Geofencing guidance for Urban Vehicle Access Regulations (working document)

Author: Lucy Sadler

Contributors: Moa Berglund, Steven Herskamp, Matthieu Graindorge, Bonnie Fenton (ReVeAL), Rodrigue Al Fahel, Kristina Andersson, Josephine Darlington (CLOSER), Bas Bongers (NL MINIENW), Marcel Otto (NL RWS)

Version 2: February 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

1. Introduction

1.1 About the ReVeAL project

Urban vehicle access regulations (UVARs) are one of the tools that can help make cities more liveable, healthier and more attractive for all. The goal of the EU Horizon 2020 project ReVeAL is to support cities producing good practice in UVAR and to add UVARs to the standard range of urban mobility approaches across Europe and beyond.

The ReVeAL project supports UVAR implementation in six pilot cities and is developing a tool to help other cities decide what UVAR measures may be appropriate for them and what to be aware of when implementing. The project is also producing a number of guidance documents on specific UVAR-related topics – this document on geofencing is one of them.

To find out more about ReVeAL, please see the ReVeAL website.

1.2 Context of geofencing

Within the context of UVARs in urban areas, geofencing serves the two main purposes of speed reduction and emission reduction.

Geofencing for speed reduction can be seen as a long-term solution; it currently generally only gives the driver a warning about excess speed but in future, it may be used to prevent a car from being able to exceed the posted speed limit.

In terms of emission reduction, geofencing can either force a fuel switch to electric mode or monitor/confirm that a switch has been made. It can be seen as an interim technology, allowing hybrid vehicles to become zero-emission vehicles in certain zones. Cities must decide whether to encourage the interim option (perhaps earlier or more rapidly) or to move directly to a requirement for full zero-emission vehicles. The interim option may be more relevant for heavy duty vehicles than for light duty ones as there are proportionally more issues with zero-emission heavy vehicles. Related questions include for which vehicles emission-related geofencing should be an option, for how long the (interim) technology should be allowed, and what alternatives may be available.

1.3 Purpose and context of this document

This document is one in a series of ReVeAL UVAR guidance documents. It is intended to support both the ReVeAL pilot cities and any other cities considering UVAR measures. It looks at how geofencing and Active Advanced Driver-Assistance Systems-based solutions (ADAS) could be used for UVARs, with a particular focus on fuel use.[1] While we refer mainly to geofencing, many of the issues are also relevant for ADAS-based solutions. Where we discuss the uses of geofencing, generally either technology could be used.

Within the ReVeAL project, geofencing (and other UVAR-related technologies) are further discussed in the context of a task on future proofing UVAR. In February 2020 a market consultation provided a first general description and examples; the work continues within ReVeAL's Innovation Observatory (a report is planned for December 2021).

[1] There are also other ways that geofencing is already being used in cities. These include putting geofencing requirements in public procurement tenders or voluntary geofencing for those who want to limit the speed of their fleet drivers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

This document is for information and guidance. ReVeAL and its partners take no responsibility for any action taken base upon its content.

2. Definitions and terminology

Terminology and clear definitions help avoid misunderstanding, particularly when dealing with terms and concepts that are new or still in development. Geofencing is one of these; it currently has no clear definitional boundaries. For this reason, ReVeAL has attempted to clearly define relevant terminology for the context of the project. For more UVAR-related terminology, please see the online ReVeAL UVAR glossary.

2.1 Geofencing (also called a zone management system by some vehicle manufacturers)

A geofence is a virtual perimeter around a real-world geographic area. The perimeter can have predefined boundaries such as a school zone or a neighbourhood, or it can be dynamically generated, such as a radius around a point, or a perimeter that changes.

What geofencing can be used for:

Geofencing can be used in two different ways for UVAR. One is by the geofencing technology *actively* switching a plug-in hybrid vehicle remotely to electric mode inside the boundary of the UVAR. In an alternative that is currently being considered in the Netherlands for ZEZ logistics, the driver is responsible for ensuring that the battery mode is used. The engine is then passively *monitored* to identify whether the vehicle used battery mode within the zone so that penalties can be sent if appropriate. The Dutch method presents fewer hurdles to implementation and can build on existing systems. In this document, we refer to the Dutch method as *passive enforcement* of plug-in hybrid use through geofencing, as opposed to *active switching* of the fuel used – or simply “passive” and “active” enforcement.

The enforcement system could be informed in real time, but more likely is that it would check periodically in retrospect (e.g., every few months), as is done with other uses of such passive technology. This could work similarly for speed.

In the context of an UVAR, having a certified geofencing device in the vehicle could be a requirement for gaining a permit to enter a limited-traffic zone or it may be required to apply for an exemption. For both options, if systems are appropriately set up, the exemption could automatically be granted with the fitting of appropriate equipment.

In the future, geofencing could be used to prevent a vehicle from even entering a geofenced zone. One step in that direction could be monitoring whether an entering vehicle complies with the UVAR (passive enforcement). For all geofencing methods discussed in this document, except for passive enforcement, either automatic number plate recognition (ANPR) or a physical barrier is needed. In most cases, ANPR or physical barriers are needed anyway to enforce the overall scheme (i.e., the non-plug-in hybrid vehicles), and to identify any vehicles not fitted with appropriate equipment.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 815008.

How it works:

Regulations (e.g., speed, energy source permitted) are defined digitally by the relevant authority for the geofenced area and are communicated digitally either to the driver through an in-vehicle notification or directly to the vehicle, e.g., by automatically switching the vehicle from petrol to electric power or lowering its speed.

Technical requirements:

To work, vehicles need to have a geofencing device and reference to a digital map of the relevant zones, so that they know when they are in a geofenced zone.

2.2 Active Advanced Driver-Assistance Systems (ADAS)

ADAS is a technology that can have similar uses as geofencing, but instead of using georeferencing, the information is given to the driver and/or vehicle by in-vehicle equipment such as cameras, which capture road signs and actively enforce the regulated behaviour.

Technical requirements:

ADAS-equipped vehicles would be able to use normal street signs (assuming they are of adequate quality and correctly placed). It also does not essentially require a central system for communicating the regulation digitally.

2.3 Intelligent Speed Adaptation (ISA)

ISA is designed to work much like cruise control to prevent the vehicle from traveling over the speed limit, or to warn the driver about the speed limit. Where the ISA prevents the driver from travelling over a set speed limit, there may be a temporary override; this can be logged to find out if its use contributed to an accident. ISA that warns the driver is required for new EU light duty vehicles starting in 2022. It can use both ADAS and geofencing.

2.4 Combining geofencing and ADAS

A good validation method (probably a digital map) will likely have to be added to ADAS so that it also works where speed signs have been incorrectly placed or are of poor quality. This means it would probably require a central system similar to geofencing. Conversely, ADAS could be used to collect and feed data into digital maps used for geofencing.

In the context of UVAR, it is important to discuss these geofencing and ADAS together, as they are two alternatives that could achieve a similar purpose. They both have different pros and cons, and both are being tested in the speed application in Helmond in the context of ReVeAL (see also section 4 below).

2.5 Spatial intervention

We use the term spatial intervention in ReVeAL to refer to access regulations based on area planning and design and physical interventions on urban roads, in city streets or more general in the public realm. As a concrete example, the ReVeAL city of Vitoria-Gasteiz regulates access through superblocks; the city of Ghent uses a large pedestrian area and a circulation scheme.

2.6 Zero-emission zone

This is a zone where only non-emitting vehicles are permitted access, either all the time or in established time windows. A scheme may allow access to (certain) geofenced plug-in hybrid vehicles when they are operating on electric power.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

3. How geofencing could work for UVARs

Where a zero-emission zone (ZEZ) is implemented on a large geographic area using spatial interventions, for example a large pedestrian zone, some vehicles may still need to enter the area (e.g., delivery of goods too large or heavy for a cargo-bike). Geofencing may be useful to regulate these.

Within the ReVeAL project, geofencing is being investigated in London with plug-in hybrid electric vehicles (PHEV) and in Helmond with Intelligent Speed Adaptation (ISA).

Geofencing enables plug-in hybrid electric vehicles to access ZEZs as the geofence can ensure that vehicles comply with the requirement to operate in battery mode. This is particularly important for heavy duty vehicles, as there are currently limitations and issues with the supply of fully zero-emission lorries. For example, if a lorry delivers to an urban supermarket from its depot a long distance away, transferring the goods to an electric vehicle at a hub may not make sense, as the entire load is going to one supermarket[2]. For light duty vehicles, it is already practical to have zero emission vehicles at city delivery relevant ranges.

It would be the vehicle operator's responsibility to ensure that the vehicle has the battery range to complete the UVAR-related journey required. If the vehicle runs out of battery and needs to switch to fossil fuel within the UVAR area, this would be logged as an infringement, and communicated to the UVAR operator. This guarantees that the vehicle either complies with the UVAR requirements or receives a penalty notice.

Another relevant use is taxis. In London, the tightly regulated London cabs have traditionally been diesel fuelled, but since 1 January 2018 all new taxis must be zero-emission capable (ZEC) and existing regulations phase out 100% diesel taxis. Many (but not all) of London's zero-emission capable taxis already have some geofencing technology fitted from the factory, making full retrofitting relatively easy.

3.1 Actively switching a plug-in hybrid electric into a zero-emission vehicle

This option does not rely on the vehicle operator remembering to switch to electric mode.

Technically the switch of a plug-in hybrid to its electric mode with geofencing has been successfully implemented with a number of deliverers in Stockholm and the project is looking to expand to other operators.[3]

There is significant interest in the use of plug-in hybrids for ZEZs. Geofencing for plug-in hybrids could also be used more broadly, with the car automatically switching to battery mode in urban areas, relieving the driver of the need to remember to switch mode and reducing the environmental impact of the vehicles.

[2] An alternative could be swapping to an electric cab/engine to pull the loaded lorry trailer or allowing for an exemption from the zero-emission requirement, but still requiring the vehicle to meet other requirements such as the highest emissions and efficiency standards and to be fully loaded.
[3] See Geofencing in Stockholm in the reference section; the broader aspect of quiet delivery may also be of interest to cities with respect to night-time deliveries.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

Making plug-in hybrid geofencing work for ZEZs

In principle, plug-in hybrids would be banned from ZEZs while battery-electric and fuel cell vehicles would be permitted. Plug-in hybrids with certified, tamper-proof geofencing equipment could apply for exemptions. The actions outlined below describe how geofencing could allow the use of plug-in hybrids in a zero-emission zone.

- Zero-emission vehicles (battery or fuel cell) could be allowed into a ZEZ automatically[4] while plug-in hybrids could gain access only via a "white list" of exemptions.
- The certified installation of certified geofencing equipment would give the right to apply for a geofencing exemption, or the registered fitting of such equipment could automatically give an exemption. Such equipment would guarantee the use of the electric motor within the zone.
- A type approval/standard as well as a certification system would be required to certify the fitting of vehicles with non-tamper-proof geofencing equipment. Type approval/ standards would be required for both factory-fitted and retrofitted equipment.
- Any manual overriding in a plug-in hybrid would be logged and passed on to the enforcing authority(s) as an infringement.
- The geofenced ZEZ (including any plug-in hybrids that enter) would be enforced by ANPR or a physical barrier.

One issue that came up in the city of London's ZEZ was a problem with the GPS or other signals amongst the surrounding high-rise buildings. One solution would be to have the geofence switch plug-in hybrids to electric propulsion earlier, where the buildings are lower and signal more reliable. This could also reduce the resistance from surrounding neighbourhoods/ boroughs/ local authorities[5]. The battery-mode operation in the extended area would be required for the plug-in hybrid exemption. Information on any overriding that took place when the vehicle had no signal would have to be stored and passed to the enforcement agency(s) when the vehicle again had signal.

If there were large numbers of geofenced vehicles in a ZEZ, it might be possible to stagger the location at which vehicles switch to electric propulsion, so that not all vehicles switch to combustion engines at the same location. This could prevent any potential increase in emissions at the scheme perimeter.

3.2 Passive enforcement (checking that the battery mode has been used in zones)

This method, which makes the driver responsible for switching to EV mode, is likely to be used for heavy duty vehicles within the Dutch ZEZ logistics until 2030.[6] From the authority's perspective, this option has significant advantages over the active switching of the fuel source with fewer hurdles to implementation. Vehicle manufacturers might choose to offer

[4] Hydrogen (H_2) combustion engines are not ZEVs but are defined as "near-zero emission"; when burning H_2 in air, the N_2 in the air causes NOx. A combustion vehicle also has an efficiency of 30%, compared with the 80% efficiency of a battery-operated vehicle making H_2 combustion less attractive. See transportenvironment.org for an explanation and further links.

[5] These might be worried about all the hybrid vehicles turning on their combustion engines at the boundary. If battery ranges are/become sufficient, a good boundary for London might be the Greater London boundary.

[6] After 2030 no plug-in hybrid vehicles will be allowed in Dutch ZEZs. For further information on the geofencing options: https://topsectorlogistiek.nl/wptop/wp-content/uploads/2020/10/20201016_Verkenning-PHEV.pdf.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

the active switching in urban areas or in specified zones for driver's convenience, relieving the driver of the distraction.

The authority uses ANPR to identify which vehicles entering a ZEZ are plug-in hybrids. Only plug-in hybrids with a certified data logger are permitted access to the ZEZ. The certified data logger stores an aggregation of data from a vehicle's computer systems log that record where the combustion engine was used (using several metrics to make cheating difficult). This data is periodically telecommunicated to the enforcement authorities directly, or a via trusted third party. Rather than monitoring the situation 'live', enforcement authorities can then review whether the plug-in hybrid vehicle was in battery mode – and send a fine if appropriate. A similar system is currently being piloted in a number of EU countries to regulate overweight vehicles[7] and in the Netherlands for company car taxation.[8]

For some vehicles, the necessary equipment already exists. Where this is not the case, equipment can be retrofitted, via hardware or software, at a cost of roughly €500-€800. In order for passive geofencing to be used, a legal instrument must exist that allows it. An industry standard may be able to provide the basis for this.

A mechanism such as the one needed for passive monitoring would also be needed for the active mode switch to check for any use of manual overrides. This highlights the advantage of the passive option, which could record the information in one of two ways: 1) by recording whether the battery mode was used inside ZEZs (requiring digital maps in the vehicle), or 2) by recording the location of the vehicle when using each fuel type, providing a means to check whether the battery mode was always used in ZEZs (requiring more data and having privacy concerns, but giving more flexibility).

As the passive option uses permanent surveillance, the signal may be sufficient to cover most of the area in locations with poor signal. With regard to the concern about large numbers of vehicles switching at the ZEZ boundary, other options would need to be used, such as negotiated agreements with large fleet operators about when the vehicles would switch to battery mode, if not at the boundary.

To address the issue of enforcement of foreign vehicles, if no other mechanism is feasible, hybrid electric vehicles from other jurisdictions that do not have the necessary geofencing equipment could be required to request an exemption or permit and simply promise to operate in battery mode.

3.3 Using geofencing in limited-traffic zones (and in other UVARs)

Having geofencing in a vehicle that can ensure electric mode and/or limit speed could be one of the requirements for gaining a permit to enter a limited-traffic zone or for receiving a taxi licence. Not all vehicles need to be equipped with ISA to reduce the average speed on the road; even if a relatively small number of vehicles is equipped, this affects the speed of all vehicles.[9]

[7] This is currently being piloted in Sweden and Estonia for exceptionally big and heavy trucks, and is also expected in the Netherlands (see CLOSER). The regulation 2015/719/EU is used as a general basis in all member states. Legal issues hinder pan-EU implementation but these may be solved if the pilots are successful.

[8] For more information see https://keurmerkritregistratiesystemen.nl.

[9] ReVeAL intends to demonstrate this through a pilot undertaken in Helmond in July 2020 with various penetration rates (up to 15%-20% in the traffic) which will be assessed and reported on by the end of 2020.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

4. Geofencing or ADAS?

Each technology has pros and cons; whereas ADAS-based solutions can avoid the need to digitise maps, geofencing allows more control and variation by the UVAR operator. There are also benefits to using the technologies in combination.

Geofencing requires the digitisation of maps and regulations as well as a satellite signal. However, as it is independent of local road signs, geofencing can be more flexible, can incorporate reactive regulations, and can refer to areas other than the zone itself – for example where no signal can be received around the zone perimeter or where large numbers of plug-in hybrid vehicles changing back to combustion fuel at the scheme boundary is undesirable.[10] As discussed above, passive enforcement is likely to use geofencing as opposed to ADAS.

ADAS can use existing road signs (as long as there are clearly visible, unobstructed road signs at every entry to the UVAR area). ADAS is not affected by signal issues and is based on technology that is already used in many vehicles to provide advisory speed information. However, it is not flexible in terms of time or geography. In addition (and importantly), information is only given when crossing the UVAR boundary, meaning that journeys begun within the zone do not receive the necessary information. ADAS is not likely to be possible for passive enforcement.

The overall number of digital maps is increasing due to their use for other purposes, such as navigation or route planning, and they may complement road signs in the future.[11] Road signs, in turn, are likely to be needed for more widespread use of ADAS – at least in the shorter term. If/when there are sufficient (appropriate) road signs, ADAS may also work without the support of digital maps. On the other hand, more and more roads will likely be equipped with advanced communication technology (e.g., 4-5G, ITS-G5, 4G and C-V2X) to support communication with vehicles. This will reduce geofencing signal issues.

Table 1 outlines the pros and cons of geofencing and ADAS-based solutions specifically as they pertain to the implementation of UVARs in cities.

Table 1: Overview of pros and cons of geofencing and ADAS-based solutions for UVAR in cities

	pros	cons
Geofencing (active switching)	• can be more flexible • can accommodate reactive regulations • can relate to geographies other than the zone itself • allows more control and variation by the UVAR operator	• requires digital maps, the digitisation of regulations and a satellite signal in the zone (for speed) or at the boundary/zones where the fuel is to be changed (for fuel source) • a passive enforcement option may be needed for any overrides used

[10] If a switch to electric propulsion were required prior to the entrance to a ZEZ, separate road signs would need to be installed at the different locations, which would also create problems for a vehicle starting its journey between the two sets of road signs.

[11] See, for example, this information from TomTom.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

Geofencing (passive enforcement)	• As above • Many fewer barriers to implementation to switching	• requires digital maps to be transmitted to the vehicle, the digitisation of regulations and a satellite signal in the zone.
ADAS	• can use existing road signs (if unobstructed, clearly visible and at every entry) • is not affected by signal issues	• not flexible in terms of time or geography • needs road signs to be checked (and replaced or added as needed) • could add to concerns about the number of road signs and the resulting driver confusion • information is only given when crossing the UVAR boundary, meaning that journeys begun within the zone do not receive the necessary information • not likely to be possible/easily used for passive enforcement

Combining geofencing with ADAS would mean that one could operate if there were no data for the other. In this case, a hierarchy would have to be established deciding where road signs take precedence (ADAS) and where the digital maps do (geofencing). This hierarchy is also needed if ADAS is to be used with pre-loaded or dynamic digital maps. However, this is less of an issue in a newly introduced UVAR as it is likely to have the appropriate road signs.

In terms of future development at the European level, there may be significant advantages if implementers of UVARs can agree on either geofencing or ADAS as the technology of choice. A single system would avoid issues both for manufacturers and for vehicles travelling across Europe. The choice of technology could be steered by the development of international geofencing standards; however, it would be useful for cities to first discuss which would be most appropriate for UVARs. Given the advantages of passive enforcement, it may well be that this becomes the preferred option beyond the Netherlands.

Other factors affect the choice of technology, such as the fact that most modern vehicles have GPS and internet signal availability and data protection.[12]

5. Challenges and open issues

One chicken-and-egg issue affecting UVARs using geofencing or ADAS is that, since it constitutes an extra cost, manufacturers are not likely to install the technology unless it is requested by customers or made mandatory by the EU. However, this need is likely to be driven by several factors, including:

- the expected large number of ZEZs in cities across Europe and beyond,
- fleet operators wanting to control the speed of their drivers,
- plug-in hybrid vehicle operators wanting to both reduce their operating costs and emit less in urban areas by switching automatically to electric mode.

[12] However so far, the OEMs do not usually make these readily available for aftermarket applications.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

Issues that may need to be addressed to allow the use of geofencing in UVARs include:

- a legal definition of geofencing that includes:
    - UNECE or EU geofencing standard/type approval. This may be needed for EU cities, and advisable also for non-EU countries as vehicle manufacturers will not want to deal with different standards. A standard is needed that includes the fitting of the equipment, including issues such as data access and transfer, override possibility and its logging, and a guarantee that it is tamper-proof. A type approval may be an EU-wide industry standard, together with an exemption option for foreign vehicles.[13]
    - A geofencing retrofit certification scheme to certify that equipment and fitted vehicles comply with the standards in each country.
    - For active switching an override may be needed/desirable. Where this is the case, and an override is used, it needs to be monitored so it can be enforced where needed. This enforcement mechanism would, in effect, be the same as the passive enforcement described above.[14, 15]
- a legal basis to enable geofencing use, including:
    - the legal ability to allow geofencing for entry into a zero-emission zone (or as an exemption for white list)
    - digitisation of traffic rules
    - good quality digital maps that also reference the digital rules.[16]
    - data sharing protocols
- sufficient equipment available (chicken and egg)
    - One way to increase the use of geofencing equipment before standardisation of technology is achieved could be to phase in voluntary geofencing (for speed and/or fuel source) among large delivery companies and other companies in a given area. They could require delivery either with zero-emission vehicles or with plug-in hybrid vehicles switching to electric mode. Geofencing could be ensured through procurement codes and contracts.
    - Vehicle manufacturers might also offer geofencing on their vehicles to either switch fuel automatically in urban areas or to limit speeds so as to reduce their environmental and/or safety impact (e.g., Volvo).

5.1 Foreign vehicle enforcement of ZEZs

It is often difficult for an UVAR operator to identify the vehicle (emissions) technology of foreign vehicles, as UVAR operators rarely have access to the national vehicle database where this data is held[17]. The identification of zero-emission vehicles may be made

[13] This needs to be checked legally.

[14] This is also potentially a Vienna Convention safety issue.

[15] Any override of the battery mode would be logged and passed to the enforcing authority(s) as an infringement, e.g., if the battery is empty or speed is used (except when used to avoid an accident). A battery level indicator and warning (as in a conventional petrol tank) may also help avoid the need for an override.

[16] To support digital maps, we encourage all to be involved with the forthcoming EU project on digitising UVAR data and making digital data, including UVAR data, available. See: www.urbanaccessregulations/news.

[17] This is a longstanding issue with UVARs and LEZs in particular. As vehicle emissions are not available for most foreign vehicles, ANPR schemes would need to require foreign vehicles to register. While a patchwork of bilateral agreements could help, the only real solution is EU-wide action.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.

easier by the fact that some countries have number plates or emissions stickers that indicate electric vehicles (however, this electric vehicle label sometimes puts pure electric and plug-in hybrids in the same category, meaning plug-ins cannot always be differentiated from pure electric vehicles).[18] The European Union is also undertaking work towards improving foreign vehicle enforcement.

6. Links to other projects / contacts

- R&I geofencing programme in Sweden, coordinated by CLOSER https://closer.lindholmen.se/en/news/how-geofencing-can-become-part-our-cities
- Dutch logistics ZEZ https://www.greendealzes.nl/en/publications/
- Report on passive PVEV enforcement in the Netherlands: https://topsectorlogistiek.nl/wptop/wp-content/uploads/2020/10/20201016_Verkenning-PHEV.pdf (in Dutch)
- Polis Urban Freight work https://www.polisnetwork.eu/topic/urban-freight-2/
- Geofencing in Stockholm, https://civitas.eu/content/night-delivery-clean-and-silent-vehicles or https://civitas.eu/news/success-stories-freight-planning-stockholm
- Plug-in hybrid EV geofencing in use for bus line 55/EL16 in Gothenburg https://www.electricitygoteborg.se/en/news/one-million-line-55
- Nordic Way Geofencing Project: https://www.nordicway.net/ and www.youtube.com/watch?v=IRNbpBbyYXY&feature=youtu..be and www.youtube.com/watch?v=nXuf_RAVtVg
- Smart urban traffic zones project https://closer.lindholmen.se/en/closer-projects/smart-urban-traffic-zones
- Gothenburg Geofencing trials (for speed and energy source): https://www.eltis.org/resources/case-studies/geofencing-new-tool-make-urban-transport-safer-and-more-sustainable or https://smartcitysweden.com/best-practice/340/geofencing-digitalising-transport/

[18] More information on this will be provided in the forthcoming ReVeAL guidance note on foreign vehicle enforcement.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815008.