUSTRATIONS

Figure 20: Speed control using variable message signs on Motorring 3 around Copenhagen

3.2.3 Example UK

GENERAL INFORMATION	
Name of service/project	Variable speed
Name of operator/organisation	Highways Agency, England
Web link	www.highways.gov.uk
Contacts	Graham.Seaton@highways.gsi.gov.uk
Other	Max.Brown@highways.gsi.gov.uk
Applicable Deployment Guideline	TMS DG02 Variable Speed Limits

GEOGRAPHICAL ASPECTS	
Country	United Kingdom
Region of implementation	England
Networks concerned	M20 J5-7 Maidstone, Kent
Deployment indicators	Number of kilometers

SERVICE DESCRIPTION	
Problem(s) addressed / Objectives	☒Reduction of congestion ☒Increase of safety ☒Reduction of environmental damage (%) ☐Other:
ITS service description	Variable Speed Limits have been deployed principally to ease congestion. Advanced Matrix Indicators set speeds at 50mph and digital speed cameras enforce temporary limits. Speeding tickets are issued. Speeds are set using an advanced algorithm managed by the Regional Traffic Control Centre. The application is mature.
Service requirements	☒Functional requirements ☒Organisational requirements ☒Technical requirements ☒Look & Feel for the end user ☐Level of Service criteria
Requirements specifications	The functional and technical requirements were developed by the Highways Agency from existing specifications following an extensive research and design process involving multi-stakeholder consultation, testing and subsequent evaluation. Look and feel accord with national perspectives that are in line with EasyWay developing guidelines. Level of Service at these locations

	determined that an intervention of this type was necessary.

IMPLEMENTATION ASPECTS	
Duration (start, end)	Start: 2007 End: 2011
Lessons learnt / factor of success	Technical The challenge to develop an algorithm to determine the level of congestion at which lower speed limits should be set, the sequenced introduction of temporary limits and development of an indicator sign that is compliant with traffic signs regulations that allows enforcement. Institutional/organisational The need to engage with Police Authorities to enforce the lower limit. Provision of evidential quality data for enforcement. The requirement to educate road users in modes of operation and expectations of behaviours in response to changed limits. Legal The need to develop a Type Approved enforcement system to allow enforcement of the displayed speed limit in a court of law. Objectives for the scheme have been met.
Impacts assessment / results	This scheme follows a similar project on the M25 J10-16 where it was proven that traffic congestion decreased, journey time reliability improved and environmental impact was ameliorated.

REFERENCES	
Documentation available on the project	Title: Relevant Project Documentation Contact: www.highways.gov.uk/knowledge/documents/ Language: English ☐ EW/TEMPO evaluation

ILLUSTRATIONS

Figure 21: VSL system on motorway in the UK

3.2.4 Example Austria

GENERAL INFORMATION	
Name of service/project	Line Control Systems in Austria
Name of operator/organisation	ASFINAG
Web link	www.asfinag.at
Contacts	Michael Schneider Coordination of inter/national traffic management ASFINAG SERVICE GMBH Traffic control centre KLINGERSTRASSE 10 A-1230 VIENNA, Austria E-mail: Michael.schneider@asfinag.at
Other	
Applicable Deployment Guideline	TMS DG02 Variable Speed Limits

GEOGRAPHICAL ASPECTS	
Country	Austria
Region of implementation	Several regions
Networks concerned	Motorways & Expressway
Deployment indicators	1 national, 9 regional Number of traffic centres

SERVICE DESCRIPTION	
Problem(s) addressed / Objectives	☒Reduction of congestion ☒Increase of safety ☒Reduction of environmental damage (%) ☐Other:
ITS service description	ASFINAG operates several line control systems on its motorway and expressway network. Variable speed limits are part of the functionality of all line control systems. The line control system has a high degree of automation, using dynamic road signs for displaying speed limits and warning signs. Automated reduction of speed limits depends on traffic or weather conditions, in special cases on environmental conditions. Manual reduction of speed limits is possible in case of incidents, accidents or road works. The system collects several traffic and weather data using different sensor technology. The first line control system (LCS Tyrol on

	motorways A12 and A13) has been in operation since 2005. Between 2005 and 2011 several line control systems have been implemented on ASFINAGs road network, the implementation process is still ongoing.
Service requirements	☒Functional requirements ☒Organisational requirements ☒Technical requirements ☒Look & Feel for the end user ☐Level of Service criteria
Requirements specifications	Additional to the national road traffic regulations and the national guidelines for roads ASFINAG provides technical and functional specifications for implementing telematic systems on motorways and expressways used for tender request.

IMPLEMENTATION ASPECTS	
Duration (start, end)	Start: 1.4.2005 End: Present.
Lessons learnt / factor of success	
Impacts assessment / results	ASFINAG, ''Wirkungsanalyse VBA Tirol, Vorher-Nachher Untersuchung, (Impact, Assessment of Line Control System Tirol, Before and After Assessment)'', ongoing, to be published. Results of above study to be included when ready

REFERENCES	
Documentation available on the project	See above reference of ongoing study Contact: Language: German ☐ EW/TEMPO evaluation

ILLUSTRATIONS

Figure 22: Example of dynamic line control road signs at the A12/A13 motorway in Tyrol

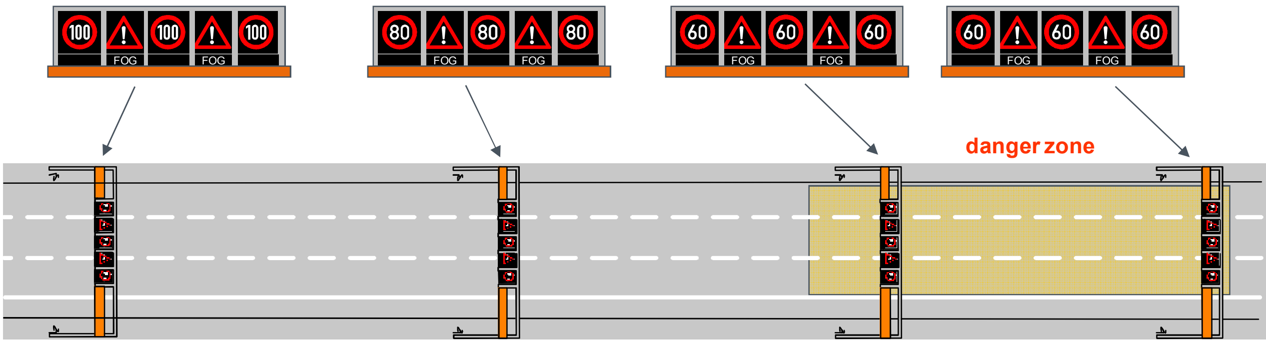

Figure 23: Example of control strategy

Figure 24: Example of an Austrian line control system with variable speed limits and warning signs on common gantry

3.2.1 Example the Netherlands

GENERAL INFORMATION	
Name of service/project	Dynamax
Name of operator/organisation	Rijkswaterstaat
Web link	N.A.
Contacts	Henk Stoelhorst
Other	henkjan.de.haan@rws.nl
Applicable Deployment Guideline	TMS DG02 Variable Speed Limits

GEOGRAPHICAL ASPECTS	
Country	The Netherlands
Region of implementation	A1,A20, A12, A58
Networks concerned	Motorways
Deployment indicators	40 kilometres

SERVICE DESCRIPTION	
Problem(s) addressed / Objectives	☒Reduction of congestion
	☒Increase of safety
	☒Reduction of environmental damage (%)
	☐Other:
ITS service description	Tests with Dynamic Speed Limits, raising and lowering the speed limit to determine the impact on congestion, environment and safety.
Service requirements	☒Functional requirements
	☒Organisational requirements
	☒Technical requirements
	☒Look & Feel for the end user
	☐Level of Service criteria
Requirements specifications	n.a.

IMPLEMENTATION ASPECTS	
Duration (start, end)	Start 2009
	End 2011

Lessons learnt / factor of success	To gain more experience with variable speed limits, a comprehensive evaluation programme of field operational tests (Dynamax), addressing different triggers to set a particular speed limit depending on actual conditions, has been carried out in The Netherlands. Innovative solutions were developed e.g. using real time rain radar data to lower speed limits in bad weather circumstances and the reduction of shockwaves using a dynamic speed limit algorithm.
Impacts assessment / results	The results of the field trials are quite convincing and demonstrate that dynamic speed limits can be applied to achieve various policy objectives, such as improving throughput, traffic safety and air quality. Road users appreciate the dynamic speed limits and adapt their behaviour accordingly. Undesired side effects were shown to be very limited to non-existent.

REFERENCES	
Documentation available on the project	Title: Dynamax contact: Henk Stoelhorst Language: English. ☒ EW/TEMPO evaluation

ILLUSTRATIONS

Figure: Rotation signs indicate a lower speed limit due to poor air quality on the A58 (left); Overhead matrix signs on the A12 Bodegraven – Woerden show a speed limit of 100 km/h as imposed in rainy circumstances (right).

3.3 Costs / Benefits analysis

3.3.1 Criteria and method for the technical evaluation of the measure

The objectives and processes of how the implementation will be validated need to be defined in the early phases of implementation projects.

Objectives

At least the following EasyWay objectives should be evaluated:

Objective 1: Safety

- Reduction of accidents with personal injuries and fatalities.

Objective 2: Network efficiency

- Effects on travel times/accessibility for people and transported goods.

Objective 3: Environmental impacts

- Reduction of harmful emissions (local and global) and/or noise.

For each of these high-level objectives several second level objectives should be defined. Socio-economic calculations should be made based on speed and flow measurements. Evaluation is an essential part of understanding the impacts and benefits of systems and services. It is also important to know the effects to justify future investments and to improve the understanding of when these services are beneficial. However, evaluations may be of less interest in the following situations:

- Similar installations in similar environments have already been thoroughly evaluated.
- When relatively small additions are made to an existing implementation.
- When implementations are done successively and a larger evaluation of several implementation stages is planned later.

3.3.2 Methodology

The TEMPO guidelines, which are maintained by the EasyWay Evaluation Expert Group, are recommended to be used for evaluations. Both ex-ante and ex-post evaluations are recommended. Documentation can be found on the EasyWay website, www.easyway-its.eu .

An evaluation plan should be made early in the project. The plan should include indicators to be measured in the before and after situations, expected benefits (target values) and evaluation methods.

The most important parameter to measure is of course speed, typically average speeds and the 85-percentile (the speed where 85% of the vehicles are going slower) need to be acquired as well as vehicle classes, at least heavy and light traffic separated, since the maximum allowed speed differ between vehicle types. Also traffic flow for the same vehicle classes needs to be measured.

When making studies of future implementations, simulation can be an effective tool to estimate the impacts and benefits. Results from earlier implementations should be used as an input and to calibrate simulation models.

3.3.3 Costs and benefits analysis

Costs and benefits analysis should be performed according to the methodology above. Key indicators, to be shared EasyWay partners, should be produced. These are:

- Calculated change in FSI (Fatalities and severe injuries); if traffic safety is one objective for the measure.

- Measured change in traffic flow and/or average speeds; if network efficiency is one objective for the measure.
- Environmental impacts, emissions of CO2 and noxious gases and/or noise reduction (can be calculated from other indicators); if environmental improvements are among the objectives for the measure.

3.3.4 Example: German ex-ante and ex-post evaluations of accident costs and time costs

Accident costs in the ex-ante method (for line control systems)

The accident occurrence during the past three years (without line control system) is analyzed, whereby a distinction is made between accidents with injured, accidents with heavy material damage and fog accidents. The method is based on the principal assumption that the accident rates for accidents with injured reaches a constant value depending on the number of driving lanes after setting a line control system into operation. The safety benefit mainly depends on the accident rate before implementation of line control. For accidents with heavy material damage a reduction by 15% is expected. In case of fog accidents it is expected that 80% of the accidents with injured in case of fog that occurred before the implementation can be avoided.

Time costs in the ex-ante method (for line control systems)

Time cost benefits are a result on one hand from the lower probability of flow breakdowns in case of high traffic loads due to the harmonizing effect of the line control system. For quantification, congestion and incident reports of one year are analyzed and traffic-related congestion hours are calculated. For traffic-related congestion hours, a reduction by 5% is expected with the start of operation. Further time cost benefits result from declining accident numbers, since accidents usually lead to a closure of one or several lanes or even a full blockage. This causes a tailback in case of a certain load level of the carriageway; its extension depends on the duration of accident clearance and the difference between traffic demand and remaining capacity. The calculation method for estimating the reduction of accident-related congestion hours is based on an estimation of the capacity reduction depending on accident severity (involved vehicles, injured, material damage) and on the traffic volume during the accidents – from AADT (Annual Average Daily Traffic) values and standard daily graphs or data archives.

4 Annex A: Compliance Checklist

4.1 Compliance checklist "**must**"

#	Requirement	Fulfilled?		If no – quote of insurmountable reasons
		Yes	No	
Functional requirements				
FR2	Sensors **must** be adapted to the service and give input to the control system. Exceptions: For systems using clock and/or calendar control, sensors are replaced by the system clock. For manually controlled systems at road works, sensors are usually replaced by a keypad (local control unit) or similar. Note: Systems may include both manual and automatic functions as well as several types of sensors. This requires well defined hierarchical rules and priorities.			
FR4	The signs **must** display the speed limit that the control system has requested and functionality **must** be monitored continuously by on duty staff.			
Organisational requirements				
None				
Technical requirements				
TR2	The Speed control / Speed limit service is characterized by the following elements: • The location of the speed limit • The length affected by the measure • When necessary the type of vehicle concerned by the speed limit These elements and the speed limit itself **must** be described in the DATEX II Model as follows: *(Please refer to section 2.4 for the schemes)*			
TR3	The following figure *(please see figure 5)* presents a selection for lorry. Additional detail can be outlined (for example tonnage of the concerned vehicles **must** be specified in **GrossWeightCharacteristic**)			
TR4	In the case that road operators have to exchange data requiring interoperability between two or more different			

	organisations, they **must** enable their system to use DATEX II. This class is a specialisation of the **SituationRecord** class, hence the information regarding Speed limit shall be published via a **SituationPublication**.			
Common look & feel requirements				
None				
Level of Service requirements				
None				

4.2 Compliance checklist "should"

#	Requirement	Fulfilled?		If no – explanation of deviation
		Yes	No	
Functional requirements				
FR1	Functional decomposition and the provision of standardised interfaces **should** be carried out to ensure interoperability in cases where the service is carried out by more than one organisation (and is in any case recommended to be prepared for an easy functional decomposition, as could be the case in the future). Control and algorithms may be done through local (roadside) or central systems.			
FR3	Automatic and semi-automatic systems **should** contain models and algorithms that calculate the speed limit and transmit it to the signs. These models and algorithms can be implemented in a central control system or at the roadside.			
Organisational requirements				
None				
Technical requirements				
TR1	Discontinuous signs (i.e. LED) **should** follow the European standard EN 12966-1 or their national counterparts. Continuous signs (retro-reflective, i.e. prism signs) **should** follow the European standard EN 12899-1 or their national counterparts where applicable.			

Common look & feel requirements				
CL&FR1	Mandatory variable speed limits **should** be displayed in one of the following ways: • Discontinuous signs: White, off-white or yellow figures on a black background enclosed by a red ring. Discontinuous VMS can also be used without colour inversion if national regulations allow or require this. Continuous signs: Sign surface similar to fixed mandatory speed signs according to national regulations. Reference to the Vienna convention: Sign C14.			
CL&FR2	• Advisory dynamic speed signs **should** be displayed in one of the following ways: • Discontinuous signs: White, off-white or yellow figures on a black background. The sign can have a white rectangular border, but no red ring. Discontinuous VMS can also be used without colour inversion if national regulations allow or require this. • Continuous signs: Sign surface similar to fixed advisory speed signs according to national regulations.			
CL&FR5	Signs **should** be located either above the carriageway or on the verge of the road. If signs are located on the verge, there **should** be signs on the right hand side of the road with possible supplementary signs to the left (opposite for countries where you drive on the left). If there is more than one lane in the direction of travel, it is recommended to have signs on both sides.			
CL&FR7	Speed limits **should** be repeated at least after every entry slip road, and the distance **should** not exceed 10 km on long stretches or according to national guidelines and operating context.			
CL&FR8	It **should** be obvious to the drivers when a section with VSL ends and what the valid speed limit is after that. Normally this is done using fixed speed limit signs			

Levels of Service requirement				
LoSR1	In the case that pre-deployment surveys / evaluations provide the necessary evidence to proceed with the deployment of the ITS-service "Variable speed limits", the minimum and optimum LoS **should** respect the following Level of Service to Operating Environment mapping table.			

4.3 Compliance checklist "**may**"

#	Requirement	Fulfilled?		If yes –remarks
		Yes	**No**	
Functional requirements				
FR5	If VSL systems interact with other services like hard shoulder running, dynamic lane management or HGV overtaking ban (or adjacent VSL systems), interfaces **may** be found either at roadsides or in central control systems. In practice, this can often be internal interfaces in the same system.			
Organisational requirements				
None				
Technical requirements				
None				
Common look & feel requirements				
CL&FR3	Yellow flashing lights **may** be added to increase visibility. In Motorway Control Systems yellow flashing lights **may** be used to alert the driver that he/she enters a section with a lower speed limit.			
CL&FR4	Supplementary information **may** be added, e.g the reason for a reduced speed limit. There is a higher need for this when it is difficult for the drivers to understand the reason.			
CL&FR6	If signs are mounted above the carriageway, you **may** have one speed limit sign above each lane or a single speed limit sign integrated in a larger VMS which is valid for all lanes.			
Levels of Service requirements				
None				

5 Annex B: Bibliography

1. S. Bradner, (Network Working Group). Key words for use in RFCs to Indicate Requirement Levels. The Internet Engineering Task Force (IETF). [Online] March 1997. http://www.ietf.org/rfc/rfc2119.txt.

2. Autostrade per l'Italia (2007), "Tutor: Attività di accertamento ed analisi dei risultati", 2007

3. Politecnico di Torino, Dept. DITIC (2008), Instruments and devices for monitoring road traffic flows, AlpCheck Interreg III B Programme, Alpine Space, June 2008

4. FGSV, Arbeitsgruppe Verkehrsmanagement (1997), Hinweise zur Wirksamkeitsabschätzung und Wirksamkeitsberechnung von Verkehrsbeeinflussungsanlagen (Recommendations on the efficiency evaluation and calculation of traffic control systems)

5. FGSV, Arbeitsgruppe Verkehrsführung und Verkehrssicherheit (1997), Hinweise für Planung und Einsatz von Geschwindigkeitsanlagen (Recommendations on the planning and deployment of speed control systems)

6. Bundesministerium für Verkehr (1997), RWVZ Richtlinien für Wechselverkehrszeichen an Bundesfernstraßen (Specifications for variable message signs on federal roads)