



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

Contract: MOVE/B3/SER/2020-716/SI2. 852092

FINAL REPORT

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Draft final report: submitted on 23rd January 2023

Final report: 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

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Abbreviations and acronyms

ACE	Auto Club Europa
ACEA	European Automobile Manufacturers' Association
ANPR	Automatic Number Plate Recognition
ATM	Metropolitan Transport Authority
CBD	Cross-Border Enforcement
CCZ	Congestion Charging zone
CEDR	Conference of European Directors of Roads
C-ITS	Cooperative Intelligent Transport Systems
CLARS	Platform on Charging, Low Emission Zones, other Access Regulation Schemes
COVID-19	SARS-CoV-2
CORTE	Confederation of Organisations in Road Transport Enforcement
DSRC	Dedicated Short Range Communications
EETS	European Electronic Toll Service
eIDAS	electronic IDentification, Authentication and trust Services
EReg	Association of European Vehicle and Driver Registration Authorities
EUCARIS	European car and driving licence information system
ExVe	Extended Vehicles
FIA	Federation Internationale de l'Automobile
FSV	Forschungsgesellschaft Straße-Schiene-Verkehr
IMI	Internal Market Information System
IRU	International Road Union
IVI	In-Vehicle Infotainment
LEZ	Low Emissions Zones
LTZ	Limited Traffic Zones
NAP	National Access Point
NAR	National Road Authority
PED	Pedestrian Zones/Areas
PEDP	Pedestrian Priority Zones

PZ	Pedestrian Zones
UNECE	United Nations Economic Commission for Europe
UVARs	Urban and regional Vehicle Access Regulation
ULEZ	Ultra-Low Emission Zones
VC	Vienna Convention
VC	Verifiable Credential
VMS	Variable Message Signs
ZEZ	Zero Emission Zones

ABSTRACT

Urban Vehicle Access Regulations (UVARs) are used to regulate the movement of vehicles in urban areas and by cities to address issues such as air pollution, climate change, congestion and the protection of historic centres. However, UVARs can be very complex regarding admittance, time frames, exceptions, etc. (e.g., low emission zones (LEZs)), which leads to challenges around how the correct information can be transmitted to the road user/vehicle. UVAR signage is not harmonised across Europe and there are also issues when it comes to the sharing of information across borders, due to the current legal constraints, the ability to access / share data and data quality. This study has two objectives. Firstly, to improve the communication of information to drivers in the vicinity of UVARs, including physical signs, variable message signs (VMS) and cooperative intelligent transport system (C-ITS) messages. Secondly, the analysis of the technical and legal challenges related to data sharing and enforcement of UVARs, giving recommendations to enable the cross-border sharing of vehicle and driver information for enforcement. Solving this issue aims at the same time to avoid the need for foreign drivers to pre-register for separate LEZs and streamline compliance checks of foreign vehicles for UVAR authorities.

EXECUTIVE SUMMARY

Urban Vehicle Access Regulations (UVARs) are used to regulate the movement of vehicles in urban areas and are used by cities to address issues such as air pollution, climate change, congestion and the protection of historic centres. However, UVARs can be very complex regarding admittance, time frames, exceptions, etc. (e.g., LEZs or congestion charging), which leads to challenges around how the correct information can be transmitted to the user/vehicle. UVAR signage is not harmonised across Europe and there are also issues when it comes to the sharing of information across borders, due to issues with legal constraints, the ability to access / share data and data quality.

The broad objectives of this study are to firstly improve the communication of information to drivers in the vicinity of UVARs (Task 1) and secondly to better enable the cross-border sharing of vehicle and driver information, both technically and legally (Task 2). The study took an evidence-based approach combined with broad, collaborative stakeholder consultation to achieve the objectives mentioned above. This was done using a combination of desk research, stakeholder consultations e.g., interviews, bilateral meetings, workshops, the development of a survey with key stakeholders and various demonstration activities. The demonstrations were conducted in European cities to test the use of signage, VMS and C-IIS to improve the communication of UVAR information and the use of different systems to enable cross-border information sharing.

The specific objectives of Task 1 were to look at how UVARs can, within their vicinity, provide easily understandable, clear, complete and updated information to road users by adequate signage, including standardisation and integration in digital tools VMS and C-IIS. The **main findings** of the first task are as follows:

1) Current UVAR signage lacks harmonisation, however, there are some keyways through which harmonisation can be achieved

While there are many similarities with the main zonal panels across the Member States, there are still ways these panels could be improved. In addition, the information provided on panels, clarifying all rules, differs a lot across Europe, both in the way information is displayed (order of information, use of text and symbols or predominance of text) and in terms of completeness and clarity of signage. However, the desk research and stakeholder consultations showed that further harmonisation of UVARs is possible, by avoiding redundant and/or not essential information, improving the use of symbols to reduce the amount of text and properly organising the information on the panels. Improved main and additional panels were designed, together with recommendations for their use, starting from existing UVAR schemes in the demo cities. These outcomes have been submitted to the UNECE Group of Experts on Road Signs and Signals as input work to improve and extend UVAR-related road signs, including the discussion on the adoption of a new sign for Low/Zero Emission Zones. The document was discussed at the 9th Informal meeting of the Group of Experts which took place on the 6 December 2022.¹ Following the same approach, national authorities should be coordinated and supported to work together in order to introduce new signs and symbols and transfer signage adaptations in guidelines or national norms.

¹ <https://unece.org/transport/events/ge2-group-experts-road-signs-and-signals-9th-informal-meeting>

2) Advance warning and UVAR design

The location of signs should be such that drivers have the chance to safely react to the information being displayed – in other words there should be advanced notice signage, certainly, signage before the last diversion is possible, as well as at the entrance of the UVAR. More informative signs positioned before the entry of an UVAR can also reduce the amount of information to be displayed on entry zonal panels. The way UVARs are designed – in terms of coexistence of more typologies, boundaries, time validity and enforcement - largely influence their comprehension by drivers. Dissemination and learning opportunities should focus more on UVAR design and practical elements but following a user-centric approach.

3) There is potential to convey UVAR information through VMS

Despite limited evidence on use of VMS in UVARs specifically, the study found that VMS can be used as a tool to convey UVAR information, particularly for schemes that are not in operation 24/7 or reactive. The recommendations developed regarding vertical signs (point above) should also be applied to VMS, along with what has already been proven to be most effective for the presentation of a VMS, including the use of pictograms, minimal text, standard colours and bilingual messages. Of course, the capabilities of this technology and advantages over typical signs should also be considered. To gain uniformity, VMS should be considered as a whole package, with a certain pictogram-text sequence as a road sign that should be made official to allow comprehension worldwide. To test the potential to use VMS as a tool to convey UVAR information, demonstrators were conducted in two cities - Lisbon (Portugal) and Monza (Italy). These demonstrators showed that, 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) There is potential for the use of C-IIS for UVARs, however, it is at a nascent stage of development and further research and innovation are required

C-IIS service provision is seen as a possibility to interact about active UVARs directly with single vehicles based on information provided directly by the regulating authority. The C-IIS demonstrator, whose aim was to show the potential of existing and upcoming C-IIS UVAR services for UVARs, showed that the length and duration of the messages were important factors. The C-IIS message was shortened and displayed the whole time (i.e., while the vehicle is within an UVAR zone and not only along the border of the zone). In addition, it was found that the C-IIS IVI message is not practical in urban areas because it was designed for a linear setup (i.e., motorways) and cannot be used for areas like a city district, which is usually the case for UVAR Zones. Therefore, the C-IIS message needs to be adapted to fit a UVAR area. However, it became evident that the use of C-IIS for UVARs is still a development task. To test the potential to use C-IIS as a tool to convey UVAR information, demonstrators were fully conducted in two cities/region – Vienna (Austria) and Trento (Italy). The deployment of C-IIS infrastructure in urban areas is currently a work in progress and many cities were not aware of the topic of C-IIS. This project raised awareness for the topic and took the first steps, nevertheless more investments and adjustments to C-IIS systems are required for them to be appropriate for UVARs in the future.

Way forward and next steps:

- **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 harmonised 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 and/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** (e.g., Italy, Spain, France). An EU UVAR Design/Signage Guidelines can be drafted combining different elements coming from national authorities and the collaborative work.

The specific objectives of the Task 2 were to understand the complexities in sharing data needed for cross-border UVAR enforcement, describing different models that can facilitate the international exchange of data relevant for enforcing UVARs, as well as some of the technical tools that are either being used or can be used for implementing these models. In addition, the legal instruments that can provide the basis needed for sharing data through different models were described, along with the challenges in using and applying them in the context of UVARs. Demonstrations were organised to show the feasibility of the data sharing models/solutions and assess their effectiveness in light of these requirements. On the basis of this, recommendations have been developed to facilitate cross-border data sharing to enforce UVARs. The **main findings** of the second task are as follows:

1) Two different enforcement mechanisms are used

Member States use different enforcement methods, including manual enforcement that covers the majority of the UVARs in Europe (in some Member States this is aided by a sticker which has to be placed inside the vehicle) or camera enforcement with number plate recognition, or a mix of the two.

2) Cross-border data exchange is currently limited to certain cases

Cross border data exchange for LEZs is currently only legally possible where a bilateral agreement is in place (e.g., between Belgium and The Netherlands), when entering a UVAR is seen as an offence (e.g., The Netherlands), where the LEZ is differential charging on an urban road tolling (e.g., Norway), where the national vehicle registration authority provides an open data feed on vehicle information (e.g., RDW in The Netherlands) or where third party ‘debt collection agencies’ are employed to find the information on both vehicle emissions and owner.

3) Three main models for cross-border data exchange were identified

The cross-border data exchange can be categorised in three different types of models, the *authority centric model* (e.g., *EUCARIS*), the *driver-centric model* (which needs to be adapted for transport scenarios) and the *vehicle-centric model*.

4) The absence of a legal basis for cross-border exchange of data is a key challenge for enforcing UVARs

Many cities have also indicated that data relevant for enforcing UVARs is already shared between EU Member States in context of enforcing other laws (e.g., safety related traffic offences), however, this data is not legally able to be shared with city authorities for the purposes of enforcing UVARs. In some cases, a reference has also been made by cities to commercial sensitivity and privacy being the

reason for not sharing the data, as well as lack of resources and/or priority for enforcing UVARs with respect to foreign vehicles.

5) Regarding the complexities in sharing data relevant for cross-border UVAR enforcement, a summary of the recommendations is as follows:

- **Authority to Authority (A to A) data sharing should be strengthened.** Authority Centric data sharing can allow a direct communication between city enforcement authorities and vehicle registration authorities of another EU Member State. This type of data sharing does not rely on registration of foreign vehicles in the cities being visited, as data on all foreign vehicles visiting a city can be consulted.
- **Empower EU citizens to share their data to complement A to A data sharing.** In parallel and to strengthen authority-to-authority data sharing, EU citizens should also be allowed to showcase that they possess required criteria to move freely within a regulated zone of an EU city. The use of COVID certificates during the COVID pandemic has led to the establishment and frequent use of EU-wide systems and technologies that allow individuals to securely share information about themselves with foreign control authorities. Individuals can also easily prove that the information being shared is authentic and can be trusted by a foreign control officer. These systems and technologies should be leveraged to complement authority-to-authority data sharing. Doing so could reduce the workload of authority centric model, as only non-compliant cases would require the use of authority-to-authority data sharing. This would also help foreign citizens to prove that any exception (such as disability) applies to them and that they should be exempted from the regulation.
- **Use growing vehicle connectivity and evolution of vehicle devices to complement A to A data sharing.** Growing connectivity of vehicles and evolution of smart tachographs/DSRC technology can also help city enforcement authorities to detect vehicles that do not comply with UVARs. These technologies can complement authority centric approach to enforcement, as authority-to-authority data sharing can then be used to obtain further information only with respect to non-compliant vehicles.

Way forward and next steps:

Authority to Authority (A to A) data sharing should be strengthened.

- **Action A – Improve the quality of data** available with vehicle registration authorities. This can be achieved by supporting the ongoing EU initiatives to revise roadworthiness package, which aims to update Directive 1999/37/EC. This will help the harmonisation and digitalization of data available with national vehicle registration authorities. The initiative aims to:
 - i. harmonise the technical vehicle data available with vehicle registration authorities,
 - ii. digitize vehicle registration certificates and mandate their electronic storage in national databases, and
 - iii. electronically link different vehicle registration authorities and national databases of EU Member States.
- **Action B – Establish an EU wide legal basis** that allows cross-border data sharing specifically for the purposes of UVAR enforcement. Such a legal basis can be established via different options:
 - iv. expanding the scope of *CBE Directive* to include in its remit UVARs and to allow *ex ante* data sharing for enforcing LEZs.
 - v. expanding the scope of *EETS Directive* to include in its remit also fine based UVARs and allow city authorities to have access to relevant data. The directive can already be used to for fee based UVAR schemes.

- vi. expanding the scope of *single digital gateway* regulation to include UVAR enforcement as a procedure for which authorities can share data.
- vii. expanding the use of data collected through *climate action* regulations for the purposes of UVAR enforcement.
- **Action C – Support the uptake and use of EUCARIS by cities.** EUCARIS already connects National Contact Points (NCPs) in each EU Member State, allowing them to share vehicle data and vehicle owner/holder data for enforcing CBE and EETS Directives as well as several other regulations. But city authorities are sometimes unable to access EUCARIS due to a lack of awareness or absence of national processes to connect to their EUCARIS National Contact Points. Cities across the EU should be informed about this possibility and countries should be encouraged to share relevant data with their cities for UVAR Enforcement, after an appropriate legal basis is established. UVAR Exchange project has identified cities that already use EUCARIS and have processes in place that can connect cities to their EUCARIS NCPs, good practices from these cities should be shared with other EU cities, so that they can become aware about EUCARIS and how to connect to their EUCARIS National Contact Points.
- **Action D – Explore the use of Internal Market Information (IMI) system** for direct administrative cooperation between city authorities and foreign national vehicle registration authorities. In addition to EUCARIS the European Commission could consider developing a workflow in IMI to facilitate direct administrative cooperation between cities and foreign vehicle registrations authorities for the purposes of enforcing UVARs.

Empower EU citizens to share their data to compliment A to A data sharing.

- **Action A – Support the changes foreseen to the Regulation (EU) No 910/2014** (eIDAS regulation v.2) and introduction of EU digital wallets.
- **Action B – Support the changes foreseen to Directive 1999/37/EC** to digitize vehicle registration certificates and mandate their electronic storage in national databases.
- **Action C – Leverage the provisions of Single Digital Gateway Regulation and implementing regulation on OOTS**, which obliges the commission to set up automated systems for the exchange of evidence between competent authorities of Member States.
- **Action D – Establish a pilot linked to European Blockchain Services Initiative (EBSI) and EU digital wallet initiative.** Through initiatives such as EBSI and EU digital wallet, the European Commission is investing considerable efforts to use new technologies and systems for different use-cases. UVAR enforcement through verifiable credentials could be added as a use case in these initiatives and piloted for uptake by Member States.

Use growing vehicle connectivity and evolution of vehicle devices to compliment A to A data sharing.

- **Action A – Leverage the provisions of climate action regulations** to facilitate access to vehicle data for checking compliance with UVARs (such as low emission zones).
- **Action B – Use ongoing initiative of the European Commission on Access to vehicle data, functions and resources**, within the framework of the proposed Data Act to seek vehicle data for enforcing regulations such as UVARs.
- **Action C – Establish collaboration with Vehicle Manufacturers** to develop a UVAR enforcement ecosystem, similar to the Safety Related Traffic Information (SRTI) ecosystem, so that vehicle data can be shared with city enforcement authorities to detect non-compliant vehicles.
- **Action D – Leverage the evolution of smart tachograph and the adoption of DSRC technology by Member States.** Tachograph and DSRC technology are used in heavy commercial vehicles as an enforcement tool. It will soon also be fitted in Light Commercial Vehicles. Smart Tachograph can be updated to also relay information about the vehicle emission standards, allowing city authorities to detect non-compliant vehicles.

INTRODUCTION

This final report was prepared for the European Parliament Preparatory action — User-friendly information tool on urban and regional vehicle access regulation schemes 2 – UVAR Exchange, based on contract No MOVE/B3/SER/2020-716/SI2.852092 implementing the No MOVE/2020/OP/0012, as outlined in the Terms of Reference.

This report presents the objectives of the study, the approach and methodology used, the limitations, a comprehensive overview of the results of the work carried out, the key findings, the recommendations and next steps.

Objective of the study

UVARs are used to regulate the movement of vehicles in urban areas. They are increasingly being used by cities to address issues such as air pollution, climate change, congestion, protection of historic centres and many more. Some UVARs might be quite simple (e.g., pedestrian zones), others (e.g., LEZs or congestion charging) are more complex and need to be properly anticipated and interpreted by the road user.

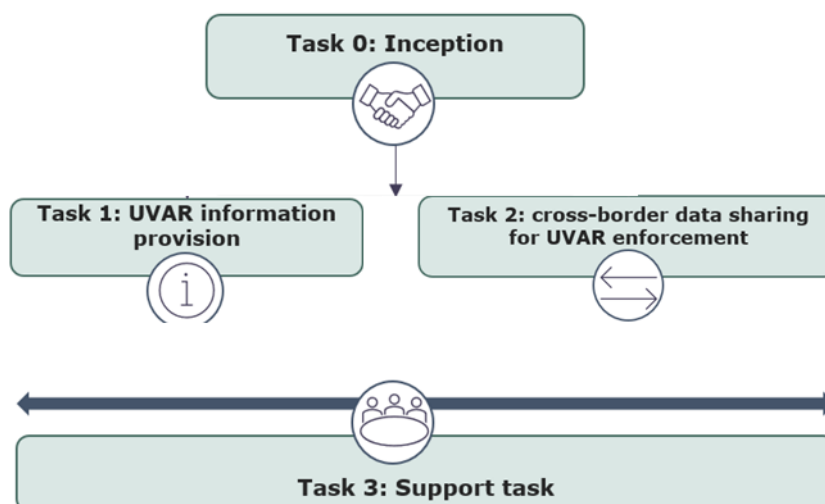
This complexity means that issues arise around how the correct information should be transmitted to the road user/vehicle. There is a lack of UVAR signage harmonisation across Europe, often local languages/abbreviations are used, and signs are often text heavy, making UVARs difficult both passing at speed, but also to those without the local language to understand. In addition, issues with legal constraints, the ability to access / share vehicle and owner/holder data and data quality hinder the cross-border sharing of information for UVAR enforcement. In the light of the abovementioned issues, this study has two key objectives:

1. Firstly, to **enhance the experience of road users by improving the communication of information** to drivers in the vicinity of UVARs through improved road signs. UVAR Exchange proposed a set of harmonised physical signs to improve UVAR signage, which has been handed to the UNECE road signs working group (the international organisation responsible for road sign coordination) for their work to produce the final legally recommended UVAR road signs. Recommendations have also been made for VMS, as well as by demonstrating the provision of information directly to a connected vehicle via C-ITS messages.
2. Secondly, UVAR Exchange addresses the technical, legal and administrative aspects of **the cross-border sharing of vehicle and driver information**. Enabling this would avoid the need for foreign drivers and vehicle operators to pre-register for separate LEZ cities and countries. The only reason this is currently needed is when cities cannot get the foreign vehicle technical information from other countries mainly due the lack of a legal framework for UVARs. Enabling this cross-border sharing would make compliance checks and enforcement of foreign vehicles and drivers by the UVAR authorities easier, cheaper and quicker.

Approach and task description

The study took an **evidence-based approach** combined with **broad, collaborative stakeholder consultation** to achieve the objectives above. Figure 1 provides an overview of the tasks, which are outlined below and then discussed in more detail in the following sections.

Figure 1: Overview of the methodology



Source: Own elaboration

- **Task 0** prepared the execution of the project, organised the kick-off meeting with the Commission and delivered an inception report. In this report, the tasks for the preparatory action were elaborated on in more detail, in accordance with the terms of reference and the agreements made in the kick-off meeting.
- **Task 1** started with a review of the practical aspects related to UVARs information provision, looking at both physical signs (including VMS) and C-ITS/geofencing. In addition, proposals were developed regarding a common European approach to tackle the fragmentation of UVAR related road signs, including guidelines for UVARs VMS. This was discussed in workshops and demonstrated in several cities in the demonstration activities.
- **Task 2** highlighted the complexity of cross-border data sharing for UVAR enforcement, by looking at the legal, technical and administrative challenges to data-sharing. In addition, the consortium developed a set of recommendations on how to overcome the barriers identified and proposed solutions to foster data sharing for UVAR enforcement. Again, demonstrators were used for testing the feasibility of data sharing for enabling UVAR enforcement with respect to foreign vehicles.
- **Task 3** is a support task, aimed at supporting the stakeholder’s engagement and consultation activities.

Methods: all the tasks were based on desk research, stakeholder consultations e.g., interviews, bilateral meetings, workshops, surveys, as set out in the inception report.

Structure of the report

The report is structured as follows:

- Introduction presents the objectives of the study, and the approach and tasks descriptions.
- Chapter 1 focuses specifically on Task 1 - Improvements of the information of the drivers in the vicinity of UVARs and presents the objective, detailed methodology, issues encountered, main findings, recommendations and next steps deriving from the task.
- Chapter 2 focuses on Task 2 - Improvement of the recognition of the vehicles, the link to actual vehicle specifications for information and the implementation of the UVARs, Identifying the legal, technical and administrative issues with cross-border enforcement and presents the objective, detailed methodology, issues encountered, main findings, recommendations and next steps.

- **Chapter 3 focuses on Task 3 – stakeholder engagement and consultation activities, presenting the objective and detailed methodology.**
- **Chapter 4 presents the references used along the report.**

1. TASK 1: PRACTICAL ASPECTS OF UVAR INFORMATION PROVISION THROUGH SIGNAGE

This chapter presents the objective, methodology followed, issues encountered, the main findings/ results achieved and the next steps related to the first task of the study, namely how urban and regional vehicle access regulations can provide easily understandable, clear, complete and updated information to road users in their vicinity (Task 1.1, 1.2 and 1.3) and the main findings from a survey that aimed at evaluating the comprehensibility of existing and proposed UVAR signage are provided. The demonstration activities conducted (Task 1.4.1 and 1.4.2) are presented in Annex 5.

1.1. Task objective

This task investigated how UVARs can provide easily understandable, clear, complete and updated information to road users in their vicinity. The overall objective is to catch all practical aspects of UVAR information provision including standardisation and integration in digital tools and the conduction of demonstrators in EU cities. Key elements are horizontal and vertical physical signage but also information on VMS and digital services communicating with vehicles by using C-ITS infrastructures.

1.2. Methodology

Task 1 was the result of both desk research activities and the collaborative work carried out with a group of stakeholders and local authorities and was comprised of five Tasks:

- **1.1 Practical aspects of UVAR information provision:** this task identified and presented all practical aspects related to UVARs on road information provision with ideas on possible improvements, based on desk research, a first workshop held in December 2021 and bilateral meetings with cities, regions and Ministries, the latter category included in both consultation and demo activities because of their crucial legal role. The full report can be found in Annex 1. A collection of UVAR signage examples across Europe is provided, complemented by a commentary section that highlights the pros and cons of the applications in terms of information redundancy versus simplification/clarity. This component was further enriched and updated during the demo foreseen in Task 1.4.1.
- **1.2. Common European road signage for UVARs:** this Task developed a harmonised European approach to define a common category of traffic signs for LEZs, based on of desk research and discussed during three online workshops. CORTE initiated a close collaboration with the UNECE Group of Experts on Road Signs and Signals which had been mandated to assess the new signs for a possible inclusion in the 1968 Vienna Convention on Road Signs and Signals in a number of priority areas, including LEZs. UNECE invited CORTE to prepare recommendations regarding LEZ signs for the Group of Experts. CORTE participated in the meetings of the Group of Experts and members of the UNECE Secretariat as well as representatives of the Group of Experts participated in the three UVAR Exchange workshops held in March, April and May 2022. The recommendations were drafted based on the discussions with stakeholders during the three stakeholder workshops. This document was submitted to UNECE and was discussed at the 9th informal meeting of the Group of Experts in December 2022.
- **1.3. Guidelines for VMS:** this Task developed guidelines for representing UVAR information through VMS, also building on the advice from Task 1.1 and 1.2. This was done using desk research, during the workshop held in December 2021 (above mentioned) and in the bilateral meetings with cities, regions and Ministries (the full report is included in Annex 2).

- **1.4. Demonstrators:** Tasks 1.4.1 and 1.4.2 – the demonstration activities were shared with a large audience during the workshop held in December 2021, followed by several bilateral meetings with the interested cities to agree upon the activities to be undertaken. Some cities were already contacted at the proposal phase and were already aware of the UVAR Exchange ambition and had expressed their interest. Based on the discussions with the cities and solution providers, the team drafted the demonstration plan including the confirmed cities, scenarios, solutions, participants, timeline planning and roles and responsibilities during the demonstrations. Annex 0 contains the full report of these activities.
 - **1.4.1 UVAR signage demonstrator:** focused on the harmonisation of physical road signs, particularly those for emerging UVAR types and the representation of key information to drivers through newly-designed “metal” road signs and the real life testing of VMS. Improved and harmonised physical signage was demonstrated with Milan and Lombardy Region (Italy), Lisbon, (Portugal), Vitoria Gasteiz and Barcelona (Spain), The Netherlands – via the Ministry of Infrastructure and Water Management. VMS was demonstrated in Lisbon (Portugal) and Monza (Italy).
 - **1.4.2 UVAR C-IIS demonstrator:** focused on sending UVAR related C-IIS messages from the infrastructure to the vehicle. Cities involved in the second demonstrator: Vienna (Austria), Helmond (The Netherlands) and Trento (Italy).

The stakeholders involved included 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 and other relevant stakeholders. Representatives of EU cities, regions and Ministries having different responsibilities and characteristics in terms of UVAR schemes joined the demonstration activities either as demonstrators or observers (to take part in collaborative activities and discussions) as for the cities of Rotterdam (the Netherlands), Brno (Czech Republic), Krakow (Poland) and Verona (Italy) 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 were crucial to feed the final versions of the reports for Task 1.1 (on UVAR signs) and Task 1.3 (on VMS), with a set of agreed recommendations and an Annex of collected UVAR signage practices across Europe and newly designed UVAR road signs.

The outputs, presented in reports “Practical aspects of UVAR information provision through signage” and “Guidelines for UVAR Variable Message Signs (VMS), from Task 1 provided information on where some of the current problems exist (practical, legal and/or technical) and supported the collaborative work with a group of stakeholders and local authorities aimed at understanding how to provide harmonised, easily understandable, clear, complete and updated information through signage (including VMS) to road users approaching, in the vicinity of and inside UVARs.

Annex 1 – Task 1.1 and 1.2 report describes how UVARs’ on-road information is provided in different EU countries, highlighting peculiarities of different UVAR typologies and current practices in road signs. It includes recommendations and a set of proposals for harmonised, easily understandable and complete UVAR signage in the European Union and presents the elements that affect the complexity and understanding of UVAR schemes with impacts on signage. It also includes as Annex a collection of existing UVAR signs and proposals of harmonised signs as a result of demo and consultation activities.

The second report (VMS Guidelines) explores the potential of Variable Message Signs (VMS) and how the information provided can be standardised and harmonised regarding UVARs’ applications.

1.3. Issues encountered

One-on-one consultation required for planning the demonstration activities. One of the main lessons learned was that the format of the workshop (or plenary sessions) to discuss the demonstration activities needed to be transformed into bilateral meetings instead. The main reason is that the cities are quite different from each other and have unique local contexts, thus it was more beneficial for them and for the project to be able to discuss their individual aspects with the consortium first and then, at a later point in time, in a workshop format. Sometimes authorities in the same country had the chance to discuss together of both legal and practical issues thus revealing a very context-specific character of the demo.

Demonstration activities hindered by authority resource constraints. Another lesson learnt relates to the resource constraints cities/regions/Ministries face, which impacted the extent to which they were able to carry out the demonstration activities. To tackle this aspect, the team created several steps within the demonstration activities, so that cities/regions/Ministries could decide which step to stop their involvement, based on the resources they have available. Some authorities participated as observers and gave their contribution as long as their time and resources allowed the possibility to interact with the demo and provide their feedback and contribution to the discussion.

Demonstration activities hindered by legal constraints. It was not possible to physically test improved UVAR zonal or advance warning signs since in many countries the format of signage, thus including the organisation and display of text and symbols on panels, is set by the national norms or national guidelines. Some flexibility was only present in Vitoria-Gasteiz and more in general in Spain since the country has not ratified the UN Vienna Convention on Road Signs and Signage. The solution was to work more on the design of new UVAR signs and to test them via the driver survey. Also, Ministries were invited to join the demo from the very beginning with participation of Spanish, Italian, and Dutch national authorities achieved.

Demonstration activities hindered by available technology. It became evident that some of the cities/regions/Ministries did not have the technology required to carry out all elements of the demonstration activities. Specifically, when it came to the VMS demonstrations, even with a panel available and suitable for the purpose, due to each panel's characteristics and consequent limitations, it was not possible to follow/apply all the recommendations identified in sub-tasks 1.1 and 1.3 at the same time. For instance, the location of the panels was not perfect since they reused existing VMS panels instead of being strategically installed for UVAR and the project purposes. Furthermore, the dimensions and resolution of the panels were a limitation to presenting more information (e.g., bilingual messages), a clearer sentence or more detailed pictograms (e.g., prohibition symbol with a polluting car inside it). In addition, identifying cities which already had suitable VMS panels was a challenge. The project did not provide any budget for cities or to install new equipment, thus, besides looking for cities willing to collaborate, an additional requirement was to have already an available VMS panel.

Infrastructure constraints were another barrier faced. During the C-ITS dry-run demo, it was found that infrastructure constraints were a significant barrier. In Europe, C-ITS systems are not fully developed yet and need further tests and investments. In this regard, dedicated awareness raising activities and "learning and training" activities for cities are the most appropriate next steps. The bilateral meetings and workshops that happened within UVAR Exchange were a first step. However, based on the learning and outcomes of the full demonstration, more, and more specific, training activities should be undertaken in the future.

Despite these challenges faced during the demonstrations, the results were very successful and made possible due to the authorities' goodwill, their contributions to the discussions and, in some cases, to real life demonstration activities.

1.4. Main findings

This section presents the main findings from the work carried out within Task 1 aimed at first understanding how information is provided through signage to road users and then elaborate a set of recommendations and proposals for harmonised and improved UVAR signs and digital information via C-IIS across Europe.

1.4.1. Understanding UVAR typologies and analyse current practices in signage

This study focused on 5 main UVAR typologies:

- Pedestrian Zone (PZ)
- Limited Traffic Zone (LTZ)
- Low Emission Zone (LEZ)
- Congestion Charge Zone (CCZ)
- Pedestrian Priority Zone (PPZ)

A fundamental reference was the 1968 UN Convention on Road Signs and Signals (and the European Agreement supplementing the Convention), which focuses on uniformity and harmonisation to facilitate international road traffic and improve road safety. The Group of Experts on Road Signs and Signals (GE.2), as part of the United Nations Economic Commission for Europe (UNECE) - Inland Transport Committee (UNECE), chaired by Mr. K. Hofman (Belgium) was both consulted, their members invited in joining project's events and supported in their regular work to properly orientate Task 1 scope.

Also, the consortium addressed mostly UVAR zonal applications: these are areas that include several streets or an entire neighbourhood/portion of the city, bordered by UVAR signage (zonal signs and sometimes also road markings) at entry and exit gates, with rules that are valid for all roads in the zone and thus avoiding the repetition of the regulatory sign at every road junction. A sign having a zonal validity is displayed on a rectangular main panel with a white/light-coloured ground and the word "ZONE" displayed above or below the sign on the panel. Additional panels can be installed below the main one in case of more information to be communicated to drivers.

The "NO ENTRY" sign shaping a red roundel (C,2 as in the Convention) and its variants, is the basic sign used for the entry zonal sign of different UVARs as further described in the next sections.

UVAR zonal signs are also complemented by **advance warning signs** at different approaching distances from the entry sign (including static or variable message signs on motorways for larger schemes). These enable drivers to be informed in time on the UVAR and in case to divert before reaching the gate. UVAR signs can be also installed inside the zone usually to inform about upcoming restrictions or of the need to register or pay a charge within a certain time after entering. Below a brief overview of the current practices in UVAR signage is provided by UVAR typology also highlighting the most relevant factors influencing information provision and clarity/completeness of such information. Further details are available in Task 1 reports.

Pedestrian Zone

The first UVAR typology is the **Pedestrian Area** or **Pedestrian Zone**, typically a square or a group of contiguous roads where no motorised vehicles are allowed and the whole space is reserved only to pedestrians, sometimes also allowing bicycles as equal or 'tolerated' status.

Pedestrian areas might admit just very few vehicle/user categories such as emergency/police vehicles, people with reduced mobility, residents who needs to reach their garage, delivery vehicles (usually in one short and off-peak time window) or micro/autonomous/cycle-based collective passenger vehicles. Parking is not allowed and admitted vehicles should proceed at walking speed. The access details are given, if appropriate and as for other zonal UVARs, below the sign on the rectangular panel or on additional panels below the main one.

The overall objective is to make these areas more liveable and safer by prioritising walking, social interaction and to protect visually and physically sensitive sites such as monuments and landscapes. Quite often such zones cover small city portions even if cities are increasingly implementing pedestrian zones over large parts of the city centre, to ensure that it is attractive to visitors.

From a driver perspective, recognising pedestrian zones is relatively easy: the intimate characteristic of the area (e.g., the presence of monuments in squares), street furniture, cobblestones in historical cores or other physical interventions transforming roads into public spaces often reinforce the message that no motor traffic is allowed thus complementing the information provided by the signs.

In most countries signs are based on a blue symbol representing one or two human figures, thus assuming more an informative character other than a restriction communicated to car drivers. In other countries such as Portugal, Spain and the UK the red prohibitive sign (C,2 roundel) is used. Additional information is displayed when the pedestrianisation is not permanent (time validity) or to indicate allowed vehicles (e.g., bicycles) or time windows for delivery operations.

Figure 2: Examples of Pedestrian Zone signs



Limited Traffic Zone

In line with the objectives of pedestrianisation and to reduce congestion, **Limited Traffic Zones (LTZ)** restrict access to only those motorised trips that are considered necessary for the functioning and daily life of the area. Residents, garage owners/tenants, caregivers, people with reduced mobility (PRM), freight carriers, shop tenants, maintenance and servicing companies are commonly authorised and pre-registered with permission to enter, plus some categories of automatically exempted vehicles such as public transport, taxis, emergency/police.

Usually covering wider areas such as historical centres or marinas, LTZs always work with permits. These authorisations must be requested in advance through a tailored website or in person at city offices. Some permits have a longer validity (e.g., 1 to 5 years for the categories indicated above) others may allow occasional access from other user types such as residents visitors or hotel guests.

LTZ might also restrict access (in addition or exclusively) to specific vehicle categories (quite common are the restrictions for lorries and coaches) or vehicle characteristics such as type, weight, size or pollution levels (noise, air quality). Parking is also allowed, and time windows are largely used to regulate freight vehicles' access and loading/unloading operations. LTZ regulations may request to display the permit on the windscreen as stickers.

The overall principle is to reduce motor traffic to the very essential and minimum level, or at least to significantly reduce it (particularly through traffic), depending on the number of categories and requirements granted by the permit system. The policy objective is to prioritise walking, cycling and public transport.

LTZs signage uses the zonal rectangular panel with the red 'C,2' roundel sign at the centre. Applications mainly differ in terms of usage of the main panel vs. supplementary panels to display the key information on permitted user categories and/or time validity. A CCTV symbol or text is added for camera-enforced schemes.

Figure 3: Examples of LTZ entry sign in EU



Low Emission Zone

The focus on pollution levels and the difficulty of meeting the EU air quality standards has led in recent years to the introduction of **Low Emission Zones (LEZ)**, also called “Environmental Zones” in some countries (i.e., Germany, the Netherlands, Sweden, Denmark).

LEZs restrict vehicular access to only those vehicle categories that meet set minimum air quality standards. The European vehicle emission standards for exhaust emission and the respective “Euro” stages, from 1 to 6 (or I to VI depending on vehicle type), are used to regulate LEZ restrictions.

Different from LTZs, the primary objective of Low Emission Zones is to reduce air pollution from motor traffic. Generally, pure LEZs rarely reduce traffic levels: their effect is to accelerate the renewal of the fleet. Compliant, less polluting vehicles are allowed to access the zone, and no other additional conditions are applied (apart for exceptions). LEZs are usually phased in, with increasingly strict standards over time. When only zero emission vehicles are allowed, the LEZ becomes a Zero Emission Zone (ZEV).

The geographical scope for LEZs normally includes a large portion of the urban territory (sometimes entire metropolitan areas) and is therefore wider than a typical LTZ.

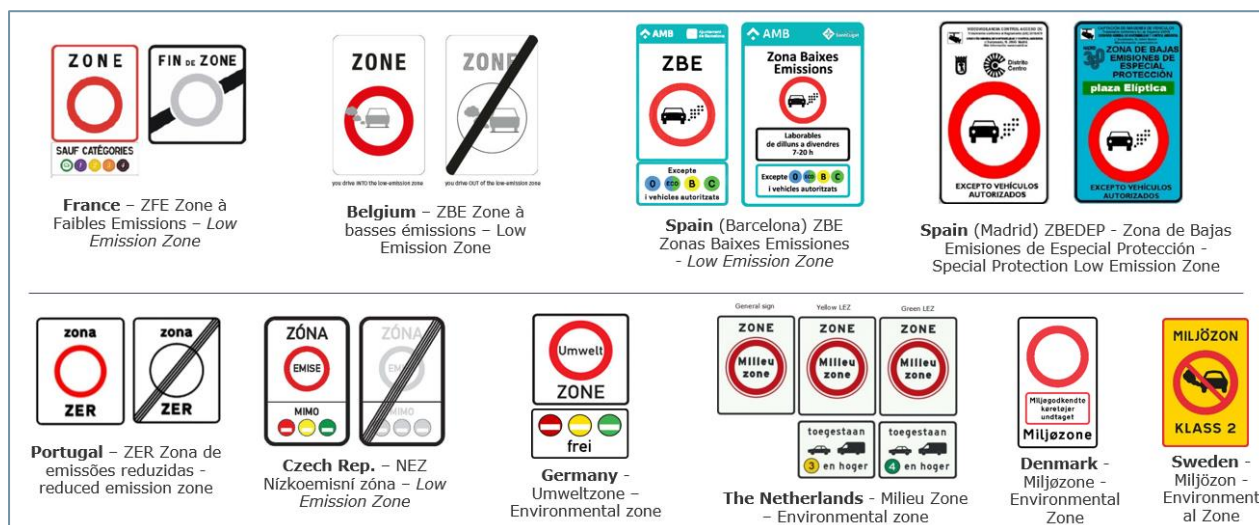
Since different standards are applied to different vehicle types and fuels, some EU countries, namely Germany, Austria, Spain, France and Denmark adopt a simplified (but unfortunately not harmonised) national classification system making use of stickers/vignette, also called environmental certificates or labels, based on a set of coloured numbers (or letters).

The distinctive visual elements for some countries are a polluting vehicle inside the red prohibitive roundel (Belgium, Spain and Sweden) that becomes a text (e.g., *milieu, umwelt, emise*) complementing the “zone” word for some other countries. This characterisation is not adopted in Italy or France where the simple “no entry” C,2 sign is used (as for LTZ) and supplementary panels indicate (via a text or symbol) the reference to admitted vehicle categories and Euro standards.

The use of stickers has the advantage of limiting the number of information to be shown on LEZ signage (these can be displayed on the main zonal or on an additional panel). Countries not using stickers should in fact specify allowed Euro standards per vehicle type and fuel type on additional panels. We observed that in some countries such information is not displayed on main entry panels thus making impossible to understand and comply to LEZ rules while driving.

Stickers-based LEZs always need the vehicle to be registered to the system (as for permits in LTZs), particularly for foreign vehicles. In non-sticker systems enforcing the scheme with ANPR, compliance is automatically checked through a direct link with the national vehicles' registry.

Figure 4: Collection of Low Emission Zone road signs



Source: national road codes and guidelines

Congestion Charge Zone

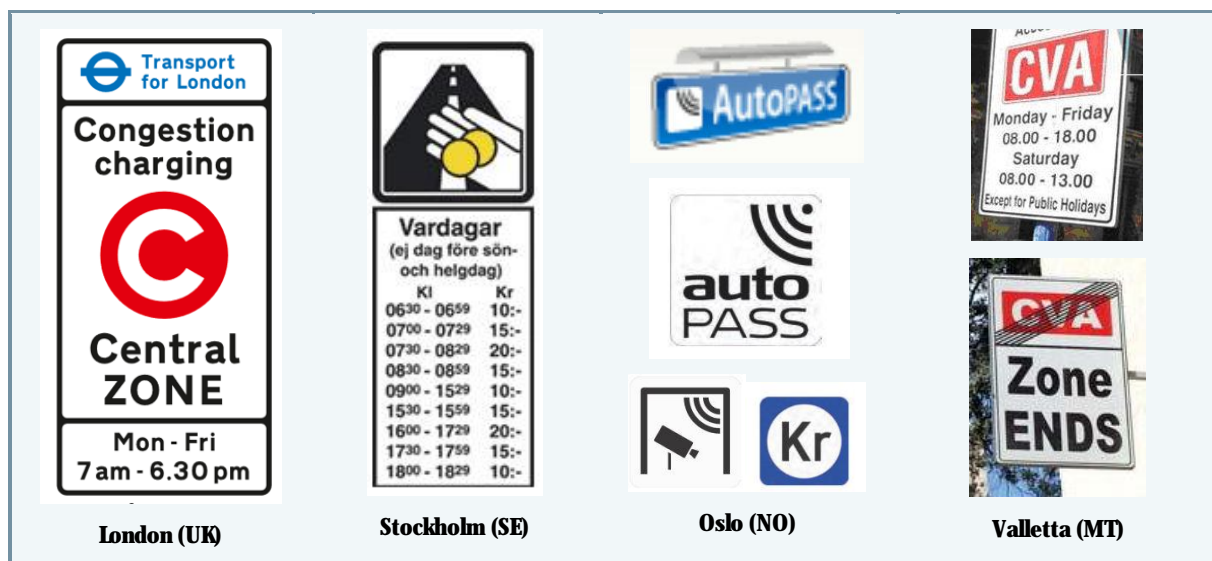
Vehicular motor traffic might not be restricted according to certain vehicle/user category or emission standard but require payment to enter.

Again, a combination is possible between the two scopes of pollution and congestion reduction (as in the LEZ and LTZ distinction): a Pollution Charge Zone is an UVAR scheme where only vehicles not meeting a set emissions standard have to pay, whereas in a Congestion Charge Zone all motor vehicles are charged irrespective of their emission standard.

Charging systems and regulations, also known as urban road tolls, usually work with ANPR or transponders (to check payments) and exemptions for some vehicle categories. Such scheme can cover both small and wider areas.

The official sign applied in London (but part of the national Traffic Signs Manual) is a white “C” (meaning “charge”) into a full red circle that tend to create an assonance with the red prohibitive roundel but not exactly communicating an access restriction as such. In Stockholm (Sweden), a tailored pictogram with coins is used. Norway uses the AutoPASS logo (that is the national automated system for collection of road and ferry tolls) but also other symbols in various formats. In Valletta (Malta) the CVA acronym is used on signs.

Figure 5: Examples of Congestion Charge and urban tolls signs



Source: TfL and CIARS)/ official websites of the schemes

Residential Area, Encounter Zone, Superblock

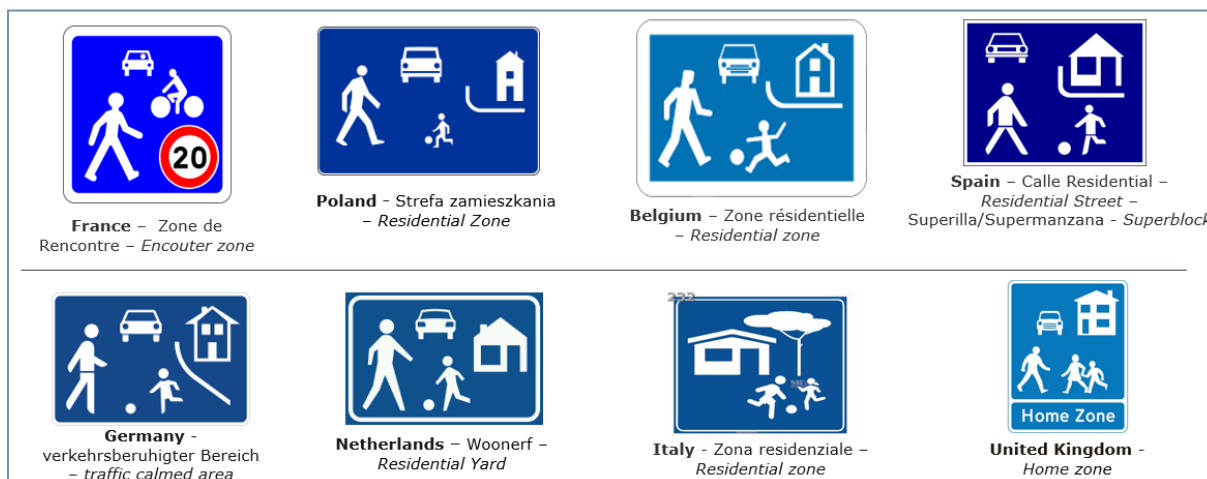
In all previously mentioned UVARs, vehicle access restrictions or charges are applied: access is regulated through legal regulations. However, there are also other UVAR typologies where motor traffic is regulated through a required change in driving behaviour or by changes in the spatial road layout.

Two typical examples are **Residential Areas/Home Zones** and **Encounter Zones/Superblocks**. Users must adapt their driving/walking style while going in/out, moving and use such areas.

The shared character of the road is the most relevant element, but typically the physical configuration of the area also reinforces and enables such coexistence. Traffic calming interventions and opposing one-way streets/modal filters are widely used to avoid through traffic.

Apart from Italy, all remaining signs use a similar and homogeneous combination of white pictograms into a blue panel: a pedestrian, a playing child, a home and a car have different dimensions according to the relative importance of each road user. The French sign for “zone de rencontre” does not include the child but a 20 km/h speed limit in the panel.

Figure 6: Pedestrian Priority road sign collection



Source: https://en.wikipedia.org/wiki/Comparison_of_European_road_signs

Advance warning signs and road marking

In addition to entry/exit zonal signs, different **advance warning signs** are also used. Some countries (e.g., Italy, France, Spain) provide clear instructions and prescribes minimum mandatory distances from the entry sign: the absence of advance warning signs can in fact invalidate fines issued via ANPR systems. The approach to an UVAR must be specifically signposted to provide users with information leading them, where appropriate, to choose an alternative route or to favour other transport modes via indications to a multimodal interchange or simply a parking area.

Advance warning signs can be present on main access roads and motorways several km before the zonal boundary but also in their proximity at distances ranging from 90 m to 500m.

Figure 7: Examples of advance warning signs



Some cities also implemented **complementary road markings** to emphasize the presence of an UVAR entry/exit gate and boundaries. This practice should be encouraged at EU level either by using linear markings or pictograms on the road surface.

Other elements influencing UVAR signage

In many EU cities, **different UVAR typologies are in place**: perhaps an ideal “concentric” situation with a city-wide LEZ, a central LTZ (and/or a Congestion Charge or a stricter LEZ) plus a pedestrianised core complemented by other pedestrian priority zones or streets. It is important to

exactly define each typology and its boundaries to enable clear signage - particularly for the main zonal panel. Also, **concentric UVARs** with boundaries along clearly recognised roads, such as the main ring roads can be easily understood by drivers with signs installed both while approaching, before the last diversion possibility, and at each entry/exit gate: the overall communicated principle is that stricter rules apply while driving to the centre.

Other UVAR schemes are distributed within the city in a more scattered way: such schemes are often 'Spatial Intervention' schemes, UVAR policies to avoid through traffic and create more liveable neighbourhoods that are implemented in smaller residential, historical, or touristic areas bordered by main roads where the traffic is not restricted nor calmed.

Proper signage is needed at each entry/exit junction and before the last diversionary possibility and other physical interventions such as kerb extension, speed cushions and lane narrowing increase the communication to drivers to support the signs, road markings and the rules/restrictions indicated on panels (e.g., speed or size limits). Usually, one-way streets as well as movable or permanent barriers/bollards are implemented to reduce the number of entry points and therefore the complexity of installed UVAR signage as well as to reduce unintentional violations from the drivers.

Multiple "nested" schemes with different boundaries, or the presence of sub-zones or streets within a single UVAR with non-homogeneous rules, can have big impacts in terms of on-road information provision and on the level of comprehension and reaction to signage by the drivers. **A proper UVAR policy should carefully take into consideration these aspects and look for a right balance between effectiveness, user needs and clarity.**

Temporal variability also adds complexity to providing information on road signs. UVAR validity can be permanent (i.e., valid all days 24h) or variable when the restrictions relate to specified: time slots within 24 hours, weekdays and holidays within the week, specific days of the week, months or periods within the calendar year. The implementation of temporally variable UVARs should be carefully evaluated.

The use of cameras with ANPR systems is used in many countries for checking vehicle's compliance with access regulations and therefore ensuring their effectiveness. The presence of cameras at entry and sometimes also exit gates (to check time windows and allowed maximum access times) add a further physical element to the main UVAR panels, thus increasing the driver's level of attention to signs and their information/prohibition messages. To limit the number of cameras (and therefore the investment for the enforcement system), check points and mobile cameras might be installed inside the zone and not (or not only) at boundary gates.

Some countries require additional mandatory panels or signs showing a text and/or a CCTV symbol due to privacy issues, are also associated to this type of enforcement and complement the overall gateway signage.

ANPR systems work with "whitelists" of authorised or exempted vehicles. This implies the functional link with another fundamental UVAR management system that associate number plates to permits, exemptions or emissions stickers/certificates. If a vehicle is not included in the whitelist, a fine is issued and sent to the UVAR offender.

When restrictions refer to specific vehicle's characteristics such as size, weight, type or emission standards, drivers might be led to think they have to check the compliance of their vehicle themselves – as usually happens for manually enforced UVARs. Camera-enforced schemes should always clarify the need of pre-registration when the automatic verification of vehicles' characteristics via the National Registry is technically not possible or not implemented by the local authority.

1.4.2. A common approach to UVAR signage in Europe: UVAR Exchange recommendations

Annex 1 presents a comprehensive set of recommendations resulting from both consultation and demonstration activities, including the results of drivers' survey.

1.4.3. Guidelines on VMS Signage

This section outlines the main findings regarding the potential of VMS and how the information provided can be standardised and harmonised regarding UVARs' applications (Task 1.3).

Overall, studies on VMS and UVARs are scarce, and VMS are currently not used for UVARs in most countries. Nevertheless, much has been analysed regarding the VMS messages and how they affect drivers' behaviour. Currently, the VMS signs already installed in European cities follow the European standard EN 12966. This European standard is binding for 28 countries². 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. In addition, several countries/regions all around the world (e.g., the United Kingdom, Ireland, Portugal, Spain, France and New York) have also defined their own guidelines for the use of VMS.

The FIVE actions (Framework for Harmonised Implementation of VMS in Europe)³ 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 differing interpretations and implementations. Along the same lines, in 2012, the EasyWay project launched the report "Variable Message Signs Harmonisation - principles of VMS messages design"⁴ 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 standardisation of the international road traffic signage system. 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 (Conference of European

² 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.

³ Framework for harmonised Implementation of VMS in Europe (FIVE), Conference of European Directors of Roads, 2003

⁴ <https://www.transport.gov.mt/PrinciplesOfVMSDesign.pdf-f1741>

Directors of Roads) Task Group O9⁵ drew a report with the aim of monitoring developments and understanding the obstacles to VMS harmonisation and interoperability.

Despite the long path already travelled, and the various initiatives that have already tried to promote harmonisation, from the analysis of existing UVAR VMS in distinct European cities, it became evident that VMS in UVARs are far from harmonised. Some similarities are commonly noticed between neighbour cities (in the same country); however, they differ a lot between countries. In addition, national abbreviations and the local language is still being used and text prevails over symbols, making the signs complex and difficult to understand – especially for those that do not read the local language. Lastly, VMS are never used for the end zone, further adding complications to understanding where the zone ends.

Such preliminary considerations and conclusions were validated with cities during the demo phase, outlined below, and recommendations developed. The full report can be found in Annex 2.

A summary of the main recommendations is presented below:

- UVARs in VMS should be based on the recommendations for vertical signs (above);
- Pictograms should be central to VMS use and the amount of text should be minimised;
 - To avoid distraction and improve understanding, free text should be limited to the minimum (no more than 5-7 words);
- The information must be easily perceptible. When using pictograms, they should be the main element of the message, and the information should be provided through official and highly-standardised pictograms (Vienna Convention, and the UVAR Exchange recommendations until these are incorporated into the Vienna Convention);
- 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;
- It must be ensured that the information is reliable, and up to date;
- Local abbreviations and acronyms should be avoided;
- To guarantee a wider coverage of drivers from distinct nationalities, bilingual messages should be used;
- The legibility of numbers/words can be improved by widening the spacing between characters;
- Generally, guidelines for VMS state that it should be avoided to add 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;
- According to the EU EasyWay Guidelines “VMS should only be used for the management of temporary events.”⁶ Within that framework, it is best to use the VMS to display the UVAR information only for its hours of operation. This allows the sign 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 also indicated that VMS are most appropriate for UVARs that are not in operation 24/7 – and particularly those that are triggered due to events (such as high pollution). This is also aligned with the Vienna Convention, Article 7; and

⁵ CEDR’s Task Group O9, VMS harmonization in Europe, 2009

⁶ 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 also harmonise their ITS deployments. <https://www.transport.gov.mt/PrinciplesOfVMSDesign.pdf-f1741>

- **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 also 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 detect the sign, read and comprehend the message, initiate and implement a response and then make appropriate decisions based on the information gained from the message.

1.4.4. Main findings on C-IIS

The topic of C-IIS has been driven mainly by motorway operators so far. For a few years cities start to raise interest in the usage of C-IIS for urban traffic management. However, the deployment of C-IIS related infrastructure in urban areas, is currently “work in progress”. UVAR Exchange project also showed even more that many cities are not aware of the topic of C-IIS at all, and specifically not related to UVAR. Looking towards the future of C-IIS for UVAR a bundle of measures needs to be implemented, considering the triangle of cities, vehicles, (legal) framework and standardisation.

On the level of the cities there is the need to raise awareness for C-IIS as a tool for innovative, demand-based traffic management in the urban areas that enables the implementation of policy measures including e.g., the reduction of the environmental impact. The major learnings show that specific awareness raising measure on the possibilities of C-IIS (connected with urban use cases like UVAR) are necessary to make the first steps towards the C-IIS implementation in cities to further enable more demand-based and dynamic urban traffic management, making use of C-IIS messages as one tool. For those cities that are already active in the C-IIS domain the topic of UVAR and C-IIS (and the potential implementation) is still new. The results of this study can be used as a starting point for more dissemination and awareness raising for the UVAR use case in those cities that are already active in this area. The demonstration of the two different C-IIS use cases (free text vs. traffic sign) also allows to come up with first insights on the potential implementation and the estimated effort for the implementation (depending on the actual status of C-IIS deployment).

On the side of the automotive industry there is the need for a stronger commitment towards the use of C-IIS as part of their user service, as this is part of the full picture for making urban C-IIS services, as for (dynamic) UVARs reality.

In addition, the third aspect on (legal) framework and standardisation aspects is of equal importance. This covers on one hand the development and standardisation of a C-IIS message type appropriate for UVARs, to decrease the implementation effort (which is a task for the C-IIS standardisation community), the need for an harmonised “UVAR sign”/pictogram also for the C-IIS services (which is a specific UVAR related task and already tackled in this report) and finally the legal bindingness of C-IIS messages e.g., for UVAR is a crucial aspect to make the steps towards the innovative urban traffic management of the future (which includes the adaption of the legal framework as as mid- to long-term measure).

C-IIS will be an important future component for UVAR in specific, and efficient urban traffic management in general. So, there is a strong need to set specific measures that will create the relevant framework conditions and raise the awareness and commitment for the topic (see Annex 5 and chapter 1.5. for the next steps).

1.4.5. Demonstration activities

A full overview of the demonstrations activities can be found in Annex 5.

Annex 5 presents the demonstration activities conducted under Task 1 for Barcelona, Brno, Helmond, Lisbon, Lombardy Region, Milan, Monza, The Netherlands, Trento, and Vienna.

1.5. Recommendations and next steps

The objective of this task was to look at how UVARs can provide easily understandable, clear, complete and updated information to road users in their vicinity, including standardisation of vertical / metal road signs, the integration in digital tools (VMS and C-ITS) and the conduction of demonstration activities in EU cities. Overall, the following conclusions and consequent next steps can be set:

Current UVAR signage lacks harmonisation. Regarding the current practices used in UVAR signage, when looking at the practical aspects of information provision across the five main UVAR typologies it was found that, despite some differences, the main zonal panels were found to be largely similar across Member States. However, the information provided on the additional panels differs a lot, both in the way information is displayed (order of information, use of text and symbols or predominance of text) and in terms of completeness and clarity of signage.

Further UVAR harmonisation can be achieved. Harmonisation is possible, particularly in terms of UVAR signage, as the research and stakeholder engagement throughout the study found. 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 panels and on different signals. For existing schemes, it is likely to be impractical to replace the road signs that are already familiar, however, rationalising -supplementary road signs might be able to be considered.

UVAR Exchange has developed harmonised road signs. It is important to underline that the amount of information that can be conveyed by road signs and understood by drivers is limited. Therefore, simple UVAR schemes with clear, harmonised main zonal and additional panels are recommended. The use of a polluting car symbol inside the prohibitory red roundel C,2 sing, largely improve the proper identification of Low Emission Zones as opposite to other traffic limitations as demonstrated by the results of our survey among EU drivers and stakeholder consultation.

These have been submitted to the UNECE Group of Experts on Road Signs and Signals and were introduced as an informal document for the discussion in the Group⁷. Further details are available in Annex 1 and summarised below.

Road sign placement. It is important to put road signs not only at the entry of the UVAR, but also at an earlier stage when approaching the UVAR, to allow drivers to take alternative action.

Despite limited current use of VMS in UVARs, VMS can be used as a tool to convey UVAR information. While not specifically on how UVAR information could be represented through VMS,

⁷<https://unece.org/transport/documents/2022/10/working-documents/other-business-submitted-corte-behalf-consortium-led>,

much has been analysed regarding the VMS messages and how they affect drivers' behaviour. The recommendations developed regarding vertical signs (Task 1.1) should also be applied to VMS in combination with what has already been proven to be most effective for the presentation of a VMS, including the use of pictograms, minimal text, standard colours and bilingual messages. Nevertheless, the capabilities of this technology and advantages over typical signs should also be considered, as well as the location of the VMS, which should be such that drivers have the chance to safely react to the information being displayed. To gain uniformity, VMS should be considered as a whole package, with a certain pictogram-text sequence as a road sign that should be made official to allow comprehension universal, as well as in combination with vertical road signs.

UVARs and VMS are not a one size fits all approach. To test the potential to use VMS as a tool to convey UVAR information, demonstration activities were conducted in two cities - Lisbon (Portugal) and Monza (Italy). These demonstrators showed that, besides having a set of recommendations to guide the process of defining a message, there is no simply defined recipe, and each case must be analysed carefully to achieve a harmonised and comprehensible result.

C-IIS for UVARs shows potential. C-IIS service provision is seen as a possibility to interact about active UVARs directly with single vehicles based on information provided directly by the regulating authority. The overall objective of the C-IIS demonstration activities was to show the potential of existing and upcoming C-IIS services for UVARs. During the full demonstration, it was discovered that the length and duration of the messages were important factors. The C-IIS message was shortened and displayed the whole time (i.e., while the vehicle is within an UVAR zone and not only along the border of the zone). This removes the need for the driver to comprehend rather complex information within a few seconds, which would be the case with using variable text panels or traffic signs. In addition, it was found that the current C-IIS IVI message as used in the test run is not practical in urban areas because it was designed for a linear setup (i.e., motorways) and cannot be used for areas like a city district, which is usually the case for UVAR Zones. Therefore, the IVI message needs to be adapted to fit a UVAR area.

The use of C-IIS in UVARs is still an innovation task. From the demonstration activities it became evident that the use of C-IIS for UVAR is still in an early stage, especially for city authorities. The deployment of C-IIS related infrastructure in urban areas is currently “work in progress” and many cities were not aware of the topic of C-IIS at all, particularly not related to UVAR. This study raised awareness for the topic and took the first steps, however more investments and adjustments to C-IIS systems are required for them to be functional and appropriate for UVARs in the future.

Way forward and Next steps:

Overall UVAR signage:

- 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 harmonised 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 and/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 (e.g., Italy, Spain, France). An EU UVAR Design/Signage Guidelines can be drafted combining different elements coming from national authorities and the collaborative work.

VMS

- 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.

C-IIS

- Next steps at this stage are to raise the awareness on the potential and the concrete development needs among cities, OEMs and the C-IIS implementation community to take the next steps.
- Dedicated workshops and sessions on C-IIS should be organised to raise awareness of C-IIS for UVARs. This should facilitate that the discussion could start based on the learnings, impact, large-scale feasibility and implementation - including standardisation, C-IIS service specifications and development needs e.g., in cooperation with the C-Roads Platform working group of urban C-IIS, tackling the C-IIS community and also vehicle manufacturer via the collaboration with the Car-2-Car Communication Platform.
- To raise the awareness for cities not familiar with the topic of C-IIS it makes sense to spread the know-how using also the existing specific networks e.g., POLIS and local/national events. The focus here will be more on raising awareness for UVAR measures in general, but also for the potential of C-IIS. As e.g., POLIS has a collaboration agreement with the C-Roads Platform, as well here a further push can be given via the Urban C-IIS working group of C-Roads.
- The interfaces between highways and urban areas are already “entry points” that are appropriate for small pilots (making use of the know-how on C-IIS existing at the motorway operators). This handover of C-IIS related messages between different operators (e.g., city operators and motorway operators) has already been managed and demonstrated by C-Roads. So having in mind the necessary developments for urban C-IIS in the upcoming years,

the linkage of UVAR messages to the interfaces from highways to the urban areas seems to be a manageable first step implementation for the UVAR C-ITS. Again, the key element is to have UVARs reflected in the standardisation as well as the C-ITS service specifications.

- The C-Roads platform WG 4 on urban C-ITS harmonisation should include the topic into their agenda to specify the concrete needs for the use case of UVARs. In addition, C-Roads WG 2 on technical aspects need to focus on UVAR-C-ITS-standard needs and to harmonise specifications for C-ITS messages including the harmonisation with the Car-2-Car Communication Consortium.
- Also for the C-ITS use case a harmonised “UVAR sign”/pictogram is needed. Here international standardisation and harmonisation activities are important (see also the finding related to Task 1.1. and 1.2).

More details are presented in Annex 5.

2. TASK 2: IMPROVEMENT THE ENFORCEMENT OF UVARS WITH RESPECT TO FOREIGN VEHICLES

This chapter presents the objective, methodology followed, issues encountered, the main findings/ results achieved related to the second task of the study (Task 2.1, 2.2, 2.3 and 2.4) and the next steps. The demonstration activities conducted (Task 2.4.1 and 2.4.2) are presented in Annex 5.

2.1. Task objective

Task 2 highlighted the complexity of cross-border data sharing for UVAR enforcement, by identifying the legal, administrative and technical challenges to data-sharing. In addition, Task 2 proposes solutions to overcome such barriers and tested the feasibility of data sharing by organising demonstrators. This task also fostered cooperation between cities and national authorities to improve access to foreign vehicle data needed for UVAR enforcement.

2.2. Methodology

This Task was comprised of four Tasks, all of which were based on desk research and stakeholder consultation e.g., interviews, bilateral meetings, workshops, and the development of a survey (designed and conducted in November 2022):

- **2.1 and 2.2 - Identification of legal, administrative and technical barriers** to cross-border sharing of data. These were two individual tasks that were merged in one, to provide a comprehensive overview of the barriers. These barriers were identified through desk research, a survey⁸ and discussed during the first workshop held in December 2021. A consolidated report of Task 2.1 and 2.2 (see Annex 3) considers the current enforcement mechanisms used by different Member States at national and cross-border levels and describes the technical challenges for data sharing and enforcing UVARs. It also considers the legal/administrative issues and provides an overview of different legal instruments, along with the challenges in using them, for exchanging data relevant for UVAR enforcement. It also describes three data sharing models (authority centric, driver centric and vehicle centric) that can foster cross-border exchange of vehicle and vehicle owner/ holder data for enforcing UVARs and lists the opportunities and challenges related to each model. Some of the technical tools that can help implement these models are also described in this report. Lastly, this report lists the requirements that are important for an EU wide solution for exchanging data that is relevant for the enforcement of UVARs. These requirements were used in the next phases of the project to analyse and assess the effectiveness of data sharing models and the technical tools for UVAR enforcement.
- **2.3 Developing recommendations:** identified solutions to overcome the barriers and foster data sharing for UVAR enforcement. Meetings with EUCARIS, IN GROUPE and EReg (Association of European Vehicle and Driver Registration Authorities) to discuss barriers and potential solutions to be tested were also held. See Annex 4 for this report.

⁸ A survey was also designed and conducted in November 2021, inviting city/enforcement authorities to share the challenges they face in exchanging vehicle data and vehicle owner/holder data for the purposes of UVAR enforcement. The survey was disseminated to POLIS, ICLEI, Eurocities, CLARS and ERRIN networks, as well as through social media, including DG MOVE Tweets, and consortium contacts.

- **2.4 Exhibiting the feasibility of data sharing by organising demonstrations:** tested the feasibility of data sharing for enabling UVAR enforcement with respect to foreign vehicles by organising demonstrators. As for the Task 1 demonstrators, the feedback collected during and after the demonstrators was crucial to understanding where current problems exist. During the bilateral discussions held, cities, regions and Ministries were engaged in the demonstration activities from Task 2.4. The list of cities for this included Barcelona, Antwerp, Brussels, Aachen, Rotterdam, Barcelona, Milan and Verona (see Annex 0 for a full overview).

The type of stakeholders consulted through the bilateral meetings and workshops were:

- City/Enforcement authorities
- Ministry level authorities
- Data Exchange solution providers – EUCARIS, IN Groupe⁹, Vehicle Manufacturers, DG GROW (IMI team), and Tachograph Manufacturers.
- Vehicle Registration Authorities through EReg¹⁰
- European Associations – EReg¹¹, IRU¹², ACEA¹³, POLIS¹⁴
- European Commission – DG MOVE

2.3. Issues encountered

The main general challenge encountered in the process was to identify cities willing and available to engage in the demonstration process. This also entailed major time costly activities not only in the identification of the right organisations in the cities and member states but also in the identification and engagement of the responsible or necessary person(s) to participate in the project demonstrations.

The main general barriers encountered and stated by cities and organisations were:

- Lack of legal framework for participating in cross-border data exchange
- Lack of access to processes and systems to allow this cross-border exchange
- Lack of capacity (time resources) to support the necessary research and developments

The main opportunities encountered were the existence of solutions (almost) ready to apply to the UVAR cross-border use case, like EUCARIS, IMI, Verifiable Credential based solution (IN Groupe) and vehicle centric solutions (connected vehicles and tachographs/DSRC).

2.4. Main findings

2.4.1. General Findings

- Enforcing any traffic rule in a cross-border context is generally a complex exercise, which requires:
 - Connections between several stakeholders,
 - Appropriate legal agreements between countries to provide the basis for exchanging data,

⁹ Specialist in identity and secure digital services, partner of the French government, www.ingroupe.com

¹⁰ Association of European vehicle and driver registration authorities, www.ereg-association.eu

¹¹ <https://www.ereg-association.eu/>

¹² <https://www.iru.org/>

¹³ <https://www.acea.auto/>

¹⁴ <https://www.polisnetwork.eu/>

- Systems that can ensure secure transfer of data, and
- Qualitative data on the vehicle and vehicle owner, which is up-to date and digitalized and can be trusted by enforcers.
- For enforcement of UVARs with respect to foreign vehicles, further layers of complexity are added:
 - There is a multiplication of stakeholders, as local/city authorities and departments get involved in enforcement,
 - Different cities use different methods to enforce UVARs, e.g., some use physical checks through traffic police, others use automated checks through vehicle number plate recognition,
 - Sometimes data needs to be consulted before the occurrence of a traffic violation (i.e., *ex-ante*) to establish if there is non-compliance with a UVAR (e.g., LEZs),
 - Exemptions to UVARs also need to be managed (e.g., disability, provision of services etc.), which may require additional data to know if there is a non-compliance with a UVAR or not.
- Different types of data-sharing models can support ‘enforcement of’ and ‘compliance with’ UVARs in a cross-border context. There are existing solutions/services that are already applying these data sharing models for enforcement of regulations other than UVARs at the EU level:

Table 1: Types of data sharing models

Data Sharing Model	Co-related solution or service applying the model
Authority Centric data sharing (A2A) – where city enforcement authorities can seek relevant data from vehicle registration authorities of the country where the vehicle is registered.	<ul style="list-style-type: none"> • European car and driving licence information system (EUCARIS), and • Internal Market Information (IMI)
Driver Centric data sharing (D2A) – where city enforcement authorities can seek relevant data from drivers or owners of a vehicle	<ul style="list-style-type: none"> • Verifiable-Credential based solution
Vehicle Centric data sharing (V2A) – where city enforcement authorities can seek relevant data from the vehicle itself or devices fitted in the vehicle. For this model “connected vehicle-based solution” and a tachograph/DSRC technology-based solution” has been discussed.	<ul style="list-style-type: none"> • Connected vehicle-based solution, and • Tachograph/DSRC technology-based solution

- Each data-sharing model and co-related solution provides distinct opportunities and challenges for helping the *enforcement* of and *compliance* with UVARs in a cross-border context. Such opportunities and challenges have been covered in details in Annex 3 (Task 2.1 and 2.2 Report).
- For a detailed description of how each data-sharing model and co-related solutions function, please see Annex 4 below (Task 2.3 Recommendations on improving data sharing to enforce UVARs in a cross-border context).
- The report in Annex 4 below also provides a detailed overview on the steps needed to actualize the data sharing solutions for the purposes of UVAR enforcement.

2.4.2. Findings on legal basis

- One of the main challenges encountered by cities is the lack of a legal basis that can allow them to access data necessary for UVAR enforcement. The table in Annex 4 Chapter 5 indicates the different EU regulations that can prove helpful for this purpose, including the recommended changes, timeline and relevance for the different solutions.
- Different types of *data-sharing models* can support ‘*enforcement of*’ and ‘*compliance with*’ UVARs in a cross-border context. There are existing solutions/services that are already applying these *data sharing models* for enforcement and compliance of regulations other than UVARs at the EU level.

2.4.3. Demonstration activities and findings

A full overview of the demonstrations activities can be found in Annex 5.

Annex 5 presents the demonstration activities conducted under Task 2 for Aachen, Antwerp, Barcelona, Brussels, Rotterdam, Verona.

The cross-border data exchange demonstrators aimed to test and showcase the organisational and technical aspects of the UVAR enforcement processes and support the identification of current barriers and potential solutions while implementing and operating a cross-border data exchange solution.

The demonstrations were performed in several different European cities to capture the different national and local characteristics of the enforcement process.

The demonstrations were done within the legal framework in place for the specific city and country. When this was not possible, an environment with simulated test data was used to demonstrate the technical possibility of data exchange between EU Member States.

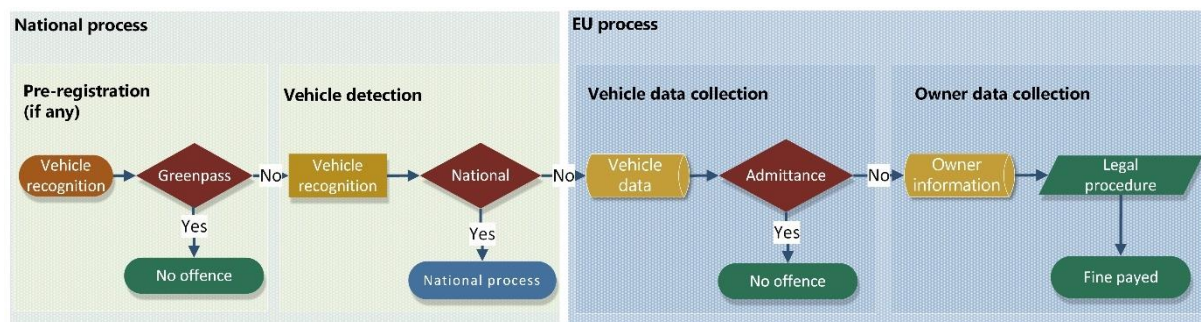
The results provided the basis for developing recommendations for the wide implementation of cross-border solutions. At the same time, the demonstrations also aimed to raise awareness among Member States, and national and local stakeholders, and contribute to the promotion of potential cross-border solutions.

The stepwise approach of engaging cities to demonstrate the (possibilities) of cross border data exchange consisted of:

1. **Preliminary meetings:** meetings with representatives of different cities in Europe discussing the goals for demonstrations, stakeholders needed for demonstrations, mapping the current situation of enforcement, possibilities for demonstrations and identification of shortcomings and challenges.
2. **Dry run phase:** A test plan was developed for each city and a walk-through was prepared. Local enforcement steps were discussed, and where applicable national agencies were also involved. A review of the main preconditions and requirements of the solution was performed. Based upon these actions to implement the solution was formulated.
3. **Life demonstrations:** based upon the findings demonstrations were planned and developed and test results were reported including recordings of the demonstrations.

The description of all the steps is reported in Annex 4 and described in a more summarised way in Annex 5. The general steps of cross-border enforcement are shown in see **Error! Reference source not found.**

Figure 8: LEZ enforcement reference process



The figure addresses the process steps with the following actors and stages.

Actors:

- Driver and vehicle
- UVAR enforcement: cities, regional or national authority
- Fine collecting agency

Stages:

- Pre-registration
- Foreign vehicle detection
- Foreign vehicle technical data collection
- Foreign vehicle owner/holder data collection

Two solution providers EUCARIS and IN Groupe collaborated with the project to demonstrate their solutions to support the enforcement of UVARs.

EUCARIS

EUCARIS provides the service used to exchange vehicle and owner data supporting the CBE and EETS Directives and other countries’ agreements under the EURCARIS treaty. From the start of the project, talks were held with EUCARIS to understand the solution for cross-border data exchange and in what way EUCARIS can support the demonstrations organised with cities and necessary stakeholders like vehicle registration agencies and the different ministries involved in cross-border data exchange and enforcement. The EUCARIS approach is that every country organises its application where public authorities within the country can connect and access is granted through the national contact point of EUCARIS.

The EUCARIS solution is demonstrated with the cities of Antwerp, Rotterdam, Verona and Barcelona.


IN Groupe

IN Groupe is a key player in identity and trust solutions. Its shares are owned by the French State and they are empowered by the State to take care of several technical implementations linked to EU and national obligations (e.g., the issuing of personalised tachograph cards in commercial road transport). IN Groupe was also responsible for the implementation of COVID pass solution in France. The COVID pass solution allows the issuance of certificates that can be controlled by foreign police forces inside the country or at border control points. During meetings, IN Groupe explained the application of COVID pass solution to enforce UVARs through verifiable credentials or using a European Trusted Repository ledger hosting UVAR-VC issuing authorities’ public keys and Applicable dynamic rules. The concept created by the IN Groupe is demonstrated as the ‘UVARwallet’ integrated solution. This is demonstrated with a user story of a disabled French driver wanting to access Brussels LEZ.

Lessons learned

This table presents a summary of the lessons learned per topic, with a set of considerations for each one. More details, including findings from the legal basis can be found in Annex 3, 4 and 5.

Table 2: Summary of the lessons learned

#	Topic	Comments
A	<p>License plate recognition Recognising foreign number plates can be challenging as similarities between license plate types of some countries can result in multiple matches.</p> <p>The practices of using Automatic Number Plate Recognition (ANPR)-system is common but not used by all Member States, e.g., in the city of Aachen, compliance check is done only manually. This is a common approach within Germany. Other engaged cities use ANPR systems sometimes combined with manual checks.</p>	<p>When setting up ANPR-systems, it is important to ensure that such systems also recognise foreign license plates.</p> <p>Many countries are starting to use special number plates for zero-emission vehicles (ZEVs) (10 Member States and 3 neighbouring countries so far, plus 3 Member States with ZEV Stickers). Remark is that in some Member States PHEVs are combined with ZEVs (numberplate or sticker).</p> <p>However, ensuring the use of this approach in a cross-border context for ANPR to detect zero-emission vehicles would require the development of standards at an international level. For this the Vienna Convention on Road Traffic, 1968 may have to be amended.</p>
B	<p>Accommodate different enforcement entities After discussions with the cities and capturing the enforcement procedures used by them, it appears that different entities are involved in different steps of the enforcement process. Each of these entities has a different information need, depending on its role in the enforcement process.</p> <p>Also, for different types of offences, different entities are in charge in Member States. For example, the entities that enforce safety-related traffic offences under the CBE Directive are not the same as those responsible for enforcing UVARs.</p>	<p>The entities in charge of enforcing UVARs can learn from the practices and experience of entities in charge of safety-related traffic offences. This information sharing at the national level can help cities move forward with the enforcement of UVARs concerning foreign vehicles.</p>
C	<p>Lack of harmonisation and quality of national data</p> <p>Different countries adopt different national low emission classifications for vehicles. Using domestic low emission classifications for foreign vehicles can be difficult due to the lack of harmonisation.</p> <p>The practices to update data in vehicle registers differ across the EU. This impacts the quality of data needed for enforcing UVARs.</p> <p>The quality of data (needed for UVAR enforcement) can also be impacted by differences in national practices on whether the license plate number is linked to a vehicle or its owner/holder.</p>	<p>Equivalence tables could be developed to help enforcers understand how a foreign country’s low emission classification matches with local low emission classifications. E.g., Spain has developed a table to reflect this:</p> 

#	Topic	Comments
		<p>The quality of data in vehicle registers of Member States should be improved, the data should be harmonised and digitized by leveraging the EU initiative to revise Directive 1999/37/EC.</p> <p>For this purpose, the recommendations and findings of the EReg topic group XXI should also be taken into account.</p>
D	<p>Pre-registration by vehicle owners should be minimized</p> <p>When non-sensitive vehicle data can be obtained, pre-registration is not necessary. For example, The Netherlands considers vehicle data to be open data and cities like Antwerp in Belgium can obtain these data for Dutch vehicles. Under such as system only those vehicles which need an exemption (such as delivery service, disabled etc.) need to register.</p> <p>The current practice is that every city has its registration system, and some of them require all foreign vehicles to register to have access to their data, using different portals and services specific to each city.</p>	<p>Registration requirements should be minimised, by reinforcing authority-to-authority data sharing solutions such as EUCARIS.</p> <p>The authority-to-authority data-sharing solution should be complemented by solutions that follow the once-only principle of the single digital gateway regulation. See the solution description of the UVARWallet approach. This also incorporates the requirement of the possibility to register once only.</p>
E	<p>Managing “white/black lists”</p> <p>Some cities require that foreign vehicles are pre-registered to have access to relevant data. The data so collected is used to create lists.</p> <p>“White lists” can include vehicles that are compliant with local regulations and sometimes also vehicles that may have committed the traffic offence only once.</p> <p>“Black lists” include vehicles that are either not registered or are not compliant with local regulations. The black lists may also indicate if a vehicle has infringed traffic regulations multiple times.</p> <p>Explanation: <i>Under the current systems, the lists are a useful mechanism allowing cities to keep track of foreign vehicles, and also allowing them the opportunity to register after arrival in a city or to make payments later. However, it is not clear how long the data can be retained by the cities and what their GDPR obligations are in this respect.</i></p>	<p>It would be important to provide guidance to cities on how such lists can be managed and provide inputs on the GDPR obligations for data retention and use.</p>
F	<p>Connection of cities with EUCARIS service</p> <p>EUCARIS manages and supports the “connections”/ interface with National Contact Points (NCP). It is up to each NCP to establish connections with the city's (or UVAR enforcement-related) authorities.</p> <p>In some countries/cities (e.g., Barcelona and Verona), these connections already exist for supporting cross-border data exchange related to traffic safety violations indicated in the CBE Directive e.g., with local police or fiscal departments. But connections with authorities responsible for UVAR enforcement are lacking.</p>	<p>The example of cities and countries that already connect to EUCARIS for the enforcement of different regulations against foreign vehicles, should be shared with other cities across the EU to raise awareness and facilitate such linkages in other countries as well.</p> <p>The technical readiness to incorporate the authority-centric model is illustrated with the rating of the requirements against the technical readiness of the engaged stakeholders, which makes implementation</p>

#	Topic	Comments
	In some countries (e.g., Spain and Italy) the technical interface between cities and NCP is already implemented centrally through national or regional level government entities, that use a web/software application for data exchanges.	possible within the time stretch of one year.
G	Data Protection Member States differ in how they categorise data as sensitive and non-sensitive. In some countries, such as the Netherlands, vehicle data is considered open data, but in other countries, it is considered sensitive and there is a reluctance to share this data. This creates a direct problem for the cross-border exchange of vehicle technical data.	While establishing a legal basis for exchanging data to enforce UVARs, the data elements that Member States can share should be specifically outlined. This will lead to a harmonised understanding among Member States. Vehicle data is already shared by Member States with each other and with the EU for different regulatory obligations (e.g., roadworthiness tests, climate action etc.). Such regulations can provide insight as to what data should be considered non-sensitive by all Member States. EUCARIS has also identified certain vehicle data sets as non-sensitive, which could be useful.
H	Vehicle technical compliance check In some countries, checks for UVARs are carried out by city authorities themselves while in other countries such checks are carried out by authorities set up at a regional or national level.	A cross-border data-sharing solution for UVAR enforcement must be able to adapt to different technical setups.

Key observations from the analysis of the demonstration activities:

- i. If a legal basis for data exchange is established, then technical and organisational implementation of UVAR enforcement can be set-up within short term (i.e., up to 1 year) using the EUCARIS system which relies on authority-to-authority data sharing. This is because technical components for EUCARIS are already in place, and it is already being used by Member States for exchanging vehicle and vehicle owner/holder data to enforce other regulations. Such implementation would only help sharing technical vehicle data and vehicle owner/holder data and would not include sharing data on conditions that may exempt a vehicle/driver from compliance with a given UVAR. Getting data on exemptions (e.g., disability permits) will have to be organised by each city or Member State separately. If cities digitalize UVAR rules using UVAR Box specifications, then vehicle owners can be better informed about UVARs and applicable exemptions for different cities.

It must be noted that the suggested timeline assumes that all Member States will allow city authorities responsible for enforcing UVARs to connect to their EUCARIS National Contact Points. This is not always easy, as administrative procedures and complexities at the national level can result in delays. However, in some Member States (e.g., Italy, Spain and the Netherlands), city authorities responsible for enforcing different traffic rules have been found to be already connected to their EUCARIS national focal points. Some countries have procedures for ensuring appropriate access by cities, and where needed, these can be shared and processes in new countries could be set up in parallel to the EUCARIS changes.

- ii. A verifiable credential-based solution (demonstrated by IN Groupe above), which uses driver-to-authority data sharing, can be technically set-up at the EU level within mid-term (i.e., up to 2 to 3 years). The technology has already been successfully applied for other use-cases (e.g., Covid

certificates) and it can be used for sharing relevant data for UVAR enforcement, including information on any applicable exemptions. The use of such a solution for UVARs will depend on the will of the EU to set up a system linked to the Once-Only Technical System (OOTS) under single digital gateway regulation, by leveraging initiatives such as the EU digital wallet and European Blockchain Services Infrastructure.

Such a solution would cover only those vehicles where a verifiable credential has been created based on the consent provided by vehicle owners and drivers. Where such consent does not exist authority-to-authority data sharing would have to be relied upon for UVAR enforcement.

For the vehicle centric solutions (which rely on connected vehicles or devices fitted in the vehicles to share data with enforcement authorities), the timeline can also be mid-term (i.e., up to 2 to 3 years), as the implementation of communication vehicle specification through the short-range communication/C-IIS solution is more likely to happen in the medium term.

- iii. In addition, some cities have been found to apply a practice of issuing a distinctive number plate for zero emission vehicles. An EU-wide introduction of a standardised way of ‘coding’ special number plates for zero-emission vehicles is technically feasible. However, given that the issuance of number plates is legally within the domain of each Member State, it may take a long time to establish a common EU-wide understanding on the recognition and acceptance of these number plates in a cross-border context. For this, changes to the Vienna Convention on Road Traffic, 1968 may be necessary along with an EU regulation harmonising the symbols used on number plates across EU.

2.5 Recommendations and next steps

The objective of this task was to look at the legal, administrative and technical challenges to data-sharing and to propose solutions to overcome such barriers and tested the feasibility of data sharing by organising demonstrators. Overall, the following recommendations and next steps can be set:

Authority to Authority (A to A) data sharing should be strengthened. Authority Centric data sharing can allow a direct communication between city enforcement authorities and vehicle registration authorities of another EU Member State. This type of data sharing does not rely on registration of foreign vehicles in the cities being visited, as data on all foreign vehicles visiting a city can be consulted. To strengthen authority to authority data sharing for UVAR enforcement, following actions are proposed:

- **Action A – Improve the quality of data** available with vehicle registration authorities. This can be achieved by supporting the [ongoing EU initiatives to revise roadworthiness package](#), which aims to update [Directive 1999/37/EC](#). This will help the harmonisation and digitalization of data available with national vehicle registration authorities. The initiative aims to:
 - viii. harmonise the technical vehicle data available with vehicle registration authorities,
 - ix. digitize vehicle registration certificates and mandate their electronic storage in national databases, and
 - x. electronically link different vehicle registration authorities and national databases of EU Member States.
- **Action B – Establish an EU wide legal basis** that allows cross-border data sharing specifically for the purposes of UVAR enforcement. Such a legal basis can be established via different options:
 - xi. expanding the scope of *CBE Directive* to include in its remit UVARs and to allow *ex ante* data sharing for enforcing IEZs.

- xii. expanding the scope of *EETS Directive* to include in its remit also fine based UVARs and allow city authorities to have access to relevant data. The directive can already be used to for fee based UVAR schemes.
- xiii. expanding the scope of *single digital gateway* regulation to include UVAR enforcement as a procedure for which authorities can share data.
- xiv. expanding the use of data collected through *climate action* regulations for the purposes of UVAR enforcement.

See Annex 4 for specific recommendations on different regulations.

- **Action C – Support the uptake and use of EUCARIS by cities.** EUCARIS already connects National Contact Points (NCPs) in each EU Member State, allowing them to share vehicle data and vehicle owner/holder data for enforcing CBE and EETS Directives as well as several other regulations. But city authorities are sometimes unable to access EUCARIS due to a lack of awareness or absence of national processes to connect to their EUCARIS National Contact Points. Cities across the EU should be informed about this possibility and countries should be encouraged to share relevant data with their cities for UVAR Enforcement, after an appropriate legal basis is established. UVAR Exchange project has identified cities that already use EUCARIS and have processes in place that can connect cities to their EUCARIS NCPs, good practices from these cities should be shared with other EU cities, so that they can become aware about EUCARIS and how to connect to their EUCARIS National Contact Points.

See Annex 4 of this document for practices used by some cities to connect to EUCARIS.

- **Action D – Explore the use of Internal Market Information (IMI) system** for direct administrative cooperation between city authorities and foreign national vehicle registration authorities. In addition to EUCARIS the European Commission could consider developing a workflow in IMI to facilitate direct administrative cooperation between cities and foreign vehicle registrations authorities for the purposes of enforcing UVARs.

Empower EU citizens to share their data to compliment A to A data sharing. In parallel and to strengthen authority-to-authority data sharing, EU citizens should also be allowed to showcase that they possess required criteria to move freely within a regulated zone of an EU city.

The use of COVID certificates during the COVID pandemic has led to the establishment and frequent use of EU-wide systems and technologies that allow individuals to securely share information about themselves with foreign control authorities. Individuals can also easily prove that the information being shared is authentic and can be trusted by a foreign control officer.

These systems and technologies should be leveraged to complement authority-to-authority data sharing. Doing so could reduce the workload of authority centric model, as only non-compliant cases would require the use of authority-to-authority data sharing. This would also help foreign citizens to prove that any exception (such as disability) applies to them and that they should be exempted from the regulation.

- **Action A – Support the [changes foreseen to the Regulation \(EU\) No 910/2014](#)** (eIDAS regulation v.2) and introduction of EU digital wallets.
- **Action B – Support the [changes foreseen to Directive 1999/37/EC](#)** to digitize vehicle registration certificates and mandate their electronic storage in national databases.
- **Action C – Leverage the provisions of [Single Digital Gateway Regulation](#) and [implementing regulation on OOTS](#)**, which obliges the commission to set up automated systems for the exchange of evidence between competent authorities of Member States.

- **Action D – Establish a pilot linked to European Blockchain Services Initiative (EBSI) and EU digital wallet initiative.** Through initiatives such as EBSI and EU digital wallet, the European Commission is investing considerable efforts to use new technologies and systems for different use-cases. UVAR enforcement through verifiable credentials could be added as a use case in these initiatives and piloted for uptake by Member States.

See Annex 4 for more details on citizen centric solution to UVAR enforcement.

Use growing vehicle connectivity and evolution of vehicle devices to compliment A to A data sharing. Growing connectivity of vehicles and evolution of smart tachographs/DSRC technology can also help city enforcement authorities to detect vehicles that do not comply with UVARs.

These technologies can complement authority centric approach to enforcement, as authority-to-authority data sharing can then be used to obtain further information only with respect to non-compliant vehicles.

- **Action A – Leverage the provisions of climate action regulations** to facilitate access to vehicle data for checking compliance with UVARs (such as low emission zones).
- **Action B – Use [ongoing initiative of the European Commission on Access to vehicle data, functions and resources](#)**, within the framework of the proposed [Data Act](#) to seek vehicle data for enforcing regulations such as UVARs.
- **Action C – Establish collaboration with Vehicle Manufacturers** to develop a UVAR enforcement ecosystem, similar to the Safety Related Traffic Information (SRTI) ecosystem, so that vehicle data can be shared with city enforcement authorities to detect non-compliant vehicles.
- **Action D – Leverage the evolution of smart tachograph and the adoption of DSRC technology by Member States.** Tachograph and DSRC technology are used in heavy commercial vehicles as an enforcement tool. It will soon also be fitted in Light Commercial Vehicles. Smart Tachograph can be updated to also relay information about the vehicle emission standards, allowing city authorities to detect non-compliant vehicles.

3. TASK 3: STAKEHOLDERS ENGAGEMENT AND CONSULTATION ACTIVITIES

This chapter presents an overview of the activities conducted under Task 3 (support to the stakeholder engagement and consultation activities). The findings of each Task were integrated into the respective Task in Task 1 and 2, hence this section focuses on the methodology followed.

3.1. Task objective

The objective of this task was to support the stakeholder engagement and consultation activities to ensure the best fulfilment of Tasks 1 and 2, to engage with existing working groups related to the topic, and to disseminate the results of the study.

3.2. Methodology

Task 3 was a transversal task, comprised of eight Tasks. The process followed for each throughout the project is discussed in more detail below.

3.1 - coordinated the validation workshops and surveys to ensure credibility, legitimacy and saliency of Task 1 and 2 outputs. As part of this Task, the following activities and results were achieved:

- First workshop held in December 2021.
- Survey on legal, administrative and technical barriers to cross border data sharing.
- The mid-stage validation workshop format was transformed into a bilateral meetings format (a few plenary sessions with all cities were held and subsequent meetings were combined where this was more efficient). In the first part of these meetings, our findings were presented to be validated and additional inputs collected.
- The team began preparing the stakeholders for the demonstration activities and a final workshop was held on the 18th of October 2022.

3.2 - supported Task 1.2 in coordinating the stakeholder engagement and online workshops. As part of this Task, the following activities and results were achieved:

- The first workshop was planned and held in February 2022. The first workshop outlined key problems faced by drivers due to lack of clarity and uniformity of UVAR signs.
- The second workshop was planned and held in May 2022. The second workshop shared practical ideas and solutions.
- The third workshop was planned and held in June 2022 (M8). The third workshop presented the key elements that a common European approach to UVAR road signs.
- In November 2022, a presentation was held of the proposed sign for LEZ/ZEZ to the Austrian Group of Experts on Road Signs (called „AA StB 10“) at Forschungsgesellschaft Straße-Schiene-Verkehr (FSV) in Vienna.
- In addition, the team started developing a questionnaire for final validation of the harmonised LEZ from the users' point of view. It was also disseminated online to encourage driver's participation and shared with ACE, ACEA, IRU, FIA to be distributed.

3.3 - supported Task 2.4 in coordinating the actors for the demonstrators. The main activity under this Task was to support the promotion of the workshops and scheduling the bilateral meetings with stakeholders to prepare them for the demonstration activities.

3.4 - involved organising workshops at least one EC mobility event to gather feedback from a higher diversity of stakeholders. The team decided to do so at the POLIS Conference being held in November/December 2022. Preparation for the event began with the submission of an abstract and the actual presentation done in December 2022.

3.5 - involved participation and liaison at legislative events, such as CBE and EETS directive. CORTE has participated in a couple of meetings related to CBE.

3.6 - involved promoting the study and gathering feedback at least four mobility events. Throughout the course of the study, the project team presented at least 8 events, namely:

- The CIVITAS Forum 2021 (October 2021), where the team presented the project together with UVAR Box, ReVeA and Dynaxibility4C.E.
- POLIS 2021 (December 2021) together with UVAR Box.
- Tomorrow Mobility (November 2022) with UVAR Box and ReVeAL.
- ITS Toulouse (May-June 2022).
- ITS Committee (March 2022).
- Urban Mobility Days – presentation of UVAR Exchange.
- POLIS 2022 (December 2022) together with UVAR Box.
- ReVeAL final conference together with UVAR Box.

Information on workshops and conferences was disseminated through consortium members contacts, CLARS newsletters, Polis, ICLEI, IRU, ERRIN.

There have also been articles written that refer to the UVAR Exchange project including two articles in the World Transport Policy and Practice Journal¹⁵ (May 2022 Volume 27.1¹⁶ and November 2022 Volume 27.2¹⁷) and an article of a digital book to commemorate the 25th anniversary of the Barcelona Metropolitan Transport Authority (ATM).

UVAR Exchange road sign recommendations are included in the EU Horizon 2020 project ReVeAL's UVAR toolkit guidance¹⁸, as being what cities should use. The information currently is as per September 2022, but it is a digital publication, so can be updated. The other aspects of UVAR Exchange have also been included.

A two-page draft of an addition to the SUMP UVAR Topic Guide¹⁹ has been submitted to DG MOVE B for information and decision-making for further utilisation. This includes references and recommendations from UVAR Exchange, as well as UVAR Box and the ReVeAL project.

3.7 - coordinated the engagement with the high-level group on road safety. CORTE had begun to join Expert Group meetings and thereafter continued to liaise with the Expert Group on signs and signals. CORTE also invited them to the 2nd workshop on pedestrians and LTZ to be held in April 2022 (continuous engagement throughout the rest of the project).

¹⁵ <https://www.worldtransportjournal.org/>

¹⁶ https://static1.squarespace.com/static/619593021331d42c0b62a1c6/t/63c5946e4d3d02361dfe4be4/1673893001228/27.2+World+Transport+Journal+011523-10.9+MB_1.pdf

¹⁷ <https://static1.squarespace.com/static/619593021331d42c0b62a1c6/t/628692b651a2392004f405f7/1652986586224/WTPP27.1-May2022-MedRes%288mb%29.pdf>

¹⁸ <https://civitas-reveal.eu/resources-overview/publications/guidance/>

¹⁹ https://www.eltis.org/sites/default/files/uvar_brochure_2019-09-26_digital_version_v2.pdf

3.8 - involved carrying out awareness-campaigns via digital means and printed leaflets. As part of this Task, the following activities and results were achieved:

- At the start of the project a press release was published on LinkedIn about UVAR Exchange. In addition, an invitation to survey and save the date for the workshop in December 2021 was also published on LinkedIn. This workshop was used to raise awareness to a broader audience, not just the participants of the demonstrators. A discussion about having a combined website with UVAR Box was also started and the website launched in January 2022.
- The team decided to present at the Transport Decarbonisation Alliance COI “Urban Freight” held in February 2022. This presentation focused on physical signage, variable message signs and cooperative intelligent transport system (C-ITS) messages.
- A presentation at the ITS Committee was held in March 2022.
- UVAR Exchange presented at ITS Toulouse in June 2022.
- Final workshop in October 2022. Held as a hybrid event (teams/Brussels) with around 80-100 participants.
- The awareness raising campaign about demo activities to be disseminated via social media is being prepared and planned to launch as soon as this report is approved.

Besides the workshop organisation, the team had meetings with UVAR Box, ReVeAL and POLIS to understand how synergies amongst the EU UVAR projects could be established. It was agreed that the UVAR Exchange website would be integrated in the existing UVAR Box. With ReVeAL, exchanges of information to be included in their Guidelines was agreed upon.

UVAR Exchange engaged more than 100 entities (see below).

Figure 9: Entities engaged in UVAR Exchange



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ANNEXES

Annex 1. Final report Task 1.1 and 1. 2- Practical aspects of UVAR information provision through signage

Annex 2. Final report Task 1.3 - Guidelines for UVAR Variable Message Signs (VMS)

Annex 3. Final report Task 2.1 & 2.2 - Challenges and opportunities related to cross-border data sharing for enforcing UVARs

Annex 4. Final report Task 2.3 - Recommendations on improving data sharing to enforce UVARs in a cross-border context

Annex 5. Final report Demonstrations activities