ReVeAL

Regulating Vehicle Access
for improved Livability

Milestone 10 – Report

Market consultation on new technology, products and policy measures

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Table of Contents

Summary sheet

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About ReVeAL

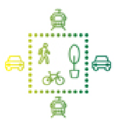
ReVeAL – Regulating Vehicle Access for Improved Liveability – is a CIVITAS project funded by the European Union's Horizon 2020 research and innovation programme. The goal of ReVeAL is to add Urban Vehicle Access Regulations (UVAR) to the standard range of urban mobility transition approaches of cities across Europe. The EU funded R&I ReVeAL project looks at this hot topic for the first time since the CURACAO project (ending a decade ago).

The overarching mission of the project is to enable cities to optimise urban space and transport network usage through new and integrated packages of urban vehicle access policies and technologies. Such policies can lead to fewer emissions, less noise and improved accessibility and quality of life, which especially benefits the people living in these cities. These policies can also encourage more sustainable transport choices, enabling cities to become more liveable, ultimately healthier and more attractive for every member of society.

To this end, ReVeAL combines conceptual work and case study research with hands-on UVAR implementation in six pilot cities, as well as systematic stakeholder interaction through professional communication activities. Different UVAR measures will be developed, implemented and tested in the cities of: Helmond (NL), Jerusalem (IL), London (UK), Padova (IT), Vitoria-Gasteiz (ES) and the project leader Bielefeld (DE). Except these cities, the project partners are Centro de Estudios Ambientes (ES), Ghent University (BE), Universitá di Padova (IT), POLIS (BE), Rupprecht Consult (DE), Sadler Consultants (DE), Transport for London (UK), TRT (IT), V-Tron (NL) and WSP Sweden (SE). The project started in June 2019 and will run for three years.

ReVeAL looks at a range of UVAR measures, both established and cutting-edge approaches, grouped under the four *Measure Fields*:

Zero-emission zones
Areas where only vehicles emitting zero emissions are permitted.



Spatial interventions
Access regulations based on area planning and design, and physical interventions in the public realm.

Pricing measures
Financial charging for accessing specific areas.

Future proofing and future options
Possible tools and emerging technologies that cut across all measures.

Description of milestone

Milestone 10 is part of task 2.6 – *Future proofing UVARs* which is the main activity of the measure field *Future proofing and future options*. This task is carried out in two parts:

1. Innovation Observatory report and city-specific readiness assessment: The observatory will cover both mobility products and services (their market penetration and potential transportation and societal impacts) as well as the potential of new technology (its potential business models). Key suppliers and developers will be consulted. With the knowledge gathered during the design phase in task 2.4, the Task Leader will perform an initial assessment of the resilience of each city's regulatory policies and measures. The assessment covers, existing policies, those under consideration and potential transition schemes and possible future adaptions. A final assessment will be made halfway through the (WP3) implementation.

2. Future ready guidelines: These will be an extract and generalized practice-based lesson from both desk research and the pilot cities. The guidelines will feed into the online Decision Support Tool and support European cities beyond the consortium.

Milestone 10 is a market consultation on new technology products and services, to be finished in month 9 in the format of a consultation report. The market consultation is an important input to deliverable 2.7 – the *Innovation Observatory Report*.

The purpose of the market consultation is to map the potential of new and future technology, services and products in enabling new types of UVAR measures, but also how the implementation of existing UVAR measures can be facilitated by these new solutions. The conclusions of the consultation will provide the project with guidance to recommendations for future-proofed actions for the participating cities, as well as to provide guidance to any stakeholders consulting the results of ReVeAL in the future.

The work package of future-proofing UVARs and more specifically the production of the Innovation Observatory Report will continue throughout the entire ReVeAL project. Since the consultation of market actors is a key ingredient in this continued work, these activities will not be concluded by this consultation report. Therefore, this milestone report should be read as a description of the initial stage of the market consultation.

Method

Elaborated from the purpose described above, the goals of the market consultation are to capture:

- What technology developments that are available and necessary to implement new types of UVARs, or implement existing UVARs in new (improved) ways
- The maturity of these technologies
- What challenges suppliers and cities face to implement these types of UVARs
- When these challenges are estimated to be overcome

To achieve this, the first step was to identify and describe new or future UVAR measures and methods. This has been done through literature studies. A few broad technology areas related to these UVARs have also been identified and described. Based on the insights of this work, a questionnaire directed to market actors was formulated. Market actors are primarily developers and suppliers of technology, products and services that are needed for the new UVARs, but also include actors that set the stage for the implementation of new UVARs, such as governmental agencies and public administrations, research organisations and cooperation platforms. The scope of the consultation has been limited to road traffic.

The questionnaire was formalised as an online, open survey, that could be accessed by anyone through a hyperlink. Respondents agreed to share their answers openly and without anonymisation. Some market actors were willing to share useful, but sensitive information under restricted conditions. This information was received in parallel interviews and not through the survey.

The survey was distributed by email to identified market actors and in expert networks, were receivers were encouraged to spread the link further in their respective networks. The full pool of receivers is therefore unknown. Around 70 organisations and networks were contacted directly, through more than 150 email addresses. The networks included the full ReVeAL consortium and reference group, among others. A summary of the receivers is given in the *Results* section. Further, the link was also posted on LinkedIn. The survey was opened on January 31, 2020 and answers were reviewed and summarised continuously during February.

The survey was introduced by a short background on the ReVeAL project and the purpose of the market consultation. The new or future UVARs were briefly described. The questions were structured around three main blocks (except for the initial contact information section):

1. **Your solutions:** questions on the solutions (technologies, products, services) relevant to new UVARs that the respondent supplies or develops
2. **Adjacent solutions:** questions on the respondent's view of other solutions than their own, that will be necessary to implement new UVARs
3. **Solution barriers:** questions on the respondent's view of barriers for full implementation of new UVARs, other than technological readiness and development of new products or services

The full survey can be found in an appendix.

Throughout the market consultation, the system view illustrated in Figure 1 is kept in mind, which illustrates the variety of components and perspectives that are required for a full-scale implementation of new UVARs.

The new technology and services covered by the market consultation affect different parts of the entire system that makes up the transport system of a city:

1. There is the infrastructure consisting of the streets, lanes, traffic signals, signs, parking, loading/unloading, pick-up and drop-off of passengers, etc.
2. The vehicles and travellers that are moving in the infrastructure, using different modes of transport and have different purposes of their trips
3. The digital infrastructure that can be made up by different cloud solutions, databases, websites, and communication channels (Wi-Fi, 4G/5G, GNSS, radio communications, and hardwired connections)
4. The city (and/or national/regional/EU-wide) administration and authorities, who decide on regulations and are responsible for communicating and enforcing them, and are the collectors of fees and fines
5. Spaces and areas of the city that are used not only for traffic but for other purposes.

Different UVARs affect several or all parts and especially the future UVARs that are more complex require that stakeholders from all perspectives cooperate. Each solution must relate to the whole ecosystem made up by these parts. Therefore, this consultation has chosen a broader perspective than just describing new technology and its potential.

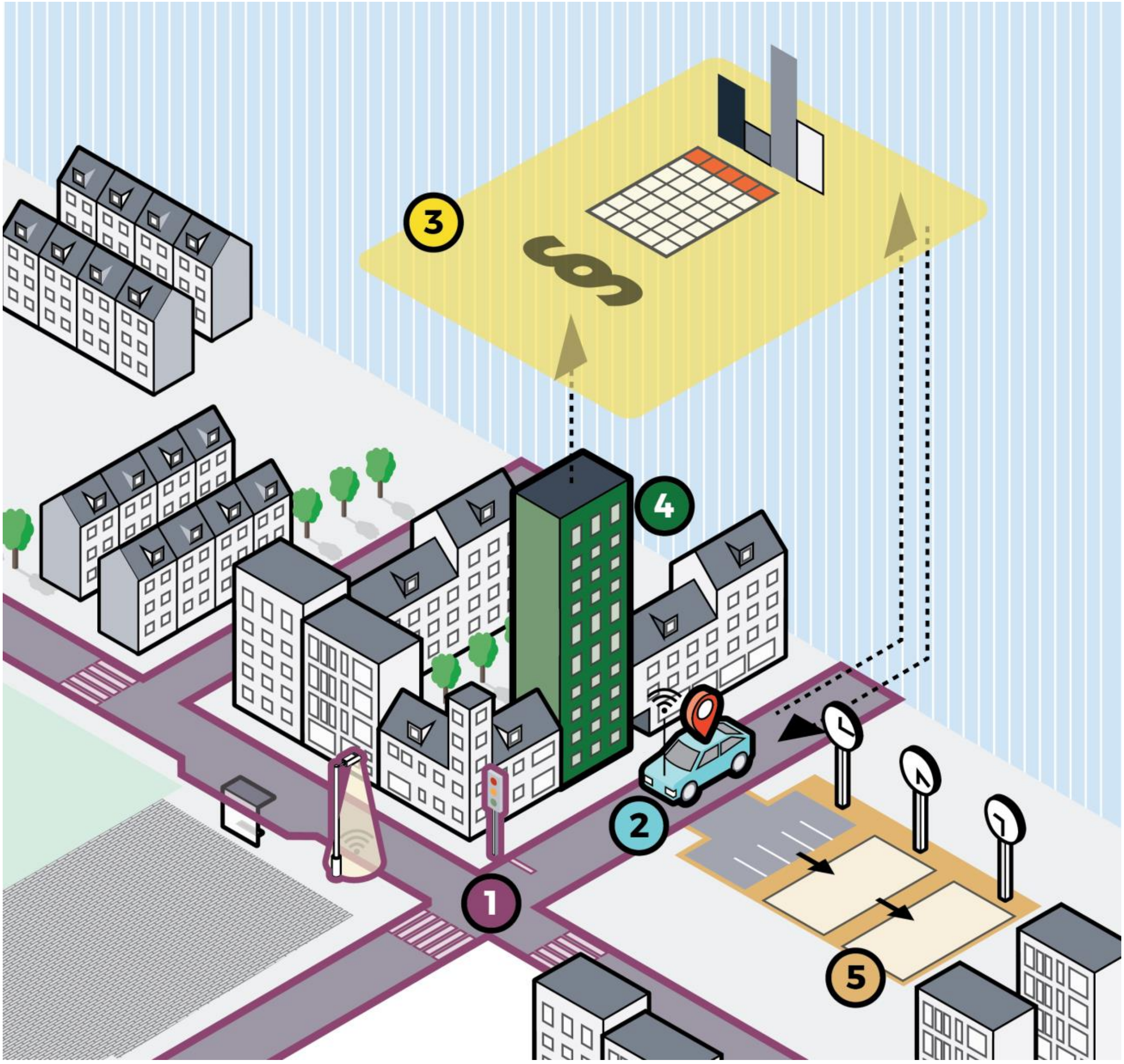


Figure 1: System view of the stage for future UVARs

Results

Description of future UVARs and related technologies

Five new or future UVARs that have been identified, and are described more in detail below:

A. **Realisation of Zero/Low Emission Zones, speed limits or access restrictions through geofencing.** Geofencing is a concept which includes technical solutions combined with suitable digital and organisational processes to make sure that vehicles follow certain characteristics or regulations within specific geographical areas. Geofencing is considered an important tool to create a safe road network in today's complex traffic environment. Geofencing is also considered to be important for future demands of safe, fossil free and more silent transports.
B. **Future pricing measures:** Charging policies that regulate access to parts of the city, streets or specific infrastructure assets. Charging policies are used today in serval cities around the world, mainly to alleviate congestion. In the future, charging could be differentiated based on exact usage of the infrastructure, in time, distance and location.
C. **New types of ITS measures.** EU defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport. Technological developments of connected vehicles, people, devices, and infrastructure are an import driver for new ITS applications where data from difference sources can be shared, merged and used to optimize and manage a variety of areas like road capacity, traffic signals, fleet deployment for private actor, transit network, etc. Connected vehicles may open opportunities for new mixed traffic road designs. Interesting ITS measures to ReVeAL relate to combinations of hardware, data, and digital platforms that support real-time control and regulation policies.
D. **Dynamic kerbside or parking management.** Kerbside space and parking space can be used not only for car parking and loading/unloading, but also as sidewalk café, transit hub, freight delivery zone, taxi stand, rain garden, or trash collection area. It could serve many purposes throughout the day, enabled by differentiated pricing or regulation, potentially through different types of digital solutions.
E. **Access delimited to high-occupancy vehicles or differentiated charging by vehicle occupancy.** Using a combination of regulation and technology, high-occupancy vehicles could be prioritized or rewarded before single-occupancy vehicles for access to specific lanes and other infrastructure.

Technology development in four main areas enable these UVARs:

1. **Vehicle automation:** automation of functionality in vehicles (mainly cars, buses, trucks) that shifts the control of certain functions from the driver to software, ultimately in a way that cannot be overridden by the driver. With a fully automated vehicle fleet, this would reduce or even eliminate the need for physical barriers, signing and manual inspection of compliance. The controlled functionality could include speed limitations (which could be set to 0 km/h on no-access lanes) or mandatory switch to electric propulsion for hybrid vehicles. Automation also requires infrastructure digitalisation, e.g. high-resolution, validated and updated maps for infrastructure and regulations (online or offline), including updates on the current state of the infrastructure with regards to road maintenance, weather, and more.
2. **Positioning:** high quality information on the exact location of vehicles in any given moment, needed for e.g. automated checks on whether vehicles are inside or outside regulated zones. Positioning work together with maps and to be useful, maps must be up to date and validated, which is an issue that varies between regions and countries depending on general level of citizens' connectivity and willingness to share information, as well as the authorities' investments in open data and validation. Current positioning (GNSS, 4G, short range radio communication) technology is often accurate enough to be used for policy enforcement, where an error margin measured in meters is generally not a problem. However, for applications where centimetres for moving vehicles are crucial, technology is still not mature enough. When it comes to parking, positioning could be completed by the vehicle cameras which will recognise line markings and other signage. Total, high precision positioning is likely not to be able to solely rely on satellite positioning (GNSS) in an urban environment, due to tunnels, dense urban networks and urban canyoning. Cell towers are an alternative but are often not dense enough. Therefore, cost-effective and high-definition real-time positioning in urban environments is still a research area.
3. **Connectivity:** enables data transfer between vehicles, infrastructure and data sharing platforms. Data could originate from e.g. sensors, cameras and positioning devices, UVAR regulations that are communicated to vehicles digitally or confirmations that vehicles are obeying these regulations. If UVAR regulation is dynamic, vehicles must be connected to always have access to the updates set of rules. For safety applications the latency needs to be milliseconds (or even higher), while for UVAR applications seconds may suffice which implies a lot can be achieved already with 4G. Connectivity has the potential to improve UVAR enforcement as vehicle identification and classification can be done much easier. Even differentiating between through traffic and local traffic can become a lot easier.
    a. **Infrastructure connectivity:** This includes sensors for parking/delivery zone occupancy, cameras for traffic flows, connected traffic lights and signs and more. Further, a consistent data governance structure is probably necessary, since

connected environments (including connected and automated vehicles) will generate large amounts of data that need to be effectively managed and organized to extract necessary information. This structure should also include cybersecurity infrastructure and data privacy/protection strategies.

   b. **Vehicle connectivity:** The three categories of vehicle connectivity are: 1) Vehicle to Vehicle (V2V) – Communication between vehicles, 2) Vehicle to Infrastructure – Communication between vehicles and surrounding infrastructure (traffic lights, traffic management centres etc.) and 3) Vehicle to everything (V2X) – Communication between vehicle and technology that connects them with other road users (e.g. cyclists, pedestrians etc.).

4. **Dynamic control:** Smart regulations, pricing schemes and control algorithms that could be used to steer traffic flows and use of space in an adaptive manner, for desired outcomes. Further, any regulation must be defined digitally in high-quality validated maps by the city (or other) administration. With new technology and data it will become possible to apply new control algorithms and have more complex pricing policies. At the same time as the market for private mobility offers increases, which applies its own set of optimisation and pricing strategies, the need for regulating these new markets will increase. Venture capitalist funded services may overload the market with capacity at a low price to gain market share or even to establish monopoly situations that could be undesirable from a public policy perspective.

These technology areas are of different importance to each new UVAR.

General results from the survey

In this section, the general results from the survey are summarised. The respondents can be divided into the following categories: regulating authorities, developers of new technology and vehicles, research institutes and software developers, see Figure 2. The described solutions include:

- Digitalised traffic rules and regulations and digital specifications of infrastructure
- Vehicle equipment and telematics to capture trip data and apply pricing policies
- Editor for authorities to manage geofencing zones and related policies/regulations
- Congestion charging and tolling systems for highways and tunnels
- Concept for controlling access to the city only if end-location is available
- Weight measurements of vans and trucks using inductive sensors
- Autonomous shuttles for first/last mile public transportation
- High-quality positioning
- Digital platforms for city resource and parking management (dynamic pricing, capacity, reservation API's)

- Digital platform for Infrastructure to Vehicle (I2V) communication with standardised communication, geofence administration and management and integration with access control systems
- Equipment and connected systems to detect and classify vehicles
- V2I communication components
- Real-time detection and reporting of vehicle emissions through remote sensing
- Detection of vehicle characteristics such as size, the temperature of the exhaust to ensure that the vehicle is in a "warmed up" condition, number plate, speed, acceleration, and ambient weather conditions
- Software for real-time behaviour analysis and intent prediction, for automated vehicles

Regarding the five UVARs presented previously in this report, nearly all respondents state that they develop and supply solutions connected to enable geofencing and future pricing measures. The least represented UVAR among the respondents is technology and solutions to benefit high occupancy vehicles. ITS measures and kerbside or parking management are represented by an equal number of respondents. Some respondents are not directly new technology developers, but have still given input to this survey by commenting on for example legislation issues and how to enable large scale tests in an urban environment.

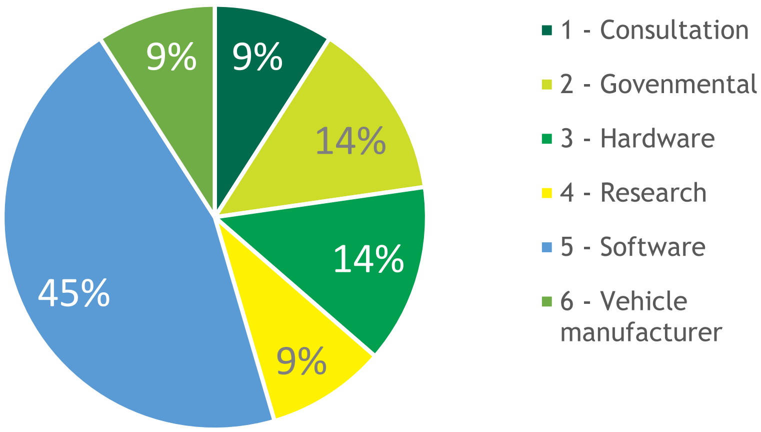


Figure 2: Business areas represented in the survey results. In total 17 respondents participated.

In the following sections, findings on each future UVAR from the literature study as well as from the survey are summarised.

Geofencing

Geofencing is a geographic zone that has been defined digitally, where connected vehicles[1] are controlled to follow a set of regulations, such as limited speed, access restrictions or limited use of powertrain (typically only electric). The ReVeAL project defines geofencing as:

"A geo-fence is a virtual perimeter for a real-world geographic area. A geo-fence could be dynamically generated – as in a radius around a point location, or a geo-fence can be a predefined set of boundaries (such as school zones or neighbourhood boundaries)."

Out of the mentioned technology areas, geofencing requires progress in some or all of them, depending on, for example, whether the geofencing zone is static or dynamic. A dynamic setup means that the regulation of the geofenced zone, or the limits of the zone, changes over time based on the current situation regarding e.g. congestion or emissions.

Geofencing is a multi-stakeholder solution that involves both public and private organisations. Solutions offered or developed by the respondents to the survey include:

- Broadcasting of regulations through data exchange platform
- Standardisation of data formats and interfaces
- Aggregation of data
- Managing financial transactions of fees generated by access to a geofenced zone
- Platforms for creating and editing geofences digitally at a low cost, which enables temporary local solutions when suitable (e.g. for events or roadworks)
- Other administration and management of geofences
- Positioning and localisation: GNSS (satellite), radio-based and motion sensors
- App-based solutions for end-users and for enforcement
- Installed equipment for automatic monitoring of compliance at street level
- In-vehicle equipment for automatic control of related functions

The TRL (technology readiness level)[2] of the described technological solutions is generally high. Most of the respondents' solutions are between 7 and 9, either now or and within two years.

[1] The term "vehicles" includes cars but also bicycles, scooters, mopeds, as well as trucks, buses and other road vehicles

[2] TRLs in Europe (from Wikipedia, February 2020):
TRL 1 – Basic principles observed
TRL 2 – Technology concept formulated
TRL 3 – Experimental proof of concept
TRL 4 – Technology validated in lab
TRL 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

However, is there still a need for commercialisation among vehicle manufacturers and cities needs to adapt the local regulations to digital standards. Authorities are still learning and exploring needs at different stakeholders and how to establish a standardised system for data sharing. This is done by pilot tests and voluntary regulations for special-permit transports.

Considering adjacent solutions, i.e. solutions that the respondents do not supply themselves, that are needed for a large-scale geofencing implementation, respondents point out in-vehicle technology (hardware and software – examples: speed control, driveline choice (diesel, electric etc.), tyre type (studded tyres), noise rating). Even though technology maturity regarding the in-vehicle equipment is high, manufacturers are not likely to install it unless it is requested by buyers or made mandatory by authorities, since it constitutes an extra cost to the customer. It is highlighted that dynamic UVARs require dynamic communication to end-users (digital signs, websites, navigation apps and more). Further, high-quality maps and reliable connectivity are mentioned. It is important to have standardised interfaces, so that visitors can understand regulations in different cities. Regulations for mandatory vehicle equipment to be in place on a given year is also suggested, and it is pointed out that a legal framework is missing, as well as international standards for data sharing formats. Among the responses to the survey, a majority point out public bodies as the owners to the adjacent solutions, such as national or regional authorities, city administrations or road operators.

There are several barriers other than the technological challenges to implement geofences. When it comes to legal matters, compliance checks and enforcement to dynamic regulations are pointed out, and how non-authorised vehicles could be stopped from entering the zone, as well as how to gain acceptance for dynamic regulation. EU-regulations need to be in place to be able to demand all vehicles to be equipped at some point, or there needs to be other strategies to handle a varying degree of equipment in vehicles. Further, the liability in case of system errors or incorrect data needs to be addressed, as well as the challenges for cities to maintain all parts of the system accurate.

Safety and security risks are highlighted as a main challenge. There is a risk for attacks on the positioning technology and data. Data must be valid, unaltered from the source and trustworthy when handling traffic flows and the systems providing the information must be secure and only operated by authorized personnel. However, these issues apply to all UVARs and should be solved in the design of the larger systems for positioning, connectivity etc. and not specifically for the geofence application. Also, when entering or exiting a geofenced zone, the operation of the vehicle must be maintained in a safe way so that sudden changes do not cause risks of accidents.

TRL 6 – Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7 – System prototype demonstration in operational environment
TRL 8 – System complete and qualified
TRL 9 – Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

However, some respondents argue that safety and security are already sound enough to allow reliable operations, and that the main issues rather concern privacy matters.

Some respondents point out standardisation issues as one of the main challenges considering geofencing. Standards are required to manage vehicle compatibility and for the exchange of UVAR information a common language is needed. One respondent also highlights that cities should have common standards and guidelines regarding factors that regulate access, for example the extent of emissions allowed in a low-emission zone.

Regarding organisational structures and/or business models, solutions must be identified for third-party data processing, billing, implementation in and monitoring of legacy vehicles, public-private partnerships and the sharing of data.

The respondents' replies on how to handle compliance (how to make sure regulations are followed, strategies for handling non-equipped vehicles, etc.) vary due the respondents different UVAR solutions. Technology exist that can measure vehicle emissions in real time, which can be used as one part of the control system. When it comes to speed adaptation a general impact can be achieved with only a limited number of vehicles being equipped with the technology. There are also solutions to ensure performance is met not just specified, but that requires more from the geofence system.

Trials of geofencing have been made in a few cities, see examples below.

Cologne, Germany

Ford is testing a geofencing solution for nine hybrid delivery vans operated by municipal authorities. Cologne has a low emission zone and the geofencing system is thought to alleviate the problems of not knowing when and where you can drive with your vehicle. With the geofencing system, electric propulsion automatically activated when entering the zone and switched off when leaving it. The distances travelled in different modes are stored using a blockchain solution and can be accessed and analysed anonymously. Vehicles are connected to allow for dynamic regulations, where the restrictions of the low emission zone can change adaptively. Ford also carried out similar tests in London and Valencia. (Elektroniknet.de, 2019)

Ford will offer a Geofencing module for plug-in hybrid vehicles from spring 2020, for the purposes described above (but currently without the blockchain capability), also possible to retro-fit. (Green Car Congress, 2019)

Gothenburg, Sweden

Project ElektriCity started in 2013 and includes a range of measures to develop, demonstrate and evaluate solutions for sustainable and attractive public transport. As part of the project, two bus lines are geofenced to automatically follow speed limits (or even lower in areas of mixed traffic with vulnerable travellers) and only use electric propulsion in certain areas that are extra sensitive to noise and emissions, see Figure 3.

The bus lines are operated by customised vehicles, equipped with a so-called Zone Management System, and the geofencing is static so the regulation and zone borders could be downloaded to the vehicles once and the vehicles do not be connected.

Drivers view the system as a valuable support to focus on operating the vehicle and reduce the risk of accidents and stress.

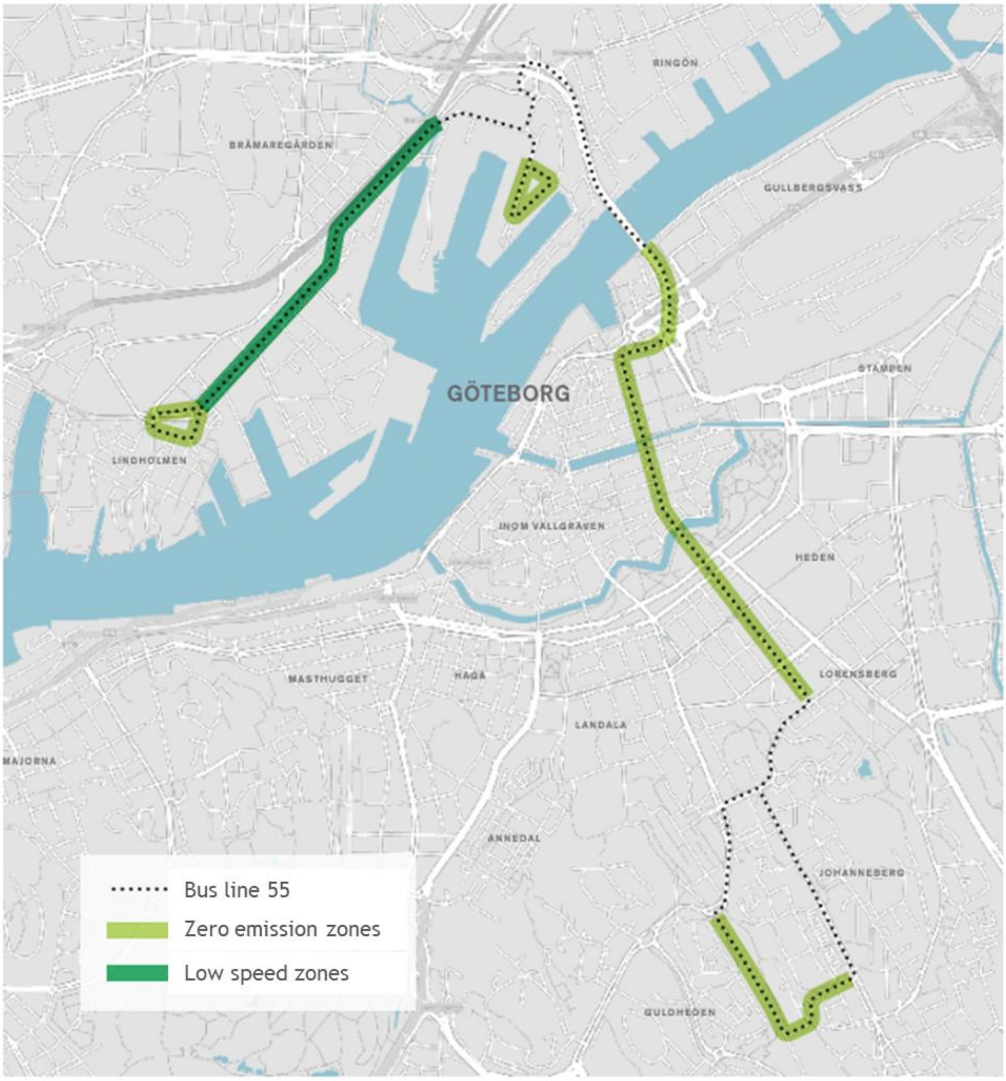


Figure 3: Zone Management System, ElektriCity (image from ElektriCity, 2016, legend has been translated)

Stockholm, Sweden

In 2018, several functions including controlled maximum speed, access restrictions and automatic electric propulsion were demonstrated in a dense area of the city, to illustrate the opportunity for safe coexistence of vulnerable travellers and vehicles.

In another trial where night-time distribution of goods is tested and evaluated, distribution vehicles are geofenced to automatically switch to (quiet) electric propulsion in areas where night-time deliveries are normally prohibited. Like the Gothenburg trials, the rules have been pre-programmed to the control systems of the vehicles. (Ny Teknik, 2019)

The Swedish Action Plan

In 2017, the Swedish government assigned the Swedish Transport Administration to test the concept of geofencing through demonstration projects, motivated primarily by the challenges to reach the goals of the transport sector regarding safety, noise and pollution. One of the outcomes of the work is a 7-step action plan to prepare for the implementation of large-scale geofencing in cities. (CLOSER/The Swedish Transport Administration, 2018). The document describes the main challenges and requirements to implement large-scale geofencing, as well as the anticipated positive effects. The action plan is created in cooperation between the Swedish Transport Administration, the cities of Stockholm and Gothenburg, OEMs Scania, Volvo Cars and AB Volvo, and cooperation programme CLOSER.

Other examples

A few more examples of successful implementations or pilot tests where some of the respondents' solutions have been applied include:

- Civitas Eccentric - Geofencing used to enforce electric propulsion and speed limits in urban areas, for a plugin hybrid truck making silent night deliveries to six Mc Donald's restaurants (Stockholms stad, 2018)
- Low emission zones in Scotland, Belgium and France where technology for remote sensing technology was used to measure emissions (EFKON)
- Geofencing a bridge in Gothenburg – maximum speed 12 km/h, seen in Figure 3
- Dalatrafiken buses – speed limitations in a pedestrian area and in an area close to a school (Byggteknikförlaget, 2019)
- GeoSUM project Oslo – pilot testing of max speed zones and low emission zones (SINTEF, 2018)
- WA RUC - a road usage charge pilot by the Washington State Transportation Commission. WA RUC is designed to test multiple mileage reporting techniques and technologies, as well as how this program might function across state lines or national borders (Washington State Transportation Commission, 2020).

Future pricing measures

Pricing measures are in use in many cities, often in terms of congestion charging. Nationwide distance-based charging is also being debated to reduce the transport sector's carbon footprint (and to compensate for reduced fuel tax revenues when the vehicle fleet is electrified).

From a city perspective, distance- and/or time-based charging could be a future development to the current congestion charging schemes, where access is typically charged when entering the zone through some type of gate. Once vehicles are connected and equipped with highly accurate positioning devices, their individual use of the cities infrastructure could be charged and price could be differentiated based on when the infrastructure has been used, for how long, how much (travelled distance), between different streets or sub-zones, or even depending on the current congestion or emission situation. Except positioning and connectivity, this UVAR also requires a central control system (dynamic or not) that is operated by the city and where the charging policies are communicated to vehicles and citizens, and which summarises each vehicle's use of the infrastructure, calculates the price and collects the fees.

There are no such setups in use yet for private vehicles, but

- in Brussels, Belgium, there is a distance-based charge in use for trucks, which uses GNSS-tracing. An on-board unit calculates the toll to be paid, based on the number of kilometres driven (calculated via satellite signals), which type of roads where used and vehicle type (EFKON, 2020, Viapass, 2020). It could be expanded to a time-based component in the future.
- In Singapore, a development from traditional congestion charging to distance-based polling is discussed, but implementation is still a couple of years in the future.
- Regarding time-based charging, it is used in the Austrian truck polling, but it has not been a common solution previously.
- In the USA, pilot tests are made for distance-based charging, but with the main goal to compensate for reduced fuel tax incomes and not for controlling vehicle flows. An example from USA is OReGO - Oregon's road usage charge program where participants pay for the miles they drive.

The respondents for this UVAR reasons that their solutions will contribute to the full-scale implementation by providing:

- Data standardisation and aggregation, application of time- and distance policy and converting it to financial transactions
- Positioning technology (and accurate time from satellite positioning). Underlying estimation of time and distance using sensors.
- Video and/or Automatic Number Plate Recognition based charging solutions to detect and classify all vehicles according to local schemes. Full back office enrichment and operation of such solutions.
- Stationary, portable and mobile solutions are available to charge and/or enforce.

- Continuous monitoring of vehicles with respect to model and more

The three latter solutions represent equipment that needs to be installed in certain places of the city, or moved around to monitor and detect vehicle movements and characteristics. While this is useful, a long-term solution would include the vehicles sharing their trip data (possibly including emissions, speeds and other useful information) in real-time and that this is converted to a differentiated fee. Possibly such a setup would still require compliance checks using other types of equipment installed throughout the city infrastructure.

The described solutions have a TRL mostly between 7 and 9, with a higher level for the distance-based component.

Other solutions that are needed for a full implementation of time- and/or distance-based pricing are solutions to guarantee privacy for the tracking and monitoring of vehicles, whereas the technology is in place. However (as for all future UVARs), for a large-scale implementation all vehicles must be equipped with this technology, or there must be a fair strategy to handle un-equipped vehicles. The accuracy of maps and odometry/tachograph data (the information on vehicle movements recorded by the vehicle using motion sensors etc.) is important as well as the user interfaces to the pricing system.

Apart from the technology, a crucial factor is the legal framework and the public authority solutions. These coincide with barriers for implementation mentioned in the survey:

- The development of a legal framework for this system
- Privacy/GDPR issues: which personal information can be provided or used for such a solution and to enforce it? This also affects whether cloud-based services could be used, since it could be prohibited to move data abroad.
- The reliable exchange of data/information in an urban environment
- The public organisation in charge must be adapted to be able to handle the solution. For example, there could be discrepancies between the organisation benefiting from such a solution and the one that needs to perform the investment.
- It is highlighted that common standards within the EU would be suitable. Currently each country, city or region often have their own standard. However, other respondents claim standardisation is not an issue in this case.
- The risk of access discrimination based on income, as lower income communities will have less options to access these zones.

New types of ITS measures

ITS measures are not in the future, but there is a wide range of ITS solutions in use in cities all over the world. However, it is a field of measures that is developing as technology and access to data evolves rapidly. Advanced solutions to manage traffic effectively in cities could be the outcome of developments in

- infrastructure and vehicle connectivity
- monitoring of congestion, noise and emissions
- communication to drivers regarding e.g. navigation, route choice and parking/loading accessibility, and traffic jams or accidents
- machine learning to find smart ways to steer traffic flows in different situations
- and more.

Using these technologies, traffic control centre could obtain detailed, real-time data on the traffic situation, provided by data streams from sensors, cameras and information shared by connected vehicles. Accurate short-time forecasts and decision-making could be supported by advanced algorithms, and traffic flows re-directed/optimised through dynamic signing and through the vehicle interface and smartphones.

Solutions provided by respondents to the survey include:

- Software to control dynamic physical barriers to an area (active speed bumps, dynamic bollards and gates)
- Privacy-proof camera detection of oncoming bicyclists to configure traffic lights in real-time (to give priority for bicyclists)
- Tools for data processing, network map matching, network reasoning, prediction and more to influence traffic flow by traffic signals, variable message signs, ramp metering etc.
- Positioning estimates, which is used for interpretation and validation of data that needs to be exchanged as part of many ITS solutions
- Solutions for standardisation, interfaces and business models
- Bus prioritisation using traffic signals
- V2I communication components
- Real-time detection of emissions from individual vehicles
- Software for footfall measurements of pedestrian and bicycle travel patterns

The ITS technology represented by the respondents has generally a high TRL, from 7 to 9 and in use. However, that is for the software part. The access control system and the technology for the micro-mobility users has a TRL between 2 to 4.

A few examples of successful implementations where some of the respondents' solution has been applied:

- Socrates 2.0 is a European project based in cooperation of road authorities, service providers and car manufacturers. The project promotes the European wide introduction of traffic management and navigation services in mobile/in-car devices. For this, a well-structured cooperation between road authorities, service providers and car industries needs to be developed, making use of newly developed business models which create a win-win-win for both public and private stakeholders and users and new data exchange protocols to provide technical solutions throughout the complete traffic management (value) chain. And also paving the way for large-scale deployment of self-driving cars (Socrates 2.0, 2020).

- TLEX I2V is a platform especially designed to connect roadside equipment to information brokers, automotive industry, road authorities and road users. It is live on a national scale in The Netherlands, processing over 250 million messages a day (Monotch, 2020).
- Traffic Solutions for Amsterdam and Copenhagen, MobiMaestro. A network management system to combine information from different traffic systems. Together with travel-time information and traffic counters, the cities can manage the whole city and not something as specific as one item such as traffic or parking guidance, but the complete flow (Technolution, 2019).
- Nordic Way 2 and 3 projects. Nordic way is an EU project to test and demonstrate the interoperability of cellular C-ITS (cooperative ITS) services both for passenger and freight traffic, piloting continuous services offering a similar user experience in the whole NordicWay network in Denmark, Finland, Norway and Sweden (Nordic Way, 2020)
- Fleetwide testing that involves notifying individual motorists based in the result of detected emission. It rewards the cleanest cars on the road in Nashville, Tennessee in the United States (Hager Environmental & Atmospheric Technologies, 2020)
- PRoPART is an EU funded cooperation project focusing on autonomous vehicles and advanced driver assistance systems. The main idea behind the project is to develop and enhance an RTK (Real Time Kinematic) software solution by both exploiting the distinguished features of Galileo signals as well as combining it with other positioning and sensor technologies (PRoPART, 2020)
- Einride – autonomous, all-electric transport vehicles (Einride, 2020)
- Asta Zero - full-scale independent test environment for future road safety (Asta Zero, 2020)
- Delivery of footfall data for several cities such as Stockholm (Bumbee Labs, 2020)

Other solutions needed for full implementation that are mentioned are correct maps, edge computing, reliable and predictable network connectivity, low-cost sensor technology and V2V and V2X communication equipment and standards.

As for the other UVARs, it is highlighted that rather than technology, which works or is at high maturity, main challenges for implementation are centred on communication, legal framework, enforcement, public authority solution and policy.

More in detail, identified barriers include the public sector being slow to implement new technology, sharing of data or access to software between stakeholders, insurance and liability complexity, and different communication standards.

Regarding safety and security, it is viewed as a challenge in terms of guaranteeing valid and trustworthy data and prevent unauthorised access to the system settings. It is not clear who will be responsible for cybersecurity oversight and be liable for the decisions. However, as mentioned earlier, these matters are not unique for this UVAR, but need to be addressed generally as the transport system becomes more connected and more data is transmitted between actors.

Other challenges concern organisational matters. Who should own and maintain the infrastructure, how will operators and purchasing organisations handle payments, forms for public-private partnerships, business models for data sharing are different examples that are highlighted.

As for other UVARs, standards are required to allow different vehicles to operate in different cities. The ideal case would be a global standard. However, some respondents claim standards are already in place.

A specific challenge in this field is sensing micro-mobility and pedestrians, as the ITS domain traditionally is very car/truck focussed. Also reaching these travellers must be done differently as bicyclists rarely use navigation apps.

Dynamic kerbside or parking management

Vehicles entering a city often (but not always) are heading one or several specific destinations, either to park, load or unload goods or pick up/drop off passengers. By controlling the how and when these destinations could be accessed by vehicles is therefore a way to regulate access. This UVAR includes all measures where the use of kerbside and parking space in managed in new ways with the consequence that the space is utilised for different purposes over time. However, these types of measures are mainly motivated by increasing market shares in for-hire vehicle services and e-commerce that lead to dramatic increase in use of the kerbside for loading/unloading of passengers and parcels. This comes with new congestion challenges and traffic safety issues. Continuous enforcement of kerbside regulations is hard, since a drop-off or pick-up only takes seconds. New types of UVAR that regulate and enforce the use of kerbside capacity in real-time are needed in a short to medium term. On the kerb itself, and/or between motorized vehicles and pedestrians, there are potentially rapidly changing conditions related to bicycle use, electric scooters, automated delivery drones that may require new types of regulation and their own dedicated space in the urban landscape.

For dynamic kerbside/parking management to work, there are (as for all UVARs) several components that should be in place. The use of the chosen space should be monitored, for example by using sensors or cameras or by the automatic reporting by the vehicles themselves. The regulation of use should be formalised and communicated, in terms of access regulations, pricing, dynamic signing and other information streams e.g. through a smartphone app or other digital channels. Finally, the regulation itself could be dynamic, to find a smart way to use the space for regulating traffic and create an attractive street environment, but still meeting the needs for accessibility, mobility and freight.

The respondents to the survey present solutions or tests including:

- Data standardisation and aggregation, application of off street parking policy and conversion to financial transactions
- Positioning and localisation technology for parking space and vehicles

- Platform for space reservation APIs, dynamic pricing and capacity management
- Solutions including sensors and better data to improve usage and availability on loading zones

TRLs vary between sub-solutions. Parking management, occupancy monitoring and positioning are at TRL 7-8 or proven technologies. However, it is considered a challenge to achieve large-scale, cost-effective and reliable sensing with high definition in urban public space, which lowers the maturity of the measure.

The respondents' solutions have been successfully implemented in:

- TLEX Parking Platform (TPP), is a technology that helps get rid of streets full of cars, while the parking garages are insufficiently used, making better use of the parking garages and reduce search time for parking spaces. Parking-providers connect the off-street parking facilities to the TPP. Once the connected service-providers can resell their parking places the service providers can offer reservations and booking to their consumers in their apps or websites (Monotch, 2020).
- Pilot projects in Washington D.C that address challenges for a variety of kerb stakeholders including, but not limited to, residents, business districts, freight vendors, nightlife patrons, and for-hire vehicles. Tools deployed to-date include real-time parking sensors, demand-based pricing, commercial loading zone fees, and time-of-day-based parking restrictions (District Department of Transportation, 2020).
- The city of Stockholm is launching a demonstration within the NordicWay project to test better loading zone usage in 2021 (NordicWay).
- Volvo M – smart car sharing in Stockholm. Ongoing test in Stockholm. Free up parking space for the city to use for something else.

There is a need for the next generation positioning (GNSS) accuracy and high-accuracy kerb-level maps to scale up this type of measure. Further, cheaper sensors with less impact in the attractiveness of public space are needed as well as solutions to protect the privacy of individuals.

Other barriers that are mentioned in the survey are for example:

- City plans that stipulate usage might delay the development
- Once again is the need for standards mentioned as a main challenge

Rewarding high-occupancy vehicles

Already today in some places, vehicles with many passengers are allowed do use bus lanes (diamond lanes in North America/car-pooling lanes), to steer against higher utilisation rates of vehicles (and thereby less vehicles). This measure could be expanded to differentiate e.g. access to low-emission zones or pricing to access urban areas. It would require automatic sensing of the number of passengers in a vehicle, and that this information could be shared with the platform that calculates fees or enforces access restrictions. There are obvious privacy issues with forcing travellers to share this type of information and checking compliance by e.g. cameras. But as an alternative, drivers could share this information voluntarily and gain access to regulated lanes or lower fees in return. Of course, information of number of passengers must be validated by trusted in-vehicle technology.

Respondents in the survey develop or supply solutions for this measure by:

- data standardisation
- connection to Bluetooth-based occupancy measures
- application of high-occupancy vehicle policy or discount, and calculation on fees based on that

Devices and solutions to estimate the number of people within a vehicle is considered a research area by some, but not all respondents.

The TRL for these development areas are between 2 and 7, which makes the solution more long-term than the other UVARs discussed in this consultation.

Some of the successful implementations are:

- In Austria, the toll sticker system has established itself as the tolling method for vehicles with a maximum permissible gross weight under 3.5t. EFKON has supplied mobile systems for the automatic control of toll stickers. The system helps to automatically identify toll violators without interrupting the flow of traffic, thus increasing traffic safety (EFKON, 2020).

To be able to get full implementation of the UVAR, the respondents need improved AI/ML for Bluetooth device-based occupancy recognition or improved OEM data sharing of occupancy data, reliable sensors and communications channels to end-users.

The respondents point out barriers considering absence of standard rules and regulations applicable for autonomous vehicle systems and there is a lack of safety directive harmonisation across the industry and government agencies. Possible manipulation of occupancy sensor data must be addressed. Further, as for all addressed UVARs, the need for standards in general is highlighted as a barrier for large-scale implementation.

Legal framework

Nearly all market stakeholders raise the need to address the legal framework around new technological solutions as one of the major issues. Access regulations (all, not just new solutions) risk conflicting with a few principles of the European transport system. Firstly, infrastructure that already exists and have been financed using taxes, i.e. the collective of citizens, should be available for all. Secondly, the principle of freedom of movement, which says all EU citizens can transport themselves throughout the union, without discrimination because of citizenship imposes challenges towards adapting new technology that may not be available in the all EU countries. If a certain technology or equipment is required to access a city, that equipment must be made available for all citizens under reasonable terms, regardless of the individual's national citizenship. However, if there is a strong common interest of the citizens of a city, those principles could be limited by the local authorities. There are legal frameworks for this, for example the Euro class of vehicles, which is a defined classification, could be used for limiting access of vehicles to a city due to the strong common interest to lower emissions. The key is that there need to be common definitions that the regulation is built around.

For example, the concept of geofencing is not defined on an EU level. The technology that is referred to when talking about geofencing must be described and proved to be safe. When that has been done, those definitions could be used in e.g. procurements by a city or in local regulations.

If a new local traffic regulation applies to everyone, it must be properly announced. This is not always done digitally and not in a standardised way throughout the EU. Where no authority is responsible to provide the regulations in validated digital maps, and can guarantee that those maps are valid and up-to-date, there will be a barrier to implement geofencing or other UVARs that rely on digital map data. It is expensive to provide this information, and not clear who will pay for it. Another example is dynamic regulations for e.g. speed, that also must be communicated to all travellers in the city in a safe way – digitally to connected vehicles but also visually to other travellers allowed on the streets, replacing static traffic signs.

Another issue lies in the extent of control of the vehicle that the driver has right to. The Vienna convention on road traffic states that the driver must be able to control his or her vehicle. Whether to change this is a political question. Do the citizens of EU want a traffic system where regulation (e.g. speed limits) *cannot* be violated no matter what, because technology makes it impossible, or should it be possible to break the rules (and then take the consequences)? This issue has consequences for the geofencing solution, on whether the control of vehicle functions should be advisory and possible to override, or forcing. Here, there is also a difference between private and corporate/public transportation. Operators could be given incentives to install forcing technology, and be given other benefits in return, such as special permits to access otherwise regulated infrastructure. In the case of autonomous functions in personal vehicles, the driver has voluntarily accepted the risks of handing over the control.

One issue that has been raised is the compliance to regulations and how it is enforced. This is an issue of e.g. low-emission zones today – unauthorised vehicles could enter the zones with little risk of consequences. Regulations could be enforced by the police or camera surveillance, but these are costly and/or there may be privacy-concerns. Some countries require front facing photo proof for identifying drivers, while in other countries number plate recognition suffices for enforcement. Also for future technology, there needs to be control mechanisms in place, the question is how they should be designed.

Regarding mandatory equipment on vehicles and new demands on vehicle performance, the individuals' right to property must be regarded. If people have invested in vehicles that suddenly cannot be utilised because of a new regulation, they need to be compensated. Alternatively, transition strategies must be in place, and the UVAR system must be designed to handle both equipped and unequipped vehicles during the transition period.

Finally, the issue of the integrity and privacy of individuals is a key question. Data on transport and mobility could reveal very sensitive personal information and how, where and by whom that information in stored and how it is utilised is a political question that needs to be addressed before large-scale solutions involving large amounts of mobility data can be implemented. If an incentive structure is in place, travellers could share data voluntarily and gain benefits in return. There could also be the case of trade with personal data, which will require new business models.

Conclusions

This milestone report should be read as a status report of the work on the *Innovation Observatory*, which will continue throughout the ReVeAL project. Therefore, no recommendations or final conclusions will be made here. The main outcomes of the report are the insights described in the Results chapter. Here, we summarise some of the most important insights so far.

Generally, the technology for the new types of UVARs that have been described is on a high maturity level. Solutions have proved to work in many pilot tests and demonstrations. Despite this, the UVARs must still be regarded as *future*. The reason is that a range of challenging questions remain to be solved:

1. **Suitable technological components for UVARs exist**, but challenges remain regarding system integration and large-scale implementation. Standardisation of data formats and communication is part of this challenge, but not the sole answer. Supporting digital infrastructure needs to be developed so that digital systems in vehicles and other equipment can be connected to the infrastructure administrator's geodata systems in a standardised manner.
2. **Technological solutions with safety critical applications:** Although technological solutions for the most common UVARs that regulate access to specific areas and roads exist, there are still hurdles to be taken in UVARs that include safety critical requirements. Both positioning and speed of communication (latency) may not be sufficient with assisted GNSS and 4G data transfers.
3. **Liabilities and organisation**: The multi-stakeholder systems required for UVARs depend on actions from different groups of actors, such as authorities, OEMs, system providers and citizens. Someone must take the lead and responsibilities must be defined and agreed for different parts of the systems. For example, who is responsible for the quality of data?
4. **There is a lack of suitable legal frameworks for new UVARs**, regarding which solutions that will be allowed but also how they could be enforced. An example on how to check compliance of new UVARs in an automatic way can illustrate this: OEMs are not likely to force their customers to share data that are not in the vehicle-owner's favour. However, they could enable voluntary sharing of information that could benefit the drivers/vehicle owners, such as the number of passengers to get access to certain lanes, trip data to get discount from the default congestion charging if utilisation is lower than average and more. The same goes for automatic switch to electric driveline in a low-emission zone – forced switch could cause safety issues if the battery is not charged enough for the vehicle to reach its destinations, but the vehicle could provide the option for the driver to avoid fees, for example. But this solution depends on the voluntary nature of the UVAR implementation, if legislation does not demand compliance from drivers and/or OEMs.
5. **Transition period and mixed traffic**: An important aspect for all UVARs that require vehicles to be equipped with new technology or other new technological solutions to be

implemented in the system, is how to obtain a quick transition, alternatively how to manage the transition period which may include retrofitting schemes. For example, adding new technology to a vehicle will raise the price of the vehicle. There are two options in addressing this. Either it is enforced by making it mandatory to equip all vehicles a certain year. Or the equipment will be sold as an add-on, most likely only available for the premium segments in the first phase. Those add-ons will only be chosen by buyers that could benefit from it and earn back the extra cost, through lower fees or access to a wider range of infrastructure. However, the latter option risks adding to equity problems. A clear view of the incentive structure for the end-users is needed to succeed with the transition period. Incentives and opportunities are different between private and commercial actors.

6. **Security of technological solutions** to external attacks and manipulation when more control is handed over to systems from individuals, and how to protect individuals' privacy when large amounts of potentially sensitive personal data are collected, stored, shared and used for UVAR purposes.

In the continued work on the *Innovation Observatory*, communication with market actors will be kept active. New solutions will be tested and demonstrated during the span of the ReVeAL project, and more lessons remain to be learnt on the feasibility of different future options depending on the conditions in each city. Recommendations on how to lead the development of future solutions will be formulated.

If you are interested to contribute to the *Innovation Observatory*, please contact the consortium via the project website www.civitas-reveal.eu.

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Respondents to the survey

2getthere

Bumbee Labs

City of Gothenburg, Urban Transport Administration

City of Stockholm

ClearRoad

Edeva AB

EFKON

Hager environmental & atmospheric technologies

Humanising Autonomy

Monotch

Waysure

RISE

Technolution

Trafikverket

Uniquesec AB

Volvo Cars

Waysure

WSP Sverige AB

Appendix: Market consultation survey

Market consultation on
Technology and Services for Future Options for Urban Vehicle Access Regulations

The goal of the ReVeAL project is to add Urban Vehicle Access Regulations (UVARs) to the standard range of urban mobility transition approaches of cities across Europe. The project includes six partner cities who all will benefit from tools for implementation. The overarching mission of the project is to enable cities to optimise urban space and transport network usage through new and integrated packages of urban vehicle access policies and technologies. Such policies can lead to fewer emissions, less noise and improved accessibility and quality of life, which especially benefits the people living in these cities. These policies can also encourage more sustainable transport choices, enabling cities to become more liveable, ultimately healthier and more attractive for every member of society.

ReVeAL combines conceptual work and case study research with hands-on UVAR implementation in six pilot cities, as well as systematic stakeholder interaction through professional communication activities.

The goal of this market consultation is to capture:
- What technology development is available and necessary to implement these types of UVARs
- What is the maturity of these technologies
- What challenges do suppliers and cities face to achieve these types of UVARs
- And when do we estimate that these challenges have been overcome

Your answers are important to us and will enable us to recommend future-proofed actions for the participating cities, as well as to provide guidance to any stakeholders consulting the results of ReVeAL in the future.

For more information about the ReVeAL project, please visit the ReVeAL Project web site; [link to website].

For any questions regarding this market consultation, please contact Moa Berglund, WSP Sweden, at moa.berglund@wsp.com.

The perspective taken in the survey is that of a European city that wishes to implement a new type of UVAR in the future.
New or future UVARs that have been identified include (but are not limited to):

A. **Realisation of Zero/Low Emission Zones, speed limits or access restrictions through geofencing.** Geofencing is a concept which includes technical solutions combined with suitable digital and organisational processes to make sure that vehicles follow certain characteristics or regulations within specific geographical areas. Geofencing is considered an important tool to create a safe road network in today's complex traffic environment. Geofencing is also considered to be important for future demands of safe, fossil free and more silent transports.
B. **Charging policies that regulate access to parts of the city, streets or specific infrastructure assets.** Charging policies are used today in serval cities around the world, mainly to alleviate congestion. In the future, charging could be differentiated based on exact usage of the infrastructure, in time, distance and location.
C. **New types of ITS measures.** EU defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport. It is an advanced application which aims to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. With new technology such as connected vehicles and infrastructure, new types of ITS measures are enabled.
D. **Dynamic kerbside or parking management.** Kerbside space and parking space can be used not only for car parking and loading/unloading, but also as sidewalk café, transit hub, freight delivery zone, taxi stand, rain garden, or trash collection area. It could serve many purposes throughout the day, enabled by differentiated pricing or regulation, potentially through different types of digital solutions.
E. **Access delimited to high-occupancy vehicles or differentiated charging by vehicle occupancy.** Using a combination of regulation and technology, high-occupancy vehicles could be prioritized or rewarded before single-occupancy vehicles for access to specific lanes and other infrastructure.

This survey consists of three main sections of questions. The only mandatory fields are the contact information. You can choose to answer as many of the questions as you find suitable for your area of expertise.

By clicking the CLOSE button, you can also choose to take a pause from the survey and later pick up where you left off. Then copy and save the survey link that is displayed when closing.

Your answers will be used for a report that will be made available to the public. If there are any restrictions on how we can use the information you provide, please contact Moa Berglund at WSP, moa.berglund@wsp.com.

Thank you for taking time to answer this survey! In the contact information section, you can sign up for the ReVeAL newsletter, and indicate whether you would like to be contacted for follow-up questions, if needed.

Your contact information?

Name: ______________________________

Company: ______________________________

Position/department: ______________________________

E-mail: ______________________________

Phone: ______________________________

Country: ______________________________

City: ______________________________

Information and contact

I would like you to keep me updated about the project ☐ yes ☐ no

It is ok for you to contact me about this survey ☐ yes ☐ no

Your solutions

The five presented future UVARs are all dependent of new solutions.

A. Geofencing
B. Time & Distance based pricing
C. ITS measures
D. Kerbside or parking management
E. High occupancy vehicles

Considering the five UVARs, what solutions does your organisation develop and supply and how is that solution enabling the UVAR?

Please describe your solution: ______________________________

To what part(s) of the full-scale implementation will your solution contribute, and how? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

At what Technology Readiness Level (TRL) is your solution today and what time frame do you see before launch? See "Current TRL definitions - European Union on Wikipedia": [link]. (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Can you describe any examples of successful implementations and/or pilots where your solution (or similar solutions) has been applied? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Adjacent solutions

(You will be able to describe any barriers to a full-scale implementation further on in the survey.)

What other solutions (except from yours) do you consider are needed for a full implementation of the UVAR(s)? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Which organisations are the owners of these solutions? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Are you aware of any ongoing development processes addressing these solutions – and if so, what solutions and who is driving them? At what readiness level (TRL) are they? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Barriers to full implementation of new UVARs

Once the technology is mature, what barriers do you think exist for a full implementation of the UVAR(s)? A barrier can for instance be legal aspects, safety and security (cyber and other), organisational structures and/or business models, need for standards, compliance checks and more. Please elaborate your response as much as possible.

Legal aspects? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________

C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Safety and security (cyber and other)? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Organisational structures and/or business models? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Need for standards? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________
C. ITS measures: ______________________________
D. Kerbside or parking management: ______________________________
E. High occupancy vehicles: ______________________________
F. Other UVAR (please describe): ______________________________

Compliance checks (how to make sure regulations are followed, strategies for handling e.g. vehicles lacking necessary equipment and more)**?** (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ______________________________
B. Time & Distance based pricing: ______________________________

C. ITS measures: ____________________

D. Kerbside or parking management: ____________________

E. High occupancy vehicles: ____________________

F. Other UVAR (please describe): ____________________

Other barriers? (Skip the UVAR(s) that are not relevant for your solution/expertise)

A. Geofencing: ____________________

B. Time & Distance based pricing: ____________________

C. ITS measures: ____________________

D. Kerbside or parking management: ____________________

E. High occupancy vehicles: ____________________

F. Other UVAR (please describe): ____________________

Thank you for contributing!

Your answers have been saved and you may close the window.