Preparatory action — User-friendly information tool on urban and regional vehicle access regulation schemes 2
UVAR Exchange

Task 1.3
Guidelines for UVAR Variable Message Signs (VMS)

Final report

PREPARED BY: Panteia, ARMIS, AustriaTech, CORTE, MAPtm, TRT, Sadler Consultants

Draft report: submitted in April 2022.
Final report v1.0: submitted on 23rd January 2023.
Final report v1.1: submitted on 17th March 2023.

FOR THE
EUROPEAN COMMISSION
European Commission, B-1049 Brussels
Directorate-General for Transport and Mobility
Directorate B - Investment, Innovative & Sustainable Transport
Unit B3 Innovation & Research contact: Isabelle VANDOORNE
E-mail: Isabelle.VANDOORNE@ec.europa.eu

Contents

List of figures

Abbreviations and acronyms

ANSR	Portuguese National Road Safety Authority
CEDR	Conference of European Directors of Roads
CEN	European Committee for Standardisation
CEN/TS 16157	Intelligent transport systems - DATEX II data exchange specifications for traffic management and information
C-ITS	Cooperative Intelligent Transport Systems
COST 30 action	European Cooperation in the field of Scientific and Technical Research
CS	Congestion charging
DATEX II	The standard for road-data exchange
DG MOVE	European Commission – Directorate General for Transport and Mobility
EasyWay	A trans-european project co-financed by the EC focusing on the deployment of ITS
EC	European Commission
EMERG	Pollution emergency schemes
EN 12966	European standard on Vertical road signs—Part 1: Variable message signs
FIVE action	Framework for Harmonised Implementation of VMS in Europe
IMT	Portuguese Mobility and Transport Agency
ITS	Intelligent Transport Systems
LEZ	Low emission zone
LTZ	Limited traffic zone
NAP	National Access Point
NRA	National Road Authority
RST	Portuguese Traffic Signage Regulation
UVARs	Urban and regional vehicle access regulation
VC	The Convention on Road Signs and Signals, commonly known as the Vienna Convention on Road Signs and Signals
VMS	Variable message signs

1. Introduction

This report was prepared within the framework of the **European Parliament Preparatory action — User-friendly information tool on urban and regional vehicle access regulation schemes 2**, based on contract No MOVE/B3/SER/2020-716/SI2.852092 implementing the No MOVE/2020/OP/0012, signed on 15 July 2021.

The report is the final version submitted to the European Commission – Directorate General for Transport and Mobility (DG MOVE) by the Consortium led by Panteia in association with ARMIS, AustriaTech, CORTE, MAPtm, TRT, and Sadler Consultants.

Its purpose is to explore the potential of Variable Message Signs (VMS) and how the information provided can be standardised and harmonised regarding UVARs' applications. The approach aims at covering the following aspects:

- It must be ensured that information is perceptible and clear to all - what languages and what symbols (text and visual elements) should be used to represent each UVAR?
- The information is dynamic - how should the temporal criteria be handled?
- The information must be provided in the vicinity of the UVAR - how are the location criteria defined?
- VMS services are attributed to only one message at a time – how message prioritisation should be defined?

The report is structured as follows: the first section is dedicated to VMS in general, covering the VMS functionalities and capabilities, the applicable standards, and actions dedicated to VMS harmonisation. Following, research was made in order to find real examples of UVAR VMS (images can be found in the annex). Section 3 also covers research studies on VMS and how their conclusions can be transposed to UVAR VMS representation, and the results from the VMS demonstrators. Finally, section 4 states a set of recommendations based upon the desk research covered in this document and the outputs from Subtask 1.1 - Practical aspects of UVAR information provision through signage.

2. Variable Message Signs functioning and applicable regulations and standards

According to the EN 12966 standard, a VMS can be described as "a sign where the information shown can be changed. The information can be text and/or symbols". This method of signalization consists of electronic and intelligent display panels, with good visibility, which allows for showing different symbols and warnings, in several languages. These panels have lots of potentials since they are used widely across Europe, are easy to manage and, when placed in strategic locations, do not require a high investment to be tested in demonstrators.

Variable message signs can be installed as permanent units, portable units, or truck-mounted units. As expected, for UVAR representation, the panel is expected to be fixed/permanent allowing greater

visibility. VMS comprises two types in terms of matrix representation: continuous and discontinuous. The definitions of both types can be the following[1]:

- **Continuous VMS:** A variable message sign that can present messages in the shape of intact sign images or intact characters or both. Continuous VMS uses a full matrix which offers the ability to vary the height of characters, display simple graphics, and use proportionally spaced fonts. From a distance, they are perceived in the same way as stationary road signs.
- **Discontinuous VMS:** A variable message sign based on pixel technique. The matrix can be modular (character blocks) or line matrix (text divided by lines).

Besides continuous VMS having an improved quality of the interface, they are still requiring increased investment since they are not so commonly seen in Europe as the discontinuous panels.

To introduce information into the VMS, a code must be created according to the protocol followed by the VMS brand that is being used. The VMS panel receives the information and displays it on the interface. However, the only information that gets out of the panel is information regarding itself (e.g., identification, location, status, and information displayed) and it is only received by the responsible concessionary, which reports it to the national authority that gets in charge of the data. The panel does not communicate with the vehicles or with platforms such as the National Access Points (NAPs). Nonetheless, information on VMS can be made available by the responsible national authority. In that case, the data should be structured according to a standard to ensure that it is machine-readable and interoperable. The Technical Specification CEN/TS 16157 details and defines component facets supporting data exchange and shared use of data and information in the field of traffic and travel, which comprises a component dedicated to VMS. The informal structures, roles, attributes, and data specifications necessary for the deployment of VMS (under the DATEX II profiles) are provided in the fourth part of the CEN/TS 16157. This document supports the exchange of graphical and textual content (of one or more signs) and provides details to comprehend the status information when configuring the VMS[2].

Currently, the VMS signs already installed in European cities follow the European standard EN 12966. This European standard is bounding for 28 countries[3]. It covers the performance requirements for VMS used for guidance of road users on public and private territory, including tunnels. EN 12966 is usually considered a visual specification, covering issues such as dimensions and tolerances, design requirements, materials, and visual and physical performance. Nevertheless, this standard also contains electromagnetic compatibility, safety, and environmental (physical) requirements. Chapter 9 covers all the guidelines for testing methods, while Annex D offers guidance for dimensions and tolerances of symbols and characters and Annex F supports the design of the messages.

[1] Vägverket (2003). Vägutrustning 94 Supplement 2, Omställbara vägskyltar. VV Publ 2003:113. Vägverket. Sweden. http://www.vv.se/

[2] https://www.arc-it.net/html/standards/standard836.html

[3] Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Moreover, several countries/regions all around the world (e.g., the UK[4][5][6], Ireland[7], Portugal[8], Spain[9], France[10], New York[11]) have already defined their own guidelines for the use of VMS.

The FIVE action (Framework for Harmonised Implementation of VMS in Europe)[12] incorporates a set of recommendations based on scientific and technical documents elaborated by different European projects and relevant VMS publications in the late 1980s and throughout the 1990s. This action was launched to prevent further divergence of VMS messages by stipulating harmonisation guidelines to be implemented by the national road authorities (NRAs). Within this framework, several NRAs reviewed their national guidelines to align them with FIVE recommendations. However, FIVE recommendations are sometimes too vague, leaving space for distinct interpretations and implementations. Within the same lines, in 2012, the EasyWay project launched the report "Variable Message Signs Harmonisation - principles of VMS messages design"[13] which presents the general philosophy of VMS message design, synthesized through 32 principles. Although it is not a standard, this supporting guideline in some cases does mention and sometimes requires the use of such standards.

Finally, the Convention on Road Signs and Signals (Vienna Convention - VC) took place in Vienna, in 1968, where the United Nations Economic and Social Council brought together the concern of standardising the signing system for road traffic internationally in use. Article 7 of the Convention is the only one involving 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". Following the VC, in 1971, the COST 30 action (COST = European Cooperation in the field of Scientific and Technical Research) was launched to improve road safety and traffic flow using electronic systems. In 2009, CEDR's Task Group O9[14] drew a report with the aim of monitoring developments and understanding the obstacles to VMS harmonisation and interoperability. The work should focus on informing CEDR about the time frame in which issues should be resolved and developing a strategy for their resolution.

---

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/397832/150123_TAL_Variable_Message_Signs__for_web_publication_.pdf

[5] https://artsm.org.uk/media/Guidance-on-the-correct-application-for-VMS-in-the-UK-120721-v2.2-FINAL.pdf

[6] https://www.whatdotheyknow.com/request/59/response/1735/attach/2/VMS%20Doc%20Issue%203%202.pdf?cookie_passthrough=1

[7] https://assets.gov.ie/34712/1bc816e06b714b7da28c8f3809d4222e.pdf

[8] https://www.imt-ip.pt/sites/IMTT/Portugues/InfraestruturasRodoviarias/InovacaoNormalizacao/Divulgao%20Tcnica/InstrucaoTecnicaUtilizacaoSinalizacaoMensagemVariavel.pdf

[9] https://unece.org/DAM/trans/doc/2011/wp1/Informal_document_05e.pdf

[10] Panneaux de Signalisation à Messages Variables. Guide Technique. SETRA. 1994.

[11] https://www.thruway.ny.gov/commercial/forms/tap633.pdf

[12] Framework for harmonised Implementation of VMS in Europe (FIVE), Conference of European Directors of Roads, 2003

[13] https://www.transport.gov.mt/PrinciplesOfVMSDesign.pdf-f1741

[14] CEDR's Task Group O9, VMS harmonization in Europe, 2009

3. Variable Message Signs and UVARs: the European overview

3.1 VMS applications

This section provides a critical overview and real examples of VMS already operating in Europe with UVAR information. Pictures and descriptions can be found in the Annex and are organized by indicating examples for the following UVAR types: low emission zone (LEZ), limited traffic zone (LTZ), pollution emergency schemes (EMERG schemes), Congestion charging (CS). We've found LEZ examples from the UK and the Paris region, LTZ in the Italian cities, CS in the UK and the Nordic countries, and EMERG all across Europe (IT, AU, ES, CHE, FR, BE, DE, HU, NO).

By analysing the existing VMS panels already presenting UVAR messages (as can be seen in the Annex), some main conclusions can be considered regarding what is already being used in distinct European cities:

- UVAR VMS in Europe are far from being harmonized; some similarities are commonly noticed between neighbour cities (same country); however, they differ a lot between countries.
- UVAR VMS are frequently used for pollution emergency schemes (EMERG schemes).
- National abbreviations are still being used.
- Usually, only the local language is used.
- Text prevails over symbols.
    - The symbols mainly used are concerning speed limits.
    - Spain uses sometimes a polluting car symbol on the EMERG schemes.
    - Switzerland, Belgium, and Germany use sometimes a warning symbol on the EMERG schemes.
    - Stuttgart uses symbols to describe the vehicles recommended on the EMERG schemes.
- VMS are never used for the end zone.

Such preliminary considerations and conclusions will be validated with cities during the demo phase, adding examples and practices on VMS coming from their own experience.

3.2 Findings from previous Variable Message Signs studies

The path aligning VMS and UVARs is still in early stages. Nevertheless, to set up recommendations, several studies were already performed to analyse the relationship between VMS characteristics and drivers' behaviour.

A study[15] was conducted to find out if the compliance was higher for a VMS speed limit sign displayed with another sign explaining why the speed limit was set. The conclusion was that speed limit signs were most often obeyed, however, the addition of information justifying the speed limit resulted in even higher compliance. The same authors conducted other experiences and the results showed that symbols were better than pure text messages and redundant information should be avoided. Within the same lines, it was recognized that in the Netherlands, when a VMS is used for the adaptation of speed limits, the compliance is greater when the lower speed is accompanied by an explanation of its reason[16].

A German study showed that when the difference between the information prescribed in the VMS and the actual traffic situation was large, the compliance was lower. This led to the conclusion that improvement can be made by optimizing the detection of an occurring incident. This seems to be a situation to consider when positioning VMS informing about UVARs. If the sign is too far from the UVAR location, the perception may not be clear. Still, the positioning has to be far enough to allow the driver to make a safe decision for an alternative route. This paradox can be solved by using a combination of signals at the entrances of the restricted areas and prior signals warning on the approximation to it (this applies not only to VMS but also to conventional signage).

Kronborgs (2001)[17] identified two major characteristics for showing effective VMS: expectations (drivers expect having the system working with updated information) and credibility (the information must be relevant). Another study[18] revealed that most drivers would be frustrated if the information on the VMS was imprecise and 80 % of the drivers that participated in the study showed interest in having available on the sign the time when it was first posted. In this framework, it must be ensured that the information is easily perceptible, reliable, and up to date. VMS has the great advantage that the information can be changed anytime. This is especially relevant for temporary and triggered schemes, such as pollution emergency schemes. Nonetheless, this functionality can also be used in other UVAR types where the UVAR information would only be displayed for its hours of operation. This would also allow the VMS to be used for other purposes when out of these periods.

A study in the United Kingdom[19] analysed drivers' comprehension of 20 distinct VMS designs for congestion information. Results showed that three lines of text were harder to understand than two

[15] Steinhoff, Christiane, Keller, Hartmut, Kates, Ronald, Färber, Brigitte & Färber, Berthold (2000). Driver Perceptions and the Effectiveness of Preventative Traffic Management Strategies. Proceedings of the 7th World Congress on Intelligent Systems, Turin, Italy, 6–9 November, 2000.

[16] de Craen, S. & de Niet, M. (2002). Extra information on Dynamic Message Signs: possibilities and effects. (Extra informatie op matrixborden: mogelijkheden en effecten.) Stichting wetenschappelijk onderzoek verkeersveiligheid SWOV, R-2002-13, p. 37. Netherlands.

[17] Kronborg, Peter (2001). VMS för omledning. Movea Trafikkonsult AB. Stockholm, Sweden. Available: <http://www.movea.se/vms_omled.pdf> [2006-02-06].

[18] Cheng, Jason J. (2002). Driver perceptions of the effectiveness of VMS. Traffic Engineering & Control (Nov 2002), 43(10), pp 383-6. London, United Kingdom.

[19] Richards, Andy, McDonald, Mike, Fisher, Granville & Brackstone, Mark (2004). Investigation of Driver Comprehension of Traffic Information on Graphical Congestion Display Panels using a Driving Simulator. European Journal of Transport and Infrastructure Research, 4(4), 2004, pp 417–35.

lines and non-flashing signs were preferred by the participants. Another study[20], conducted in Sweden, revealed that there is a conflict between clarity and reading time of the information. Thus, the authors suggested that it is better to make sure that the message is read, i.e. a short message, than to know the exact reason of the message. Moreover, a study[21] concluded that VMS messages including numerals had lower legibility, nevertheless, the legibility could be improved by widening the spacing between the characters. The same conclusion was noticed for difficult words.

Some studies[22][23] also analysed the impacts of bilingual VMS messages. The general conclusions were that if the message is kept short (up to two lines per language), it will not affect much the reading times. Also, to facilitate the reading, the message should be grouped by language and not by content. The first language displayed is also the easiest/fastest to read.

3.3 UVAR Variable Message Signs demonstration activities

3.3.1. Overview

This section presents the VMS demonstration activities done within the scope of the UVAR Exchange project. After the first draft delivered in April 2022 and continuing the discussions that started with the first workshop in December 2021, additional discussions with cities and organizations related to signage systems took place with and a feedback loop was created between the UVAR Exchange consortium and the cities aiming to participate in the VMS demonstrator.

Two cities were able to demonstrate the feasibility of using VMS for UVAR related messages, the city of Lisbon (Portugal) and the city of Monza (Italy). The cities were involved in discussions with the consortium, and after some iterations it was possible to come to an agreement about the messages to be displayed. The two demonstration activities are presented in more detail below.

3.3.2. Lisbon

The city of Lisbon in Portugal took part at both the demonstration on standard physical UVAR road signs and VMS. Besides the municipality experts, during the workshops the National Road Safety Authority (ANSR), and the Mobility and Transport Agency (IMT) were also present.

The city has two Low Emission Zones (LEZ). Zone 2, represented in yellow in Figure 1, restricts access for vehicles pre-Euro 2 (vehicles before 1996) and Zone 1, represented in pink in Figure 1, is more restricted and doesn't allow vehicles pre-Euro 3 (before 2000) to enter the zone.

[20] Samuelsson, Stefan (1999). Trafikantens förståelse av skriftliga trafikmeddelanden. VTI notat 40-1999. Sweden: Statens väg- och transportforskningsinstitut.

[21] Cooper, B.R., Freeman, M. & Mitchell, J.C. (2004). MS4 off-road research summary report. TRL Report TRL604 (Revised version of TRL556). TRL Limited. Berkshire, United Kingdom.

[22] Jamson, S.L., Tate, F.N. & Jamson, A.H. (2001). Bilingual variable message signs: a study of information presentation and driver distraction. Proceedings of the first international symposium on human factors in driver assessment, training and vehicle design, Aspen, Colorado, August 14–17, 2001, pp 153-8. University of Iowa.

[23] Jamson, S.L. (2004). Evaluation of techniques to improve the legibility of bilingual Variable Message Signs. Advances in Transportation Studies: An International Journal, vol 4, pp 71–88.

Figure 1: Lisbon's LEZs and VMS panels' locations.

From the panels already installed and available in the city, two panels were in an appropriate location to provide information about the LEZ active in the city center. The yellow marker in Figure 1 shows the location of panel 1, which should indicate the approach to Zone 2. The pink marker (already inside Zone 2) should indicate the approach to Zone 1.

The panels are from different brands and have different characteristics (e.g., dimension and resolution). After a loop of discussions and iterations, the messages considered for both panels are the ones shown in Figure 2.

For the pictogram included in panel 1, it is considered both options presented in Task 1.2 recommendations' report *"Towards the common European road signage for LEZs & ZEZs: Outcomes and recommendations from a series of workshops with stakeholders"*. This report proposes two possibilities for the main panel roundel: Option A: Red roundel, blank centre (C2 sign); Option B: Red roundel with the symbol of a polluting car. The explanation of these proposals is detailed on the above-mentioned document. Following this approach, the inclusion or not of the polluting car inside the C2 pictogram (red circle) would depend on its quality after running the first test. After further discussions with the Portuguese National Road Safety Authority (ANSR), it was indicated that the sign with the polluting car was not included in the Portuguese Traffic Signage Regulation (RST) and therefore it could not be legally used. For panel 2, since it had a reduced number of pixels, the polluting car symbol was technically not an option.

Figure 2: VMS messages proposals for Lisbon: a) panel 1; b) panel 2.

Panel 1 (approaching Zone 2)

a)

Panel 2 (inside Zone 2 and approaching Zone 1)

b)

Unfortunately, during the demonstration's activities period, the panel 1 was not available and only panel 2 was used. It is worth mentioning that we also received feedback from ANSR on panel 2, which was partially approved. They agreed with the message, however, according to the RST, the message should have used capital letters. Unfortunately, this feedback was only received after the real-life demonstration and could not be corrected in time, being mentioned in the present report.

The real-life demonstrator took place on the 12th of October 2022. Figure 3 shows real photo of the implementation.

Figure 3: Real photos from the VMS demo in Lisbon: a) panel without the message (showing the time); b) panel with the UVAR message (from distinct frames).

3.3.3. Monza

The Mobility Agency of the city of Monza in Italy took part at both the demonstration on standard physical UVAR road signs and VMS. Also, the Lombardy Region and the city of Milan have been involved in demo activities and all these entities are subject to the rules of the multi-regional agreement on air quality in the Po Valley which includes the application of a Low Emission Zone.

This is the largest coordinated pollution emergency scheme implemented in in four Northern Italian regions (Piemonte, Lombardia, Veneto and Emilia Romagna) as part of the agreement for air quality in the (river) Po basin.

Municipalities are divided into 3 groups with different applicability of restrictions that also includes home heating and agriculture.

Permanent restrictions

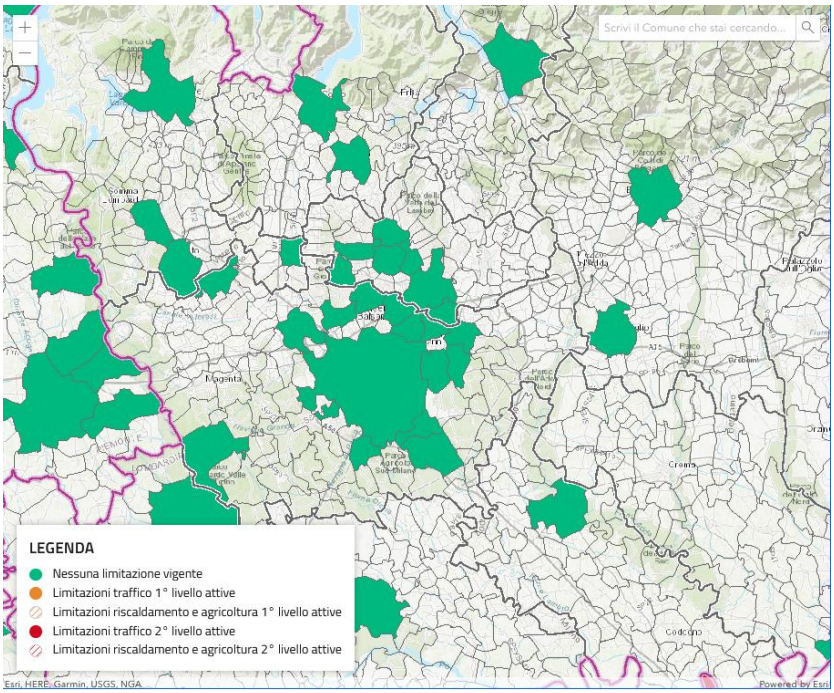
• *Minimum emission standard Diesel Euro 4, Petrol Euro 3, Moped/Motorcycle Euro 2; active on weekdays,* from 7:30 to 19:30

Pollution Emergency (October to March)

• *Level 2 (orange) – 4 days PM_{10} exceeding concentration of 50 µg/m^3 : minimum Diesel standard Euro 4 also during weekends (8:30-18:30)*

• *Level 3 (red) – 10 days PM_{10} exceeding concentration of 50 µg/m^3 - minimum Diesel standard Euro 5 all days 8:30-18:30*

Figure 3: Location of the pollution scheme.



The real-life demonstrator in Monza took place on the 17th of October 2022. Figure 4 shows a real photo of the implementation.

Figure 4: Real photo from the VMS demo in Monza.

3.3.4. Results and challenges

Overall, it was possible to consider two cities for the VMS demonstration activities: Lisbon (Portugal) and Monza (Italy). A total of three UVAR messages were designed but only two could be tested in real-life, due to legal issues. The demonstration had a theoretical phase where the messages proposals were discussed considering previous findings from studies and current practice, and a practical phase where the technical, legal and operational requirements were assessed, and the necessary adjustments made.

One of the main challenges faced was the limitations associated with each panel's characteristics. The regulations and standards must be carefully followed, however, when it comes to recommendations, they serve only as guidelines for obtaining a result with the higher quality possible. This applies to the defined UVAR VMS messages used in the demonstration activities. While trying to follow the recommendations identified in Tasks 1.1, 1.2 and 1.3, it was possible to conclude that not all can be applied at the same time since there are always limitations from different kinds. For instance, the location of the panels was not perfect since they were reused instead of strategically installed for project purposes. Furthermore, the dimensions and resolution of the panels were a limitation to present more information (e.g., bilingual messages), a clearer sentence, or more detailed pictograms (e.g., prohibition symbol with a polluting car due to lack of legal basis).

In that framework, besides having a set of recommendations to guide the process of defining a message, there is no defined recipe, and each case must be analysed carefully to achieve a harmonised and comprehensible result.

4. Recommendations and Final Considerations

Overall, studies on VMS and UVARs are scarce. Nevertheless, much has been analysed regarding the VMS messages and how they affect drivers' behaviour. Recommendations have already been released regarding vertical signs (subtask 1.1). UVARs in VMS should be based on these recommendations, in combination with what has already been proven to be most effective for the presentation of a VMS (established on standards, research studies, and the overall documents found on VMS guidelines towards harmonisation). Of course, the capabilities of this technology and advantages over typical signs should also be considered.

The main conclusions from this preliminary research are therefore converted into a set of recommendations for representing UVARs through VMS. Moreover, this was an iterative work based on the feedback gathered in our interactive sessions and demos.

4.1 Recommendations & next steps

In summary, the following **recommendations** can be set:

- Pictograms should be central to VMS use. The amount of text should be minimised. It should be noted that this is often not currently the case for UVAR VMS in practice (see photos in Annex).
- It must be ensured that the information is easily perceptible. When using pictograms, they should be the main element of the message, and the information should be provided through official pictograms (Vienna Convention); only highly standardized pictograms should be used.
- For common understanding, pictograms displayed on VMS must also reproduce as close as possible the ones used in common vertical signs in terms of proportions and colours. Since VMS often have a black/dark grey background, sometimes, colours can be adapted to guarantee an adequate contrast between the background and symbols. The same can happen between day and night messages, according to the natural light (this applies for continuous VMS, which are capable of changing the background colours – check pictures from the Pollution emergency scheme in Valladolid (ES) in the annex.
- It must be ensured that the information is reliable, and up to date. Experience has shown that, if the information displayed is out of date, drivers soon learn to disregard the signs, thus negating the value of the VMS.
- To avoid distraction and improve understanding, free text should be limited to the minimum. Following the FIVE standards it should contain no more than 5-7 words.
- Local abbreviations and acronyms should be avoided.
- While primarily designed to serve the citizens of each country, nowadays VMS must be understood by road users of all nationalities to be fully efficient. To guarantee a wider coverage

of drivers from distinct nationalities, bilingual messages should be used; the information should be organized by language displaying the local language in the first place (since it is the one which will be read more often); the message should be short (up to two lines per language) and simple (avoiding national notions). When using symbols, preference should be given to those that can be applied internationally (e.g., à, =, /, or those from the Geneva Convention main and sub-signs).

- The legibility of numbers or difficult words can be improved by widening the spacing between the characters.
- Generally, guidelines for VMS state that we should avoid adding more information using complementary text (e.g., explanatory text), however, sometimes the use of additional information explaining the restriction can be valuable to help increase compliance (if it gives valuable information and if it is kept simple and does not add too much complication to the sign). Also, the accuracy of the information benefits drivers' understanding and resulting behaviour (e.g., indicating "LEZ in 2 km" is preferable to "LEZ ahead").
- According to the EU EasyWay Guidelines "VMS should only be used for the management of temporary events."[24] Within that framework, it is best to use the VMS to display the UVAR information only for its hours of operation; allowing the signal to be also used for other purposes such as awareness-raising/campaign messages at other times. To avoid distraction, the VMS can also be switched off (or only displaying the hour) when the UVAR is not active. This is also aligned with the Vienna Convention, Article 7.
- Flashing signs and alternating messages should be avoided (they are a potential distraction to drivers and do not add any benefit to the communication of the UVAR).
- There are several issues to take into consideration when determining where the VMS should be located. These are related to the kinds of information provided and, in each case, the VMS location should be such that drivers have the chance to safely react to the information being displayed. For UVAR information, the panel is displaying strategic information, so it should be positioned far enough from the gates to allow the consideration of an alternative route or to change the travel plans as necessary; however, it should be close enough for the drivers to perceive the situation and better identify the restricted area. Additional advance warning signs/panels (VMS or not) can be used to inform about the distance to a restriction and gather attention/alertness to further signals.

  In sum, when determining the VMS location, the following reaction times must be ensured to enable the driver to:

  - Detect the sign
  - Read and comprehend the message
  - Initiate and implement a response

[24] The EasyWay PRINCIPLES OF VMS MESSAGES DESIGN Supporting guideline. The European Member States have consequently launched the EasyWay project together with the European Commission as a platform to harmonise their ITS deployments https://www.transport.gov.mt/PrinciplesOfVMSDesign.pdf-f1741

    - Make appropriate decisions based on the information gained from the message

- To gain uniformity, VMS should be taken as a whole package, considering a certain pictogram-text sequence as a road sign that should be made official and allow comprehension worldwide.

After drafting recommendations and guidelines for designing UVAR messages for VMS panels, the following **next steps** could considered:

- Harmonisation is possible. This can be done by avoiding redundant and/or not essential information, improving the use of symbols instead of/ or in association with text, and properly organising the information on the panel. Collaborative work among authorities focusing on signage should continue in order to come up with real harmonized UVAR signs on the streets. This could be done via the CIVITAS Initiative (trainings, workshops, etc.) or through an "UVAR3 action".
- There is a need to invest more efforts in UVAR design (focus on the presence of different UVAR schemes, boundaries, time validity, etc.) and adopt a driver perspective to allow for better comprehensibility. Collaborative work should always include a preliminary module on UVAR design.
- The involvement of national authorities in collaborative work (via the UNECE WG or other coordination bodies at EU level) for the adoption of a common approach to UVAR signage is fundamental. Cities cannot change signs and panels layouts alone and must continue to work closely with the UNECE WGs.
- Some national "practical" guidelines on UVARs have been released (Italy, Spain, France). An EU UVAR Design/Signage Guidelines can be drafted combining different elements coming from national authorities and the collaborative work.
- The recommendations and guidelines should be implemented in real-world scenarios. This requires collaboration between the relevant authorities, such as traffic and transport departments, and the manufacturers and suppliers of VMS panels.
- Once implemented, the UVAR messages on the VMS panels should be tested and evaluated to ensure that they are effective in communicating the intended message to drivers. This could involve monitoring driver behaviour before and after the installation of the VMS panels or conducting surveys to gather feedback from drivers. Moreover, based on the results of the testing and evaluation, the UVAR messages on the VMS panels may need to be refined or revised.
- Even with clear and effective UVAR messages on VMS panels, it is important to educate drivers about the importance of following urban vehicle access regulations. This could involve targeted outreach campaigns, such as social media ads or posters in high-traffic areas, to raise awareness and encourage compliance with UVARs.
- Finally, it is important to continue monitoring and improving the effectiveness of the UVAR messages on VMS panels over time. This could involve regularly reviewing and updating the messages to reflect changes in regulations or best practices, or conducting periodic evaluations to ensure that the messages are still effective in achieving their intended goals.
- To implement the steps above, it is crucial to establish partnerships, define clear testing protocols, allocate resources, and create education and outreach programs.

4.2 Final considerations

The focus of this report was to conduct research that would result in recommendations for representing UVAR VMS in a simple, inclusive, and comprehensible way. To achieve this end, research was conducted, as well as demonstrators and interactive sessions with a targeted audience.

In April 2022, the first version of the report was released, mainly fed by desk research. Then, the report was validated and further enriched during the UVAR Exchange demonstrators that aimed to share common practices of UVARs' information provision across the EU and above all to foster cooperation to enable completeness, clarity and harmonisation of UVAR VMS/physical road signs.

UVAR Exchange Demo 1 involved city officials dealing with traffic management and UVARs, different city authority departments (e.g., transport, environment, data) but also key representatives from the Transport Ministries as well as other relevant stakeholders.

Representatives of EU cities having different characteristics in terms of UVAR schemes joined the Demo either as demonstrators (the cities of Lisbon and Monza tested the VMS in their local context) or observers (to take part in collaborative activities and discussions). They were asked to share their views, experiences, and resources (including photos of installed signs and VMS at different locations) and to take part in interactive plenary discussions.

Results from the demonstrators, discussions, and Task 1.1, were crucial to feed this final version of the report, with a set of agreed recommendations and an Annex of collected UVAR VMS practices across Europe.

ANNEX 1 – Collection of UVAR VMS

Low Emmission Zones (LEZ)

Figure 5: LEZ in Antwerp (BE) (source: https://vrtnws.be/p.L7oK3KM9M)

Translation: low emission zone from 1 February 2017; check car on SNA.BE/LEZ

Figure 6: LEZ in Bath (UK) (source: AFP)

https://en.prothomalo.com/environment/uk-city-where-romans-bathed-penalises-polluting-cars

Figure 7: LEZ in London (UK) (source: autoexpress.co.uk)

https://www.autoexpress.co.uk/news/357494/plans-expand-ulez-london-wide-2023

Figure 8: LEZ near Paris (FR) (source: THIERRY GACHON / MAXPPP)

Translation: pollution; adapt your speed

https://www.francetvinfo.fr/economie/automobile/diesel/circulation-differenciee-zones-a-trafic-limite-mobilites-douces-ces-mesures-a-court-ou-moyen-terme-pour-reduire-la-pollution_3507009.html

Figure 9: LEZ Île-de-France region (FR) (source: ornikar.com)

Translation: pollution; differentiated traffic; vignettes 4 and 5 traffic bans

https://www.ornikar.com/code/cours/ecologie/ecomobilite/circulation-differenciee

Figure 10: Diesel ban Oslo (NO)

Picture of VMS in use for ban of diesel cars in Oslo 2017

Figure 11: LEZ Milan (IT) (source: TRT)

Limited traffic zones (LTZ)

Figure 12: LTZ in Cittadella and Parma (IT) (source: aesys.com)

https://www.aesys.com/it/prodotti-soluzioni/smart-cities/pmv-infomobilita-en12966.html

Figure 13: LTZ in Lecce (IT) (source: TRT)

Figure 14: : LTZ in Rome (IT) (source: ARMIS)

Figure 15: LTZ in Brindisi (IT) (source: TRT)

Pollution emergency schemes (EMERG schemes)

Figure 16: Pollution emergency scheme in Treviso (IT) (source: TRT)

Translation: Ecological Sunday; Level 2 RED All days 8:30-18:30

Figure 17: Pollution emergency scheme in Salzburg (AU) (source: Neumayr/MMV)

IG-L: Air Pollution Control Law

https://emobly.com/de/news/oesterreich-hebt-umwelt-tempolimit-fuer-e-autos-auf/

Figure 18: Pollution emergency scheme in Madrid (ES) (source: a) Victor Sainz b) Álvaro García/EP c) Denis Doyle/Getty Images News; d) EFE/ Sergio Barrenechea

a)

b)

c)

d)

Translation: a) b) due to high pollution; c) d) M30 - accesses; recommended speed

a) https://elpais.com/ccaa/2018/12/25/madrid/1545733669_183707.html
b) https://elpais.com/ccaa/2018/12/04/madrid/1543954695_302658.html#?rel=mas
c) https://autoesporte.globo.com/carros/noticia/2016/01/madri-restringira-circulacao-de-carros-se-poluicao-piorar.ghtml
d) https://www.elperiodico.com/es/trafico-y-transportes/20161222/madrid-limita-la-velocidad-en-los-accesos-por-contaminacion-5706831

Figure 19: Pollution emergency scheme in Valladolid (ES) (source: a) EUROPA PRESS - ARCHIVO; b) @PoliciaVLL)

a) **b)**

Translation: contamination protocol; activated

a) https://diariodevalladolid.elmundo.es/articulo/valladolid/ayuntamiento-valladolid-activa-alerta-preventiva-contaminacion-atmosferica/20200109134108370517.html

b) https://www.tribunavalladolid.com/noticias/desactivada-la-situacion-1-por-contaminacion-atmosferica-en-valladolid/1551725196

Figure 20: Pollution emergency scheme in Geneve (CH) (source: O DL/SC)

Translation: air pollution peak; 80 km/h; obligatory

https://www.ledauphine.com/haute-savoie/2019/11/06/circulation-differenciee-a-geneve-en-cas-de-pollution-des-le-15-janvier

Figure 21: Pollution emergency scheme in the surroundings of Paris (FR) (source: a) 2015/REUTERS/Charles Platiau; b) AFP; c) 2015/REUTERS/Charles Platiau; d) Mario Fourmy/SI

a)

b)

c)

d)

Translation: a) pollution; slow down; b) 10/01 speed limit of 70 Km/h; c) vehicles - prohibited pairs; d) critical air 3/4/5/NC prohibited

a) https://www.capital.fr/economie-politique/la-circulation-alternee-ne-sera-pas-reconduite-mardi-1025068
b) https://www.challenges.fr/afp/circulation-alternee-une-mesure-experimentee-sans-pagaille-il-y-a-un-an_105407
c) https://www.20minutes.fr/paris/2569083-20190722-paris-circulationalternee-fait-retour-mardi-capitale

Figure 22: Pollution emergency scheme in Paris (FR) (source: Getty / Manuel Cohen)

Translation: exterior peripheral access golden door; peripheral road closures; info roadway; 17/03 from 5:30 am traffic prohibited

https://www.franceinter.fr/economie/4-millions-d-euros-par-jour-le-cout-de-la-circulation-alternee-a-paris

Figure 23: Pollution emergency scheme in Lyon (FR) (source: villedegenay.com)

Translation: pollution peak; less than 20 km/h; mandatory

https://www.villedegenay.com/alerte-pollution-de-niveau-2-particules-fines/

Figure 24: Pollution emergency scheme in Vlaanderen Region (BE) (source: verkeerscentrum.be)

https://www.verkeerscentrum.be/veelgestelde-vragen/wat-betekent-smogalarm-op-de-snelwegen-hoe-en-wanneer-wordt-de-smogmaatregel

Figure 25: Pollution emergency scheme in Stuttgart (DE) (source: a) b) c) Lichtgut/Leif Piechowski; d) Stadtblick Stuttgart / Fotolia; e) ddp/imageBROKER/Lilly)

a)

b)

c)

d)

e)

Translation: a) Fine dust alarm; until 24 o'clock today; Stuttgart environmental zone; Use buses/trams

b) to e) Fine dust alarm in Stuttgart; currently please

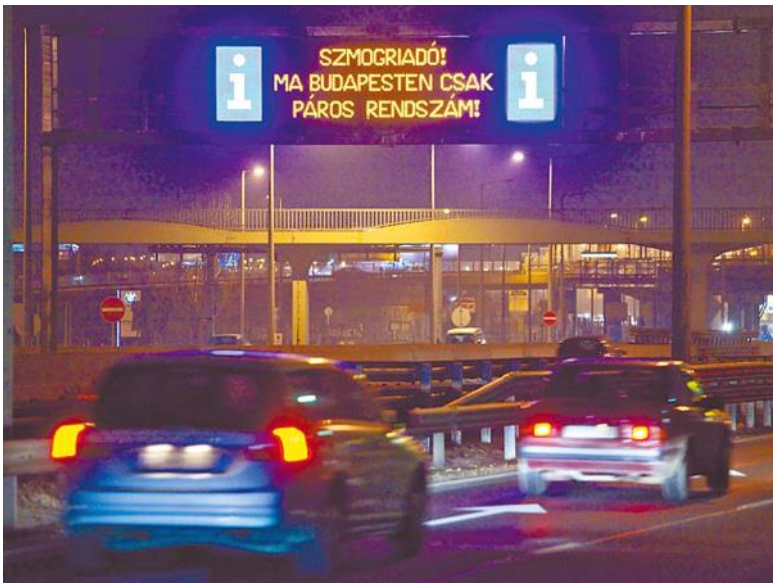
a) https://www.stuttgarter-nachrichten.de/inhalt.stuttgart-schafft-einen-streitpunkt-ab-endgueltiger-abschied-vom-feinstaubalarm.fc439ee3-63bd-4177-bed9-4fefd8649892.html

b) https://www.stuttgarter-zeitung.de/inhalt.feinstaub-in-stuttgart-stadt-kuendigt-naechsten-feinstaubalarm-an.23c62d3b-e60a-4cc1-856d-ae4ff045b787.html

c) https://www.stuttgarter-zeitung.de/inhalt.feinstaubalarm-in-stuttgart-schnellere-infos-ueber-apps.0ca2ac47-ebe5-448e-b239-83bee526387e.html

d) https://www.geo.de/natur/nachhaltigkeit/16871-rtkl-stuttgarter-diesel-urteil-fuer-das-recht-auf-saubere-luft

Figure 26: Pollution emergency scheme in Budapest (HU) (source: Németh András Péter)



Translation: smog alert today in Budapest only even number plates.

Figure 27: Pollution emergency scheme in Oslo (NO) (source: Håkon Mosvold Larsen / NTB scanpix)

Congestion Charging (CS)

Figure 28: CS in Stockholm (SE) (source: urbanaccessregulations.eu)

Figure 29: CS in Bergen (NO) (source: aftenbladet.no)

https://www.aftenbladet.no/lokalt/i/21A0LG/sjokk-effekt-av-rushtidsavgiften-i-bergen

Figure 30: CS in London (UK) (source: a) Avpics/Alamy Stock Photo/Alamy; b) David Dixon)

a) **b)**