EasyWay Harmonising European ITS Services and Actions

Traffic Management Services
HARD SHOULDER RUNNING

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

Easy Way 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 Easy Way 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

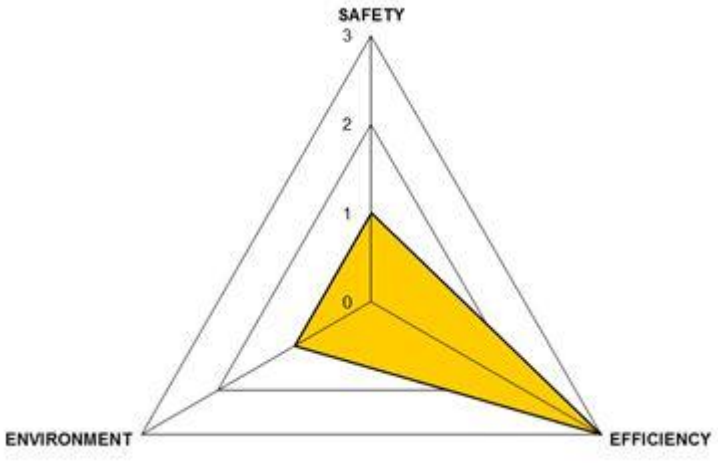
Hard Shoulder Running enables the dynamic temporary use of hard shoulders at road sections, including junctions with the aim to increase road capacity when necessary. Hard Shoulder Running could be considered similar to the creation of an extra lane, but with specific safety issues due to the fact that it is still a hard shoulder where users can stop if they breakdown.

Hard Shoulder Running is triggered by traffic demand, at fixed times or due to manual requests and applied to bottlenecks, locations with poor safety records (black spots) with a recurrent - but not constant - lack of capacity.

SERVICE OBJECTIVE

The goal of Hard Shoulder Running is to increase road capacity on a section of the road network necessary, in order to minimize (heavy) congestion and to reduce the probability of congestion caused incidents.

SERVICE BENEFIT RADAR



EUROPEAN DIMENSION

The main European aspect is harmonizing European road user perception and to achieve a European-wide commonly agreed safety level for the Hard Shoulder Running service. Hence future European deployments should deliver:

- Similar unambiguous instructions, on the basis of agreed protocols, for road users to ensure they know how to behave when facing an open or closing hard shoulder.
- Similar safety protocols for the deployment of Hard Shoulder Running and for scenarios when it is necessary to open or close the hard shoulder.

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List of abbreviations

AGR	European agreement on international main arteries
CEN	European Committee for Standardization
ESG	EasyWay expert and study group
HSR	Hard Shoulder Running
ITS	Intelligent Transport Systems
OE	Operating environment
RFC 2119	Request For Comments 2119
TERN	Trans European Road Network
VMS	Variable Message Signs
FR<#>	Functional requirement <number>
OR<#>	Organisational requirement <number>
TR<#>	Technical requirement <number>
CL&FR<#>	Look and feel requirement <number>
LoSR<#>	Level of service requirement

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

The hard shoulder running service enables dynamic temporary use of hard shoulders.

Hard Shoulder Running should only be implemented when the safety level remains the same or improves. It can be applied on network areas, route sections and junctions prone to capacity problems. The capacity problems can be on a regular basis (e.g., Tuesday versus Friday, peak hour versus off peak hour) or for a longer period (major road works). The roads are able to cope with extra capacity on trunk roads and in urban areas each both upstream and downstream.

The measures must include strict safety precautions in order to maintain the existing safety levels and can only be deployed if special criteria are met, such as 'no expected increase in emission levels'.

In a normal situation a hard shoulder has a specific set of users, mainly road users in emergency/breakdown situations. Opening the hard shoulder to all road users can cause problems for its regular users and therefore their needs must always be considered.

Opening the hard shoulder for regular traffic without additional measures could give the hard shoulder an ambiguous character. This can cause confusing situations for road users, some examples of which include:

- A commuter accustomed to an open hard shoulder during peak hours, may also expect it to be open during off peak hours.
- A commuter who is accustomed to an open hard shoulder during peak hours may use it while it is closed due to an emergency/breakdown situation downstream.
- Road users who are unaware you are allowed to drive on the hard shoulder will not adapt to a new lane, which can cause dangerous situations and under-utilisation of the hard shoulder lane by the user.

Good unambiguous instructions and education can counter these problems.

1.2.1.2 What is the Vision?

The goal of Hard Shoulder Running is to increase road capacity on a section of the road network necessary, in order to minimize(heavy) congestion and to reduce the probability of congestion caused incidents.

1.2.1.3 What is the Mission?

Hard Shoulder Running:

- is applied for bottlenecks/problem areas in the network with recurrent, but not constant, lack of capacity, i.e., recurrent peak hour congestion;
- is similar to creating a dynamic extra lane triggered by traffic demand, at fixed times (peak hours) or even manually, and therefore requires dynamic traffic management control (see also TMS-DG01 Dynamic lane management).This extra lane is also to be controlled in the case of the use of the hard shoulder by a broken-down vehicle.

In specific cases Hard Shoulder Running:

- can be referred to as peak hour lanes. It should be noted that these can also imply extra lanes, which are not necessarily hard shoulders
- can be conceived as an interim solution until an appropriate traffic solution is in place to counter capacity problems
- can be used for dedicated lanes, thus creating extra capacity for a dedicated set of road users like public transport (application case not covered by this deployment guideline, see also TMS-DG01 Dynamic lane management).

1.2.1.4 EasyWay harmonization focus

- [Which Aspects of the service are highlighted / mainly addressed by this EasyWay-Deployment guideline?]
- Pan-European understanding of the functionality and the benefit of the Hard Shoulder Running service
- Uniformity in the appearance of the road and road signing (common look & feel for the road user)
- Uniform assessment criteria for the Hard Shoulder Running service related to a uniform operating environment classification.

1.2.1.5 Distinctiveness from other ITS-services

Hard Shoulder Running is a special application of dynamic lane management. As a special service it interacts with the following other European ITS core services:

- TMS-DG02 Variable Speed Limits
- TMS-DG01 Dynamic Lane Management
- TMS-DG05/08 Incident Warning and Management

Note: By applying Hard Shoulder Running, incident warning and management can become more complex. In this instant an extra step in the incident warning and management process is needed, i.e., to check if the hard shoulder is clear or can be cleared.

1.2.2 Contribution to EasyWay Objectives

1.2.2.1 Service radar

The graph below provides a quantification of the added value of "Hard shoulder running" services regarding the three main objectives of EasyWay which are: safety, efficiency and environment. The applied scales for the service radars are based on an expert view and not on specific scientific analysis.

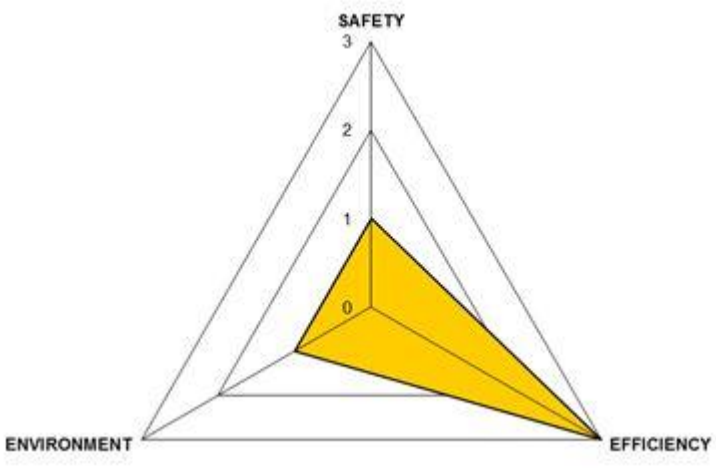


Figure 1: Hard shoulder Running& EasyWay Objectives Radar

1.2.2.2 Safety

Hard Shoulder Running enables the temporary, demand-responsive capacity increase of road sections. This results in a better distribution of traffic by allowing road users to adjust more easily to dangerous situations and results in reduction of accidents due to the decrease/elimination of (upstream) congestion.

The impact analysis of comparable systems confirms the positive effect on traffic safety (see also Part B - Example of deployments).

Note: Hard Shoulder Running may have negative impacts on safety when broken-down vehicles need to stop. To avoid this, HSR sections of road have to be controlled and the operator's response to such a situation has to be as fast as possible

1.2.2.3 Environmental impact

By providing extra capacity, Hard Shoulder Running systems reduce congestion and journey times and reduce accidents. This improves the efficiency of journeys and reduces the pollution generated by each journey (see also Part B - Example of deployments).

1.2.2.4 Network efficiency

A demand-oriented increase of the capacity on route sections and at junctions result in an improved traffic flow on the whole network area concerned. From the point of view of users, this also contributes to a more regular traffic flow (due to a better use of road capacities) and to a reduction of travel time losses.

The impact analysis of comparable systems confirms the positive effect of Hard Shoulder Running on network efficiency (for concrete figures see also Part B - Example of deployments).

1.2.3 Current status of deployment

Hard Shoulder Running is a complex and delicate combination of traffic measures and ITS. Although many European countries have gained much experience with some form of Hard Shoulder Running in the previous years, few are fully rounded or presume that the service is fully developed.

Depending on the organisation and functional area, a check of the carriageway is done by video cameras or traffic inspector patrol cars, which in the future could be supported by automatic scan functions, before the release of a lane. Detected incidents, stranded cars or obstructions on the hard shoulder are transmitted to the operator. After it has been determined that the hard shoulder is clear of obstructions, the operator starts and stops the release of the hard shoulder. If the hard shoulder is not clear the operator aborts the release. For visualization, matrix signs are applied as along with variable routing signs (in LED or prism technology).

1.2.4 European Dimension

The main European aspect is harmonizing European road user perception and to achieve a European-wide commonly agreed safety level for the Hard Shoulder Running service. Hence future European deployments should deliver:

- Similar unambiguous instructions, on the basis of agreed protocols, for road users to ensure they know how to behave when facing an open or closing hard shoulder.
- Similar safety protocols for the deployment of Hard Shoulder Running and for scenarios when it is necessary to open or close the hard shoulder.

2 Part A: Harmonization Requirements

2.1 Service Definition

Hard Shoulder Running enables the dynamic temporary use of hard shoulders at road sections, including junctions with the aim to increase road capacity when necessary. Hard Shoulder Running could be considered similar to the creation of an extra lane, but with specific safety issues due to the fact that it is still a hard shoulder where users can stop if they breakdown.

Hard Shoulder Running is triggered by traffic demand, at fixed times or due to manual requests and applied to bottlenecks, locations with poor safety records (black spots) with a recurrent - but not constant - lack of capacity.

2.2 Functional Requirements

2.2.1 Preliminary Notes

Note: The hard shoulder can also be used on a regular basis for specific type of vehicles, e.g. public transport. This application case is not covered by this "Hard Shoulder Running" service guideline.

2.2.2 Feasibility study

Functional advice

- Before implementation of a Hard Shoulder Running measure feasibility should be carried out answering at least the following questions:
  - Is it necessary?

    Sometimes extra capacity is only needed for 2 or 3 hours one day of the week. The costs should not outweigh the benefits. In addition, reduced speed limits when HSR is in operation will be perceived as a delay by drivers if there is no need for it.
  - Will it benefit traffic flow on a network level?

    Studies show that an increase in capacity has only a limited impact on congestion. Extra road attracts extra road users. Simulation is recommended to ensure that the measure can cope with extra capacity both upstream and downstream in order to avoid negative network effects.
  - Are we allowed?

    Air and noise pollution legislative rules are strict (see also EU-legislation). Inhabitants in the area or a near extinct ant or vegetation variety can put plans on hold for years.
  - Is the hard shoulder construction suitable?

    Construction of the hard shoulder must be suitable for a heavy traffic load.
  - Is deployment safe?

    How is safety guaranteed or improved? Are e.g. safeguarding protocols for the deployment of Hard Shoulder Running available and suitable?
  - Does the network have sufficient capacity?

    The network must be able to cope with extra capacity both upstream and downstream. Increasing the capacity of a single stretch within the network, not considering upstream and downstream sections and intersection capacity, has only limited impact. Simulations of different scenarios are recommended.

2.2.3 Operational phase

2.2.3.1 Functional Architecture

Hard Shoulder Running is carried out with a control algorithm or due to manual request according to conditions like high traffic demand.

Hard Shoulder Runningis carried out via the following (illustrated by examples):

- Monitoring - **Collect real time information** on the traffic situation of the network or relevant/chosen route sections
- Safeguarding-**Check if the hard shoulder is free** of debris and free of vehicles obstructing safe use of the hard shoulder and free of vehicles
- Information-**Inform the road user if the hard shoulder is open**. If a signalling system is available signing above the hard shoulder indicates either the allowed speed limit or a symbol like a green arrow pointed downwards. Another option is the use of dynamic or static road signing which can provide the road user with instructions that the hard shoulder is open for use. Both options can be used simultaneously to support each other to indicate that the hard shoulder can be used.
- Information -**Inform the road user if the hard shoulder is closed or clearing**. If a signalling system is available to start the clearing process, a yellow (flashing) arrow pointing diagonally downward is used as transition signal. The clearing process can take place through a lane change that can be done for the whole road section simultaneously or by means of discharging.

The following figure shows the typical functional architecture and control flow of a “Hard Shoulder Running Service”.

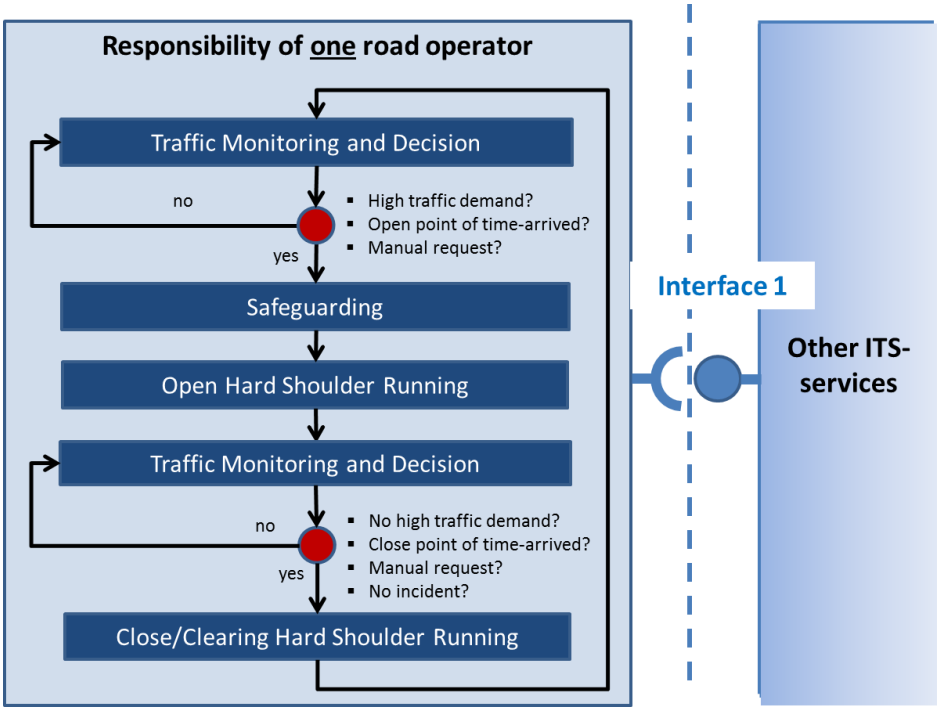


Figure 2: Functional architecture and control flow of Hard Shoulder Running

Functional requirements:

Safeguarding

- **FR1**: Incident detection and verification **must** be possible for the whole Hard Shoulder Running section. Incident detection does not need to be automated.
- **FR2**: Detection and verification time, as well as reaction time, **should** be as short as possible.

- **FR3**: Safety protocols and instructions **must** be available to ensure the opening, running and closing of the Hard Shoulder Running is done safely.
- **FR4**: In case of failure of the Hard Shoulder Running signalization the system **must** be transferred immediately into a safe state.

Functional advice:

Traffic Monitoring and Decision

- Before starting the Hard Shoulder Running opening/closing procedure, continuous traffic monitoring could be carried out along the entire section of Hard Shoulder Running as well as upstream and downstream road sections (network effects) using at least one of the following traffic monitoring means:
  - real time traffic monitoring systems (loops, cameras, radar, laser…)
  - visual control (i.e. cameras)
  - Optionally: a decision support system to automatically recognize whether the operator should start the opening or closing procedure.
- To ensure safety on the hard shoulder in case it is used as a running lane, the following options could be provided:
  - safe havens/ERA (emergency refuge areas) for broken down cars (to leave running lanes),
  - visual control(i.e. cameras, possible extra public lighting for dark periods or camera's which function in low light conditions)
- In the instant where automatic incident detection is used as a safeguarding support system:
  - the automatic incident system can be well calibrated in order to maximize the detection rate and minimize the number of false alarms and
  - it can be clearly defined what type of incidents/accidents have to be detected by the automatic incident system (pedestrian, broken down vehicle, animal, vehicle running the wrong way down the lane...)

Enforcement

- To avoid illegal use of the hard shoulder when it is closed to traffic, (automatic) enforcement may be used. Cameras are one type of equipment which can be used as enforcement.

2.2.3.2 Interface requirement

Functional requirement:

- **FR5:** The information on the speed limit and open or closed hard shoulder **must** be available for other relevant ITS-services. Hence the Hard Shoulder Running service **must** require an interface with the following information structure (see **TR1**):
  - allocation and spatial dimension of the Hard Shoulder Running section
  - status of the hard shoulder (open/close)
  - speed limit

2.2.4 Hard Shoulder Running evaluation

Functional advice:

- Quantitative evaluation

To evaluate the impact of Hard Shoulder Running on safety, network efficiency and environment, it is necessary to collect data from cameras, loops and radar or other monitoring devices installed along the relevant road section. Nevertheless, the type of data collected and its interpretation can be considered before collecting data, creating and possibly using a database. Furthermore, data from all available monitoring devices should be comparable. When collecting data from cameras sufficient data storage can become a problem and efficient use of capacity is advisable.

General data required for evaluation:

- Monitoring data
  - Congestion
  - Traffic volumes and speed
  - Incidents
  - Weather conditions
  - Road conditions (snow, ice, oil, salt...)
- Logging Hard Shoulder Running measure
  - Date
  - Start time/end time
  - Reason for releasing hard shoulder
  - Reason for closing hard shoulder
  - Congestion level
  - Average speed
  - Duration
- Logging failure notices
  - Failure of the systems
  - Switching command which has not been carried out
  - Improper command
- Qualitative evaluation

From a qualitative point of view questionnaires can be prepared and distributed in order to know users' opinions on safety and network efficiency. Road operators could also be addressed with such questionnaires, differently formulated, in order to share their experiences on the impact of the dynamic allocation of lanes on the environment, safety and traffic flows.

Safety

As far as safety is concerned, the use of Hard Shoulder Running implies a decrease in the accident rate overall if the infrastructure has been significantly adapted for its use.

To determine the impact of Hard Shoulder Running on safety the following aspects must be determined:

- Quantitative: Accident rate, road user acceptance
- Qualitative: road user experience

Network efficiency

As far as network efficiency is concerned, the Hard Shoulder Running enables an increase in infrastructure capacity to keep a constant traffic flow to lower speed-reducing congestion. Compliance of the road user is another relevant aspect of network efficiency. The percentage of vehicles driving on the hard shoulder determines the extra capacity.

To determine the impact of Hard Shoulder Running on network efficiency the following aspects must be determined:

- Quantitative: traffic intensities, traffic flow, average speed, road user acceptance
- Qualitative: road user experience

Environmental impact

As far as the environment is concerned, if traffic flows do not increase, emissions are likely to be reduced. Their levels can be monitored by special tools installed along the section affected by the dynamic management of the lane. However, using special algorithms, traffic intensities together with vehicle classification can also give a good indication of the emission levels. In addition to that, one could also monitor the noise levels.

To determine the impact of Hard Shoulder Running on the environment the levels of emissions (noise and pollution), traffic intensities and average speed must be determined.

2.3 Organisational Requirements

In general it is necessary for national and European law and legislation to allow for the use of hard shoulders (AGR- European agreement on international main arteries, Annex II, section III.3.2).

Per Member State different organisational standards and guidelines are used for hard shoulder measures. This does not necessarily affect the uniformity of the service for the road user.

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 DATEXII-Profiles

Interoperable interfaces between systems are essential for the delivery of many EasyWay objectives like the continuity of services and cross-border traffic management cooperation. Hence, EasyWay has itself decided to actively contribute to the establishment of the required standardisation effort by launching a dedicated working group ESG5 and liaising with the relevant European standardisation body, namely with CEN TC278 WG8 ("Road Traffic Data"). The result of this cooperation is the "DATEX II" specification for interoperable machine-to-machine communication of ITS services, available as European Standard CEN/TS 16157. This specification is used throughout EasyWay for interoperable access to dynamic traffic and travel data.

In the TIS context, 'organisations' mean Traffic and Traveller Data providers and Services providers

Technical requirement:

- **TR1**: 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, specifically the DATEXII-Profile[1] for **interface 1 - Dissemination of Hard Shoulder Running service information**.

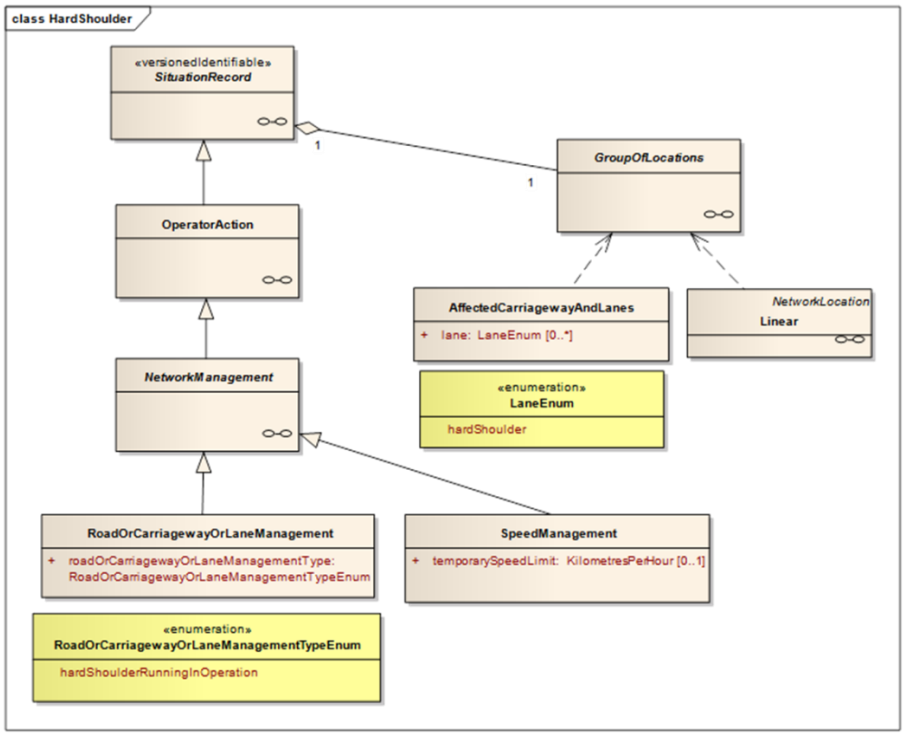


Figure 3: DATEXII-Profile interface 1 - Dissemination of Hard Shoulder Running service information

2.4.2.2 Need for Additional Specifications

None

[1] DATEX profiles consist of a set of data elements taken from the overall DATEXII model and can include a subset (Schema) of relationships between those elements

2.5 Common Look & Feel

Information for the end user must be self-consistent independent of the media and end user device where it is displayed and, respectively, broadcast

Common look & feel requirement:

- **CL&FR01:**

  The display of signs/pictograms on VMS or other end-user devices **should** be in accordance with prevailing national road codes and where applicable be in line with the requirements of the EW-DG for Variable Message Signs Harmonization VMS-DG01:

  - MS which ratified the 1968 Convention MUST respect the 1968 Convention and SHOULD consider the Consolidated Resolution on Road Signs and Signals (R.E.2);
  - MS which did sign but not ratify the 1968 Convention SHOULD follow the 1968 Convention and also consider the R.E.2.

Driver information:

- The road user can be informed on the road, but also in a general way, of the goals and functionality of Hard Shoulder Running services (Driving school, communication by websites, brochures and other media…).
- Lane colouring:

  In order to emphasize the presence of the lane for Hard Shoulder Running, a different colour of the tarmac can be applied.

Common look & feel requirements:

Safe havens/ERAs (emergency refuge areas)

- **CL&FR02**: Safe havens/ERAs **should** be provided in order to create safe zones for broken down vehicles.
- **CL&FR03**: Safe havens/ERAs **should** ensure a safe use (length and width).
- **CL&FR04**: The maximum distance between safe havens/ERAs **should** be 1000m.

Road marking

- **CL&FR05**: Road markings at junctions and cross sections **should** be in line with general standards used for road sections without Hard Shoulder Running.

Public lightning

- **CL&FR06**: Good quality surveillance and monitoring functions for traffic operators **should** be guaranteed. Examples to establish these conditions are public road lighting or the use of infra-red cameras.

Indication distances

Temporarily Hard Shoulder Running is displayed to users by means of Variable Message Signs.

- **CL&FR07**: Indications for an open or closed hard shoulder **should** be located at a distance which guarantees the road user good visibility of the successive signals/signs along the relevant stretch of road.

Hard Shoulder Running signage

- At the moment there are some different approaches with regards to the presentation of Hard Shoulder Running services to the road user. EasyWay choose to allow several options, because:
- There is no conclusive evidence that one method is better than another.
- A road operator depends on the equipment available to them

Common to all options is that they answer to the following:

- What message should be conveyed to the road user?

  - Hard shoulder is closed (CL&FR08)
  - Hard shoulder is open (CL&FR09)
  - Hard shoulder is clearing (CL&FR10)
  - End of the hard shoulder section (CL&FR11)
- What is the applicable speed limit?
- What signs will be used to convey the message?
- When and where will this message be conveyed?

EasyWay did choose to limit the options to the following set in order that EasyWay partners will not develop yet another parallel approach in the future (unless it is considered a large improvement by all). EasyWay will study what can be considered the best approach between 2013 and 2020. In the near future dynamic control systems might be transferred to in-car systems and this will also be taken into account for the study.

No dynamic equipment

In some cases the use of static signs can be sufficient. This is an option for Hard Shoulder Running that is used at set times (i.e. weekdays – 7:00-9:00) – no guidance will be given for this situation in this guideline.

Limited dynamic signs (Figure 7 to Figure 13 **10)**

Hard Shoulder Running service with limited dynamic route signing, showing the available lanes and/or speed limit reduction at the beginning and end of the Hard Shoulder Running section.

Dynamic controlled systems (Figure 8 to Figure 11)

This section addresses a Hard Shoulder Running service in combination with a control system including variable speed limit on overhead signals and additional roadside VMS.

Common look & feel requirements:

- **CL&FR08** Hard shoulder is closed **should** be displayed according to either figure 4 or figure 8
- **CL&FR09** Hard shoulder is open **should** be displayed according to either Figure 5 or Figure 9
- **CL&FR10** Hard shoulder is clearing **should** be displayed according to either Figure 6 or Figure 10
- **CL&FR11** End of hard shoulder section **should** be displayed according to either Figure 7 or Figure 11

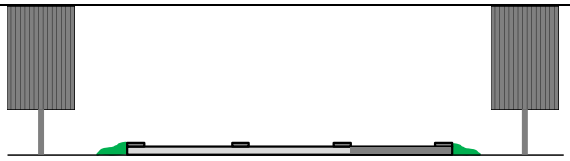
CL&FR08-1	Options HSR is closed
Look of sign	Sign empty
Where	on the side of the road
When	at the start of the HSR section
Example	

Figure 4: Limited dynamic signs for CL&FR08-1

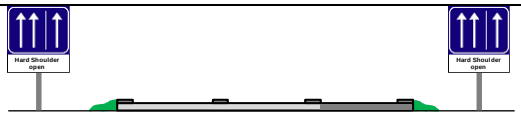
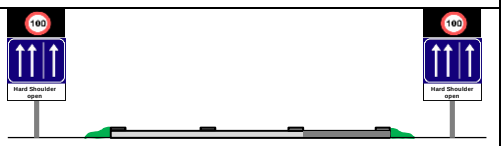
CL&FR 09-1	Options HSR is open	
Look of sign	Sign "E, 20a" Vienna convention	Sign "E, 20a" Vienna convention + speed limit
Where	on the side of the road	on the side of the road
When	at the start of the HSR section	at the start of the HSR section
Example		

Figure 5: Limited dynamic signs for CL&FR09-1

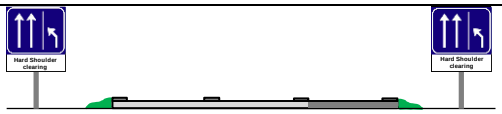
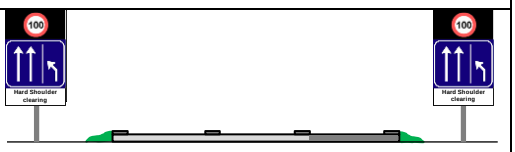
CL&FR 10-1	Options HSR is clearing	
Look of sign	Sign "E, 20b Vienna convention	Sign "E, 20b" Vienna convention + speed limit
Where	on the side of the road	on the side of the road
When	Before the end of the HSR section	Before the end of the HSR section
Examples		

Figure 6: Limited dynamic signs for CL&FR10-1

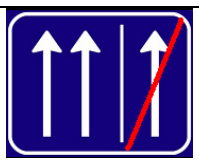
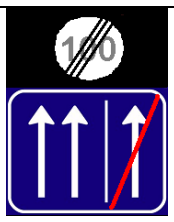
CL&FR 11-1	Options end of HSR section	
Look of sign	Sign "E, 20c Vienna convention	Sign "E, 20c" Vienna convention + speed limit
Where	on the side of the road	on the side of the road
When	At the end of the HSR section	At the end of the HSR section
Examples		

Figure 7: Limited dynamic signs for CL&FR08-1

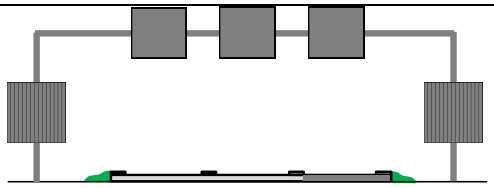
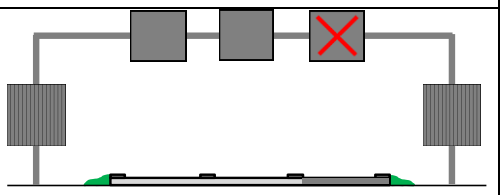
CL&FR 08-2	Options HSR is closed	
Look of sign	no signs at all	a red cross
Where	n.a.	above the Hard Shoulder Running lane
When	n.a.	At least every 1 km
Example		
Background choice	A hard shoulder is not an official lane, so no signage is needed.	For safety reasons it can be recommended to use a cross above the HSR lane. • The presence of a matrix sign implies a regular lane. • For more regular Hard Shoulder Running sections the road user gets used to the use of the HSR lane.

Figure 8: Dynamic controlled systems for CL&FR08-2

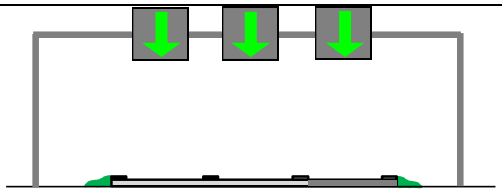
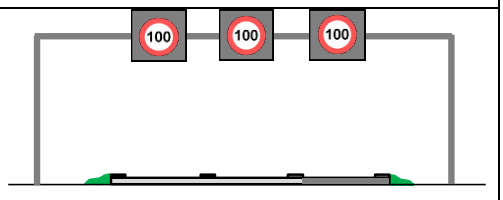
CL&FR 09-2	Options HSR is open(combination of both is an option)	
Look of sign	green arrow	speed limit
Where	Above all lanes	Above all lanes
When	At least every 1 km	At least every 1 km
Example		

Figure 9: Dynamic controlled systems for CL&FR08-2

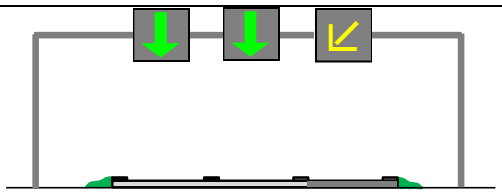
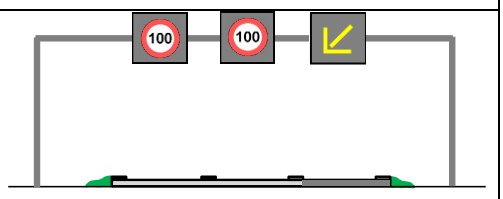
CL&FR 10-2	Options HSR is clearing(combination of both is NOT an option)	
Look of sign	Yellow/white tilted arrow (with or without flashing lights) + green arrows	Yellow/white tilted arrow (with or without flashing lights) + speed limit
Where	Yellow./white tilted arrow above HSR lane Green arrows above regular lanes	Yellow./white tilted arrow above HSR lane Speed limit above regular lanes
When	Before the end of the HSR section	Before the end of the HSR section
Example		

Figure 10: Dynamic controlled systems for CL&FR09-2

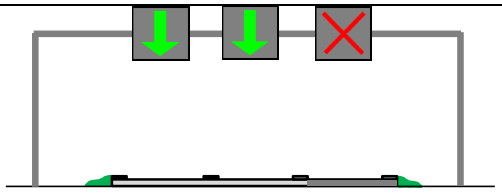
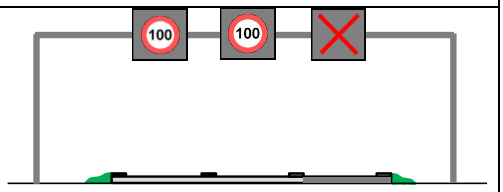
CL&FR 11-2	Options end of HSR section	
Look of sign	Green arrows above regular lanes + a red cross	Speed limit above regular lanes + red cross above hard shoulder
Where	Yellow/white bulbs	
When	At the end of the HSR lane	At the end of the HSR lane
Example		

Figure 11: Dynamic controlled systems for CL&FR10-2

2.6 Level of Service Definition

2.6.1 Preliminary remark

The scope of EasyWay is to provide Core European Services to European road users. These services are harmonized in content and functionality, but also in their availability as road users shall be able to expect a certain offer of services 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.

The “level of service” (LoS) can be defined as the amount, kind and quality of service that, on one hand, is appropriate to the needs and desires of the customers or users that a company - or a public body or agency - serves or wishes to attract and, on the other, is not high for the investments or costs of the company.

The service level therefore describes the quality levels of the service from the perspective of the user of the services or the road operator providing the service.

The service level is also expressed as “a percentage of a goal”, for example, the percentage of time that a network or system is operative or the percentage of successful transactions processed[2].

The service level process implies the following steps:

1) Definition of goals: e.g., time for emptying a tunnel in safe conditions; number of vehicles which pass through a gate in a certain time and with a certain waiting time in the queue;

2) Fixing one or more levels of quality which may vary according to the goal that is pursued. It could be consequently a % (of drivers, of vehicles - in this case a level of efficiency of the service), a waiting time (in this case a level of quality of the service), time for passing from a dangerous situation to a safe one (in this case a level of efficiency of the service associated with quality if we ask whether it was without any problem or deviation from a standard procedure);

3) Fixing the parameters and methods for analysing how to evaluate the level of service.

[2]In telecommunications applications, especially in telephonic call centres, it refers to the achievement of specific goals for customer handling. These goals are usually expressed in terms of call-answering percentage, percentage of calls dropped, average hold time, average call duration and other measures of efficiency and productivity.

2.6.2 Level of Service Criteria

Levels of Service Table: Hard Shoulder Running Service			
Core Criteria	**A**	**B**	**C**
Road signing	Manually on site	Dynamic prism/VMS	-
Monitoring	Manually through traffic officers and/or police	Semi-automatic via traffic officers and/police and camera's	Automatic through cameras, loops, sensors
Safeguarding	Physical	Physical and through cameras	Physical and through cameras + Automatic detection
Activation and de-activation (decision and action)	Manually and manually on site	Manually and remote controlled	Manually, based on decision support systems and remote controlled
Enforcement*	Physical and periodical	Semi-automatic	Automatic
Note: Hard Shoulder Running can be carried out in a first stage or in the case of very rare applications, by the police / traffic officers without technical installations.			
***Note**: "Enforcement" has to be considered a complementary criterion in the identification of the level of deployment, depending on national or regional policies and local characteristics of the service implementation. The "enforcement" criteria could not be considered as critical or mandatory while achieving a level of service. Therefore, binding obligations concerning the implementation of enforcement cannot be imposed on EasyWay partners.			

Table 2: Level of Service

2.6.3 Level of Service Criteria related to Operating Environment

Level 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 "Hard Shoulder Running", the minimum and optimum LoS **should** respect the following Level of Service to Operating Environment mapping table.

HARD SHOULDER RUNNING Criteria for the Levels of Service [reference TMS - DG04]			EasyWay OPERATING ENVIRONMENT																
			C1	T1	T2	T3	T4	R1	R2	R3	R4	R5	R6	R7	R8	S1	S2	N1	N2	P1
Road signing	C	-																		
	B	VMS/Dynamic prism	O			O	O							O	O		O			O
	A	Fixed	M	NR	NR	M	M	NR	NR	NR	NR	NR	NR	M	M	NR	M	NR	NR	M
Monitoring	C	Automatic through cameras, loops, sensors	O														O			OM
	B	Semi-automatic via traffic officers and/police and camera's				O	O							O	O		M			M
	A	Manually through traffic officers and/or police	M	NR	NR	M	M	NR	NR	NR	NR	NR	NR	M	M	NR		NR	NR	
Safeguarding	C	Physical and through cameras + Automatic detection															O			O
	B	Physical and through cameras	O			O	O							O	O		M			M
	A	Physical	M	NR	NR	M	M	NR	NR	NR	NR	NR	NR	M	M	NR		NR	NR	
Activation and deactivation (decision and action)	C	Manually, based on decision support systems and remote controlled															O			O
	B	Manually and remote controlled	O			O	O							O	O		M			M
	A	Manually and manually on site	M	NR	NR	M	M	NR	NR	NR	NR	NR	NR	M	M	NR		NR	NR	

Recommendations for LoS per OE:					
	M	Minimum LoS recommended	O	Optimum LoS recommended	
	OM	Minimum = Optimum	NR	Non relevant	

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 2 lanes	1	X			and	X	
	2	X			and		X
	3		X	X	and	X	
	4		X	X	and		X
R 3 or 4 lanes	5	X			and	X	
	6	X			and		X
	7		X	X	and	X	
	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 Examples of deployment

3.1.1 Examples of implementation of Hard Shoulder Running in EasyWay

Country	Year – status quo	Deployment
The Netherlands	2008	148 km of HSR, an extension is envisaged to 235 km
Germany	2007	250 km of temporary operational HSR, a supplement of 150 km is programmed. 250 km of temporary operational HSR, a supplement of 100 km is programmed
France		A3-A86, A4-A86, A48, A1,... Many study projects particularly in "Île de France" region.
United Kingdom		40 km deployed, 400 km of HSR identified by Highways Agency

Table 5: Examples of implementation of Hard Shoulder Running in EasyWay

3.1.2 Example "Managed Motorways – Highways Agency - England"

3.1.2.1 Example 01- Hard Shoulder Running

GENERAL INFORMATION ON THE SERVICE	
Euroregion:	Streetwise, England
Contact	Graham.Seaton@highways.gsi.gov.uk, Steve.Self@highways.gsi.gov.uk
Name of the service:	Managed Motorways - Hard Shoulder Running
Status:	Operation of HSR
Date of Implementation:	Start: 12/09/2006

Traffic management measures applied:	Hard Shoulder Running, Speed limitation
SERVICE DESCRIPTION	
Hard Shoulder Running has been deployed to ease congestion, improve journey time reliability and increase available capacity. Advanced Matrix Indicators set lane speeds and open hard shoulders at peak flow. Digital speed cameras enforce temporary speed limits. Hard Shoulders are opened using a set of agreed operating guidelines supported by an advanced algorithm and managed by the Regional Traffic Control Centre.	
SPATIAL ASPECTS	
Expansion:	National
Network involved:	M42 J3A - 7, Birmingham

Influence area:	

Figure 12:Example 01 - Hard Shoulder Running

ORGANISATIONAL ASPECTS	
Stakeholders involved:	Highways Agency, England
Regulatory framework concerning the Service:	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.
Organisational lessons learned	The need to engage with highways operations, police authorities and road users to develop and agree safe operational regimes. The need to increase the level of complexity of operational regimes over a period of time using a phased introduction. The need to actively communicate and educate road users during introduction of alternative approach to road use.
TECHNICAL ASPECTS	
Technical lessons learned	Development of algorithm to determine the level of congestion at which lower speed limits should be set and hard shoulders opened, the operational sequencing of temporary speed limits, and the time required for the developmental processes for an indicator sign that is compliant with traffic signs regulations that allows enforcement. They need to undertake a robust safety assessment and scheme design

	which ensures the scheme operates without compromising safety levels.
IMPACT ASSESSMENT/RESULTS	
Description of impacts	This scheme delivered a 7-9% increase in capacity, journey time reliability increased by up to 25%. Speed compliance was in access of 94%. There was an approximate 50% reduction in monthly personal injury accident rate.
REFERENCE	
Managed Motorways Monitoring Evaluation: http://www.highways.gov.uk/knowledge_compendium/8E4B66F290A04A6FA4DC3243A90AE86F.aspx	

Table 6: Organisational aspects

3.1.3 Example "ZSM programme - Rijkswaterstaat – The Netherlands"

Context:

Due to European legislation with regards to emission levels, Rijkswaterstaat was unable to build additional lanes to the existing road network. A short term Hard Shoulder Running programme was set up to increase road capacity at highly congested areas in The Netherlands. For every location Rijkswaterstaat had to prove in advance the Hard Shoulder Running measure would not worsen the emission levels.

System implemented

From 2005 to 2007, 150 km Hard Shoulder Running was implemented at several highly congested areas on the Dutch main road network.

- Typical Hard Shoulder Running for Rijkswaterstaat involves:
- Video monitoring
- Extra monitoring on the hard shoulder
- Extra VMS above the hard shoulder
- Static prism signs alongside the road
- adaptation of the hard shoulder, with extra safe havens
- Widening hard shoulder (sometimes)

The positive results have lead to a second deployment programme in 2008-2010.

Responsible of the implementation/contact:

Edwin Verhagen: Edwin.verhagen@rws.nl

3.1.4 Example "A13 Hard Shoulder Running– The Netherlands"

Region

Rotterdam – Delft: A13 Northbound from junction 11 (Berkel en Rodenrijs" to junction 10 (Delft - Zuid) which is 5 kilometers, 3 lanes + HSR

System implemented:

- HSR system implemented:
- Incident detection with existing loops from section control system MTM.
- Cameras average spacing 150 m.
- Overhead lane signals every 600 m (from existing MTM)
- Safe havens every 1000 meters.

- Activation by traffic flow threshold value of 1500 veh/h/lane, triggered by decision support system.
- Speed limit 100 km/h (permanently)
- Public lighting along whole stretch The positive results have lead to a second deployment programme in 2008-2010.

Lessons learned:

Technical aspects: Camera location planning and configuration appeared to be very relevant due to safety demands for inspection and surveillance. 3D simulation tools have been developed to determine adequate location for cameras taking into account road alignment and road furniture (avoiding occlusion).

Organisational aspects: The organisation of the project (technical manager) should involve the operational staff in an early stage i.e. all employees in the traffic control centre responsible for control tasks and system & configuration management.

Legal aspects: Special attention should be given to environmental legislation. An environmental impact assessment is recommended. Design and layout of the HSR measure should be consistent with national traffic act, markings and signing should be as much as self-explaining.

Financial aspects: Special attention should be given to testing procedures for HSR systems. Testing parameters should be SMART in order to minimize discussions and additional costs afterwards.

Results: 10% growth of traffic during the period June 2006 – June 2007. 90% reduction of congestion. 65% reduction of travel time delay. Some underutilisation of HSR lane shortly after opening times, hence hard shoulder use satisfying. No traffic safety problems noticed.

Responsible of the implementation/contact:

Bert Helleman:bert.helleman@rws.nl

www.spitsmijden.nl

Figure 13: Closed HSR

Figure 14: Safe Haven

Figure 15: HSR in operation

3.1.5 Example "Hard Shoulder Release and Line control - Frankfurt"

Context

- A3 south of Frankfurt interchange (Hessen)
- A5 between Friedberg and Northwest interchange Frankfurt (Hessen)

System implemented

In Hessen the temporary hard shoulder release is usually connected with a line control system. The control is carried out via corresponding sub- and video centres, which are connected to the traffic control centre Hessen. Video cameras, installed along the whole section, check whether the hard shoulder is free of broken down vans, objects or other obstacles. The check by the staff in the TCC is repeated both directly before and after the release in regular intervals. This enables the immediate annulation of the release in case of, e.g. a breakdown. Outside the peak hours the hard should remain blocked for flowing traffic.

Responsible of the implementation/contact

Hessisches Landesamt für Straßen- und Verkehrswesen, Verkehrszentrale Hessen
Westerbachstraße 73-79
D-60489 Frankfurt am Main
Phone: +49 69 743057-0

3.1.6 Example "Ring Munich, Autobahndirektion Südbayern"

Context

Motorway ring Munich (A99)

System implemented

On the motorway ring road Munich a traffic control system was installed to improve traffic safety and reduce the frequent congestion. In case of increased traffic volume and speed breakdowns the hard shoulder release is automatically suggested. An operator checks then by means of the additionally installed video surveillance system whether the hard shoulder is free of obstacles and its usability. Only then the hard shoulder is released connected with a situation-dependent speed limit. The installed variable message signs above the hard shoulder allow a quick closure if necessary.

Responsible of the implementation/contact

Autobahndirektion Südbayern, Verkehrsrechnerzentrale

Heidemannstr. 219, D- 80939 Munich

3.1.7 Example "Motorway A73 - Autobahndirektion Nordbayern"

Context

Motorway A73, section access point Möhrendorf - access point Erlangen-Bruck

Due to its position in the network it is mainly regional commuter and economic traffic on the A73 with destination Nuremberg-centre, -port, stadium and Nuremberg Fair; moreover supra-regional traffic particularly in times of high traffic volume on the parallel A9 in the East.

The A73 avails of a 2x2 cross-section that is extended to 3 lanes into a continuous merging lane in the direction of Nuremberg between access point Möhrendorf and access point Erlangen-Bruck by means of reallocation of the hard shoulder . A 2x3 full extension is not possible due to the restricted conditions in the urban area.

In the planning area there are altogether four access points, which lead here – in the urban area of Erlangen – to an urban motorway character by the dense consecution of access and exit points. The temporary hard shoulder release is carried out by lane signalization and variable guidance panels (WVLT), their functionality can be monitored by video camera, that also take over event detection (e.g. the detection of drivers in the wrong direction, breakdowns and pedestrians).

System implemented

Temporary hard shoulder release with line control system on the federal motorway A73, section access point Möhrendorf – access point Erlangen-Bruck incl. video detection , section length about 6.4 km.

Especially on the incident-prone section all possible technical measures have to be planned to avoid accidents and to reduce the effect of incidents on the motorway. For this reason the hard shoulder release is complemented by the installation of a line control system.

Responsible of the implementation/contact

Autobahndirektion Nordbayern

Flaschenhofstraße 55

90402 Nürnberg

3.1.8 Example "Study on the A4-A86's operation - INRETS - France"

Context

Socio-economic evaluation is based on dispense-advantage method. Impacts taken into account include time effect, environment effect (without noise nuisance) and road safety. Every variant of road operating is then qualified according to the sum of its "monetary effects".

System implemented

On the network's motorway about common section influence, the decrease of the total time passed in traffic is about a winning of, 4 549 vehicles hour (veh*h) during working days, 3 094 veh*h on Saturday and 3 958 veh*h on Sunday. On the public economical counting convention base, the annual time winning in 2006 is about 1 226 906 veh*h (16 388 224 €) in comparison with 2003's data.

On the same influence network, the decrease of principal emission of pollutants, of gas with greenhouse effect, and consumption is about an annual economy of 3 144 823 € in comparison of the reference situation of 2003.

In comparison with 2002-2003's period, the promotion of the impact on road security in 2006 is about a winning of 5 235 000 €.

The total investment of 19 M€ must be in relation with the total and annual effective winning (without noise nuisance) estimated to 24,8 M€. The common section A4-A86's operation is secured a return in less than one year.”

Responsible of the implementation/contact

CERTU/SETRA's group

3.1.9 Example "Section A4-A86 – INRETS-DIRIF - France"

Context

Hard Shoulder Running on the section A4-A86 in France.

System implemented

Results evaluation Hard Shoulder Running:

Increase of capacity of 900 veh / h by use of the dynamic auxiliary way, in comparison with reference situation.

The principal emission of pollutants and gas with greenhouse effect decreases like the energy consumption. The reduction attains 20 % for oxides of nitrogen, 39 % for the monoxide of carbon and more than 85 % for the dioxide of sulphur. It is about 4,25 % for greenhouse effect gases, 15 % for the consumption of essence.

During the traffic saturation and with the auxiliary way open, sound level increase about 2,2 dB (A), while the ear receives a variation of noise only from a difference of 3 dB (A). Moreover, the new set up surfacing decreases this sound savings from 4 to 7 dB (A). For the rest of the day and the night, there is not increase of the traffic flow and the sound balance sheet remains always favourable with the use of this new tarmacadam.

There's a decrease of accident about 8%. This tendency is not significant because of the weak size of samples and it deserves to be deepened and confirmed.

Responsible of the implementation/contact

INRETS

3.2 Business Model

3.2.1 Stakeholders in Service Provision

Road authorities and road operators

The road authorities/operators are responsible for the planning, development and operation of the systems for Hard Shoulder Running. The corresponding guidelines, regulations and references have to be taken into account. For the implementation and later operation, the optimization of traffic safety and traffic flow has to be the primary target. In this context all possibilities have to be exploited in view of an economic realization and later of the parameterization and regular test of the operation. The respective competences of the responsible authorities have to be considered here.

Forces of law and order

The operator or, in case he/she has no unlimited access to the operational area per video system, the police or the staff of the responsible highway surveillance on site have to prove first, if switching is feasible. Only after their explicit release the measure can be activated.

Regular users of the hard shoulder

A hard shoulder has a specific set of users like emergency services, police and road users in emergency/breakdown situations. Opening the hard shoulder to all road users can cause problems for its original users. Their needs must always be kept in consideration.

Resources

- Material means:
- Real time detection systems (loops, cameras, radar, laser)
- Dynamic information systems for the road user (i.e. VMS, text-cars)
- Communication between Hard Shoulder Running location and the traffic control centre (glass fibre, GSM, DECT)
- Visual control (i.e. cameras, extra lighting for dark periods)
- Decision support systems (automated incident detection, automatic indication if hard shoulder should be open/close)
- Human resources:
- Traffic inspectors for surveillance (and control)
- Traffic managers for control
- Software developers for decision support systems, control systems and evaluation tools
- Civil engineers for feasibility assessment before deployment

Since hard shoulder necessitates considerable safety requirements, only a semi-automated operation is possible. At least the personnel support by e.g. operators in a traffic control centre with unlimited video access is necessary.

3.2.2 Cost / Benefit Analysis

The benefit of Hard Shoulder Running results in the reduction of traffic- and accident-related congestion. Particularly in case of highly varying traffic demand and in combination with other measures of traffic control, the cost-benefit analysis leads to a positive result. In a pre-assessment the following points should be considered particularly:

Traffic volumes and load situation on different work days (daily graphs) at different day times.

- Traffic due to special events on the section to be signalized and also short-term varying load situations (e.g. varying peak traffic streams during phase of arrival and departure).

- Further influencing variables on economic efficiency are:
- Length and frequency of measure.
- Number of influenced vehicles.
- Connection with other measures.
- Complexity of the system.

It is important to bear in mind that the evaluation area should be wide enough. Otherwise, one could miss the fact that some problems are simply solved themselves.

A study on the A4-A86 in France shows an increase of capacity of 900 veh / h by use of Hard Shoulder Running, in comparison with reference situation

4 Annex A: Compliance Checklist

4.1 Compliance checklist "**must**"

#	Requirement	Fulfilled?		If no – quote of insurmountable reasons
		Yes	No	
Functional requirements				
FR1	Incident detection and verification **must** be possible for the whole Hard Shoulder Running section. Incident detection does not need to be automated.			
FR3	Safety protocols and instructions **must** be available to ensure the opening, running and closing of the Hard Shoulder Running is done safely.			
FR4	In case of failure of the Hard Shoulder Running signalization the system **must** be transferred immediately into a safe state.			
FR5	The information on the speed limit and open or closed hard shoulder **must** be available for other relevant ITS-services. Hence the Hard Shoulder Running service **must** require an interface with the following information structure (see TR1): allocation and spatial dimension of the Hard Shoulder Running section status of the hard shoulder (open/close) speed limit			
Organisational requirements				
None				
Technical requirements				
TR1	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, specifically the DATEXII-Profile[3] for **interface 1 - Dissemination of Hard Shoulder Running service information**.			

[3] DATEX profiles consist of a set of data elements taken from the overall DATEXII model and can include a subset (Schema) of relationships between those elements

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				
FR2	Detection and verification time, as well as reaction time, **should** be as short as possible.			
Organisational requirements				
None				
Technical requirements				
None				
Common look & feel requirements				
CL&FR01	The display of signs/pictograms on VMS or other end-user devices **should** be in accordance with prevailing national road codes and where applicable be in line with the requirements of the EW-DG for Variable Message Signs Harmonization VMS-DG01: • MS which ratified the 1968 Convention MUST respect the 1968 Convention and SHOULD consider the Consolidated Resolution on Road Signs and Signals (R.E.2); • MS which did sign but not ratify the 1968 Convention SHOULD follow the 1968 Convention and also consider the R.E.2.			
CL&FR02	Safe havens/ERAs should be provided in order to create safe zones for broken down vehicles.			
CL&FR03	Safe havens/ERAs should ensure a safe use (length and width).			
CL&FR04	The maximum distance between safe havens/ERAs should be 1000m.			
CL&FR05	Road markings at junctions and cross sections **should** be in line with general standards used for road sections without Hard Shoulder Running.			
CL&FR06	Good quality surveillance and monitoring functions for traffic operators should be guaranteed. Examples to establish these conditions are public road lighting or the use of infra-red cameras.			

CL&FR07	Indications for an open or closed hard shoulder **should** be located at a distance which guarantees the road user good visibility of the successive signals/signs along the relevant stretch of road.			
CL&FR08	Hard shoulder is closed should be displayed according to either Figure 13 or Figure 8			
CL&FR09	Hard shoulder is open should be displayed according to either Figure 5 or Figure 9			
CL&FR10	Hard shoulder is clearing should be displayed according to either Figure 6 or Figure 10			
CL&FR11	End of hard shoulder section should be displayed according to either Figure 7 or Figure 11			
Level of Service requirements				
LoSR1	In the case that pre-deployment surveys / evaluations provide the necessary evidence to proceed with the deployment of the ITS-service "Hard Shoulder Running", the minimum and optimum LoS **should** respect the following Level of Service to Operating Environment mapping table.			

4.3 Compliance checklist "**may**"

None

5 Annex B: Bibliography

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