



Urban Mobility Next 6

Urban vehicle access regulations: from design to implementation

EIT Urban Mobility | October | 2022

Supported by



EIT Urban Mobility

October 2022

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Acknowledgements

EIT Urban Mobility wishes to thank the following experts for their contributions and insights.

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Key outcomes & recommendations

Features and impacts of UVARs

- UVARs can take many shapes to address specific city needs such as tackling air pollution, limiting traffic congestion, improving road safety, redistributing public space (for example, since their implementation the UVARs in the city of Milan have led to a reduction of 76% in nitrogen oxides and of 38,5% in number of average daily trips)
- UVARs can increase the attractiveness of cities and improve liveability in urban areas by changing and remodelling public space
- UVARs can be permanent or apply only at certain times of the week, for instance on weekends only, at peak hours, or during high pollution episodes

Enforcement

- Effective UVARs implementation requires a coherent system that is properly enforced, non-discriminatory, and user-friendly. Provision of information to users is essential in the successful implementation of UVARs
- The right technology combination (GNSS, ANPR, OCR, etc.) facilitate UVAR enforcement by enabling seamless conformity checks of vehicles entering restricted areas (for example, in 2021 43 cameras monitored the access to Milan's Area C of ca. 80 000 vehicles per day)
- Standardized criteria for UVARs enforcement technologies – for instance through the adoption of a national framework – would help cities implement congestion charges and low and zero emission zones. Alternatively, an EU-level guidance on enforcement technology to be used by cities would provide similar support
- EU and national level guidance on UVARs can help cities with enforcement for foreign vehicles, technological applications, and revenue allocation to sustainable mobility policies. For instance an update of the traffic enforcement directive, broadening its scope to include environmental traffic fines would allow UVARs to be effectively enforced on foreign vehicles that do not register in local UVARs systems

Stakeholder and citizen involvement

- Being a politically sensitive topic, it is important to target specific urban mobility objectives UVARs should contribute to, and to measure their impacts

- Public acceptance (and adjustment) of UVARs is an ongoing process. Having achieved it once does not necessarily mean that gaining public acceptance does not require further efforts. Congestion charges were introduced in Stockholm in 2006 as a seven month trial, followed by a referendum where a majority voted in favor of the charges. This led to the reintroduction of congestion charges in August 2007, and they have been operational since then
- UVARs need to be complemented by adequate alternatives to private cars, such as a strong public transport system and the availability of shared mobility options
- Stakeholders' acceptance is also dependent on the right exemptions being granted (for example, in Jerusalem, the city designed their LEZ to target only specific vehicles causing a large amount of emission)
- Successful UVAR implementation requires full appreciation of the equity issue. The right exemptions are needed to fit the needs of specific people (e.g. people with accessibility needs or not driving often)

1. Introduction

With the adoption of the European Green Deal, the European Union has set a greenhouse gas (GHG) emission reduction target of -55% by 2030, with the objective to become the first climate neutral continent by 2050. Currently, more than 70% of Europeans live in cities and expect solutions for better and safer mobility, congestion, GHG emissions as well as air and noise pollution.

This means all transport modes need to transition fast to zero-emission, with the right incentives to favour the most sustainable transport options. Both problems and opportunities lie within cities. **23% of greenhouse gas emissions in cities come from transport and air quality legal limits are still being breached in over 100 European cities.**ⁱ Luckily, urban mobility is one of the sectors that can be decarbonised more quickly than harder to abate aviation, maritime, and road freight sectors. In fact, one of the UVAR policy objectives identified in the SUMP-UVAR practitioners' guide is climate change mitigation.ⁱⁱ

In line with the above, the EU launched the climate neutral and smart cities missionⁱⁱⁱ, aiming to support, promote and showcase 100 European cities in their systemic transformation to climate neutrality by 2030 and making these cities innovation hubs to put all European cities in a position to become climate neutral by 2050. A Yougov survey^{iv} for the Clean Cities Campaign in 15 European cities shows that **a clear majority demands more space for clean mobility: 68% for public transport, 66% for pedestrians, 56% for cyclists.**

In this context, many European cities have introduced Urban Vehicle Access Regulations (UVARs) in order to tackle air pollution, limit traffic congestion, improve road safety, and redistribute public space. UVARs can be broadly defined as measures to regulate motor vehicular access to urban infrastructure. They can be broken down into different categories:

- Tolling/congestion charging
- Low emission zones (LEZ)/ Zero emission zones (ZEZ)
- Pedestrian areas
- Parking schemes
- Limited traffic zones

The present report aims to contextualise the growing number of UVARs in Europe^v (1) as climate and environmental concerns become more important for urban dwellers, and to highlight best

¹The number of Low Emission Zones, a type of UVARs, has increased by 40% between 2019 and 2022, from 228 to 320.

practices and recommendations that can facilitate their implementation. It addresses the questions of UVARs objectives, design, and enforcement, as well as aspects related to stakeholder and citizen engagement around equity and acceptance.

Insights presented in this report draw on discussions facilitated by EIT Urban Mobility during an online workshop on 7 and 9 June 2022. The report puts in perspective the different views expressed by the experts who contributed to the discussions (see Acknowledgement section), in a consolidated and reader-friendly way. Views and opinions expressed do not necessarily reflect the position of EIT Urban Mobility.

2. Regulatory and operational framework

At EU level, **Urban vehicle access regulations (UVARs)** fall under the **EU urban mobility framework** (see figure 1). This initiative replaces the 2013 Urban Mobility Package and envisages new pathways for European sustainable urban mobility. It aims to support cities in their role as essential transport hubs within the single market. The main focus of the initiative lies on public transport, active mobility, safety, fair and sustainable taxi and ride hailing fleets, zero emission logistics, multi modal hubs, and smart digital solutions and services.

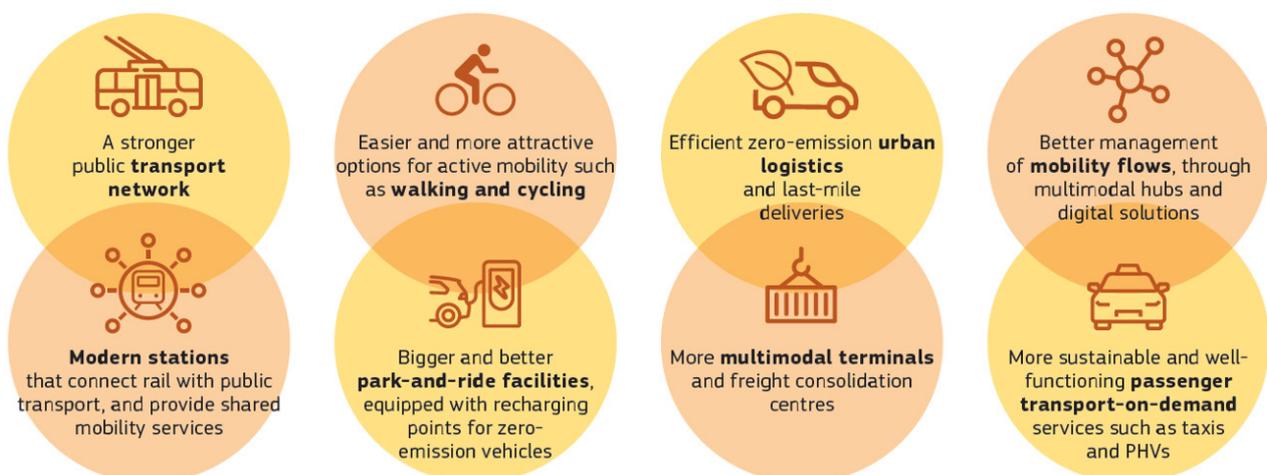


Figure 1: Focus areas of the EU Urban mobility framework (source: European Commission)

Many EU cities face air quality issues related to road transport - **In Europe, 94% of the urban population is exposed to NO₂ pollution levels above the WHO guideline^{vi}** - and implement UVARs to address them. **In Europe, 73% of UVARs are low (and zero) emission zones.^{vii}** UVARs are considered as subsidiarity issues and have to be dealt with at local level. According to the European Commission, their intrinsic diversity raises questions regarding the functioning of the internal market and might sometimes lead to discrimination of non-residents, which need to be avoided.

For cities themselves implementing UVARs is also a challenge to the extent that it requires a coherent policy that is properly enforced, non-discriminatory, and user-friendly. In this regard, **access to UVARs and availability of information is often a subject of complaints from motorists who are not aware of local requirements linked to these UVARs.** This is especially true for the obligation for foreign drivers to register before driving in cities with a specific LEZ. The current situation is complex as motorists failing to pre-register may be subject to heavy fines even if their vehicles comply, but cities that do not have access to foreign vehicle databases must pre-register foreign vehicles in order to identify their emission class and enforce the access regulation (LEZ in this case).

To improve the situation, **the EU has focused its efforts on improving the provision of information, and on data sharing.** In particular, the following legislative acts and initiatives are relevant:

- Regulation (EU) 2018/1724 on the Single Digital Gateway, which since December 2020 requires public authorities to provide information to road users – including on UVAR - through the Gateway^{viii}: this establishes a single-entry point for people and businesses to get easy access to relevant info and procedures.
- Commission Delegated Regulation (EU) 2015/962 on real time traffic information (RTTI) requiring Member States to give access to a broad range of static and dynamic information. This regulation entered into force in 2017 and works through the National Access Points. The regulation has been revised in 2022^{ix} to include new data sets, such as those pertaining to UVARs (applicable from January 2025 onwards).
- The SUMP topic guide on UVAR^x.
- The 'Uvarbox' project^{xi}, which aims to help cities develop a user-friendly tool to provide data in a standardised format on urban and regional UVAR schemes. UvarBox supports cities in streamlining and simplifying their digital procedures.
- The 'Uvarexchange' project^{xii}, which aims to improve the communication of information to drivers in the vicinity of UVAR zones and to improve the local authorities' access to information, especially with respect to foreign vehicles and drivers, for seamless travel and enforcement of UVARs by local authorities.

From the EU perspective, **harmonizing UVAR across Europe would not solve the issue since the design and implementation of the schemes should always be tailored to the specific city situation.** Indeed, the variety of UVAR schemes corresponds to the diversity of European cities and allow each one to set their own ambition level in line with their individual situation and objectives.

National regulatory frameworks also directly impact the design of UVARs, for instance on aspects related to camera enforcement and monitoring, as well as revenue management. In Spain for instance, the legal framework does not allow to allocate revenues collected through UVAR to specific policies (such revenues flow directly into the larger city budget). This limits the efficiency of communication to the citizens, as cities cannot directly show that UVAR revenues

Beyond the legal frameworks as such, improving information exchange and dialogue between cities is critical to design and enforce more efficient UVARs.

serve to improve the shared and public transport system. On the other hand, bilateral agreements can support effective UVAR enforcement as in Milan, where the city had issues with enforcing their congestion charge for foreign vehicles. The issue was solved by agreements with relevant foreign countries to share their databases of registered vehicles that enabled the city to enforce the scheme². In Poland for example, cities are collaborating and discussing the best ways to coordinate their UVARs. This is especially important

as the main original goal when UVARs have been implemented in Poland was to make cities more walkable, while now their focus is more about pollution reduction.

In parallel to an enabling legal framework, **strong political commitment and support is a key success factor of UVARs**. This in part explains differences between EU cities when it comes to sustainable mobility policies and the transition to zero emission mobility, in which low and zero emission zones are instrumental - Oslo and Amsterdam can be considered best practices in this regard.^{xiii} Importantly, local action and ambition make a big difference in the efficiency of sustainable mobility policy, even within same countries, as the discrepancies in France between cities such as Paris and Marseille illustrate.^{xiv}

While tackling the existing polluting fleet now through LEZ is key, urban redesign away from individual car ownership still represents a significant political risk. As the debate on LEZ in EU countries like Germany illustrates, the political sensitivity of the subject makes public engagement more complicated than on other urban policy topics (see also part 7). In this context, it is especially relevant to target specific urban mobility objectives UVARs should contribute to, and to measure their impacts.

Main takeaways

- In Europe, 94% of the urban population is exposed to NO₂ pollution levels above the WHO guideline - and implement UVARs to address them. 73% of UVARs are low (and zero) emission zones
- Access to UVARs and availability of information is often a subject of complaints from motorists who are not aware of local requirements linked to these UVARs. To improve the situation, the EU has focused its efforts on improving the provision of information, and on data sharing
- Improving information exchange and dialogue between cities is critical to design and enforce more efficient UVARs, as well as strong political commitment, are key success factors of UVARs

²Enforcement is widely acknowledged as a public policy tool that helps the credibility of legal instruments, buy in and behaviour change of road users.

3. UVAR objectives & impacts

By discouraging car use in cities, the main objectives of UVARs are to reduce CO₂ emissions and air pollution, congestion, and to improve road safety. But beyond these considerations UVARs can increase the attractiveness of cities and improve liveability in urban areas by managing public space.

It is important to clarify that UVARs are not schemes whose primary objective is to generate revenues. The revenue aspect – i.e. under what conditions can UVARs generate revenues – is a debated topic.

Use case 1: ReVeAL project

A purpose-oriented definition of UVARs has been proposed by the ReVeAL project^{xv}. It goes beyond just low emission zones and congestion charging, and comprises:

- **Regulatory measures:** Such measures restrict the vehicles that have access to a given area using regulations or bans. Regulations may be put in place, for example, to reduce emissions (low-emission zone or zero-emission zone) or the amount of traffic (limited-traffic zone) or to improve safety (regulating by vehicle size or dimension). Non-complying vehicles are not allowed into the regulated area and their owners/users can be punished with a fine if they do enter.
- **Spatial interventions:** These measures change the physical space in the city, creating spaces where cars are not able/allowed/easy to pass through. These can include things like roadblocks, parklets or reallocation of road space to walking or cycling or speed limit reductions.
- **Pricing aspects:** These are measures that require people to pay for vehicle access to a given area. Pricing can apply to all vehicles in an area (e.g., a congestion charge) or certain categories of vehicles (e.g., a charge based on emissions standards or on vehicle size) and can also include parked vehicles (various forms of parking charges). Charging can be flat rate or differential.

Several aspects are common to all these areas of intervention. ReVeAL identifies these cross-cutting themes as follows:

- **Governance:** subsidiarity is key here, and legal framework as well, including institutional setting and organisational arrangement. For instance a national framework can oblige local authorities to put emission stickers in place.

- **Financing:** a range of activities need to be financed to allow UVARs to be deployed. These include feasibility studies, installation of the equipment, communication and public involvement, enforcement, operation and maintenance, as well as monitoring and review. It can also include considerations of how income from a given scheme is invested.
- **User needs/acceptance:** proper transparency and communication of the enforcement measures to ensure awareness among citizens. Fairness and equity need to account for the diversity of users. Awareness and anticipation of the acceptance curve^{xvi} help successful implementation of UVARs. Public acceptance (and adjustment) is an ongoing process. Having achieved it once does not necessarily mean it has been achieved forever.
- **Complementary measures:** a complementary measure is an additional measure that complements a given UVAR building block to enable access of people, goods and services into the UVAR area while maintaining the goals of the UVAR, easing compliance and facilitating the best adaptation to the new reality. It may also act to minimise any equity issues that result from the measure it complements.
- **Ensuring compliance:** Compliance is about making sure people can comply with the rules, and cities can meet their objectives. Enforcement is one element of compliance, but not the only one. The type of enforcement used depends on political and cultural acceptance, but also on the resources available to match the right enforcement option with the type of UVARs. In Helmond for instance, the city experimented with vehicles equipped with Intelligent Speed Adaptation (ISA) systems to limit the speed of all vehicles on a single-track road.

Figure 2 summarizes in a visual way the interaction between measures (measure fields) and cross-cutting themes (aspects common to all UVARs).

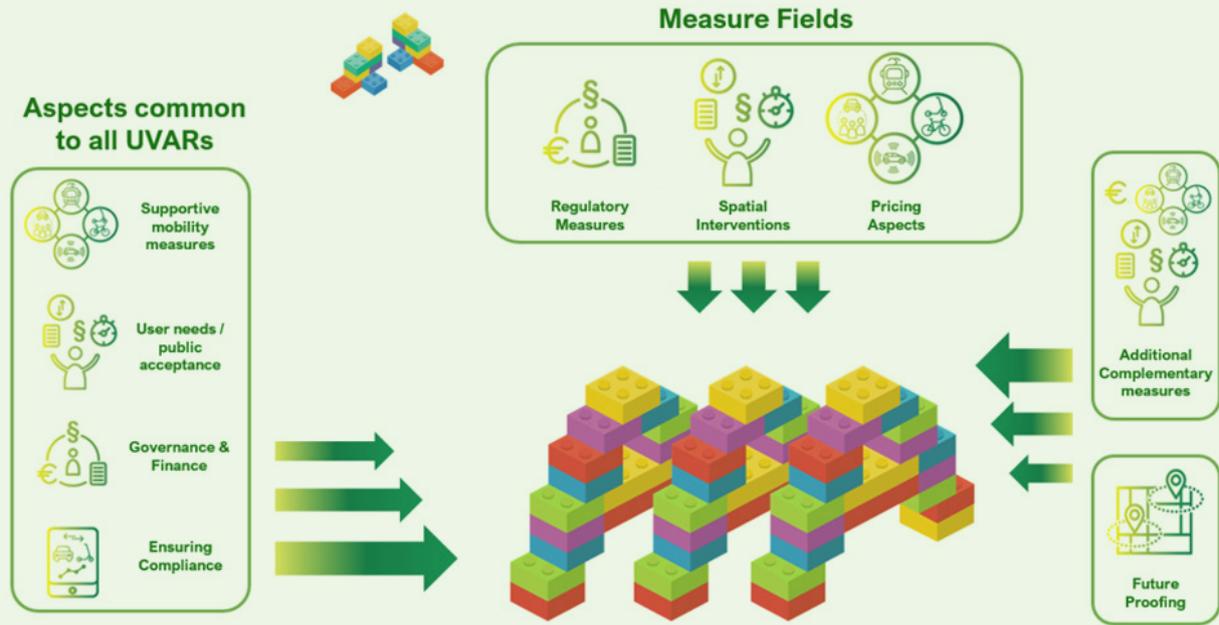


Figure 2: strategic building blocks of UVAR planning (source: ReVeAL project)

Further material from the ReVeAL project including best practices and advice to practitioners can be accessed online on the project website.^{xvii}

The cities of Milan and Barcelona provide good examples of clear objective identification and impact measurement.

Reducing private car ownership is often an adjacent objective to LEZ, in which case it is sensible to move from LEZ to Congestion Charging to have positive impacts: it stimulates modal shift, on top of reducing pollution. In the case of Milan, the objectives of Area C congestion zone are to:

- Decrease traffic congestion
- Improve public transport speed
- Decrease the occupation of on-street parking
- Reduce road deaths
- Reduce pollutant emissions caused by traffic
- Reduce health risks related to air pollution
- Increase the share of sustainable modes of travel
- Improve urban centre quality and attractiveness
- Raise funds for sustainable mobility services and infrastructures

In 2021 Area C celebrated ten years of operations. **Since its entry into force, Area C has led to a 38,5% reduction in the number of average daily trips to the area.** Since 2011, the share of Diesel vehicles entering the zone has decreased from 52,8% to 43,1%, while electric and hybrid vehicles' shares went up (from 0,1% to 2,7% and 5,3% to 22,2%). Regarding air pollution there is a gradual and constant reduction in concentration of PM10 exhaust from 9,3kg/ day in the Area C to 1,2kg/ day, total PM10 (exhaust and friction) from 19,3 to 7,8, and total nitrogen oxides (NO_x) from 274 to 66. More details about Area C can be found in part 4.

In the case of Milan, the city decides on the repartition of income from Area C. **In 2019 the scheme generated more than €30mio.** 75% of these incomes were transferred to update the enforcement technology and enhance the public transport system. **25% was allocated to fund sustainable urban mobility projects.**

In Barcelona, the Low Emissions Zone (LEZ) within Barcelona's ring roads (ZBE Rondes de Barcelona) is an area of more than 95 sq.km which includes Barcelona and the municipalities adjacent to the ring roads, where traffic of the most polluting vehicles will gradually be restricted. The LEZ is applied on a gradual basis to different vehicles depending on their environmental label allocated by the responsible Spanish ministry. Since January 2021 the LEZ led to fleet renewal in the city, with only 2% or less of the fleet not compliant with the LEZ. However, the pandemic impacted the implementation of the measures and made it difficult to single out and properly measure the impact of the LEZ.

The LEZ is one of Barcelona's measures – along with initiatives such as the superblocs – to ensure better air quality and guarantee the right to health in the city.

Main takeaways

- The main objectives of UVARs are to reduce CO₂ emissions and air pollution, congestion, and to improve road safety. But beyond these considerations UVARs can increase the attractiveness of cities and improve liveability in urban areas by managing public space
- Example of impact of UVARs on congestion: Since its entry into force, Milan's Area C has led to a 38,5% reduction in the number of average daily trips to the area
- In 2019, Area C generated more than €30mio. 75% of these incomes were transferred to update the enforcement technology and enhance the public transport system. 25% was allocated to fund sustainable urban mobility projects

4. UVAR scheme design

Our workshop discussions revealed that **cities struggle to differentiate between the different UVARs and to develop the most suitable approach**. In Poland for instance, the distinction between the old kind of UVARs which restricted most of the traffic in heritage areas and the more recent LEZ focusing on emissions and affecting fewer vehicles is important. Differentiating between LEZ and pedestrian areas is a challenge, which led to misunderstandings in the country's debates about UVARs.

Being able to identify the type of vehicles responsible for high emission levels allow to adapt UVARs' design to their purpose – enabling a more granular regulation by vehicle type, or by vehicle dimension.

For instance, while limited traffic zones – like pedestrian streets – mean motorists can enter only if they have a permit, LEZ forbids non-compliant vehicles from entering unless these are exempted. The mix of the two approaches in the same city can lead to confusion. In Jerusalem, the city designed their LEZ to target only specific vehicles causing a large amount of emission such as construction vehicles.

As far as UVAR scheme design is concerned, the example of Milan showcases some key learnings.

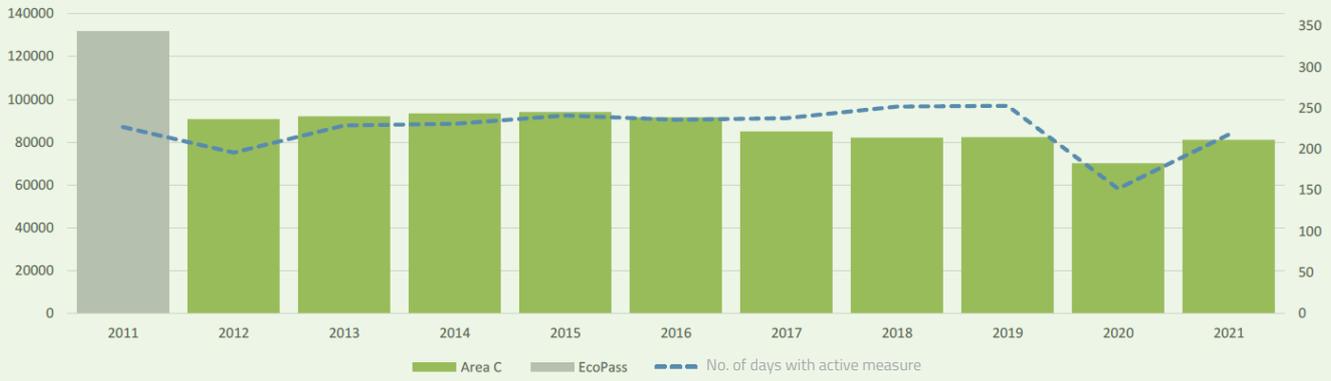
Use case 2: AMAT Milano

Milan is the first city in the world that experienced two kinds of road pricing measures:

- The Ecopass, a pollution charge introduced in 2008. It is based on the polluter pays principle; users pay according to their vehicle's emission class.
- In 2012, the pollution charge evolved to congestion charge – with large approval by referendum (79%). This contrasts with the experience of other cities where similar referenda led to negative outcomes for the suggested UVARs.

The Ecopass led to good results, with a traffic reduction of 21% in the first year of implementation (see figure 3). However over time the increase in the share of exempted vehicles (from 50% exempted vehicles during the planning stage to 90% in 2010) diluted the effectiveness of the scheme and traffic returned to previous levels within a few years. The 2012 referendum sanctioned the transition to the Area C congestion charge in the inner part of Milan. It covers 8,2 sq. km, or 4,5% of the whole territory of the Municipality of Milan. 77 950 inhabitants live within the Area C. **With more than 295 000 employees, the zone accounts for 37% of the total employees in Milan.**

Average daily transit trend from 7:30am and 7:30pm per year



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Average daily transits	131.898	90.849	92.175	93.342	94.033	91.687	85.049	82.140	82.306	70.195	81.181
Variation compared to y. 2021	0,0%	-31,1%	-30,1%	-29,2%	-28,7%	-30,5%	-35,5%	-37,7%	-37,6%	-46,8%	-38,5%
Number of days with system in operation	227	196	229	231	241	236	238	252	253	152	218

**In order to allow comparison between years with different operating hours, the accesses from 7.30 am to 7:30 pm on weekdays with an active measure have been taken into account.*

Figure 3: Average daily transit trend in Area C

Area C is active from Monday to Friday between 7:30am and 7:30pm. 43 cameras with Optical Character Recognition (OCR) are in place for the enforcement of the congestion charge. Enforcement is automated and fines are sent automatically. For Area C residents, the first 40 yearly accesses to area C are free. From the 41st access onwards residents pay 2€ per access. 80% of residents do not exceed the 40 allocated accesses per year. For all other motorists, a fee of 5€ a day allows entry to Area C. About 500 000 people enter the zone every day from surrounding areas. The Area C has specific time windows to allow for freight vehicles in specific times. Access is forbidden to freight vehicles (except electric ones) from 8 am to 10am.

The design of Area C aims at clamping down polluting vehicles gradually. The access is free of charge for electric vehicles, mopeds & motorbikes, and M1 hybrid vehicles emitting as much or less than 100g CO2/km.

In 2019, the city of Milan launched Italy’s largest Limited Traffic Zone, the Area B. **It is one of the largest LEZ in Europe covering 132 sq.km, covering ca 70% of the city area, where 97% of the population lives.** The system controls the access of most heavy and pollutant vehicles. The enforcement system is integrated with the system of Area C. In 2030, all Diesel vehicles will be banned from Area B, affecting not only private vehicles but also the 1000+ large bus fleet. The most common used vehicles in the Area B are petrol vehicles (41%) and Diesel vehicles (38%).

Main takeaways

- Cities struggle to differentiate between the different UVARs and to develop the approach best suited to their needs
- Being able to identify the type of vehicles responsible for high emission levels allow to adapt UVARs' design to their purpose – enabling a more granular regulation by vehicle type, or by vehicle dimension
- Milan's area B is one of the largest LEZ in Europe extending over 132 sq.km, covering ca. 70% of the city area, where 97% of the population lives

5. Stakeholder impact

Cities have very little choice but to introduce restrictions such as LEZ or congestion charging in order to **respect their legal obligations to meet air quality limit values**. One of the key issues faced by cities is the management of UVARs' negative effects on stakeholders, which is crucial for the schemes' acceptance.

First, there is a need for comprehensive and accurate data to inform the UVAR policy: what problem it should solve and what vehicles to target. It also **helps anticipate the calls for exemptions that may arise from the UVAR implementation**, and accordingly have a proper consultation process to address calls for exemptions or watering down of the measures.

Technical details of the schemes turn out crucial to properly anticipate effects on stakeholders. For instance when London was planning its congestion charge, there was a debate as to when the scheme would stop each evening (e.g. at 6.30pm or 7pm), as this would have an impact on the entertainment sector in central London. When London was preparing its low emission zone, the city asked Heavy Duty Vehicles (HDVs) to register in advance before entering London. As well as contacting European trade associations, London had people at the port of Dover handing out leaflets to HDV drivers. The city's good preparation and communication meant that the vast majority of foreign HDVs registered for the scheme in advance. But this required **a proper organisation and a budget to deliver clear information to the right stakeholders**.

Some positive impacts of UVARs on stakeholders can also be noticed in European cities: in Milan, Area C achieved important results not only in terms of environmental indicators, but also with regard to economic and social sustainability. The reduction of the cars circulating in the city centre has enabled the reuse of the public spaces once reserved to the parking. For instance, an area of approximately 15 sq.km near Castello Sforzesco was turned into a pedestrian area, and

new bike sharing stations and car sharing services were set up in the city. Moreover, the traffic reduction generated benefits to the whole transport system. In fact, according to the AICAI (Italian Air Couriers Association), Area C has resulted in a 10% increase in productivity of freight deliveries in the city centre.

Providing mobility alternatives to stakeholders, for instance with a strong public transport network and affordable shared mobility options, impacts the acceptance of UVARs. Likewise, **it is key to communicate to citizens and stakeholders that UVARs are not just about generating revenues to avoid resistance and also prevent fake narratives from emerging**. For instance the LEZ in Jerusalem affects mostly small businesses, so the city put a complementary measure by introducing subsidies for air quality filters. This helped communicating clearly to citizens that the scheme is not about generating revenues but about reducing emissions. Where the legal framework allows, earmarking revenues from UVAR to finance sustainable urban mobility measures can lead to increased acceptance.

Stakeholders' acceptance is also dependent on the right exemptions being granted. For instance a quota of free entrance per years (e.g. eight per year) can allow for exceptional circumstances when the use of a car is necessary, for instance for urgent hospital visits, without jeopardizing the UVAR objectives.

Currently there is a legal case against the LEZ in Barcelona. The plaintiffs claim that the justification from the city to implement such a LEZ is not sufficient. Because the LEZ lacks an economic impact assessment study, they question the necessity of such a large scheme. Also the lack of alternatives has been pointed out as a limitation. This again illustrates the importance of anticipating and managing the impact on stakeholders for UVARs to be successful.

Main takeaways

- Cities have very little choice but to introduce restrictions such as LEZ or congestion charging in order to respect their legal obligations to meet air quality limit values
- A proper organisation and a dedicated budget are essential to deliver clear information to the right stakeholders
- It is key to communicate to citizens and stakeholders that UVARs are not just about generating revenues to avoid resistance and also prevent fake narratives from emerging

6. Technology and Enforcement measures

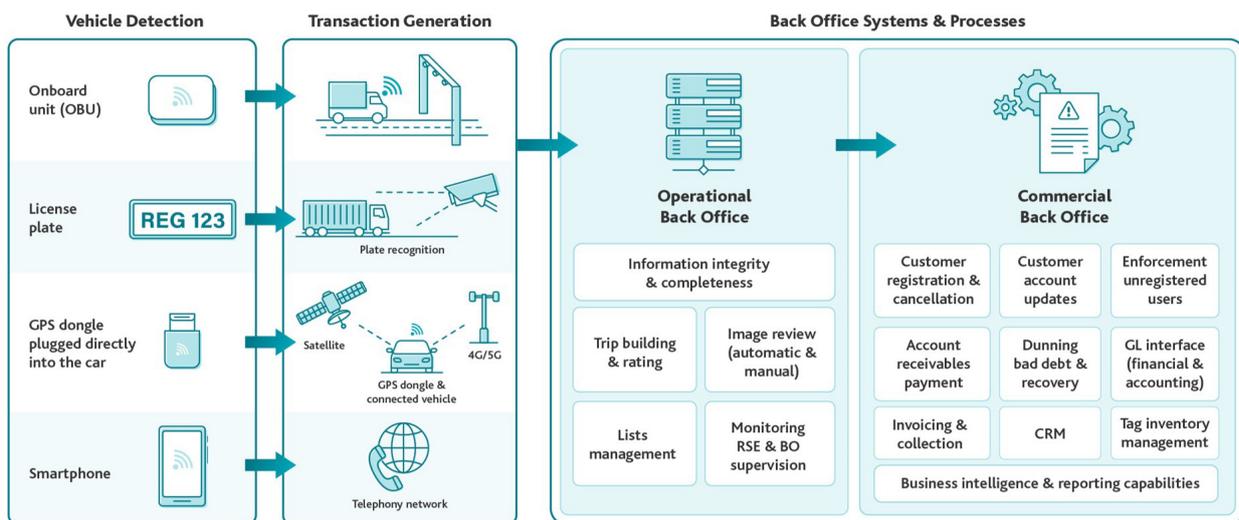
Technology

UVARs can be designed in many different ways depending on the schemes' goals (see part 3). UVARs can target specific types of vehicles such as high polluting vehicles, lorries, etc. or specific trip purposes, for example commuter traffic or urban freight distribution. These objectives and UVAR design have implications for their enforcement. Indeed, implementation can vary from toll ring schemes, distance or time-based enforcement, or neighbourhood access schemes as for the superblocks in Barcelona.

UVARs can be permanent or apply only at certain times of the week, for instance on weekends only, at peak hours, or during high pollution episodes.

Technological options available to implement these schemes are manual inspection done by the police or traffic authority, automatic number plate recognition (ANPR), dedicated short range communication (DSCR) and Global Navigation Satellite System/cellular networks (GNSS) among others.

The following figure shows the systems, technologies, and processes to implement UVAR schemes, based on the technology to identify the vehicle and on the central back-office systems.



These systems and processes are similar for all tolling solutions

Figure 4: Systems, technologies, and processes to implement UVAR

The technology to apply differs depending on the type of UVAR project, size of the city, UVAR main objective, type of vehicles, type of restrictions, etc.

Use case 3: Abertis Mobility Services (AMS)

The implementation of LEZs produces three **immediate effects**:

- The **most polluting cars are discouraged** from entering the sector delimited by the LEZ, thereby achieving the immediate objective of reducing polluting gases and airborne dust.
- With fewer vehicles on the road, **congestion is also reduced**.
- **Income** for the administration is **generated from the fines** applied to cars that enter the LEZ.

However, in the medium and long term, this measure encourages the renewal of the vehicle fleet for **electric & clean vehicles**.

The result will be that the LEZ will remain low in emissions but will again be **congested** and **revenues** for the city council will converge to a **minimum**.

As two pillars of a holistic approach, an integrated solution of Low Emission Zones and demand management allow to maximise the scheme's benefits. Access and circulation in the LEZ can include the payment of a toll, based on the "polluter pays" and "user pays" principles. In summary, smart mobility management enables to:

- Mitigate contamination and pollution
- Reduce congestion and accident rates
- Internalise transport costs: congestion, emissions, and crashes
- Use dynamic pricing application based on mobility
- Ensures consistency with the pyramid of mobility

Regarding technologies and systems, combining ANPR and Optical Character Recognition (OCR) technologies with Global Navigation Satellite systems (GNSS) technologies allows to design UVARs so they contribute to the goals of improving air quality (LEZ) and reducing traffic (Congestion charge). Drivers' fees and tariffs can be dynamic depending on the moment of the day (rush hours), the vehicle type (euro class), the distance travelled, and the CO2 emission level of the vehicle or the power and horsepower of the vehicle.

AMS' enforcement and UVAR success stories include the case of a Middle East capital city, where the scheme started with a LEZ project, and has been extended to a congestion charge zone. The project has seen the deployment of 150 ANPR cameras for vehicle identification and currently monitors 29 million vehicles a year. The implementation of Congestion Charge schemes reduces emissions and congestion, generates recurrent incomes to the administration to invest in public transport and furthermore helps increase citizen's active mobility.

In the US states of Virginia, Utah, and Oregon, AMS – through its subsidiary Emovis – is operating Road User Charging (pay per use) schemes through cloud-based and on-premises solutions based on satellite technologies and location services. From the enforcement perspective, such approach provides benefits in terms of deployment and implementation speed, scalability, ubiquitous access, as well as data security and privacy (GDPR compliant). It is important to point out that GDPR and privacy is guaranteed, and citizens enrolled in the program accept and authorise the use of their data only for this purpose and application. The increased conversion to electric and connected vehicles, with satellite technology and location services based on GNSS, allows administrations to implement new pay-per-use systems and models to guarantee the financing and long-term sustainability of the road network.

Enforcement

It is important to note that the objective of enforcement is to improve and guarantee compliance for all citizens. AMS has developed an innovative and digital smart enforcement solution. It consists in a series of initiatives of technical and procedural nature that AMS has expanded and launched to equip intelligence offender management systems with the ability to learn and make the right decisions in future cases. The objective of this “smart” approach is to reduce unnecessary efforts and costs while maintaining or even improving the image and compliance of the authority.

Enforcement for GNSS technologies can be simple and easy compared with traditional ANPR technologies and do not require the installation of gantries and ANPR cameras, which represent a high cost in terms of CAPEX and OPEX. The GNSS technology can detect fraud immediately and can notify drivers about the impact of this fraud, generating a fine or denying access or registration to the UVAR program.

In terms of enforcement, automated systems, compliant processes, and access to foreign databases are pre-requisites to ensure proper compliance of UVARs. **Standardized criteria for UVAR enforcement technologies – for instance through the adoption of a national framework – would help cities implement congestion charges and low and zero emission zones.** Alternatively, an EU-level guidance on enforcement technology to be used by cities would provide similar support.

Innovations in the field of enforcement rely often on connectivity services. For instance, Brussels, in which 353 ANPR cameras monitor the LEZ since 2018, has launched the new Smartmove project pilot^{xviii} that allows drivers to download an app tracking their movements. Smartmove's goal is to remove a local vehicle tax to vehicles in the city and replace it with a pay-as-you-drive charge, so as to better reflect the real usage cost. It is however considered unfair in the two other regions located outside Brussels, where commuters would still be paying the existing vehicle taxes on top of the Smartmove charge. The future of the project currently relies on political agreement between the regions.

Main takeaways

- UVAR implementation can vary from toll ring schemes, distance or time-based enforcement, or neighbourhood access schemes
- Standardized criteria for UVAR enforcement technologies – for instance through the adoption of a national framework – would help cities implement congestion charges and low and zero emission zones

7. Equity and citizen engagement

Wider approach to UVAR, and in particular to LEZ requires full appreciation of the equity issue. Defining the right exemptions to support people with handicap or who very rarely drive to city centres are important flanking measures to UVAR, as is the case in Ljubljana that is running free electric minibuses in the centre for people who need them.^{xix}

The city of Milan offers another relevant example of equity measure: In 2019, in parallel to Area B the city of Milan launched an equity project addressed at street vendors with high emitting vehicles. To help them keep their vehicles and carry on with their work, they were granted 500km per year within the Area B (monitored with an GNSS On-Board Unit). This has now been merged with the Move-In project^{xx}, an experimental project of the Lombardy region with a black box installed in vehicles which allows real travelled distances to be monitored. With this system, vehicle owners are free to circulate on any day and at any time until they reach an annual mileage limit. The mileage allocation is based on the Euro class of the vehicle.

Move-In rewards drivers who adopt an environmentally friendly driving style by awarding them additional kilometers that expand on the originally planned ceiling.

The complication of UVAR schemes call for even more engagement and clear communication to the citizens as to the objectives and design of the UVARs. In the case of Milan, agreements were sought with stakeholders and lengthy citizen engagement processes allowed transparent and clear information provided to the residents.

Use case 4: participatory processes and citizen engagement

For the city of Barcelona, participatory processes consist of meetings scheduled between citizens and the city council to promote a debate on specific issues in the city. **A participatory process may be used to carry out an analysis of a specific question or subject, to search for creative and innovative ideas to put into practice and to suggest what types of intervention are most appropriate according to the characteristics of each initiative, context, and case.**

The participatory process has four phases (see also figure 5):

- Information that about the process and engagement opportunities
- Debate: several meetings are organised to collect opinions
- Return: the city gives feedback to the citizens and stakeholders
- Monitoring: how have the results been applied

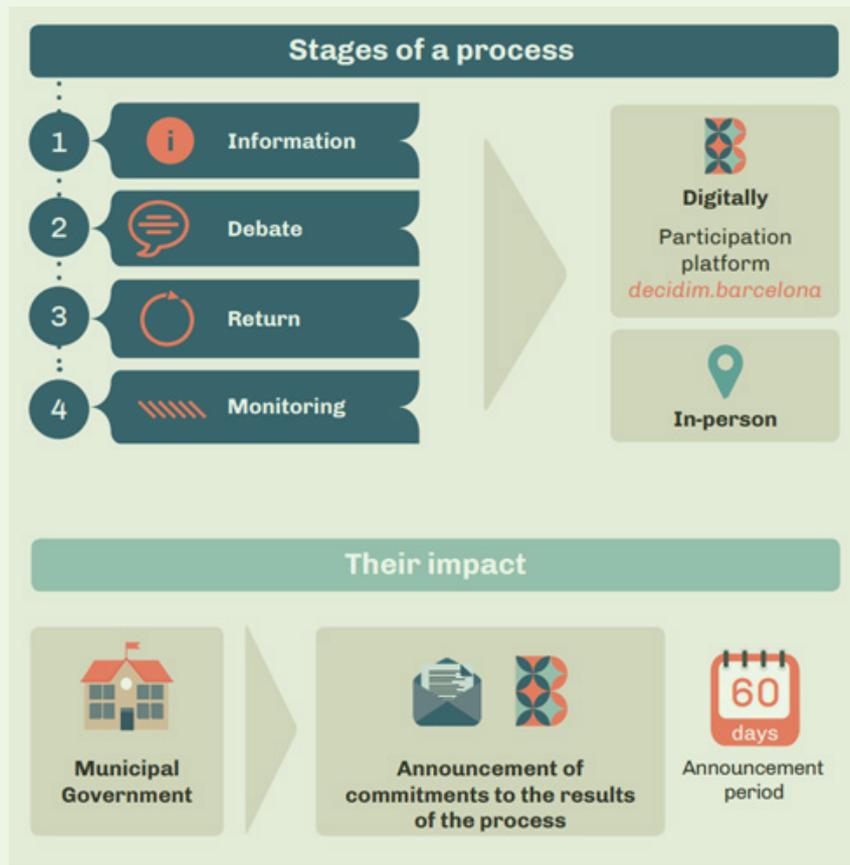


Figure 5: phases of the citizen engagement process (source: City of Barcelona)

Results from participatory processes are not binding for the administration but the city needs to explain how they have been taken into account in the final decision. Results of the engagement process are published in [decidim.barcelona^{xxi}](https://decidim.barcelona), Barcelona City Council's digital participatory platform for building a more democratic and transparent city.

Throughout the process, **full access and equality of participatory conditions are ensured for all the citizens taking part, guaranteeing that all voices are represented**. According to the Citizen Participation Regulation, the City Council has the duty to promote participatory processes when it wishes to carry out some actions that have specific impacts – which is the case for the LEZ. Anyone affected by the question under discussion may take part in the participatory process, without any limits on age or origins. Furthermore, legal entities are invited to take part in the debates, such as:

- Resident associations
- Professional associations
- Trade unions
- Political parties
- Commercial companies

Individuals can also take part when, because of their specific technical knowledge, they may facilitate a better understanding of the subject matter.

In the case of the Barcelona LEZ, **a total of five debate sessions were held with different types of entities, citizens, other groups of stakeholders.** The same questions were asked to all groups of participants, and the participatory process lasted from May to December 2019.

Up to 400 people took part in both in-person sessions and in the digital platform. Participants expressed their views on cards delivered at the start of the session and/or through direct interventions, reflecting on the questions below:

- How do you consider the vehicle fleet affected by the driving restrictions?
- How do you consider the permanent exemptions?
- How do you value the time in force?
- How do you overall value the LEZ implementation?
- Do you think that some additional measures or strategy are lacking to improve air quality in Barcelona?

The consultation process helped the city develop a list of permits with targeted exemptions for people with reduced mobility, medical condition, or disabilities, etc. All affected vehicles benefit from ten driving permits per year.

The main advantages and drawbacks of participatory processes can be summarised as below:



- Wider approach to UVAR, and in particular to LEZ, requires full appreciation of the equity issue
- Participatory processes can foster creative and innovative solutions, facilitating the development of the most appropriate interventions according to the characteristics of each initiative, context, and use case
- Full access and equality of participatory conditions for all citizens are essential to guarantee that all voices are represented

8. Conclusions and recommendations

UVARs are important measures in cities' toolboxes to address road transport emissions, air pollution, and congestion. It is worth reminding that **UVARs are temporary responses to acute issues faced by cities, which are eventually aiming to transition to fully zero-emission and low carbon mobility**. The expert discussions have shown that UVARs cannot succeed based on these three objectives alone but should be integrated in a **broader set of sustainable urban mobility measures** – for instance in the framework of the SUMP and accompanied by improved public transport, safe cycling conditions and a robust parking policy.

The need for a holistic approach at metropolitan area level is clear, combining measures to reduce the number of urban vehicles circulating, favour the renewal and transformation of the urban private and commercial vehicle fleets, and redesign urban space (see the Airuse project^{xxii} for more details about this approach). Integrated with safe cycling infrastructure and new mobility options from ride sharing to micromobility, public transport can offer an attractive alternative to the private car and play a key role as a complementary measure to UVAR implementation.

Importantly, a strong public transport network is essential to provide mobility alternatives to city dwellers and commuters.

The variety of UVARs in the EU reflect the diversity of local contexts and ambitions. For this reason, **a blanket harmonisation of UVARs at EU level would not necessarily contribute to better implementation of UVARs. However, EU and national level guidance is needed**. This is especially the case to support cities with enforcement for foreign vehicles, technological applications, and revenue allocation to sustainable mobility policies.

When deploying UVARs, local authorities should pay attention to clear communication of objectives toward users. Similarly, UVAR design should be aligned with the stated objectives (e.g. tackle pollution, reducing traffic, etc.) to ensure acceptance and efficiency of the schemes. On this point, best practice exchange between cities is key. The same goes for enforcement measures,

which need to be in line with the scheme design. **The availability of new technologies provides cities with diverse options that can make seamless enforcement a reality for users.**

A progressive rollout of UVAR, as in the example of London or Milan, with a combination between different schemes (e.g. Low Emission Zone, Congestion charge, pedestrian areas) turns out to be an important success factor in UVAR deployment. —————

It allows stakeholders and residents to adapt to the new rules, while the UVAR impacts are gradually monitored.

In parallel to the phased approach, the report has shown that **complementary measures to ensure equity, including exemptions to specific users and at specific times of the day or week, greatly contribute to the fairness and acceptance of UVARs.** The same goes with proper anticipation and management of stakeholders' impact, considering early in the process the needs of public and private user groups.

Lastly, **it is crucial for cities to organise participatory processes** that engage the residents, businesses, and other relevant stakeholders like public transport authorities, and consider different perspectives .

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Co-funded by the
European Union