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VMS harmonisation in Europe

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Executive summary

Background

Variable Message Signs (VMS) inform road users and manage traffic flow. They are becoming more widespread and are growing in importance. While primarily designed to serve the nationals of each country, VMS need to be understood by road users of all nationalities to be fully effective. Also needed is a continuity of operation across state boundaries. Increasing use of the network and further developments in network operation will increase the pressure to develop a strategy for dealing with VMS.

Goals

The objective of this task shall be to monitor developments across Europe and to understand the issues arising from and the obstacles to VMS harmonisation and interoperability.
The work shall focus on informing CEDR about the time frame in which issues should be resolved and developing a strategy for their resolution.

Expected output

- A report on the results of the aforementioned monitoring activities shall be produced.
- Recommendations on the need for a formal strategy and the type of strategy required shall be made.
- A collective view on how and when harmonisation and interoperability of VMS could be achieved shall be provided.

Status

A report has been produced on the basis of the continuous monitoring of developments across Europe and participation in discussions on research and development of VMS systems. What follows is only a summary of the major aspects of the document 'VMS harmonisation in Europe', which resulted in the following observations and recommendations:

- The WERD/DERD FIVE initiative has led to three parallel initiatives:
  1) Mare Nostrum (now called ES-4 within the EasyWay framework),
  2) at the request of the UNECE, a small working group of four countries is working on the revision of the resolutions on road signs and signals (Vienna Convention), and
  3) the research project SOMS IN-SAFETY for the EU 6th Framework Programme.
- There are currently 3 bodies involved in VMS harmonisation in Europe: CEN, CEDR, and ES-4, each of which has its own specific task.
- There is a new trend in VMS around the world: the provision of journey time and traffic status information may, where appropriate, be displayed on a dedicated sign using colours, graphics, and/or text.
- Specific messages are used in various countries for special situations e.g. air pollution.

Several NRAs have changed their national guidelines to be more in line with FIVE. However, FIVE still leaves room for interpretation, especially in informative-type messages. This requires improvements, which were identified in a survey. Some relevant observations are listed below:

- After a proposal was submitted to the UNECE committee in 2003 for a revision of the Vienna Convention (VC) to update the road sign catalogue and add variable signs to the VC framework, a working group on VMS drafted a proposal in November 2007. Finally, a second presentation took place in March 2008, after which the proposed text was adopted.
- Actions regarding the link with on-board information and guidance systems are ongoing. It is stated that 'the signs used in on-board information units must be strictly identical to the ones used on roadways'. Some European projects are active in this area. Consistency with websites is also discussed.

Interesting points regarding the use of VMS in Europe:

- Use of different speed limits on adjacent lanes. This has been introduced in several countries, but is still forbidden in others.
- VMS is not only being used for text messages; new pictograms are also being introduced.
- Pictograms are increasingly appearing on VMS that are mounted on cars. Such pictograms provide graphical representations of the traffic situation, and even animations. This is questionable from the point of view of respecting the Vienna Convention.
- In some countries, small VMS are used to indicate to drivers that they have exceeded the speed limit. NRAs should exercise great caution when it comes to the use of such VMS.
- It is important to ensure cross-border continuity of information.

On the basis of monitoring actions, recommendations were made regarding:

- the enforcement of VMS
- the pre-eminence of VMS
- the display of actual speeds on VMS
- the harmonisation of safety messages
- the monitoring of the development of in-car (and Internet) information systems
- the development of a harmonised library of messages
- the harmonisation of tests for VMS and VMS systems

Decisions

On the basis of the above-mentioned observations and recommended actions, Task Group O9 advises:

1) the incorporation of the work into EasyWay's strategic study on VMS ('Mare Nostrum'); this task will notably comprise a permanent small group for monitoring the VMS domain, and
2) the monitoring of these activities as part of task 14 in CEDR's Strategic Plan 2009–2013.

Contents

1 Introduction

Variable Message Signs (VMS) inform road users and manage traffic flow. They are becoming increasingly widespread and are growing in importance. While primarily designed to serve the nationals of each country, VMS need to be understood by road users of all nationalities to be fully effective. Continuity of operation is also needed across state borders.

Due to the importance of this issue and an awareness of existing problems, CEDR decided to launch a specific task (task O9). The ToR (terms of reference) for this task group are included in appendix 2.

The objective of this task was to monitor developments across Europe and to understand the issues arising from and the obstacles to VMS harmonisation and interoperability.
Of course, the idea was not to harmonise the material itself, but the information provided to the road users.

The work has focussed on identifying remaining obstacles and the issues that should be resolved (along with possible ways of solving them).

The following countries were officially represented in task O9: Belgium-Flanders, Denmark, France (chair), Germany, the Netherlands, Norway, Portugal, Switzerland, and the United Kingdom. The list of experts involved is included in appendix 1.

During the first meeting, which was held in Amsterdam on 1 February 2007, it was decided that a comprehensive report should be prepared on the different aspects of VMS, notably those relating to harmonisation and interoperability.

Several drafts of this report were circulated among task group O9 members; experts from France, Italy, and Spain were also consulted.

Two chapters in this document (chapters 2 and 3) deal with historical matters. Technical matters are dealt with in chapters 4 to 11. Chapters 12 and 13 are devoted to recommended actions for the NRAs and studies to be launched. An abridged version of these two chapters is given in the executive summary. Lastly, a set of appendices provides relevant background information such as a bibliography, glossary, various technical matters etc.

Following the kick-off meeting in Amsterdam, two other meetings were organised in Paris by the chairman. These took place on 16 June and 29 September 2008. The chairman also presented provisional and definitive conclusions to CEDR members at meetings held in Lyon on 5 October 2007 and in Brussels on 7 November 2008 respectively. The minutes of each of the task group's meetings are available on request from the chairman.

2 The history of fixed message signing

Today it seems as if traffic signs have always existed, which is to a certain extent true. However, road signing began in earnest with the introduction of the motor car at the end of the nineteenth century. Although a variety of different systems have been implemented since 1890, it was not until 1909 that the first international convention was negotiated.

A United Nations conference on highways and road transport was held in Geneva in August and September 1949. Delegations from 28 states attended. The conference referred to the draft convention (prepared by the Internal Transport Committee of the UN Economic Commission for Europe) and the 1943 Inter-American convention on the Regulation of Inter-American Automotive Traffic.

The results of this conference were, firstly, a decision to draw up a road signing protocol and secondly, the admission that it was impossible to arrive at an agreement on a uniform road signing system that would be universally acceptable to the interested countries.

The two systems' sign shapes and colours still differ, with a red border prevailing in the European system (used in Europe and many Asian (primarily China) and African countries) and yellow and black in the American system (used in the United States and, with variants, in Ireland, Canada, Mexico, some Central and South American countries, Japan, etc.).

Examples of both systems are provided below (Fig. 1):

Fig. 1: Example of an 'American' sign … … and a 'European' sign

European countries, aware of the need to harmonise their regulations, formed the habit of meeting regularly since 1949, under the aegis of the European Commission, the United Nations in Geneva, and the European Conference of Ministers of Transport (ECMT), recently transformed into the FIT (International Transport Forum).

After a string of international agreements, efforts to standardise and harmonise road signs reached a milestone in 1968 when the Convention on Road Signs and Signals—the so-called 'Vienna Convention'—was drafted and supported by a large number of countries in Europe as well as some Asian countries, including Korea.

Reminder:

- Countries that support the Vienna Convention are not obliged to use all the traffic signs outlined in the convention. However, they are not allowed to develop their own signs if a sign with the same meaning already exists within the convention.
- Furthermore, countries that support the Vienna Convention normally have a period of 10 years in which to make the necessary investments in and changes to their road infrastructure and equipment in the event of any changes to the convention.

3 The emergence of variable message signing

Article 7 was the only article in the historic Vienna Convention of 1968 to make any mention of variable signing: 'Nothing in this Convention shall prohibit the use, for conveying information, warnings or rules applying only at certain times or on certain days, of signs which are visible only when the information they convey is relevant.'

In the last decades of the twentieth century, there has been rapid growth in the number of cars on the roads and the number of road problems. In sharp contrast, little time has been devoted to developing the latest stage in the road information cycle, namely road signs displayed on VMS. As VMS have gained in popularity, various road management administrations and road operators have tried to make the most of the possibilities available.

The COST 30 action (COST = European Cooperation in the field of Scientific and Technical research) was launched in 1971 and was followed by two study phases: COST 30 phase (1977–1980) and COST 30 bis (1980–1985). Twelve countries took part: Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom, and Yugoslavia). Its general aim was to improve road safety and traffic flow through the use of electronic systems.

A number of actions were recommended for variable message signing, in particular:

- the use of new pictograms, including the advisory diversion arrow, the 'Recommended Speed' symbol, and new 'Accident' and 'Traffic jam' pictograms. Furthermore, as no fixed signing versions of these pictograms existed, they were the first to be created for operational needs.
- the introduction of black and white inversion (light symbols on a dark background) in the current regulations (this is now used around Europe and the world, with the exception of Italy).

Furthermore, some of the COST experts' main recommendations (notably the design of the congestion pictogram and the possibility of inverting black and white to make the most of existing technical display capabilities) were introduced in the 1995 amendment of the 1968 Vienna Convention.

Fig. 2: Pictograms recommended by COST 30 bis

Please note that the 'Danger: rain, fog, or snow' warning sign envisaged by the group was eventually dropped.

Because the 'Accident' warning sign was not considered clear, it was amended by some countries as follows:

Fig. 3: Amended COST 30 bis accident warning sign pictogram

In addition to the COST initiative, many European projects dealing with VMS are worthy of a mention: VAMOS (Drive 1, 1991), TROPIC (4th Framework Programme, 1999), EAVES (Drive 2, 1994), other more general projects such as PLEIADES and MELYSSA (1995), as well as the MAGIC and TELTEN initiatives. A major report on TELTEN and TELTEN 2 was produced between 1995 and 1997 and covered a number of areas including variable message signs.

If one looks at the VC 'catalogue', it becomes clear that only a few variable-event pictograms (e.g. congestion) have been introduced. Moreover, the only additional technical innovation, was the authorisation to use black and white inversion (see above), which was introduced in article 8 of the 1995 amendment of the VC. At the same time, however, far from being stuck in their ways, most road administrations and road operators have tested (or improvised) new pictorial designs in order to find answers to their particular road traffic problems. Several European projects under the Framework Programmes (FP6 and FP7) have tested the required designs (notably accident or fog warnings).

Another important milestone was reached with the FIVE initiative: by order of the West European Road Directors (WERD) and their deputies (DERD), the FIVE (Framework for harmonised Implementation of VMS in Europe) action was launched in 1996 as a follow-up inventory of needs and priorities for international harmonisation. Two important conclusions were drawn during the FIVE workshop, which was held in Amsterdam in September 1997:

- The representatives of DERD member states considered common European VMS practice to be feasible. Such common practice could even cover the composition rules relating to text-based messages.

- The majority of DERD representatives regarded the combination of signs/symbols with additional explanatory texts as the most appropriate for informative messages. Symbols are preferred to texts for regulatory and danger warning messages, because they are proven to be perceived and responded to quickly by international drivers.

Fig. 4: Pictograms recommended by FIVE for use on VMS
(the lane allocation signals have been considered here as part of the VMS set)

The impression that the FIVE report did not cover all possible VMS situations led to three parallel initiatives since the year 2000:

- Mare Nostrum (now called ES-4 within the EasyWay framework) has embraced FIVE and is trying to further VMS harmonisation. It began by concentrating on language-independent 'coded texts' using symbolic characters for multi-purpose VMS that can display pictograms and 2–3 lines of texts. Details about this action are provided in appendix 4.
- At the request of the UNECE, WP.1 Road Traffic Safety, a small working group of four countries, submitted proposals for the revision of the resolutions on road signs and signals (Vienna Convention), in order to prepare for the inclusion of variable message signs in the Vienna Convention on Road Signs and Signals. For more details, see part 6 of this document.
- The research project SOMS IN-SAFETY for the EU 6th Framework Programme has created comprehensible pictograms that will substitute written messages used on roads, and optimise written messages that cannot be substituted by pictograms with regard to comprehension and harmonization, taking into account the official languages of the EU. Many universities and institutes are involved, but no NRAs. At the end of the project, a report on text + pictograms for fixed message signs and variable message signs has been produced.

The 'small group on VMS' ended its work in 2008. The are now currently three main bodies involved in VMS harmonisation in Europe:

- CEN, which promotes VMS standards that basically deal with perception issues (luminance, legibility, readability etc.);

- CEDR, which promotes general VMS design parameters according to main road signing functions (regulatory, danger warning, informative) and highlights main issues (present and future) involving systems that display road information (interoperability); and
- ES-4, which deals with VMS harmonization at its most concrete level, according to specific parameters such as road/traffic situations (congestion, re-routing, unplanned events, roadworks, weather etc.), VMS location (when VMS are far, near, within the events), and VMS type (pictogram + text; pictogram + text + pictogram; two pictograms + text; full matrix).

Finally, it is important to note that some non-signatories to the Vienna Convention have adopted a completely different approach. Right from the start, VMS in Japan, for example, have been completely different from fixed message signs and have been designed by cartoon-designers. This explains why Japanese VMS look very different from fixed message signs (see examples below).

Fig. 5: Japanese cartoon-style pictograms

4 Technical matters

VMS differ from fixed message signs in two respects: firstly, they can be switched on or off and secondly, they can display various messages.

Technically, there are two types of VMS: continuous VMS and discontinuous VMS.

- Continuous VMS are very similar to fixed message signs, the only difference being that various messages can be displayed on them using electro-mechanical means.
- Discontinuous VMS create messages using individual elements, thereby allowing various messages to be created on the same sign face.

Because of the fact that a continuous VMS 'looks' like a fixed message sign, it is sometimes advisable to add some means of drawing attention to it, for instance using flashing lights. Otherwise drivers might not notice that the message has changed.

It is less likely that drivers will 'overlook' discontinuous VMS. Nowadays, most discontinuous VMS are of the light-emitting type and use LEDs. Although this renders the sign more conspicuous, it also can cause problems if the VMS is not correctly designed.

Aspects that must be considered include luminance, luminance ratio (contrast), colour(s), letter heights, beam width etc. Details of these aspects are not provided in this report.

Remark on letter heights:
When using text, care should be taken that the text can be read at a sufficient distance. One rule of thumb is that the minimum reading distance (in metres) is about 5 to 6 times the letter height (in cm). For example: a 36-cm high letter can be read at a distance of about 200 m from the sign.

When planning to install new VMS, authorities should know that the European VMS standard (EN 12966) is obligatory for all fixed VMS signs used in traffic applications. This is not yet the case for temporary or mobile VMS because the Construction Products Directive (CPD) is only valid for products that are in permanent use. An informative appendix of the European VMS standard (EN 12966) provides guidance in choosing the correct combination of the various items mentioned above.

5 VMS around the world

For obvious reasons, it is not possible to provide the reader with a complete overview of all VMS used around the world. Moreover, it is more interesting to limit such an overview to highlighting new pictograms and trends on the one hand, and to some specific signs on the other.

5.1 A new trend: displaying journey time and/or diagrammatic signs

The provision of journey time and traffic status information may, where appropriate, be displayed on a dedicated sign using colours, graphics and/or text. It is, by nature, variable information, the concept of which is used all over the world. For examples, see the figures that follow.

Fig. 6: Japan and South Korea have spearheaded the development of dedicated travel time and traffic status signs that provide network information

Fig. 7: Graphical signs are now used in China (particularly in Beijing and Shanghai)

Fig. 8: Some European countries have adopted this type of display in recent years. Here we see examples from Germany, Holland, and Spain

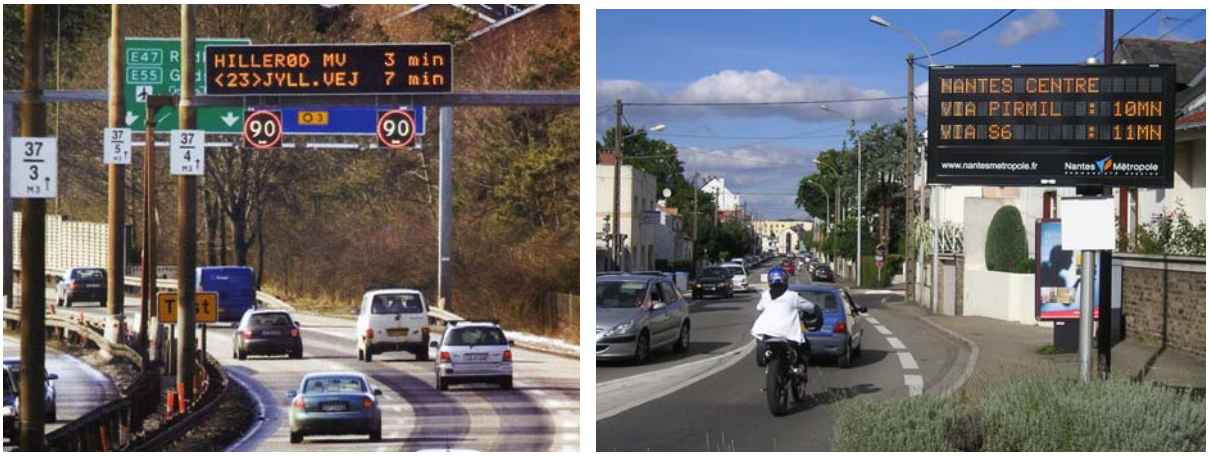

Fig. 9: VMS signs can also display numerical information, as illustrated by these examples from Denmark and France

Fig. 10: This kind of sign can also provide link information and is used in Scotland and Australia

Fig. 11: The great demand for multimodal information has led to the appearance of multimodal VMS (such as these examples from Germany and Japan)

Several recommendations regarding signs that provide journey time and/or traffic status information were made during a workshop of European experts in Heathrow in March 2003. The main recommendations are listed below:

- Red lines/blocks should be used to designate heavy congestion.
- Yellow lines/blocks should be used to designate light congestion.
- The absence of illumination supported by an indication of the journey time should be used to represent free-flowing conditions. Alternatively, green may be used to indicate free-flowing conditions where the lack of illumination is not appropriate.
- Further research should be done to determine whether the use of colour-coded text is beneficial for indicating journey times on the shortest route.

- Link-based signs should display the total journey time from the current location to the destination. If it is proposed to display journey times for individual links, research should be done to demonstrate that the information is clearly understood and that it doesn't undermine the understanding of the signs showing total journey time.
- The interim recommendation based on research in the Netherlands is that signs should be pointed in the direction of travel. Alternative methods of display may be tested, providing research is done to determine that the signs are well understood and that they do not undermine signs pointing in the direction of travel.
- The information displayed on the signs is the best available, based on the data collection and processing systems. If the information changes between when the driver passes the first sign and when they leave the network, an update should be given, with a reason for the change, if possible.
- Journey times should be displayed to the nearest minute using an average, rounded off number of minutes.
- If possible, a section of the sign should be capable of displaying text to explain why accurate information cannot be displayed on the sign. When the road is closed or blocked, journey time information should not be displayed. When the information for a section of road is incomplete, the display should be left blank unless it can be accurately estimated by other means or if leaving the sign blank could be misinterpreted as free-flowing traffic.
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5.2 Specific signs

It is worthwhile highlighting a number of signs that are used in specific countries.

Fig. 12: **Italy**: the use of 2 pictograms with text (please note that 'dark and light' inversion is not used in Italy)

Fig. 13: **South Korea**: the use of dynamic image-type VMS can provide a certain amount of traffic information, including, as illustrated here, the current status of traffic a few kilometres ahead

6 Various points of interest regarding the use of VMS in Europe

6.1 Use of pictograms and text, and pictograms only

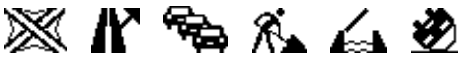
Historically, the use of text and the use of pictograms was strictly separated. In the case of lane control systems, such as the German system illustrated in Fig. 14, pictograms are used to display restrictions and/or warnings. In most cases, these pictograms are taken from the highway code.

Fig. 14: German lane control system

Text signs are not normally used for lane control, but for displaying warning messages and/or information about the traffic situation. In most cases, the text part of these signs is not suitable for displaying pictograms. However, in many applications (most notably in the south of Europe) one or two separate pictogram displays are installed at the side(s) of the signs. This makes it possible to indicate the essence of the message graphically in a way that makes it more comprehensible, especially for foreign drivers (see Fig. 15).

Fig. 15: Combined use of text and pictograms in Italy

The Mare Nostrum project has investigated the use of simple symbols (like →, or =), in the text part of messages. This enables the message to be language independent, for instance by displaying a queue pictogram combined with the text '= 10 km'. For details on the Mare Nostrum project, please refer to appendix 4.
Since modern VMS signs often use advanced technology (more LEDs, smaller pixel distances), it has also become possible to use more sophisticated 'line-symbols' embedded in the text, such as:



for 'intersection', 'exit', 'queue', 'roadworks', 'bridge open', and 'accident' respectively.

Finally, freely programmable VMS provide even more opportunities to mix pictograms, text, and line pictograms, as the picture below illustrates. It is advisable, however, to restrict this 'freedom' by having a good set of rules for the way these pictures may be used in order to avoid overly complex pictures or pictures that are proposed by the traffic operators but not wanted by the road authorities!

6.2 Use of different speed limits on adjacent lanes

The question is whether it is advisable to use variable message signs to indicate different speed limits for different lanes on the same cross section of road.
While this option is possible in some countries (such as Belgium-Flanders, the Netherlands, and Italy), it is forbidden in others (such as France).

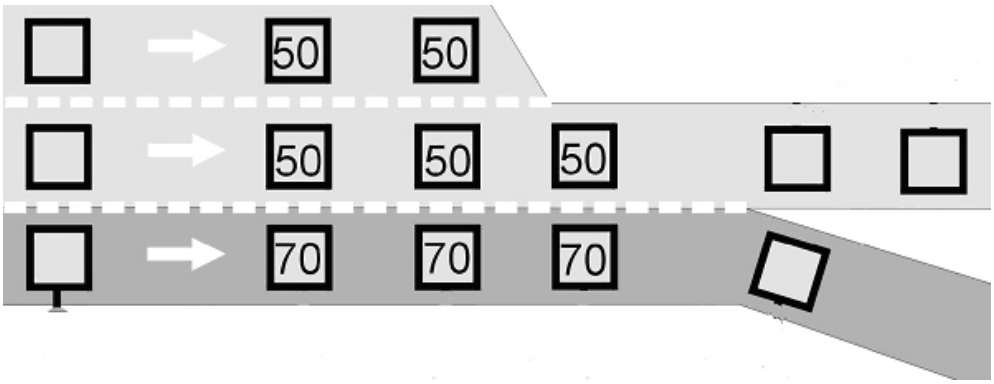
It can be argued that it is unsafe to encourage speed dispersion on adjacent lanes. In fact, displaying different speed limits on the same cross section of road may lead to an increase in lane changes and therefore an increase in risks.

On the other hand, encouraging lane change (especially towards the high-speed lane) could be beneficial in terms of throughput or even safety (see case 2 below) in some specific situations.

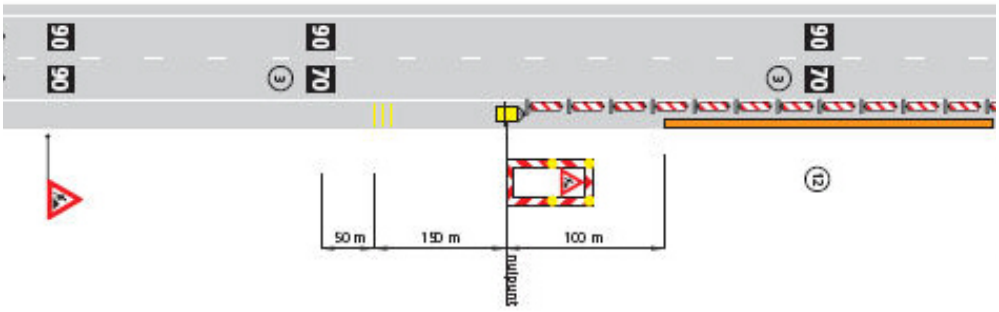
In all cases, the difference in authorised speeds between two adjacent lanes should be limited to a maximum of 20 km/h (as in Belgium-Flanders and the Netherlands). Other countries may have similar rules.

Typical cases in which different speed limits are being/could be used for different lanes are given below (please note that the rest of the paragraph 6.2 relate to countries that drive on the right):

Case 1:
Probably the most common situation is when there are two different ‘traffic streams’ at motorway junctions or at ‘merging sections’ near exits and entries (used in Belgium-Flanders and the Netherlands). Lane-choice in such cases is subject to destination, which minimises lane changes encouraged by speed limits.



Case 2:
Different speed limits for different lanes can also be used in the event of roadworks, when applying a lower speed limit (70) to the right-hand lane.



Case 3:
They can also be used for special vehicle lanes such as HOV-lanes, bus lanes etc. where a speed limit is used strategically in order to encourage the use of public transport. This is the case in Belgium-Flanders and France (buses on the hard shoulder during peak hours in Grenoble).

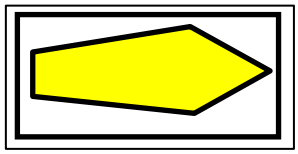
Case 4:
They can also be used when a speed limit is applied, e.g. for traffic reasons, on multi-lane motorways (3 or more lanes), in some cases the left-hand lane is under used because there is no urge to overtake. This could affect throughput, and could be avoided by applying a slightly higher speed limit on the left-hand lane.

Case 5:
In cases where the emergency lane is used, specific measures could be applied. However, further investigation is needed in order to reach a common solution.

6.3 Rerouting signs

There is still a need for a special, uniform European rerouting symbol. In the past, several proposals were made.

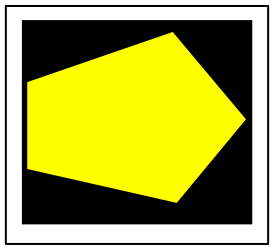
The so called ‘délestage’ arrow was created in France at the end of the 1960s.



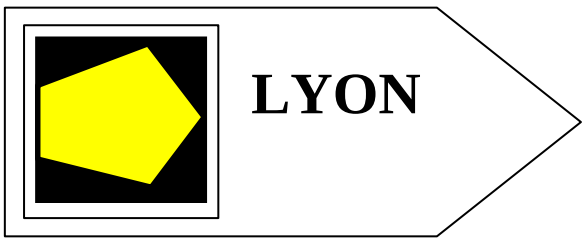
The COST 30 bis action recommended the use of such an arrow, which was adopted (with variants) by Belgium and Germany.

A comprehensive re-routing sign study was conducted under the aegis of the SERTI project in 1998. In Europe, there is still a debate about which symbol is preferable. Both the Euro-Regional Projects and the European VMS Platform have been very active in this domain.

SERTI proposed the following panel:



Examples of possible uses are given hereafter. However, it was found that this symbol was clear when used on a fixed message sign, but was not very legible when used on a VMS.



CENTRICO launched a proposal that is supported by the Netherlands, Belgium, Norway, and Germany. Spain also supports the CENTRICO arrow and introduced it into the Spanish National Highway Code in November 2003. Norway also added it to its Traffic Sign Regulations in 2006.

Initially, France was not in favour of this symbol, which looks very much like another symbol already used in France to indicate one-way roads.

However, in accordance with the updating of the road signs catalogue and the variable message signs added within the VC frame, the SERTI and the CENTRICO rerouting signs have been included together in the Consolidated Resolutions. Each country or group of countries in Europe will then be authorised to choose either one type or the other.

6.4 Possible priority of variable signs

It may be desirable to introduce a regulation that gives VMS pre-eminence over fixed message signs, for example in situations where speed control is needed.

This rule could be useful in some countries (e.g. France), where dynamic speed control has been introduced. However, other countries (e.g. Sweden and Japan) do not need such a regulation, because all highway signs dealing with speed limits are variable and can be changed according to needs.

This hierarchy seems necessary. However, it is also difficult to implement because the public at large may have difficulties in making a distinction between the two kinds of signs. A system is therefore required that will make fixed signs easier to distinguish from variable signs.

This is an open question that has been discussed in the UNECE WP.1 Small Group on VMS. One solution might be to use black and white inversion for variable signs. However, this could cause problems in Italy.

Details of the Spanish approach (the inclusion of such a priority in the highway code) are provided in appendix 5. Although it is very interesting, this approach raises several questions, including that of comprehension by the public at large.

A more general approach is provided in appendix 9, with an interesting Danish text.

Lastly, it is worth pointing out that the current situation becomes more complex with the development of new devices, e.g. panels that are able to ‘read’ the speed limit, display them on the dashboard, and even adapt the maximum speed of the car on the basis of the information gathered in this way.

6.5 Implementation of FIVE rules

The FIVE action (Framework on Implementation of VMS in Europe) was launched in order to prevent further divergence of messages on variable message signs (VMS) by stipulating harmonisation guidelines to be implemented by the national road authorities (NRAs).
As a result, several NRAs changed their national guidelines to bring them into line with FIVE.

However, FIVE still leaves room for interpretation, especially as far as informative-type messages are concerned. Due to the fact that FIVE was set up as a first attempt to harmonise VMS on the basis of best practice, the FIVE recommendations are a little too general and can be interpreted in too many different ways. There is a lack of specificity regarding the different types of devices and message strategies.

The required improvements identified in the survey and workshops are:

- new pictograms for dynamic situations (see the pictogram for 'bad visibility' on the FIVE list, COST 30, and symbols for new traffic management situations such as 'temporary use of the hard shoulder');
- use of speed limits and use of lane-control signs with successive gantries;
- language independent symbols (+, =, ->, …) in text messages;
- more realistic rules specifying text structure;
- a clearer distinction between immediate danger warning messages (close to the event) and informative ones (far from the event);
- another distinction should be made between immediate information or information dealing with future information (e.g. 'tomorrow, avoid this zone');
- long- or medium-distance diversion or rerouting messages have not been precisely studied, but this does not appear to be a top priority for the majority of participating countries.

6.6 The European VMS Platform

The European VMS Platform was a working group set up in 1999 by the DERD (Deputy European Road Directors). The aim was to implement and continue the VMS harmonisation work done by the action group FIVE.

On the basis of a comprehensive questionnaire and a series of workshops, the VMS Platform produced a summary position paper on:

- information messages
- location criteria
- danger warning pictograms
- message prioritisation
- mandatory pictograms

The participating countries were: Belgium, Denmark, England, Finland, France, Germany, Ireland, the Netherlands, Northern Ireland, Norway, Scotland, Spain, Sweden, Switzerland, and Wales.

At the request of the European Commission, a joint workshop with the Euro-Regional Projects was held in Düsseldorf in June 2003. The aim was to coordinate the work in the different working groups and to discuss future work.

This joint workshop led to a report (see appendix 6) which contained:

- Proposals for harmonising pictograms for tunnel signs, danger warning signs, regulatory signs, information messages and graphical real-time information signs.
- 'The Way Forward', i.e. a proposal for a potential organisational structure.

In spring 2003, a new version (version 3.4) of the Five Report 'Framework for harmonised Implementation of VMS in Europe' was drafted. New chapters included chapter 3.7, 'Dedicated journey time and/or traffic status signs with link information', and chapter 3.8, 'Dedicated journey time and traffic status signs with network information'.

Lastly, CEDR's Subgroup Telematics produced a document, entitled 'Recommendations on FIVE implementation' dated 8 April 2005. This document concluded:

'Dynamic traffic management and real time traveller information are developing rapidly, as it is necessary to optimise the efficiency and the level of services of existing road networks.

The FIVE and VMS Platform groups produced a strong set of rules and recommendations for defining road traffic messages and the use of VMS. These principles are still valid, but need to be amended in order to suit different local or national situations and technical possibilities. A small working group could be set up in order to extend the existing results in terms of:

- what should be strongly confirmed and applied at European level (definition of situations, use of pictograms and symbols etc.), and
- what should be adapted to suit specific national or regional situations (types of problems and traffic, organisations and devices, existing rules and driving habits etc.).

The design and use of VMS can be specified for each main category of sign (prescriptive, warning, informative) and, if necessary, complementary tests can be conducted to check users' needs and whether they understand the signs.

To improve common understanding among European operators and travellers, brochures presenting core common rules could be produced and distributed. National or regional guidelines could be added as well.'

6.7 Legal aspects of VMS use

During the TROPIC trial phase, which ended in 1997, the legal aspects of VMS use were discussed. The problem of displaying false information or not displaying information was at that time recognised as a real problem, albeit more a potential problem than an existing one.
Moreover, the threat of prosecution was not considered very high: most countries did not consider it a problem, whereas others thought that it could pose a problem although it never actually had in the past.

Today, although legal proceedings associated with VMS are very rare, there been have some in Europe, notably in the Netherlands. Furthermore, in France, for example, some messages are forbidden, in order to avoid court cases (e.g. to display the temperature when it is near 'zero'). In addition, there are examples of cases where people who were rerouted to a toll motorway asked the road administration to reimburse their toll fee.

In this respect it is important to ask whether it is compulsory for a traffic manager to provide drivers with all available information or to conceal part of the truth.

Furthermore, in order to avoid potential problems, road operators are generally advised to keep a record of VMS messages for a specific period of time (at least 3 years in France).

6.8 Enforcement of variable speed limits

In this respect, the situation differs throughout Europe:

- In England, the enforcement of variable speed limits exists; the photo shot must show the variable sign and the driver at the same time.
- In Germany, there is no enforcement for a time period of approximately 5 minutes before and 5 minutes after the speed limit is changed to avoid controversy.
- In the Netherlands, variable speed limits are only enforced during stabilised periods (i.e. periods where there are no queues etc.).
- In France and Spain, enforcement is possible but not implemented at the present time.

Even though the link to VMS might appear to be slight, the enforcement of average speed on a road section (also called 'section control') is also relevant. It is used in the Netherlands and England, but is not allowed for the time being in France for legal reasons.

Finally, every country should clarify this point. It is important for the credibility of VMS and will be required if the European enforcement process is harmonised.

Furthermore, it would be useful to invent a new panel that indicates to drivers that they are entering a zone where speed limits could vary depending on a number of parameters.

Please note that in Japan, variable speed limits have been introduced on and fixed signs have been removed from some motorways.

6.9 Specific messages for air pollution

This type of message is sometimes used to recommend that drivers reduce their speed.

In certain countries, such as France, this type of message can also be conveyed by radio or newspaper, which can lead to problems as listening to the radio and reading newspapers are not obligatory!

In other countries, panels indicate the area where the speed limit is reduced for pollution reasons (see Fig. 16). A common pictogram might be useful.

Please note that speed regulation usually has very positive impacts on road safety, the environment, and the efficiency of the road network (the optimum speed being approximately 60/70 km/h).

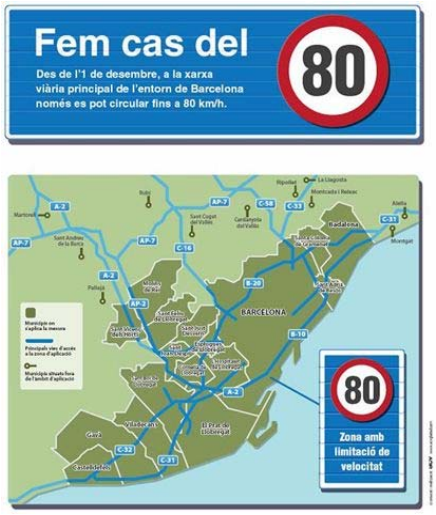


Fig. 16: Sign used in Spain to indicate a speed limit as a result of air pollution

6.10 Mobile variable message signs

The use of variable messages for traffic applications is not limited to fixed signs.

As the following examples show, VMS panels can also be mounted on cars (shown in Fig. 17 on an incident management vehicle) or on trailers.

Fig. 17: VMS mounted on a vehicle

For these mobile applications, improved technology now makes it possible to do more than just display texts. Pictograms are increasingly appearing on these signs, providing graphical representations of the traffic situation.

In some cases, animation can even be used to indicate the desired motorist behaviour. This is questionable from the point of view of respecting the Vienna Convention, even though the countries using this kind of device (e.g. Germany and Switzerland) seem happy with them.

Further studies are requested in order to answer the following questions: For certain specific configurations, is it acceptable to use animated signs (which try to show drivers what behaviour they should adopt in non-typical cases)? If the answer is 'yes', is this acceptable for all VMS or for mobile VMS only (the latter seems more reasonable)?

Fig. 18: Mobile VMS

6.11 Variable message signs relating to excessive speeds

In some countries, small VMS are installed in order to indicate to drivers that they have exceeded the speed limit.

These signs have been studied in the OECD Working Group on speed management (Chairman: Jacques Nouvier). The section on these signs reads as follows:

'Some countries measure the actual speed of the vehicles and display it on variable message signs (either the actual speed itself, or a message like "too fast"). Such systems may, however, induce a perverse effect, as some road users may try to "break records" knowing that no punitive measures are associated with such information systems.
However, this effect is limited if the message only indicates "too fast" and not the actual speed for those exceeding the speed limit.'

The photograph in Fig. 19 shows a VMS displaying either the actual speed or the message 'too fast'.

Fig. 19: Norwegian VMS that alert drivers to excessive speeds (Fartsmåling = Speed measurement; Din fart = Your speed; For høy = Too fast)

NRAs should consider the use of such VMS very carefully before they decide to use them. This becomes even more important, especially as several manufacturers are now producing VMS that can display not only the actual speed but also the associated penalty points and even the size of the potential fine!

6.12 Safety messages/blank messages

As stated in the text prepared and adopted for the future revision of the Vienna Convention, a VMS should remain blank when no traffic related messages have to be displayed. An exception might be the display of dots or the time to indicate that the VMS is working (blank messages). However, it might be acceptable to display other messages (e.g. safety messages or 'amber alert' messages). One should be aware of the fact that this kind of message could reduce the efficiency of VMS situated downstream.

7 Interoperability/Operation

VMS are sometimes installed near borders. In such cases, they can provide messages that relate to a country other than the one in which they are located.

It would be overly optimistic to imagine that all VMS in Europe will become interoperable in the near future. The scenario whereby interoperable VMS could be controlled by any TCC in Europe (or at least any TCC with the right to carry out such actions) can be referred to as 'technical interoperability'.

It would be more realistic to think in terms of 'functional interoperability'. According to this scenario, each country would maintain control over the VMS within its territory and agreements would be made regarding the display of messages requested by neighbouring countries.

For example, following the signing of an agreement between the two motorway companies, certain VMS located on the ESCOTA motorway in France now provide messages concerning the l'autostrade dei fiori in Italy. Moreover, in order to facilitate the task of the operators in the TCCs, a certain number of measures have been developed, such as bilingual faxes in French and Italian.

It is also important to ensure cross-border continuity of information. Initially, the intention was to call the present report 'VMS harmonisation and interoperability'. However, the title was modified as the 'interoperability' aspect, while not secondary, appears to be more closely linked to the issue of border traffic management.

As far as VMS operation is concerned, one question is frequently asked: under what conditions should automation be allowed (e.g. an AID system directly sending messages to the VMS)? The idea is to improve reaction time, but not to lose credibility by displaying incorrect information too often. The definitive answer is therefore not obvious.

8 Revision of the Vienna Convention

In 2003, official representatives of several European countries considered the situation, and a proposal regarding the possibility of updating the road signs catalogue and adding variable signs within the VC frame was submitted to the UNECE WP1 committee.

After the decision to create a subgroup (the so-called 'small group on VMS', which comprises members from France, Germany, the Netherlands, and Spain), several meetings took place, and a proposal was submitted in November 2007 to the WP1 in Geneva (UNECE). Several points were discussed by the members of the group.

Finally, a second proposal was tabled and a presentation was made to WP1 in March 2008, and the proposed text was adopted.

The main points of the group's proposal can be summarised as follows:

- to use the design of fixed message signs (or designs very similar to those of fixed message signs;
- to avoid conflicts between fixed message signs and variable message signs;
- to adopt and even to encourage 'dark and light' inversion;
- to ban the use of VMS for some types of signing, e.g. priority signs;
- to add new pictograms, which should only be used on VMS (e.g. accident);
- to provide rules regarding the use of VMS (structure of message, use of pictograms, use of red triangle, prohibited use of advertisements or commercial messages etc.).

It should be noted that other points, such as the possible pre-eminence of VMS over fixed message signs, have been examined, but are not considered 'mature' enough to be integrated into the convention as yet (see the specific paragraph on this matter for more details).

The chairman of CEDR's task group O9 has been involved in all phases of this process and would be happy to provide any additional information, if needed.

9 Links with on-board information and guidance systems

Before examining the links between on-board information (units) and guidance systems, it is worth considering the European committee for standardization's definition of 'on-board unit (OBU)'. For CEN ISO/TS 14823, an OBU is a unit that is fitted in a vehicle to display traffic and travel information, which gathers road traffic information and transfers information and public transit information.

The European Commission recently (2008) produced recommendations regarding these devices. Some of them are listed below.

Firstly, the signs used in on-board information units must be strictly identical to the ones used on roadways.

Respect of this requirement by the worldwide automotive industry should be continually monitored. However, as explained below, two different signing systems exist throughout the world.

Compared to road signs, in-car systems can have several benefits:

- Coverage of the complete road network instead of parts of the highway network
- Drivers receive only relevant information when it is needed. Incident management will definitively improve because of better and earlier information about incident location and the possibility of inter-vehicle communication and communication between vehicle(s) and traffic management centres.
- In-vehicle messages are more flexible and different signals from different sources can be integrated. Obviously, great efforts must be made to ensure the coherence of the different data and the relationship between traffic management messages and other driver services.
- In the long term, it may result in huge savings on installing and maintaining roadside equipment.

Consequently, one can say that on-board information units increase the effect of traffic signs and improve traffic safety.

When installing such in-vehicle systems, NRAs must be aware that different problems of integration and acceptance may occur:

- On-board information may distract drivers from performing primary tasks. The mental workload must be minimized, otherwise it could impact on traffic safety. Some experiments recommend displaying few messages and one message at a time. Others point out that drivers do not favour auditory messages.
- The process naturally depends on public acceptance. Will all car-owners accept the receipt of messages or will they consider it a violation of privacy? How will drivers adapt their behaviour to this type of system in the long term?

- It should be pointed out that there is an important difference between roadside VMS and on-board systems: in the case of roadside VMS, road authorities need to communicate with all road users at the same time, whereas in the case of on-board systems, communication occurs on an individual basis and language is no longer an issue.
- Responsibilities in the event of an accident related to the on-board information system must be defined. Did the government instigate the in-vehicle information or the traffic management centre?
- The problem of the platform and its standardisation must be discussed.
- In future, other questions relating to in-vehicle systems could be discussed, i.e.
- Some systems could be designed to react to improper driver behaviour after passing the traffic sign. This issue is linked to a need for feedback.
- Multimodal information could be integrated into the system.
- The problem of law enforcement will have to be debated. In fact, in-vehicle equipment can monitor certain driver behaviour characteristics (speed, overtaking, parking location etc.) that are subject to restrictions by law.

Integration of on-board traffic sign information is a promising approach that includes a number of aspects that make its realization complicated. The NRAs, the scientific community, and CEDR need time to investigate the various effects of these systems on driver behaviour.

Finally, the chairman of the group has links with the BNA (Bureau de normalisation automobile, the body in France that is responsible for the standardisation of dashboards) in order to avoid possible problems (e.g. some signs which could appear as ambiguous when compared with the traffic signs).

Some European projects linked with this theme are described below:

- HARDIE: this project sought to achieve harmonisation between VMS messages and on-board information messages. It made some recommendations regarding the presentation of information to drivers based on comprehensibility, usability, and safety while driving, as well as harmonisation with externally presented information.

- ROAD WISE: supported by the Dutch Ministry of Public Works and Water Management.
  This project investigates the possibilities and the consequences of providing traffic management information through navigation and communication equipment in cars. An important characteristic of the Road Wise system is that the driver is confronted only with information that is important for his/her current position and current route.
  Experiments have shown that customised in-car information can have clear advantages for road users and traffic managers. Data analysis revealed that the system should calculate the permitted workload and apply an information filter based on this workload. Furthermore, for a traffic information system to work effectively, all main roads in the road network need to be integrated into the system, and information on the minor road network should be available so as to present reliable information.

- INVENT: supported by the German Federal Ministry of Education and Research.
  One component of the project is called 'The Network Traffic Equalizer', which incorporates sophisticated traffic management strategies into a new generation of navigation systems using advanced methods, including machine intelligence. These navigation systems will provide drivers with the best alternative routes to their destinations, avoiding delays and taking into account public traffic management policy, safety, and environmental considerations. In certain situations, the danger of overburdening drivers or causing excessive distraction because of too much information could arise. This danger can be effectively reduced by an appropriate design and interconnection of the subsystems.

- IN-SAFETY project: The main idea is to build a consensus on priorities for regulation and standardisation processes with a view to integrating the deployment of ADAS and IVIS on existing road infrastructure.

Even though the chairman of CEDR's task group O9 is also a member of the BNA, it is requested that an on-going task be created. In view of the fact that this participation will cease in the near future, a more permanent solution should be found.

10 Signs used on websites

Certain countries (or regions or towns) have set up websites in order to provide the general public with traffic information. In certain cases, 'American'-style pictograms (mentioned above) have been used. It is probable that these symbols were the only ones available to the webmaster! This is regrettable and should be discouraged by public authorities (or even forbidden for websites for which they are responsible). For the time being, it is essential that the national authorities take informative action.

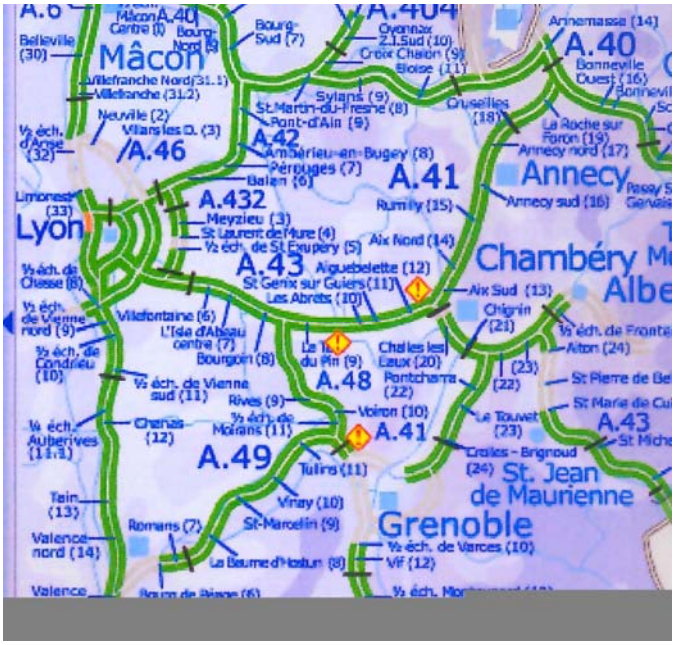


Fig. 20: Example of a website using 'American'-style pictograms

11 Methods for creating new VMS

As for new messages and pictograms, considerable attention must be paid to their definition and assessment. New pictograms are defined by national or European working groups and are subsequently tested under laboratory conditions.

It is out of the question that road operators invent pictograms and display them on their networks.

For messages, a road operator must first establish an inventory of what already exists, with accompanying documents. If a requirement expressed or suggested by users cannot be met using existing messages, an assessment process can be launched in order to test the comprehension and legibility of a new message. Such assessments are also useful as they enable road users to see that their point of view is being taken into account.

Once new messages or pictograms have been established, a number of steps have to be taken following discussion by members of a working group:

- Firstly, a pre-study that is in line with the ISO [2001] procedure is conducted in order to assess the acceptability, comprehension, memorizability, and the impacts of these new messages (or pictograms).
- This study can be carried out via Internet with road users indicating what they understand when they see the new message or pictogram. For the use of a new sign to be accepted, the minimum percentage of correct answers required is 65%. As minimum requirements, ISO recommends testing the signs with no less than 50 people of three different nationalities.
- Next, laboratory tests are undertaken under precise and controlled conditions. There are three basic procedures for testing new signs: ‘tachistoscope’, simulator, and closed circuits. Due to the cost of these procedures, the tests usually involve between 30 and 50 people.
- The last stage involves on-site surveys and observations, which will usually confirm or clarify previous remarks or reflections. Messages are typically displayed on a VMS and interviewers question drivers in designated off-road areas (rest areas or service stations), located a short distance from the VMS (2 to 4 km).

In conclusion, it is of a paramount importance that great attention be paid to the design and testing of new VMS. Some additional ideas on this matter are provided in appendix 7.

12 Recommended actions

It is true to say that considerable efforts have been made in the past to harmonise VMS in Europe. However, there is undeniably still much to be done. Action could be taken by CEDR and additional studies should be launched in a certain number of cases.

These actions are listed in the present chapter, whereas additional studies are listed in the following chapter.

The following actions are recommended to NRAs:

- **Actions regarding enforcement of VMS**

  Although it is clearly indicated that VMS have the same value as fixed signing, a certain reluctance to admit this fact can be noted, especially in the case of police forces. This notion therefore needs to be clarified and related constraints identified, with possible enforcement actions in mind (including automatic enforcement).

  It would therefore be desirable for national authorities to examine this aspect. A year's reflection seems a reasonable time limit.

- **Actions regarding the pre-eminence of VMS**

  As mentioned above, in a certain number of counties, the use of variable signing requires that all signing must be variable. This can lead to problems, for example in the event of electrical failure. However, under these circumstances, there is no inconsistency between fixed signing and variable signing. For economic reasons, other countries use both types of signing, which can lead to inconsistencies. This obviously damages the credibility of signing. It also leads to enforcement difficulties, e.g. in the case of speed control measures.

  This is why the Small Group on VMS, which has been charged with examining issues relating to the Vienna Convention, came up with the idea of introducing the notion of pre-eminence of variable message signing over fixed message signing.

  However, this supposes that users can clearly distinguish between both types of signing.

  One country (Spain) has already included the principle of the pre-eminence of variable message signing in its traffic regulations. However, the design and location of VMS in this country are such that there is no ambiguity.

  For other countries, a solution needs to be found: such a solution might, for example, be to say that when both types of signing exist, variable message sign should have 'a black background', in conformity with article 8 of the Vienna Convention, and it has priority over fixed message signs.

  Although it is interesting, this proposal has not been put forward for the next revision of the Vienna Convention as the Italian authorities would have to be convinced to adopt a reverse (black) background (Italy is the only country not to have adopted this possibility). However, informal meetings have shown that the competent Italian authorities do not seem opposed to this idea in principle.

In the future, one country will have to take the initiative to examine this issue with the Italian authorities and then introduce this idea into a future revision of the Vienna Convention.

Bearing in mind the usual time requirements, this is not likely to be achieved within the next 4 or 5 years.

- **VMS that display actual speed**

  The NRAs should consider very carefully whether they want to deploy VMS that display the actual speed of the cars, due to potential adverse effects.

- **Harmonisation of 'safety messages' (and other possible messages not directly related to traffic management)**

  'General safety' messages should be used very sparingly in accordance with proposals for the revision of the Vienna Convention. But what is the actual definition of these messages? Are messages in the event of a heatwave or child abduction (amber alert) etc., acceptable and if so, under what conditions? To reflect upon this matter (and others), the creation of a small ad-hoc group would be useful (see below).

- **To continuously monitor the pictograms displayed on dashboards, especially on guidance systems**

  As indicated above, it would be useful to monitor continuously what vehicle manufacturers plan to introduce, for example through the long-term presence of a European VMS representative within the BNA. This should be an on-going action.

- **To continuously monitor pictograms displayed on the Internet**

  As mentioned above, each country should monitor websites containing road signs and contact webmasters in order to convince them to adopt pictograms that are in line with the Vienna Convention. Here again, on-going action is required.

- **To build a harmonised library of messages, by going a step further than FIVE**

  FIVE enabled considerable headway to be made and Mare Nostrum enabled further steps to be taken. Ideally, however, work should be continued. This would be possible if a permanent group on this issue were to be created at European level.

- **To try to harmonise VMS and VMS system tests**

  It should be pointed out that new needs continuously arise, necessitating new VMS or new uses of VMS. Among other things, work on this harmonisation would be highly beneficial in terms of reducing the cost of testing new signs. The countries participating in Mare Nostrum paved the way for this type of initiative (see appendix 7).

- **To recommend that NRAs establish and permanently finance a small group of European specialists dealing with VMS**

  This group should have one or two meetings a year, a permanent secretary, and a website for exchanging information, reports, and good practice. It is very important to take into account the difficulties encountered by previous initiatives in order to overcome the expected difficulties.

a) It is therefore evident that continuity of action is absolutely essential. Moreover, the numerous contacts made through European projects and at the initiative of the CEDR, have enabled the creation of a network of specialists in Europe. To take advantage of this situation, a permanent group comprising the main European nations interested in such issues should be set up and kept active.

It goes without saying that in order to function, this group would need to be given adequate means (travel budget, secretariat, a website that would facilitate the exchange of information). It has to be admitted that this is not the first time that such an action has been proposed. However, to date, the national road authorities (NRA) have not been resolutely committed to taking such a step. This is why the idea has been put forward again.

13 Studies to be launched

Task group O9 recommends the launch of several studies:

- **Speed per lane, within speed control measures**

  There is currently no harmonisation of national regulations and experts have different opinions on this issue. Work must therefore continue.

- **Fog and pollution (to be investigated)**

  Speed limits are imposed in the event of fog and pollution. One country (France) has adopted original regulations in this area. However, more knowledge of the situation in other countries is required.

- **Animated signs**

  Here too, expert opinions differ as regards conformity with the Vienna Convention. Is it acceptable to use animated signs (which try to show drivers what behaviour they should adopt) for certain specific configurations? Is this acceptable for all types of VMS or only for mobile VMS?

- **Integration of VMS into systems (e.g. Swedish approach at crossroads, automated VMS, directly coupled to AID systems etc.)**

  Under what circumstances should such automation be allowed? The idea is to improve reaction time, but to avoid losing credibility by displaying incorrect information too often.

- **Proportion of drivers to be re-routed according to a message displayed on VMS (according to the travel time displayed or the type of problem)**

  The idea is to better dose the traffic sent to alternative routes. Another idea is to confirm what is suspected, i.e. that users reactions can differ greatly in the event of long delays.

- **Drivers' understanding of place names or other abbreviations**

  The work carried out in FIVE and Mare Nostrum should be continued.

- **Optimum positioning of VMS in roadwork areas**

- **When and where are bilingual messages useful? How should they be displayed?**

- **Design and location rules for diagrammatic signs**

  The Netherlands has produced some interesting signs and has, in particular, reflected on the design of these signs. This initiative should be shared.

- **The influence of 'blank messages' and 'safety messages' on the information system**

  Several studies carried out in France show that 'blank messages' or 'safety messages' displayed on a VMS could have a very negative influence on the effectiveness of VMS situated downstream: drivers do not read the VMS situated downstream as carefully as they might otherwise have done and do not obey the message correctly. However, it might be useful to launch such studies in other countries, in order to confirm (or not) the aforementioned results.

14 Conclusion

VMS need to be further harmonised, and NRAs should firmly support the proposal prepared by the 'Small Group on VMS'. Several actions are described above, as are several studies, which should be launched as soon as possible.

It is also important to remember that VMS use is strictly reserved for roads, except for rare and serious events (e.g. an AMBER alert), despite the 'temptation' for several road operators to use them for other purposes.

Another challenge is to try to establish a kind of hierarchy between all traffic signs and especially to give variable message signs pre-eminence over fixed message signs (this could be very useful for applications such as speed control).

More generally, it should be pointed out that the effectiveness of signing and signalling cannot be assessed at location level only. Broader consideration needs to be given to area- and system-wide effects. Improved consistency and overall public credibility are important objectives in this wider context.

At the same time, in-vehicle sign display, ADAS (advanced driver assistance systems) or the so-called e-Safety vision, are developing. The pictograms used must remain consistent with road signing. In a global automotive market where two different signing systems exist, this is not as simple as it sounds. It is obviously a challenge for the future.

Finally, it should be pointed out that the new ES-4 project, launched within the EasyWay framework, could help continue the process of harmonization of the use of VMS.

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APPENDIX 2: Revised ToR of task group O9

by Jacques Nouvier, chairman

1 Summary

Variable Message Signs (VMS) inform road users and manage traffic flow. They are becoming increasingly widespread and are growing in number.

While primarily designed to serve the nationals of each country, VMS need to be understood by road users of all nationalities to be fully effective. Continuity of operation is also needed across state borders.

Increasing use of the network and further developments in network operation will increase the pressure to develop a strategy for dealing with VMS.

2 Goals

The objective of this task shall be to monitor developments across Europe and to understand the issues arising from and the obstacles to VMS harmonisation and interoperability.

A comprehensive view of the question is needed; therefore, a quick look at other approaches (i.e. outside Europe) should be considered as useful and will be provided.

Of course, the idea is not to harmonise the material itself, but the information provided to road users.

The work shall focus on informing CEDR about remaining obstacles (if any) and about the time frame in which issues should be resolved and on developing a strategy for their resolution.

3 Strategy

The small project group for this task shall:

- ✓ liaise with NRAs in order to monitor and review the work currently being undertaken or planned;
- ✓ take a rapid look at VMS around the world;
- ✓ briefly examine the links with on-board information and guidance systems;
- ✓ monitor implementation of FIVE rules (e.g. basic protocols to provide consistency);
- ✓ liaise with WP1 (United Nations), which is in charge of the revision of the Vienna Convention;
- ✓ report to CEDR to help it identify future actions and their time schedule to allow VMS harmonisation and interoperability to be achieved.

4 Expected output

- ✓ A progress report will be produced.
- ✓ A final report on the results of monitoring will be produced; this report will comprise elements on how and when harmonisation and interoperability of VMS could be achieved.

5 Existing work

Although CEDR has already undertaken significant work through the VMS Platform, progress stalled before an agreement could be reached.

One possible reason for this is that NRAs are at different stages of network operation and VMS usage. Another possible reason is that the approaches in several countries are still too different.

Even though a group of key VMS experts from CEDR's subgroup Telematics concluded that FIVE is generally implemented correctly, some issues remain to be carefully examined.

Furthermore, ongoing activities regarding the development of pictograms and message structures and activities to encourage the UNECE to include VMS guidelines in the Vienna Convention should be continuously monitored.

6 Added value created by CEDR

CEDR members shall have a clearer view of their respective NRA's future use of VMS in network operations. Collectively, CEDR shall assess the level of harmonisation and interoperability required and shall schedule targets to resolve remaining questions. CEDR is the only organisation that represents the views of the NRAs. Monitoring current development activities shall limit the risk of having to cope with technologies not suited to or not in the best interests of NRAs.

7 Human resources

A total of 30 person days should be sufficient for the project group to monitor developments, contact NRA experts, and liaise with and report to the CEDR.

8 Financial resources (other than NRA manpower, printing, and translation)

No other additional financial resources are envisaged at present.

9 Time schedule

- ✓ Monitoring shall be an ongoing task.
- ✓ A progress report shall be delivered in August 2007.
- ✓ The final report shall be delivered in June 2008.

APPENDIX 3: Bibliography

The bibliography provided hereafter is a very selective one. In fact, a lot of literature has been produced about VMS.

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APPENDIX 4: Mare Nostrum

by **Antonio Lucas**,

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The Mare Nostrum VMS project (MN-VMS), now 'ES-4' within the EasyWay framework, is engaged in two main activities, both concerning VMS harmonisation: empirical studies and the integration of VMS design strategies. Both activities are interconnected and provide feedback to each other.

INTEGRATION OF VMS DESIGN STRATEGIES

The MN-VMS Working Book

The integration of design strategies and practices has been undertaken with the aid of the so-called **MN-VMS Working Book**. Harmonisation requires the consideration of several parameters: firstly, the specific road/traffic situations must be made explicit (there is no point in harmonizing 'in a vacuum'); secondly, the specific informative elements and layout structures must also be made explicit by the different partners. In short, the real VMS used by the different partners must be shown and shared. In this way, all messages for the same situation can be compared and potential harmonisation problems and solutions can be identified and handled by the members involved in the harmonisation process.

The first version of the working book was published in 2006 (i2TERN, Barcelona), presenting information (real practices) from four countries (France, Italy, the Netherlands, and Spain). Late in 2006, five more partners entered the MN-VMS project: Portugal, Slovenia, Sweden, the Republic of Ireland, and the United Kingdom. The state of North Rhine-Westphalia (Germany) also entered the group late in 2007. As a result, the working book has grown in terms of both the number of partners and the number of road/traffic situations included. The new working book is a more complex, comprehensive, and interesting piece of work.

The new enlarged version of the working book will be edited for i2TERN 2008 in Taormina. The presentation will explain and exemplify the changes in this new edition.

The ES-4 Guidelines

The elaboration of the working book was and is both necessary and quite important as it explains the 'state of the art' of VMS design in the different countries. It also provides an insight into the specific solutions adopted by the different partners. Sometimes it is a direct path to harmonisation.
However, the work done within the framework of the working book is not enough. Today, partners on the European Study 4 feel that the time is ripe to offer an alternative to all these design possibilities shown in the working book. Among all the possible messages, is there one message better than the others? Is there a best practice design recommended by the group for given road/traffic situations? What recommendations can be made for a hypothetical European VMS operator?

With this in mind, the group has decided to focus on the elaboration of **the ES-4 Guidelines**. The idea is to focus on best practices that could be adopted by anybody running VMS in Europe. The structure of the working book has also changed, adapting the content structure to what most road operators in Europe would expect (pre-announcements, congestion, weather-related events, dynamic management etc.). In theses guidelines, the group recommends fixing only one specific VMS design solution for each of the four different types of VMS used in Europe (VMS showing one pictogram + text; pictogram + text + pictogram; two pictograms + text; full matrix). That is the pragmatic contribution that should be expected at European level concerning VMS design for a variety of road/traffic situations (up to 32). In this way, differences concerning VMS layout are considered in detail and in parallel, solutions are compared (within logical restrictions, given the differences between VMS devices). The aim of the ES-4 Guidelines is to build a set of European-wide recommendations concerning VMS design.

The first version of the ES-4 Guidelines will be published for i2TERN 2008 in Taormina (meeting to be held in October 2008).

EMPIRICAL STEPS AND FEEDBACK

Empirical studies (following the 4-step method explained above) and integration of VMS design strategies are both interconnected and provide each other with feedback. For example, the production of the ES-4 Guidelines highlights that some road/traffic situations do not yet have a common pictogram—a key element in the harmonisation process. One possibility is, therefore, to devise tests in order to obtain designs that could be applied by all. On the other hand, the empirical steps followed in the last two years could introduce a couple of abstract message formulations (to indicate length; distance-length) that will allow the group to eliminate language barriers in some messages (notably congestion length). The suitability of these message formulations for pictograms other than congestion and functions other than danger warning should also be assessed. The group will address these issues in the future.

APPENDIX 5: Possible priority of variable signs: the case of Spain

by **Antonio Lucas**,

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The Spanish highway code establishes a clear distinction of priorities for the country. These are listed in order of priority below.

1 **Traffic Police Agent.** What the traffic police say or indicate takes precedence over all other road signs or markings, regardless of what the signs may say.

2 **Variable Message Signs and beacons**. Special road markings and signals (e.g. that indicate upcoming roadworks) and VMS are the second priority because they indicate better than other signs what is happening on the road at the present time. These kind of signs are known as 'circumstantial signing' in Spain. It is worth noting that real-time traffic information signs display the most up-to-date information and should take precedence in terms of safety and efficiency.

3 **Traffic lights** are next in the chain of signals (mainly urban) that are available as variable elements. They determine the regularity of traffic flows, taking into account the fact that they are respected by a very large majority of drivers. This includes red cross and green arrow signs for lane assignment.

4 **Fixed message signs**. Fixed message signs are the most frequent type of signs and make the best contribution under normal circumstances. Fixed message signs must be obeyed in normal driving conditions and when no higher-ranking information (e.g. from VMS or police) is available.

5 **Road markings**. Road markings (e.g. double line, pedestrian crossing, etc.) indicate alternative courses of action or cases where no action need be taken on the road. In the absence of other indicators, road markings also let drivers know how they should behave. Road markings represent the fifth level in terms of pre-eminence.

In Spain, pre-eminence is assumed by agents or signs that can better represent the exceptional character of situations. Road markings are quite general and unspecific. They represent the general layout of the road and notably indicate the limits of the road. Fixed message signs draw attention to certain dangers or limitations, but in a general way. VMS 'break out' of the restrictions of conventional signing and present extra-ordinary information. Traffic police officers represent the top level of pre-eminence, affirming with their presence on the road that they both are aware and in control of the specific situation.

	Traffic police	**VMS**	**Traffic lights**	**Fixed message signs**	**Road markings**
Position	Vertical	Vertical	Vertical	Vertical	Horizontal
Elements of conspicuousness	Movement, shape, colour, light	Shape, light	Shape, light	Shape, retro reflective paint	Paint
Normal driver attitude	High attention paid	Attention paid	Regular attention paid	Low attention paid	No attention paid
Main signing function	Regulatory	Danger warning	Regulatory	All	Informative

APPENDIX 6: Notes on the VMS Platform

by **Antonio Lucas**,

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Several meetings of the European VMS Platform took place between 2001 and 2003. The group had a true interest in VMS harmonisation and its output was interesting. However, certain setbacks hampered the potential of the group. The following two points summarise what happened:

1 The European VMS Platform tried to achieve harmonisation without clarifying the role played by the type of VMS itself. Different VMS devices may display either text, pictograms, or both, and this very fact has an influence on the harmonisation process. How can harmonisation be achieved without considering the types of informative elements (pictogram, alphanumeric) that can be displayed and whether these informative elements are supra-linguistic in nature? In principle, harmonisation can only be achieved with VMS that display at least one pictogram because pictograms are the most important international elements of VMS.

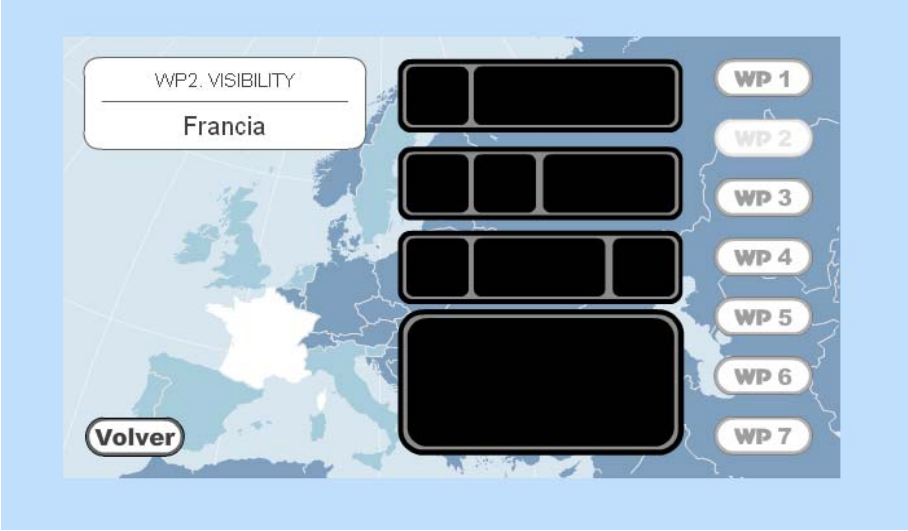

Fig 21: Types of VMS within the MN-VMS project

2 The European VMS Platform tried to harmonise without considering the specific road/traffic situation at hand. It is clear that we cannot harmonise 'in a vacuum' or in general terms. Beyond FIVE's basic recommendations, harmonisation must be specific. In order to harmonise, we have to take account of the number of specific road situations that need to be considered, the specific signs available for each situation, the different uses made by the different partners, and the potential ways to achieve a consensus on common practice. This approach has been followed in MN-VMS, and the inherent complexities are exemplified by Fig. 22.

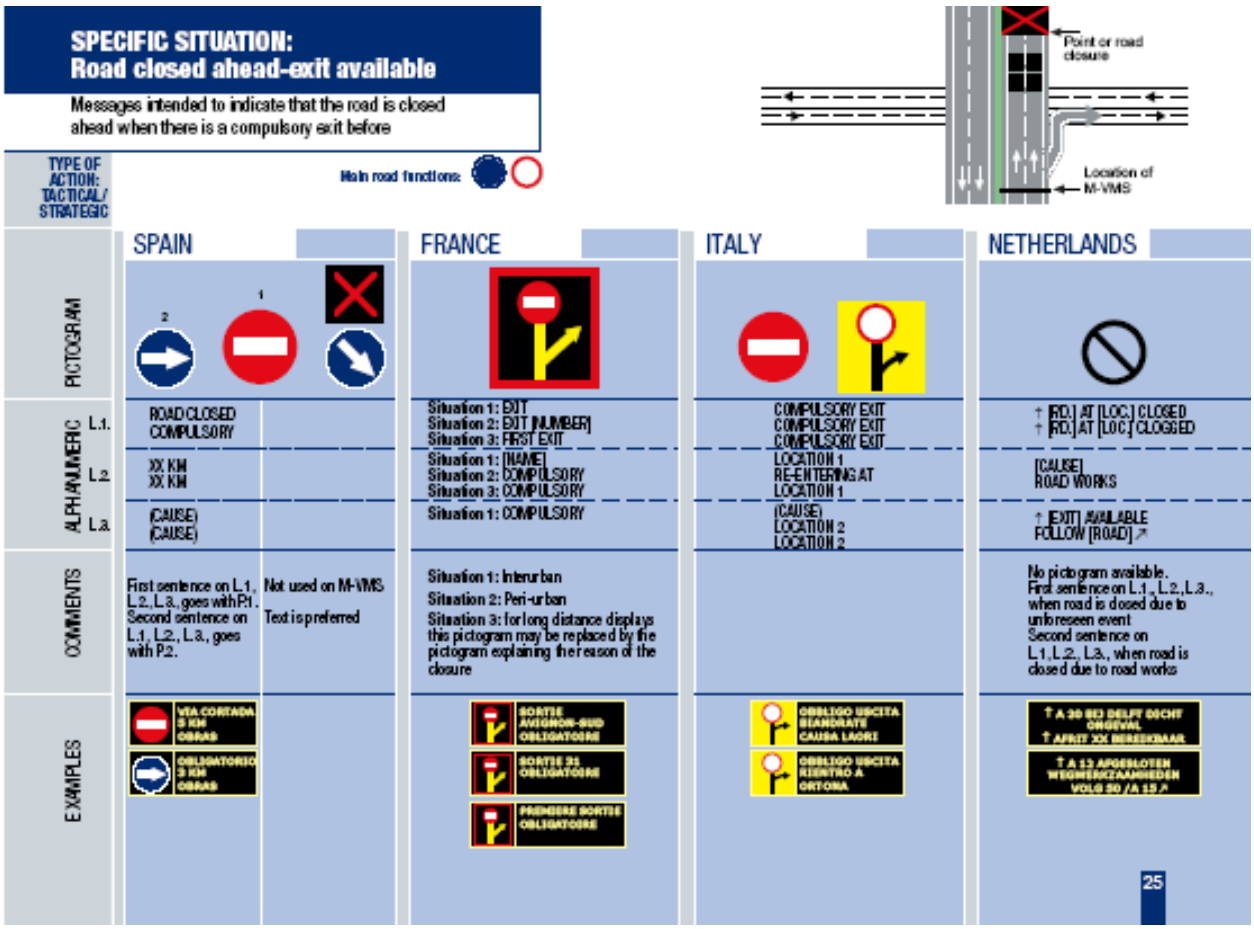

Figure 22: One situation, four visions: problems must be identified if harmonisation is to be achieved

APPENDIX 7: Methods for creating new VMS

by **Antonio Lucas**,

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Introduction

Potential hazards (e.g. road accidents) can be prevented by a hierarchy of actions: firstly, eliminating the hazard by applying an alternative design; secondly, using physical or procedural guards against the hazard; and thirdly, warning motorists, i.e. attempting to influence behaviour through information (Wogalter, DeJoy, and Laughery, 1999). Road transport systems are too complex to solve all potential hazards using first- or second-level actions, which means that road signs are, at present, unavoidable. The impact of road signs can best be theorized using a Communication-Human Processing Model (Wogalter et al., 1999; Wogalter, 2006) that identifies key steps between the road/traffic information (source, channel) and factors that influence end behaviour (conspicuousness, attention, memory, comprehension, attitudes etc.). In general terms, road signs should be designed in such a way that users can perceive, comprehend, and be influenced by them. They should also be harmonised (in accordance with internationally accepted structural and formal characteristics) and be designed in such a way that drivers from different countries understand them.

According to the information processing chain, research has traditionally focussed on perception-attention related issues, parameters that influence attention and maintenance (effects of contrast, duration, brightness, colours, borders, size, legibility, font type and size, symbols vs. text etc.), and only later on comprehension, influence, and harmonisation (Wogalter et al., 1999; Castro and Horberry, 2004; Wogalter, 2006). The impact of road signs has been studied using all techniques, methods, and procedures within the human sciences repertoire (from paper and pencil to field research, laboratory and simulation studies etc.).

Comprehension of new or unknown pictograms in particular has evolved according to a clearly standardized procedure. Krampen (1983) described three main methods: if there is no pictogram at all for a given concept, people can be asked to draw sketches of their own ideas (*production method*). If a pictogram exists but its meaning is not clear, people can be asked to select the definition that best fits the pictogram or simply to describe it in their own words (*recognition method*). Finally, if there are several pictograms for the same concept and the best pictogram must be identified, people can be asked to list them according to their preference and comprehension level (*ranking method*). Similarly, ISO (2001) and ANSI (2002) recommend a three-step method: design (*production method*), ranking and selection of best alternatives (*comprehension estimation*), and finally 'pure' understanding with open-ended questions (*comprehension tests*). In all cases, provision of a reasonable account of the context where the sign would be seen is recommended (Wolff and Wogalter, 1998).

Once acceptable levels of comprehension have been checked and in particular in those cases where the signs will be read under time pressure (as road signs are), additional t-scope techniques (checking comprehension levels after controlled exposure times, e.g. after 150, 300, 600 milliseconds etc.) may help clarify the accessibility of pictogram designs in terms of habitual memory patterns and expected reading time (Doré, 2000).

The 4-step method

In accordance with the recommendations above and making the most of best practice at the national level, the Mare Nostrum VMS group has created a chain of research steps that allows for the identification of potentially useful (comprehended) pictograms and alphanumeric signs. It is known as the 4-step method:

1 **Judged comprehensibility**. Similar to what Krampen (1983) called the ranking method, this test follows ISO procedure (2001). Typically, drivers are shown a group of pictograms at the same time. These pictograms are arranged in a circle around a text that describes the potential meaning of the pictograms. The drivers are then asked to write beside each pictogram the percentage of drivers they think would understand that each particular variant of the pictogram. Validation studies have shown that this method allows very good signs and very bad signs to be identified with a high degree of certainty. Research has shown that results from the judged comprehensibility test can predict the results of the comprehension test within a 20% margin of error. Signs scoring below 45% on the estimation test are unlikely to meet the 65% acceptance criterion on a subsequent comprehension test and should, therefore, be excluded from further consideration (Zwaga, 1989; Brugger, 1999). Along these lines and according to the results of recent meetings of the ISO TC145 technical committee on graphical symbols (Paris, May 2003), a modification of comprehension criteria will differentiate between public information symbols and safety symbols. For public information symbols, for which the consequences of misinterpretation are likely to be annoying rather than dangerous, 66% correct answers in the judged comprehensibility test is acceptable. Safety symbols, where the consequences of misinterpretation could be catastrophic, have a much stricter criteria, requiring 95% correct answers in the judged comprehensibility test (this is closer to the 85% required by ANSI). The 45% criteria could be taken as the reference percentage for keeping valuable signs and also for deciding whether to proceed with the second step, the comprehension test. ISO recommends testing on samples from at least three different cultures and using no less than 50 subjects per sample.

2 **Comprehension test**. This is the comprehension test ‘par excellence’. It is also in line with the ISO procedure (2001). Drivers should be told the context in which the sign would appear (e.g. on the motorway), but not much else. They are shown a pictogram and asked to write below it what they understand it to mean. It is as simple as that. For a sign to be accepted as a potential alternative, 65% of answers or more must be correct. Fewer correct answers (e.g. between 50% and 65%) could be interpreted as a need for improvement. The Mare Nostrum VMS group has performed several of these tests via the Internet. Again, the ISO recommends testing on samples from at least three different cultures, using no less than 50 subjects per sample. The MN-VMS group normally includes no less than 100 subjects per set of signs. A typical test would involve about 600 subjects per country.

3 **Laboratory tests**. The third step involves different types of test, depending on national preferences. It normally implies laboratory tests (i.e. tests done under highly controlled conditions). Three main examples are the t-scope test, the simulator test, and the closed circuit test. Due to the cost of these procedures, samples are normally small, between 30 and 50 subjects per test.

- **'Tachistoscope'**. This is normally used in France. After being provided with the general context (cars, road, VMS), drivers are shown the signs for a very short time (e.g. 150ms). They are then asked to state a) the informative elements they saw and b) what the signs mean (comprehension). For example, one may know what was on screen and yet not really know what it means. Exposure times are progressively increased (300ms, 500ms, 750ms…) and the same questions are repeated to drivers (informative elements identified, comprehension). Finally, there is no limit to the exposure time; the driver may look at the sign as long as he/she likes.

- **Simulator**. This method is used in Italy and Spain. Drivers drive along a road in a graphic simulator. They see the VMS, and the interviewer sitting beside them asks them what they think it means and writes down their answers. The exposure time is more natural and the driver selects the speed.

- **Closed circuit**. This method is used in the Netherlands. Subjects are driven in a closed circuit and approach motorway speeds. They don't drive themselves; a professional driver accompanies them. When they approach a VMS, they are asked to state the reading distance, the sign's meaning, etc.

4 **Field test**. This is the last step, which is also used in France. Typically, road authorities select a location where real VMS will display certain messages and a safe location (e.g. petrol stations, rest areas) where interviewers will ask drivers about the information displayed on the VMS. Typically, such safe locations are not far away from the VMS (2–4 km). Interviewers normally take about 5 minutes to interview drivers and will ask a large number (between 500 and 1,000 drivers) a few questions.

References

See general bibliography

APPENDIX 8: Glossary

ADAS	Advanced Driver Assistance Systems
BNA	Bureau de normalisation automobile (automotive normalisation office)
CEDR	Conference of European Directors of Roads
CEN	Comité Européen de Normalisation
CERTU	Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques
COST	Cooperation in the field of Scientific and Technical research
CPD	Construction Product Directive
EAVES	Evaluation and Assessment of Variable European Sign Systems
ECMT	European Conference of Ministers of Transport
EN	European Normalization
ESCOTA	Société des Autoroutes Estérel, Côte d'Azur, Provence, Alpes
EU	European Union
FIT/IFT	International Transport Forum
FIVE	Framework for the Harmonised Implementation of VMS in Europe
FP	Framework Programme
HOV	high occupancy vehicle
IN-SAFETY	infrastructure and safety
ISO	International Organization for Standardization
LED	light emitting diode
MELYSSA	MEditerranean sea LYon Stuttgart Site for Advanced telematics
MN-VMS	Mare Nostrum VMS Long Distance Corridor
NRA	national road administration
OBU	on-board unit
SERT	Southern European Road Telematic Implementations
SOMS	Substituting/Optimising (Variable) Message Signs for the TERN
TCC	Traffic Control Centre
TELTEN	Telematics implementation on the Trans-European road network
TERN	Trans-European Road Network
TOR	terms of reference
TROPIC	Traffic Optimisation by the Integration of information and Control
UNECE	United Nations Economic Commission for Europe
VC	Vienna Convention
VMS	variable message signs
WERD/DERD	West European Road Directors/Deputy European Road Directors
WG	working group
WP.1	Working Party on Road Traffic Safety

APPENDIX 9: General text regarding road signs and VMS

This text is an English translation of the introduction to the new Danish guidelines for VMS, still in progress. The text provides a broad overview of VMS-related questions.

HOW IS DRIVER BEHAVIOUR AFFECTED BY ROAD DESIGN AND THE CURRENT TRAFFIC SITUATION? THE CONSEQUENCES FOR VMS

by Gabriel Helmers, phD (gabriel.helmers@bredband.net)

In order that our road and street environments may be well designed, it is necessary that we have a good understanding of how we function as road users. For this, we need a good explanatory model for road user behaviour. In such a model, a number of fundamental considerations must be formulated. These considerations must be firmly established in up-to-date behavioural research and must, at the same time, be based on long-term experience as a road user.

In Section 1, an attempt is made to formulate some fundamental considerations that may be instrumental in creating a deeper understanding of road user behaviour. This section may be regarded as an early contribution to a better and more useful explanatory model.

The subsequent sections discuss the ability of road users to read road signs (2), the willingness of road users to obey fixed message signs (3) and, finally, some essential requirements for variable message signs (VMS) to be obeyed to a greater extent than the fixed message signs (4).

1 Some starting points: fundamental considerations

Road user behaviour in an evolutionary perspective

For a better understanding of how we function as road users, we may refer to the reflections of Charles Darwin[1] and James J. Gibson[2] on how, in the course of evolution, we developed in interaction with our physical environment. The description of road user behaviour is then largely based on Gibson and Crook's[3] classic and as yet unsurpassed article from 1938 on how we function when we are driving a car.

One appropriate starting point is Darwin's theory of the 'survival of the fittest'. Those species and individuals who have been best fitted to the demands of their environments have survived. Our senses and our brain have therefore, in the course of evolution, developed to comprehend, in an increasingly effective manner, what is important for us in the surrounding environment. Another condition for survival has been that we have simultaneously developed an increasingly improved ability to move about in our environment. In this way, individuals in the species that have survived have been successful in satisfying their primary needs—to eat, to rest, to protect themselves and to reproduce.

1 Darwin, Charles R. (1859) *Origin of Species*.

2 Gibson, J.J. (1986): *The Ecological Approach to Visual Perception*. Lawrence Erlbaum, Hillsdale, NJ.

3 Gibson, J.J. and Crooks, L.E. (1938): 'A theoretical field-analysis of automobile-driving'. The American Journal of Psychology. Vol. 51 No. 3, pp. 453-471.

During evolution we have thus developed an increasingly effective brain and senses of ever greater effectiveness, and at the same time a constantly improved ability to move about and also in other respects to successfully act in (and manipulate) our surroundings. Those species and individuals who, with the least possible effort, have managed to acquire the greatest possible 'benefits' have survived. The general 'benefit/cost principle' which we use on a daily basis has in this way been constantly active in the process that has shaped humans. This 'design principle' has created a rational, effective, and adaptive human built for moving about in the environment in which our senses, our brain, and our motor system act as an effective entity.

Conclusion: When we move, we act very rationally and effectively—the greatest possible benefit for the least possible effort.

A new theory of perception

In their classic article from 1938, Gibson and Crooks show that driving is principally a perceptual task. This implies, inter alia, that the behaviours of road users are to the greatest degree based on the perception they have of the road as a whole and of the traffic environment here and now. Perception of the traffic environment as a whole is therefore much more important than the perception of the various components of the traffic environment.

Gibson's new theory of perception implies that the information about surroundings is 'out there' and is merely registered in the brain via our senses. The visual information about what the surroundings look like is then 'embedded' in the rays of light which, after being reflected from surfaces and objects in the surrounding environment, meet our eyes. The brain automatically registers the information contained in the rays of light. In such a way, without any effort on our part, we form immediate impressions of the appearance and nature of the world around us. At the same time, our perception of the situation here and now is also 'forward looking'. This means that we know where we are going when we move through space. We also perceive what is happening in this space just before it has occurred. For example, we see that the pedestrian on the crossing in front of us will have time to reach the footway before we pass.

All our senses deliver simultaneous information to the brain concerning conditions in the surroundings. The brain registers this information and gives us, instantly and automatically, the best possible holistic picture of the situation at hand. The more detailed the information that we receive via our senses, the faster we have a correct perception of the world around us. In daylight we seldom have any problems, while in the dark and in night-time traffic we often have poor quality and unsafe information. This means that the brain is obliged to perform an interpretation on the basis of an insufficient 'input' from the sense of sight. In such a situation it takes longer for us to gain a correct impression of the (road) space. In the worst case, our interpretation is incorrect, and we misjudge the situation.

According to the traditional theory of perception, the senses transmit their impressions to the brain, which must interpret them. When the interpretation has been completed, we have a perception of the surroundings (the information is created by the brain). One of the difficulties with the old theory is that it cannot explain why, in daylight, we immediately have a correct visual perception of our surroundings.

Conclusion: Through vision and our other senses, we form an immediate holistic perception of the world around us.

Driving is a skill that we apply without thinking about what we are doing

The ability to move about effectively in their surroundings is a fundamental characteristic of humans and of our relatives, the mammals. One example: Visualise the dog as it chases the hare at breakneck speed over stones and sticks in the forest. It senses the hare's scent through its nose, it hears any noise generated by the hare's flight, and it sees the forest terrain along the hare's trail. All this must be registered at lightning speed by the dog's brain which must give the dog an immediate perception of the situation and the way it is developing. The brain immediately sends impulses to the muscles about where the feet must be placed so that the dog may move as fast as possible without losing the trail, and at the same time avoid all obstacles and make use of all the opportunities that exist to get ahead faster. This very effective pattern of action is performed by the dog entirely automatically and without thinking (which the dog is incapable of doing).

When we are walking, cycling, or driving a car, in most situations we function in the same way as the dog in the above example. Through our senses, we form an immediate perception of the road environment and what is happening in it and we adapt our progress subconsciously to the way the road and the traffic situation changes. Walking, cycling, and driving are all similar perceptual-motor tasks that we have learned to master through long-term training. Walking, cycling, and driving are therefore skills that we apply without thinking what we are doing or how we are doing it.

Conclusion: When driving a car, in the large majority of cases we select our speed and position on the road spontaneously on the basis of our overall perception of the road and the current traffic situation.

Driving is an automatic activity

In contrast to the dog, we have also evolved a brain to think with. However, our ability to think does not help us to walk, cycle, or drive better. Our ability to think instead gives us the ability to perform more complex tasks, something the dog and our near relatives among the mammals do not have. The best examples of this are tasks that require the use of language and the understanding of symbols. Mastering language and symbols is an essential requirement for the ability to learn from others, solve (logical) problems, be able to understand what has happened (in the past), and plan (in the future).

Controlling the position of the car on the road and adapting speed to the circumstances are control tasks that are performed automatically. We then simultaneously have the capacity to direct our thoughts to something else. In conjunction with demanding manoeuvres, such as overtaking and lane changing, we make conscious decisions based on assessments of whether or not the manoeuvre is appropriate. This demands concentration and focus. The only driving task that requires conscious and logical problem solving is 'navigation', i.e. planning the journey, orienting oneself in the road space, and selecting the right route to reach the destination. One task that demands conscious reading and interpretation is to assimilate the message on the road signs one passes. The actual meaning of each road sign must not only be understood, the message must also be related to the current road environment in which the road sign is placed. If the information is ambiguous or difficult to understand, the road user has a problem.

In driving as an automatic activity, drivers have excess capacity. They then talk with the passengers or listen to the news on the radio. In contrast, however, when performing various manoeuvres or when navigating, the driver is wholly focused on the task. Talk ceases and the content of the news is missed.

As pointed out above, drivers act rationally. With very few exceptions, they automatically select the speed in accordance with conditions presented by the road and the actual traffic situation. Since driving is largely an automatic activity, drivers spend most of the time spontaneously thinking about other things (even when drivers make an effort to think consciously about how they are driving, they cannot do so for very long; their thoughts quickly 'take flight' again).

Conclusion: Walking, cycling, or driving are all everyday perceptual-motor activities which, once learned, are performed automatically, i.e. we do not think about what we are doing or how we are doing it.

The self-explanatory road

Gibson also claims that we directly perceive what possibilities (i.e. 'benefits' and 'threats') there are in the surroundings and what the environment offers us to utilise or to avoid (Gibson's 'affordance' concept). We immediately perceive that the path through the forest offers us faster progress than the unbeaten terrain alongside, and that the steep drop along the path is a potential danger that we avoid. A chair invites us to sit on it. A better road standard invites us to drive faster. A tight bend warns us to slow down and to take care. Our ability to perceive immediately and to adapt to 'benefits' and 'threats' in the surroundings, implies a further effectiveness of our adaptation to the environment.

Gibson's 'affordance' concept and his theory as a whole, lead in a natural way to the concept of 'the self-explanatory road'. What this means is a road designed with the help of various 'design characteristics' in such a way that road users immediately understand how they should drive on the road. This means that road users must perceive what function the road and its various parts have.

Conclusion: The road environment should to the greatest possible extent be 'self-explanatory' so that road users immediately perceive its 'benefits' and 'threats' and how they must drive.

Drivers' expectations

We have earlier shown that humans as road users act very rationally and effectively according to the principle of the 'greatest possible benefit at least possible cost'.

Everybody, since childhood, carries with them the experience of what the environment is like and how we should adapt to the demands it makes. How do we, as drivers, make use of this wealth of experience in the most rational way? What we do is that in every type of (road) environment of which we have experience we automatically set up quite precise expectations of the demands which similar, but to us unknown, roads will confront us with as drivers.

When we enter a road for the first time, we already have expectations of what the road will be like. If the road is a national main road, we expect that its standard will be relatively good. If the road is a local main road, we have lower expectations. If the road is a minor road in the country, we expect that it will be narrow and have a variable speed standard. Our 'inner image' of such a road may be that it might be a narrow gravel road with sharp bends, but also that it may have better and paved sections.

When we drive onto a road for the first time, we are generally initially curious as to what the road will be like in detail. But once we have driven a few kilometres on the previously unknown road, we have already built up a detailed expectation of how the road will continue. The best judgment we can make is that the road will continue as it has begun. If the road gradually deteriorates, we form the expectation that it will be even worse further along, and vice versa.

If we exit from a motorway in countries that drive on the right, we expect the exit ramp to begin in the right-hand lane and that we will drive off to the right. We have built up this expectation through our experiences that motorway exits, practically without exception, conform to this general principle.

When the road meets our expectations, we rarely have any problems. However, if the exit ramp takes off to the left from the left-hand lane of the motorway, what happens then? There is a great risk that we find out far too late that the road does not agree with our expectations. We immediately change from our automatic driving behaviour to making conscious assessments of the situation. We must first of all re-orient ourselves in the traffic environment and quickly try to understand the road's function so that we have sufficient data to decide how we must handle the car. All this happens while we are greatly pressed for time. This means that there is a high risk of missing important information and make the wrong decisions. In our haste, we perform hasty manoeuvres, which mean that there is a high risk of having an accident.

Conclusion: Our previous experiences make up a 'knowledge bank' from which our expectations are formed. Roads must therefore be built in such a way that our expectations concerning the design and function of the road are reinforced. This means that the road must be designed in accordance with obvious general principles from which exceptions are not allowed.

The current visual impression v. the memory of the road one knows well

According to Gibson, we have over the course of millions of years been 'programmed' to expect our physical world to remain stable and if it does change, that this change occurs very slowly. We expect, for instance, the surroundings of our childhood to be unchanged when we return later in life.

We get to know our physical environment spontaneously, and effortlessly learn what it is like. We usually find our way about in a place we have been to before. Through experience, drivers construct a specific memory of the road. This means that when they have travelled on the same road several times, they have a much stronger expectation of what the road is like further along, and what their speed should be in every sharp turn the next time they are on that road. Drivers therefore have two sources of information as regards the design of the road, their memory of the road and their present visual impression of the road. If visibility is poor (dark, fog, rain, and snow), visual information deteriorates and the memory of the road becomes increasingly important as the source of information. If the road has been realigned since the driver passed the last time, the two sources of information provide contrary information. This increases the risk of mistakes.

It sometimes happens that, while walking along a path in the forest or driving on a familiar road, we suddenly feel that we are lost. What has happened? The path may have been indistinct and we may have come into a turning without noticing it, or the four-way intersection on the road may have been converted into a roundabout since the last time we were here. What happens when we notice our mistake? Drivers immediately 'switch off' the memory of the old road and begin to familiarise themselves with the new layout. They do this by completely relying on what they see. The problem for drivers is that they must have a sufficient margin of time for action if the new road poses a higher demand for adaptation than the old one. For the road management authority, the problem is to build the new road in such a way that drivers detect in good time that the layout has been changed.

Conclusion: Changes made in the road environment which increase demands on drivers should be preceded by a section designed in such a way that drivers no longer recognise it and consciously begin to re-orient themselves in the new road environment.

Humans cannot be 'rebuilt' and improved; our traffic environments can be

The modern human (homo sapiens sapiens) evolved over 100,000 years ago, and has not changed very much since then. On the other hand, our traffic environments are at most 50 years old, and are continuously changing. One good goal therefore is to try and construct road environments that are well suited to human nature. To be successful in this, it is essential that we have a proper understanding of how we function as road users.

2 The ability of road users to read road signs (symbolic road information)

To see and read road signs

Most road signs have good visibility. The problem is that, in spite of this, road users do not read them. In the previous section, we have shown that driving is to a high degree an automatic activity. Reading and understanding a road sign requires the driver not only to look at the sign, but also to assimilate the symbolic information conveyed by it. The latter is then a conscious action.
Drivers endeavour to drive in such a way that they feel they are in full control of the car at all times. Full control implies that they feel the risk of an accident is nil. Drivers also feel directly 'in their whole body' when they have driven so that the margin of safety has been too low or negative
(purely intellectually, however, drivers understand that there is always a certain slight accident risk).

When drivers drive along a road for the first time, they are more attentive and extra careful, especially in bends for which there are warning signs. Drivers then have a direct need to read the road signs along the road so as to avoid being surprised (and risk losing control). On the other hand, when drivers are on a road they know well, they know how they should drive and what speed they should have in each bend. In such cases, the fixed message road signs do not convey any new information but are more in the nature of 'landmarks'. In the latter case, drivers have no need to read the road signs.

Conclusion: In order to ensure that road signs are read, they must satisfy drivers' need for information.

One activity at a time

Drivers perform one demanding activity or manoeuvre at a time. During the time they perform this manoeuvre, they concentrate on this and are 'blind' to the road signs they pass.

First example: At an intersection, the driver must drive on to a major road with fast traffic. When there is a suitable gap in the traffic flow, he/she pulls out onto the road. His/her primary driving task is to get up to speed quickly so as to keep up with other traffic. He/she simply passes the speed sign on the side of the road right after the intersection. Once he/she has got into top gear and has almost reached 90 km/h, the driver must know whether the maximum permissible speed is 90 or 110 km/h (the standard speeds in Sweden). The driver now looks for a speed sign, but there is none to be seen. It had been placed immediately after the intersection and was passed during the acceleration when the driver was 'blind' to the sign.

Second example: A left-hand turn in a signal-controlled intersection with a lot of traffic is a demanding task which takes up the driver's full attention. In such a situation, the driver must solve the most important components of the task in the proper order (task hierarchy). First, he/she must slow down and stop in the correct lane in front of the red light, and when the light changes, he/she must turn. He/she checks that other cars at the intersection have stopped for the red light. He/she then looks out for cyclists and pedestrians who are near or on the crossing and whom he/she must pass. He/she then concentrates on keeping the vehicle in the correct position during the entire turning manoeuvre. When he/she has finally passed the crossing at the intersection, he/she relaxes and begins to find out about the new road link he/she has just entered: What information does he/she receive from the physical road layout and the traffic situation? He/she increases speed and looks for additional road sign information at a suitable (reading) distance. But there are no road signs! They were so near the intersection that he/she was 'blind' to them when he/she passed them.

Since driving a car is an automatic (not conscious) action, drivers must have an immediate need for the information in order to read it. Drivers do not plan the actual driving task in advance, but read the road signs when they are relevant to the task here and now. One example: Drivers waiting for green do not read in advance the road signs that are clearly legible on the other side of an intersection, but concentrate on passing through the intersection. It is only after they have got through the intersection and come on to the new road link that drivers need information. But in such a case they miss the road signs if these are placed too near the intersection.

Conclusion: Road signs must be sited along the road so that drivers are in immediate need of information drivers are not busy with some manoeuvre when they are supposed to read them after the manoeuvre, drivers see them at an appropriate distance (not too near).

General conclusion: The immediate need of a driver for road sign information directly decides whether or not road signs are read.

Benefiting from direction signs

The only driver task of a problem-solving nature (performed consciously, based on knowledge and on logical thinking) is 'navigation', i.e. deciding which route to take to get to the destination and then following the selected route.

One problem is that drivers must receive information in good time before choosing their route. They need this in order to have time to get their bearings and to get ready to read the direction signs and to make a decision. Where am I? Which route should I choose? Drivers also have a certain expectation as to the names of the towns which will be listed on the direction signs. When they get near enough to the direction sign to read it, drivers perhaps find that the town they are looking for is not displayed on the sign. Which town should they aim for instead? This often demands a knowledge of geography and a good knowledge of the road network.

The most general problem with direction signs is that there is too much information on the signs. Drivers must read and understand the information before they pass the sign. They should also have had time to decide which way to turn at the intersection. If they do not have time to do all this before passing the sign, they must base their choice of route on an uncertain memory of the information on the sign (three names on each sign is probably the optimum, while four is acceptable; everything else probably leads to mistakes). In order to ensure that drivers are likely to make the correct decisions, direction signs should be repeated, for instance in advance of motorway exit ramps.

If drivers know the road well from earlier on, they have no need for direction signs except as 'landmarks' to show exactly where they are. If, on the other hand, there are new roadworks on the road, it represents a potential threat and therefore requires the driver to look for new information concerning the roadworks and diversions. The problem is that roadworks are often unexpected events along the road that require extra strong sensory inputs in order to 'wake up' the driver to make appropriate adaptations for retaining full control.

Conclusion: Direction signs in advance of intersections and strict limitation of the number of towns displayed on the sign are essential for effective route guidance information.

Direction signs for the choice of route which make use of complex variable signs, e.g. those which display maps of links in the motorway network, pose problems. There are several reasons for this. One important reason is that a driver's route choice task is of problem-solving nature. This means that drivers must have access to all necessary information for the entire duration of the time they need to make a decision. This implies that drivers must be able to read the information several times to make a judgment about two or more route options and to choose one. Solving such a task takes time. At the same time, drivers cannot reproduce from memory a sign they have passed. The consequence of this is that drivers in an unknown traffic environment would need to stop in front of the sign until they have made a decision. This is not possible.

On the other hand, those drivers who regularly drive along the road should be able to use the information after developing simple criteria for their choice. In such a situation, reading the sign would be in the form of a rapid 'pattern recognition'. One group of similar patterns results in choice A, while another group of patterns produces choice B.

3 The willingness of road users to obey fixed message road signs

'Natural' and symbolic information in the road environment

Drivers attempts to remain in full control implies that they are always looking for relevant information concerning the road and the traffic situation.

By far the greatest proportion of the required information is embedded in drivers' immediate visual perception of the physical layout of the road space and the traffic situation. Let us call this 'natural information'. Our senses are designed to detect changes in our surroundings. This is essential for our ability to adapt rapidly to a situation that is changing all the time. In this way, we manage in most cases to adapt rapidly to an expected change in the road environment and traffic situation.

This 'natural information' can then be supported and reinforced by symbolic information in the form of road signs. This implies that the 'natural information' and the symbolic information on road signs must 'say the same thing' so that, in cooperation, they may convey the same message to drivers. If, on the other hand, the information on road signs is in conflict with the 'natural information', in most cases the latter will be most important for driver behaviour.

The task of road signs in the form of mandatory and prohibition signs, together with the layout of the road, is to regulate traffic by giving road users unambiguous information and instructions on 'where' and 'how' they should drive and tell them 'what they must not do'. In this case also, the road layout and the traffic situation as a whole, together with the mandatory and prohibition signs, must make road users feel that the regulation is well founded and necessary. Road users must be made to feel that transgressions are both risky and unnatural.

Conclusion: The physical layout of the road and the symbolic information on road signs must work together in order to give road users unambiguous information of how they must drive.

Messages on road signs must be credible and relevant

If the information on the road sign is not credible in view of drivers' perception, here and now, of the 'benefits' and 'threats' of the road space, drivers will tend to rely on the 'natural information' and ignore the symbolic information (i.e. road signs). For safe driving, it is essential for drivers not only to feel in full control but also to have a realistic comprehension of the actual demands posed by the current traffic environment. A warning of a sharp bend ahead must also mean that the driver perceives the bend he/she has just gone through to have been dangerous (if the driver did not drop his/her speed). Otherwise the warning will lose its credibility.

Conclusion: Information on road signs must have a high degree of credibility to be obeyed.

Messages on road signs must be understood by road users

One important duty of road signs is to warn about something that cannot yet be seen and therefore cannot be perceived as a threat. In this case too, road users must feel that the warning is credible and relevant.

Road users base their behaviour not only on the information they receive of the traffic situation here and now, they also try to understand, for example, why the permissible speed has been reduced on a certain section of the road. By giving drivers simultaneous information, through additional signing, as to why speed has been reduced, the measure can also be made understandable. If drivers decide that the reduction in speed is not only intelligible but also relevant and motivated, they will reduce their speed a lot more than if no such information is given.

Conclusion: Explain to road users the reason for the restriction. Understanding of a relevant and credible measure is essential for observation of the restriction.

Can the reason for the signposted maximum permissible speed be understood?

Most prohibitions and directions are absolute. This means that one either ‘must not’ or ‘must’ do something. There are only two possibilities, one either does the right thing or the wrong thing. Speed, on the other hand, is a continuous variable. Signs concerning the ‘maximum permissible speed’ imply a prohibition to drive faster than the speed limit, while at the same time this level of speed is determined through administrative and/or political decisions. In any case, when the maximum permissible speed is determined for a certain section of road, road users have no say in the matter. This may mean that road users do not have the desired favourable attitude towards the decision.

Drivers are very rational beings, they look for safe and fast transport to their destinations. They also drive in such a way as to feel they have full control of the car and the traffic situation they are in. Experienced drivers have developed a very good capacity to adapt their speed to the demands posed by a changeable traffic environment. This means that they can judge the reasonableness of speed limit signs. If drivers consider that the maximum permissible speed on a certain section is unreasonably low, it cannot be expected that the speed limit will be properly observed.

The choice of speed in such a case depends on the system of sanctions and the assessment of the drivers as to the risk of detection. On a road that is under surveillance, an absolute maximum speed level is usually also the maximum speed that drivers consider they can maintain without risking the loss of their driving licence. A few drivers decide to drive at a speed that will result in fines. One good way for drivers to maximise their benefit (getting to their destination as fast as possible) and at the same to minimise their effort (keeping to the maximum permissible speed) is to use cruise control.

Conclusion: The signposted maximum permissible speed must be judged credible and motivated in relation to the road standard and the traffic situation.

4 Some essential requirements for variable message signs to be obeyed to a higher degree than fixed message signs

The requirements specified above for fixed message signs also apply to variable message signs. Some additional requirements should also be met to ensure best performance.

Road users must see when a road sign is a variable one

Road users must read variable message signs regardless of whether they are driving on the road for the first time or drive along it every day. This means that road users, irrespective of whether or not the road sign is activated, must be able to see from a long distance that the road sign is variable and not fixed. In this way, road users also learn to look for information on the sign every time they pass it.

Conclusion: Road users must be able, without any difficulty, to determine whether a road sign is variable or fixed.

Easy to read, credible, relevant, and understandable message

Variable message signs must, to a higher degree than fixed message ones, display current, credible and relevant information. This makes it necessary for variable message road signs to be given such a function that they are more conspicuous (when activated) than fixed message signs. Because they are conspicuous, they attract drivers' attention and curiosity, which stimulates the drivers to read the sign. When activated, the brightness of variable road signs must be adapted to the general light level, so that good legibility without glare is guaranteed, irrespective of daylight/dark. When a variable road sign is not activated, it must however have a neutral appearance and not contain any message. Each display must be permanent and must not under any circumstances flash or alternate between different messages, since this makes it difficult to interpret the message and also diverts the attention of road users from what else is happening in the road space.

Conclusion No. 1: When activated, variable message signs must be conspicuous. The information displayed must be more up to date, credible, and relevant than in the case of fixed message signs.

Conclusion No. 2: Variable message signs must work together with fixed message signs and the rest of the road environment so as to give road users an added value.

Overall conclusion: If the road management authority cannot manage to satisfy stringent demands regarding the credibility and relevance of the various displays, variable message signs must not be used.

The text above is a translation into English of the introductory section on road user behaviour in the new Danish Guidelines for the use of Variable Message Signs (VMS). In progress.
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