Public Procurement and Geofencing – lessons learned from a pilot with geofencing of service trips.

GeoSence

The project GeoSence elaborates on geofencing solutions aiming at improving urban traffic management and planning.

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GeoSence elaborates on geofencing solutions aiming at improving urban traffic management and planning.

The overall objective of the project is to design, trial and evaluate geofencing concepts and solutions for specific cases in cities, within the project and from other previous and ongoing geofencing initiatives, and to propose new ways of successfully deploying geofencing technologies. Tools for implementation, as well as approaches to scale-up and spread the innovation further in Europe, will be proposed including e.g. ways of integrating geofencing functionalities in the decision-making, built environment and traffic management in cities.

The project is a Joint programme initiative (JPI) Urban Europe project funded by European Union´s Horizon 2020, under ERA NET call Urban Accessibility and Connectivity and gather project partners from Germany, Norway, Sweden and UK. GeoSence project period is April 2021 to March 2024 with a budget of approx 1,6 million euros.

Partnership: City of Gothenburg, City of Munich, City of Stockholm, Norwegian Public Roads Administration (NPRA), Chalmers University of Technology, RISE, SINTEF, Technical University of Dresden, University of Westminster & CLOSER.

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Summary

Public Procurement and Geofencing – lessons learned from a pilot with geofencing of service trips.

The city of Gothenburg public procured geofencing technology and did a pilot during fall 2022 with geofenced service trips vehicles (retrofitted). This report investigates the challenges and opportunities associated with procuring geofencing technology, addressing aspects such as needs, market analysis, risk, alternative solutions, legislative framework, and much more based on lessons learned from the pilot.

Geofencing, defined as the creation of virtual boundaries to monitor, inform, and control traffic using electronic communication technologies or predefined boundaries within vehicles, lacks standardization and comprises various technical solutions. Its functionality depends on digital mapping, vehicle tracking methods like GNSS, onboard equipment, real-time connectivity, and additional databases for traffic rules. Geofencing offers degrees of control, from informing and alerting drivers about speed limits to actively restricting vehicle speed, with possibilities for static, dynamic, and smart adaptations. Applications range from enhancing traffic safety by alerting drivers and controlling vehicle speed to improving transport efficiency through optimized route selection and environmental benefits by reducing emissions and noise pollution. However, regulatory challenges persist, such as the absence of type-approved geofencing equipment and the need to define functional requirements rather than specific technologies in legal frameworks, presenting both opportunities and obstacles for its implementation in road traffic management and procurement processes.

The first step in public procurement involves laying the groundwork by comprehensively understanding the buying organization's needs and market capabilities to meet them. The city identified key goals such as safe travel and driver assistance. The city explored existing agreements and engaged operators for a geofencing pilot to address speed compliance and traffic safety concerns, alongside researching market options and risks associated with third-party equipment installation and data privacy. Alternatives like ISA and ADAS were considered but deemed insufficient.

In the second step the procurement is carried out, which includes tasks such as producing procurement documents, advertising, evaluating tenders, and ultimately selecting a supplier. The city procured the geofencing technology by direct public procurement and used a traditional public procurement to get hold of vehicles and drivers.

In the third step of the public procurement implementation is in focus on, executing the pilot and evaluating its outcomes, particularly concerning geofencing technology. Challenges arose during implementation, including difficulties in accurately mapping zones to individual vehicles due to problems with the speed box installed. The city of Gothenburg learned valuable lessons, highlighting the importance of direct communication with drivers, verifying technology before widespread adoption, and close collaboration between all stakeholders. Despite challenges, the pilot provided valuable data and insights, with recommendations offered for future geofencing initiatives, emphasizing early supplier dialogue, thorough testing, user experience understanding, and involving relevant stakeholders from the outset.

In this report insights, advice and lessons learned are also shared. Technical hurdles include the lack of standardized geofencing, difficulty in retrofitting diverse vehicle fleets, and limited market availability. Organizational challenges encompass the need for a needs-driven approach, internal and external collaboration, and balancing technology with user acceptance. Concerns about data privacy and driver behaviour emerge, requiring careful navigation of GDPR regulations. Strategically deciding the city's role in IT-solutions, data collection, and responsibility for vehicle behaviour poses business-related challenges.

The report concludes that while geofencing technology isn't yet ready for full-scale implementation, further pilots are necessary for development. Future work involves exploring alternative solutions, enhancing internal processes, and conducting larger pilots to advance understanding and implementation of geofencing technology.

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List of abbreviations

Abbreviation	Definition
ADAS	Advanced Driver Assistance Systems
IMY	Swedish Authority for Privacy Protection
ISA	Intelligent Speed Assistance
ITS	Intelligent Transport Systems
GDPR	General Data Protection Regulation
GNSS	Global Navigation Satellite Systems

Preface

This project report was conducted in the project GeoSence – Geofencing strategies for implementation in urban traffic management and planning. It is a Joint programme initiative (JPI) Urban Europe project funded by the European Union´s Horizon 2020, under ERA-NET Cofund Urban Accessibility and Connectivity and gathers project partners from Germany, Norway, Sweden, and the UK. The goal is to present the current state of the art, and describe use cases, based on the working definition of geofencing in the project, where geofence is defined as a virtual geographically located boundary, statically or dynamically defined. The overall objective of GeoSence is also to design, trial and evaluate new geofencing concepts and solutions for specific cases in cities and to propose new ways to deploy different geofencing applications.

We would like to extend a big thank you to everyone who participated in the project and contributed with their time, competence, and opinion. We would like to extend a special thank you to Malin Stoldt and Tomas Hagelberg, the City of Gothenburg, for all the support and help with the production of this report.

We would like to emphasize that the views and standpoints in this report are the authors´ alone. Other parties or representatives may have a different analysis and come to different conclusions.

If you would like to know more about the pilot, the report and the GeoSence project, please contact kristina.andersson@ri.se

Gothenburg, February 2024

The authors

1. Introduction

1.1 Background

Urbanization leads to increased transport of people and goods in the cities, which creates more complex traffic systems where vehicles and vulnerable road users need to interact. This development has a substantial societal, environmental, and economic impact affecting people´s safety and health. Investing in new physical infrastructure is needed but is usually very expensive and cities need to find more cost-effective ways to plan and manage traffic. New digital and connected solutions are being developed with the potential to effectively reduce these issues. Cities are trying to figure out how these new solutions can be used and efficiently integrated into existing systems targeting challenges such as data management, governance structuring, policy development, user acceptance, etc.

One of these technologies, regarded to have a major role in various solutions within urban traffic planning and management, is geofencing. In traffic and mobility-related conditions, geofencing is a way to define geographic zones wherein certain criteria and limitations for vehicle operations are defined. The technology can influence speed, powertrain and access control, and has the potential to become a powerful tool for cities in creating and maintaining more sustainable and high-quality urban spaces for their citizens by increasing traffic safety, lowering emissions, ensuring better traffic management, increasing the comfort of driving and increase transport efficiency and mobility.[1],[2] The technology could also be used for fair charging for tolling, to accurately measure road use and charge for miles driven on taxable roads.[3],[4]

Challenges include building up a secure and high-quality digital infrastructure, policy and legislation, technology acceptance, development of new business models, new organizational structures and processes, and missing evidence of impacts and benefits of geofencing in reducing negative externalities in transport. Lack of collaboration and coordination between actors is also a challenge and one of the reasons why other ITS-/C-ITS technologies with high potential to reduce negative effects from transport have not been introduced on a larger scale.[5]

One way to work with the challenges is to create a market for geofencing and experience the technology. Using geofencing in real life will provide us with knowledge about how to tackle the challenges mentioned above and evaluate the way forward. In the GeoSence project, we investigate, among other things, how a city can create a market for geofencing by using public procurement.

[1] Fagnant & Kockelman, 2015
[2] Taeihagh & Lim 2018
[3] Bomberg et al 2009
[4] Swedish Government Investigation DS 2021:28 pp 258
[5] Turetken et al., 2019

1.2 Purpose of the report

The GeoSence project as such is about "Geofencing strategies for implementation in urban traffic management and planning", where the objective is to define, trial and evaluate geofencing concepts and solutions for specific cases in cities, within the project and from other previous/ongoing geofencing initiatives, and to propose new ways of successfully deploying geofencing technologies. This report is a part of work package 3 in the GeoSence project. Work package 3 is about exploring new policies supporting the solutions and do an analysis of relevant policies, legislations, and processes in partner cities.

Gothenburg is one of the partner cities in the project. In the GeoSence project the city is addressing geofencing in public procurement, e.g., how to describe requirements for geofencing functionality and how to follow up compliance to the requirements stated in the contract between the city and a traffic operator. The main purpose of this report is therefor to investigate challenges and opportunities with public procurement of geofencing in relation to the pilot in Gothenburg. The purpose of the report leads to the following research questions:

- What is the current state of the art market analysis showing available products and potential solutions regarding geofencing in the relation to our pilot?
- Which legislation regulates public procurement in relation to our pilot?
- What supporting legislations are there and how do they work?
- What can we learn from the pilot – experience and evolution?

1.3 Methodology

In this report we combine a top-down approach with a more practical, bottom-up approach. The top-down approach consists of a theoretical study and the bottom-up approach consists of a pilot where we demonstrate public procurement of geofencing.

This report also follows a qualitative approach. The work has been carried out partly through literature studies (e.g., studies of relevant legislation, articles, reports, and publications), partly through dialogue with relevant actors in collaborative workshops and interviews. We have worked with an agile and iterative process where we have checked results and various solution proposals in several workshops to validate our results.

1.4 Limitation

This report is subject to limitation. Public procurement has a broad scope and involves many different activities with corresponding rules. Our report focuses on the situation in Sweden in relation to the pilot we carried out.

We will not name persons that have participated in this report, i.e., those we interviewed, due to confidentiality.

2. Geofencing

2.1 Definition of geofencing

The term geofencing is given different meaning in different contexts. The definition of geofencing in traffic management and planning in this report is consistent with the working definition in the GeoSence project, which is: *Creation of a geofence for monitoring, informing and controlling traffic (mobile objects/vehicles) located within, entering or exiting the geofence, using electronic communication technologies or pre-defined geofences embedded into the mobile objects/vehicles, where a geofence is defined as a virtual geographically located boundary, statically or dynamically defined.*[6]

Note that geofencing is not a standardized technology. Also, geofencing does not consist of one technical solution. Instead, it can consist of different technical solutions together and the combinations of these can change over time.

2.2 How does geofencing work?

Geofencing consists of several building blocks. First, a digital map is needed where the digital fence is marked. The rules what should apply within the zone are stated on the map. This can be done in the vehicle's fleet management system, or a digital platform developed by 3rd parties. The geofencing zone can be large or small and come in all shapes.

[6] Hansen et al., 2021

Second, for the vehicle to use geofencing, a method is needed to determine whether the vehicle is inside or outside geofencing. One common method is to use the Global Navigation Satellite System (GNSS).

Third, the vehicle must also have the technical ability to understand if it is outside or inside the zone and to comply with the rules that apply in the zone. The equipment can be mounted by the manufacturer of the vehicle or retrofitted by 3rd parties.

Fourth, the vehicle is most often connected to the platform or the vehicle´s fleet management system and can send or receive information in real-time.

Fifth, there are also supporting building blocks like the Swedish national road database where ordinary traffic rules are stored.

Geofencing has different degrees of control: 1. *Inform*, by alerting the driver about e.g., speed limits, low emission zones, etc. 2. *Warn/restrict*, by giving the driver the option to restrict e.g., vehicle speed and 3. *Restrict/steer*, where the system is allowed to take physical actions e.g., restrict vehicle speed, with or without the option for the driver to override the restriction.

Geofencing can also be applied with different degrees of functionality such as: 1. *Static*, traffic rules are communicated when entering the geofenced zone e.g., low emission zone. The zone itself stays the same. 2. *Dynamic*, recommendations and rules can be changed dynamically, based on triggering, or reporting events e.g., time/accident reports. The zone itself can also change (in time and size), and 3. *Smart*, includes a feedback loop enabling smarter self-regulated systems.[7]

As described above, geofencing can be used to monitor or control vehicle speed, to control access to specific parts of the transport system and to warn or notify the driver or other road users about specific conditions. The use cases are often summarized as follows:

Inform or alert. Geofencing can be used to inform or alert the driver. For instance, regarding current (or a change of) speed limit, recommended/alternative driving paths, accidents, or ongoing events.

[7] Swedish Government Investigation, DS 2021:28, pp 258.

Control vehicle – Static geofencing. Geofencing can be used to control how a vehicle is driven. When the conditions within the specific geofencing zone are set and do not change, it is considered a static geofencing zone. The conditions can for instance relate to speed restrictions for public transport on specified routes or road sections.

Control vehicle – Dynamic geofencing. As above, with the difference that restrictions can depend on, for instance, time of day.

Control vehicle – Smart geofencing. As above, but the restrictions alter depending on external factors. For instance, sensors can detect a high number of pedestrians in a certain area which in turn can trigger reduced speed in passing vehicles.[8]

2.3 Geofencing applications

There are several transport related needs where geofencing could be a solution. These include traffic safety, efficiency, and environmental aspects, which are all common challenges within the industry.

2.3.1 Traffic safety and working environment

Speeding vehicles constitute a major concern related to traffic safety and for those that are in some way active within the transport system, be it drivers, pedestrians/cyclists or workers at adjacent road work or construction sites. This especially applies within high-risk zones, such as densely populated areas or on high traffic roads.

Reduced speed has the potential to lower the probability for severe effects of accidents drastically. Here geofencing, or other types of technology, could be a solution, as it can be used to inform drivers of potential risks as well as be used to (automatically) lower speeds in specific areas or on specific road sections. The technology could also be used to digitally restrict access to an area or specific street entirely, which is a method that could be used to hinder terrorist attacks being performed using (heavy) vehicles.[9]

[8] Report on market analysis – geofencing-based services in road transport (CLOSER, 2022)
[9] Report on market analysis – geofencing-based services in road transport (CLOSER, 2022)

2.3.2 Transport efficiency

Certain infrastructure, such as bridges, are sometimes closed for heavy vehicles, due to buoyancy limitations. In certain cases, such vehicles could be allowed to pass provided they do so at a reduced speed. Here geofencing could be a possible solution.

In populated areas there are often limitations on when during the day a delivery can be made, due to noise pollution. The use of electrical vehicles could help mitigate these effects, as they run quieter than their combustion engine counterparts. Hybrid vehicles could of course give the same effect, given that they use their electrical powertrain. Here geofencing could be used to make the vehicle automatically switch to electric powertrain when entering specified areas or streets. Being able to make deliveries (or pick-ups) during nighttime allows transporters to work during a time of day with less congestion, leading to increased transport efficiency.[10]

Fleet management systems including functionality for monitoring of vehicle geographical position, constitute good conditions for optimizing route selection and, specifically, what vehicle handle which delivery or pick-up. This is especially useful regarding changes in the daily plan and has the potential to reduce distance traveled and increase vehicle utilization, and thereby reducing costs. Added functionality in the form of geofencing enables, for instance, notification when a vehicle enters or leaves the terminal area.

2.3.3 Environmental aspects

Reducing the speed of vehicles in general means that emissions from them are reduced.
Environmental zones can also be used to enforce use of more environmentally friendly vehicles. However, controlling compliance is often a challenge. As described above, here geofencing could be used to automatically switch to electrical powertrain (in the case of hybrid cars). Not only does this lead to reduced emissions, but it also results in less noise pollution. As an alternative to automatically switching the powertrain, drivers could be informed about the environmental zone, or other aspects such as air quality, specific traffic rules, etc.

[10] Hansen et al., 2021

2.4 Geofencing and regulations

Geofencing is more of an idea/concept that can be filled with different content depending on the area of use within road traffic. Geofencing enables several different functions and can therefore be used to control or adapt road vehicles in different ways. Is it about speed control, access to a street in time and space, no go zone, no parking zone, or a tool to reduce environmental impact? From a legal point of view, this is both and opportunity and an obstacle.

One obstacle is for example that there is not yet type-approved vehicle equipment for geofencing. A type-approval is useful for example to describe *how* something shall be achieved (more of detail requirements). Instead geofencing can legally be described based on functional requirement answering the question *what* is to be achieved.

There is nothing legal to prevent commercial actors from using geofencing applications as a tool in their own business or from entering into agreements with others to use such applications for example with the aim of increasing the safety of employees. Public actors can also make demand on geofencing applications in public procurement for example when buying transport services (see below).

A government inquiry[11] highlighted that it is possible to set functional requirements for geofencing in procurement if the five basic principles of procurement are followed (see below). However, because functional requirements are not specific to a particular technology, a supplier can meet the functional requirements with non-geofencing technologies, such as ISA (see below), if e.g., the target is speed limitation.

3. Public procurement

In this report we focus on public procurement and geofencing. To do public procurement with geofencing a city must consider several regulations depending on various factors e.g., public procurement, geofencing as such and data sharing. We describe these regulations in more detail below.

[11] Swedish Government Investigation, DS 2021:28 pp 304-305.

3.1 What is public procurement and why is it done?

Public organisations, like a municipal, finances its purchases through tax revenue. Public procurement is a tool that can be used to make sure what taxpayers' money is used as efficiently as possible. When a city uses public procurement, it puts its purchases out to tender. By using public procurement, the city can make sure that companies doing business with the city must do so on equal terms. Citizens also have a right to know how their tax money is spent and by making public procurement public this is full field. All public procurement is based on an EU directive that sets out five principles for procurement.[12] These are:

1. The principle of non-discrimination; The principle means that it is forbidden to discriminate against suppliers based on nationality.
2. The principle of equal treatment; The principle implies that suppliers should be treated equally and given equal opportunities.
3. The principle of transparency. The principle imposes an obligation on the contracting organization to ensure transparency by providing information on the procurement and how it will be carried out.
4. The principle of proportionality means that the requirements set in the procurement must be reasonable in relation to what is to be procured.
5. The principle of mutual recognition means that certificates and certificates issued by the competent authorities of one Member States also valid in the other Member States.

The EU directive has been introduced into Swedish law through the Public Procurement Act (2016:1145). In the pilot, the city of Gothenburg used two kinds of public procurement: traditional public procurement for the service trips and direct procurement for the geofencing solutions used in the pilot.

In traditional procurement, all purchases assume that the buying organization has a need that it cannot meet itself and therefor decides to buy something. The next step will be to find out if what you want to buy is available in a market by conducting a market analysis. The work will result in the terms and

[12] Article 18 Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC.

conditions that are relevant to set in the procurement. The terms and condition are thereafter collected in the tender documents and published in a certain way. Interested suppliers submit tenders. The buying organization evaluates the bids and ultimately decides who won the tender. Direct public procurement can be used if the value of the procurement is less than 700 000 SEK. The advantage of direct public procurement is that it is not so formalized. There is e.g., no need for advertising or tenders in a specific format.

It is possible to use public procurement in combination with new emerging technologies to find a path that enables more innovation. When an authority is unsure of what solutions are available on the market or that can be developed, the authority can conduct a so-called early dialogue, e.g. by meeting potential suppliers or inviting to a written dialogue through request for information (RFI). Through the early dialogue, the procuring organization can present needs and desired results to the suppliers. The buyer can also gain knowledge about what solutions the suppliers can offer. The suppliers can, in turn, come up with suggestions for solutions. Early dialogue can be carried out in different ways if the five basic principles are respected. The early dialogue may result in the market not being able to solve the need.
In this situation, the buying organization has different options. One option is to carry out a Pre-Commercial Procurement (PCP), which is legally an exception to the Public Procurement Act. Even if the PCP is outside the scope of procurement legislation, the five basic principles must be followed. The buying organization can procure research and development services such as concept studies, prototyping and testing to create a market. After the PCP is completed and the product developed, a regular procurement can be carried out.

Another option is to carry out an innovation procurement. Innovation procurement can be used when the buyer's needs cannot be met by the market, but development and research are required for suppliers to develop a new product or service. For example, it may be that a new development of a product or service or a new solution exists, but it has not been tested in practice. Innovation procurement is a form of procurement that is suitable for procuring previously unknown solutions to a defined problem. In innovation procurement, government and industry can meet.

A third way to open for innovative solutions is to use functional requirements in the procurement instead of specifying a specific solution. This means that the buying organization describes the needs to be met or what effect is to be achieved, and then leaves it open for the bidders to solve how it should be done.

The requirements are therefore often linked to goals and measured as desired effects and results. Functional requirements are good if specific requirements mean that only one or a few suppliers can deliver. Functional requirements also do not lock the supplier into a particular technology, working method or product. Instead, it will be possible for the suppliers themselves to decide what the solution should look like. See more below.

A fourth option is the so-called dynamic purchasing system. In a traditional four-year framework agreement, new suppliers cannot join during the period of validity. A dynamic purchasing system is open for new suppliers to join during the validity period if they meet the qualification requirements. A dynamic purchasing system can be likened to a pre-qualification system. The affiliated suppliers are not obliged to bid for an invitation to tender and can also leave the system at any time. The advantage for the buying organization that new suppliers can connect as new technical solutions become available on the market.

3.2 Public procurement of geofencing in Sweden so far

Public procurement of geofencing combined with vehicles is not a completely novel phenomenon in Sweden.

After the terrorist attack in Stockholm in 2017, the Swedish government gathered various authorities, vehicle manufacturers and others to find solutions to prevent vehicle hijackings in the future. One suggestion that was highlighted at the time was geofencing. The Swedish Transport Administration was later commissioned by the government to continue working with geofencing solutions. The Swedish Transport Administration is one of largest buyer of construction logistics transports in Sweden. Now the authority is investigating if geofencing could be publicly procured regarding construction logistics transports. Buying geofenced transports through public procurement is also in line with the authority´s work on safe transport.[13]

The city of Stockholm has a mandate from the political leadership to implement geofencing for speed enforcement in the city's own cars where technically possible. Over the past three years, the City has surveyed vehicle suppliers through framework agreements for vehicles (passenger cars and transport

[13] Geofencing - Bransch (trafikverket.se)

vehicles up to 3.5 tonnes) and asked if they have vehicles or will have vehicles with technology that can limit the speed of vehicles on certain routes or areas. The requested technology can also be delivered from an external supplier in cooperation with the vehicle supplier. The answer from the vehicle suppliers is that none of them can offer the requested technical solution.

In 2019 a public bus driver in Stockholm took the wrong way and the roof of the bus hit a tunnel wall. The gas bus caught fire. The Swedish government commissioned the Swedish Transport Agency to investigate and submit proposals for measures that would increase safety in public transport. In November 2019, the Swedish Transport Agency presented its proposals for measures in the report *Road safety enhancing measures for gas buses*.[14] One of the proposals in the report was that public transport authorities should require geofence functions when procuring bus services so that gas buses are restricted access to, or that the driver is warned at, road sections with passages with limited height. This is to prevent accidents caused by tall gas buses driving onto roads with limited heights or on other roads with an increased risk of accidents. According to the Swedish Transport Agency, such procurement requirements can lead to positive effects on traffic safety and traffic flow, as well as lower operation and maintenance costs for the bus. However, it can also lead to higher costs for public transport authorities and municipalities, for example when introducing the technology or through higher tender costs, which could ultimately lead to higher ticket prices for travellers. The benefits, risks and costs must be assessed on a case-by-case basis by the contracting organization.

As for now geofencing is only used in public transport in a limited scale and not in the way The Swedish Transport Agency suggested. We have interviewed Västtrafik (the regional public transport authority in the Gothenburg area) about their experience with geofencing so far. Västtrafik has developed their own geofencing solution. In their public procurement it is stated that operators must be able to communicate with Västrafik´s geofencing technology (their platform). Västtrafik has tested geofencing that warns the drivers of danger ahead but according to Västtrafik the geofencing technology is not yet good enough because the drivers get too many false alerts. Västtrafik use geofencing today as an example in combination with bus stops. The bus stop is a geofenced zone and the bus communicates to Västtrafik when arriving/leaving the bus stop.

[14] Transportstyrelsen (2021) Utredning av säkerhetskrav för gasdrivna bussar och uppföljning av säkerhetshöjande åtgärder. TSV 2020-5385

Another application for geofence is services for collecting freight transport data through connected vehicles. A pilot to test to get a statistical service on geofenced freight transport information was carried out in 2016-17 by the city of Gothenburg. It was a part of a joint initiative to use Intelligent Transport System (ITS) regarding freight transport to make the traffic situation less chaotic during the many years that the large infrastructure projects in the region of Gothenburg called "Västsvenska paketet" will last. A pilot test was carried out with 5000 connected vehicles in Västra Götalandsregionen together with a Fleet Management System system provider (that owed the data in their system) and a data analytic company that could use the data to collect statistics, visualize the result in a Geographic Information System application and also export statistics on an aggregated level. One of the goals for the pilot was to test what was possible to do with the information and several zones were geofenced and it was possible to get statistics from these separately.

4. Privacy and drivers

In the GeoSence project the city of Gothenburg is interested in gathering information on an aggregated level from the vehicles, but not gathering personal data about the drivers e.g., their personal behaviour. The city is for example interested in aggregated information about vehicle speed. But to get data on an aggregated level also means that the original source is personal data, and that data might reveal crimes such as speeding.

The processing of personal data is regulated by the General Data Protection Regulation (GDPR)[15]. Personal data is any kind of information that can be directly or indirectly linked to a living person. The decisive factor is whether the information, individually or in combination with other information, can be linked to a person. The GDPR also uses the concepts of pseudonymised and anonymised personal data. Pseudonymisation refers to the processing of personal data in such a way that the data can no longer be linked to a specific person without additional information. For example, the encoding of personal data is pseudonymisation. Coded data cannot be linked to a specific person without a key. Anonymisation means that personal data is processed in such a way that the person can no longer be identified and in an irreversible manner.

[15] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data and repealing Directive 95/46/EC (General Data Protection Regulation).

Lawful grounds: To be allowed to process personal data, a lawful ground is required (Art. 6). Here are some examples of lawful grounds:

- **Consent** – The data subject has consent to the personal data processing.
- **Contract** – The data subject has a contract with the data controller.
- **Weight of interest** – The data controller may process personal data without the data subject´s consent if the data controller´s interests outweigh those of the data subject and if the processing is necessary for the purpose in question.
- **Legal obligation** – There are laws and rules that oblige the data controller to process certain personal data in its activities.
- **Task carried out in the public interest or in the exercise of public authority** – The data controller must process personal data to carry out its duties as an authority or to carry out a task in the public interest.

An employed driver cannot give consent to data collection at work because there is too great a power imbalance between an employee and the employer. A driver also does not have a contract with the city. Furthermore, there is no legislation that says that the driver must hand over the information the city wants in the pilot. What is left is weight of interest, but an authority cannot use that accordingly to GDPR. Drivers' employers can however use this lawful ground. That is left for the city to use is the lawful ground task carried out in the public interest.

Collecting speed data is also more complicated because such data can reveal that the driver has committed a crime (e.g. driving too fast). Collecting data on crime is in Sweden a police matter. Other authorities may collect personal data on crimes if this is necessary for the performance of the authority's task (art 10 GDPR). Stockholm city asked The Swedish Authority for Privacy Protection (IMY) for advice in this matter. The city wanted to procure a driver record system with ISA. The challenge for the city was that such a system would also reveal if employees were driving too fast. IMY advised the city against proceeding with the procurement as collecting this data was not necessary to perform one of the

city's tasks in general. But IMY also mention what service trips might be a reason to collect data about speed violation.[16]

It is also possible for an employer as such to collect data about crime in a geofencing zone e.g., speeding provided that IMY has granted permission to do so. But getting a permission takes a long time.[17]

5. Traffic safety and the city of Gothenburg

In the early 1990s, Gothenburg city was considered to have the most dangerous traffic situation in Sweden. The city realised that something had to be done about the situation. Since then, the city of Gothenburg has worked to increase traffic safety in the city in various ways, for example by working with speed-limiting measures. The city started by rebuilding physical road infrastructure like building speed bumps, elevated pedestrian crossing lines and roundabouts. The measures had a great impact and the number of seriously injured and killed in traffic decreased. But in the early 2010s the city realised that the numbers of seriously injured and killed didn't decrease anymore. It wasn't enough to rebuild infrastructure to reach vision zero, that is zero people killed or seriously injured in traffic. Something else had to be done. The city started to investigate if digitalisation was the next tool to control and reduce speed. Geofencing was a promising technology that the city wanted to move forward with and explore. The city is also a partner in the government´s national action plan from 2018 to introduce geofencing on a larger scale in Swedish cities.

The first project with geofencing that the city participated in was ElectriCity 2015-2020[18]. In the project public transport buses were mandatory geofenced for the purpose to reduce speed, noise, and emissions. Another project was Digitalized Infrastructure Zones (DIZ2)[19] 2019-2022. In DIZ2 a digital platform was developed that allowed the city to quickly create geofencing zones with corresponding rules and communicate them in a standardised manner. After a geofencing zone was created, the bus´s fleet management system could retrieve data from the platform about the new zone and communicate the new

[16] Swedish Authority for Privacy Protection, Prior consultation on the processing of personal data in connection with the use of electronic mileage logs with ISA function, DI-2022-1227, 2021-05-19 (Nobina buses)
[17] IMY Decision, DI-2022-253, 2023-06-02
[18] ElectriCity Forskning för hållbara städer | Electricity (electricitygoteborg.se)
[19] DiZ2 Göteborgs Stad Trafikkontoret, TN-information (goteborg.se)

rule to the bus and inform the driver. The city is also a partner in the projects Nordic Way 2 and 3[20] from 2019 and onwards where dynamic geofencing is explored. The city wanted to go ahead and test geofencing on their own publicly procured fleet. This motivated the city to participate and engage in the activities within the project GeoSence.

6. Service trips

An important task for Gothenburg city is to provide "service trips" (special transport services) to travellers who have difficulties to travelling with ordinary public transport. It could be a child with special needs travelling to school or an elderly person travelling to a meeting. The travellers need a certain permission to use the special transport services. About 1 300 000 journeys are carried out each year.

The city buys transportation from different operators through public procurement. The vehicles are owned by the operators. There are two pools of vehicles. One pool consists of vehicles painted green (about 70 % of the fleet, = 260 vehicles). These are only used for the city´s needs. One pool consists of ordinary taxis that can be used during peak hours when there are not enough green painted vehicles available (about 30 % of the vehicles).

[20] NordicWay 2 & 3 NordicWay 3

Fig 1. Example of green-painted vehicles that do service trips for the city. Images kindly provided by Peter Svensson.

7. Public procurement and the pilot

The Swedish Public Procurement Act (2016:1145) contains procedural rules governing the preparation and implementation of procurement. Procurement can be described as a circular process as a procurement is usually renewed when the contract period expires. In a simple model, the purchasing process consists of three parts:

- Phase 1 – prepare (plan, map and analyse)
- Phase 2 – procure (tender documents, advertisement, tender period, opening, tender evaluation, decision and contract signing)
- Phase 3 – realize (implement, manage and evaluate)

The city of Gothenburg followed the three phases in their procurement of geofencing. How the city of Gothenburg did it is described in this chapter.

7.1 Phase one – prepare procurement

The entire foundation for the public procurement is laid in this phase. The buying organisation needs to understand its needs and how the market can meet them. For example, the buyer can collect data from their own business on needs, interview experts and contact different suppliers and ask questions. The work will result in an understanding of the terms that can be set in phase 2 and how the requirements should be formulated.

7.1.1 Plan, map and analyze needs

The first step is to understand what skills and resources are needed within the buying organization as well as to start a task force. The City of Gothenburg has been involved in the Swedish government's work with geofencing since 2018. The city became aware of the Joint programme initiative (JPI) Urban Europe project call (which later came to fund the project) and realized that this was a good opportunity to finance testing geofencing in combination with service trips. The city also understood that a public procurement of geofencing was necessary to be able to perform the pilot. A working group from the traffic office department and service trips department were put together. Persons from department of purchasing and procurement and department of data protection and law were engaged. Traffic engineers were also a part of the group. The city then began to work with the application together with other actors.

Prior to a procurement, it is important to identify and analyze what needs geofencing should satisfy. For the city, there were three general needs to be met. These were:

- Safe and secure travel for customers. Customers are particularly vulnerable due to their disabilities.
- Safe and secure travel for other road users. Since 1990s, the city has been working actively to improve the traffic situation in general (see above).
- Driver assistance. Help the driver to increase the quality of the journey (e.g., drive legally).

To meet these three general goals regarding service trips, the city has previously worked with e.g., driver training, aggregated data about performance monthly from operators, sampling of compliance with the public procurement agreement, customer surveys and customer complaints.

Another key to understand the pilot is to know that a former head of service trips was interested in geofencing and worked for the technology to be used in the cars from 2014. He ensured that already in the agreement from 2016 to 2020 (later prolonged to 2022), a section was included in the public procurement agreement of service travel about whether participating in geofencing tests may be relevant during the contract period. But the city didn't use this option from the beginning. Instead, during this period, the city informed the operators about their plans with a geofencing pilot. The city also decided to start with the green-painted cars in the pilot. As mentioned, the existing public procurement agreement already provides for the possibility of using the vehicles and drivers for the pilot. Two operators agreed to participate in the pilot.

By using geofencing the city especially wanted to address vehicle speed (safe journey). In the current public procurement for service trips, there is a clause stating that the operators shall work on preventive measures for speed enforcement. Upon request, the operator shall also provide aggregated speed enforcement statistics and measures taken to reduce speeding violations.

The idea behind using geofencing was the hope that with the help of this technology support drivers to keep the speed limits and to increase the safety of trips for the customers. In this way, all journeys would be carried out within the permitted speed. But the aim was also to ensure that speed limits were being respected especially around areas where vulnerable road users stay e.g., nearby schools (increased traffic safety in general).

The city was focusing on three research questions regarding geofencing:

- How can a city use public procurement to accelerate the use of geofencing? How to describe requirements for geofencing functionality when procuring transport services to achieve higher speed compliance to increase traffic safety and to give travellers a safe and secure journey, but without unnecessary limiting the "freedom" of the driver. How to use geofencing to assist the driver?
- Compare and evaluate user behaviour, experience, and acceptance during test with geofencing during three different phases.
- Learn more about pro´s and con´s using retrofitted equipment and geofencing.

One part of the pilot was also to do a web survey to drivers before and after the trials about their experience. The result from the web survey is published in another report.[21]

The service trips cars today all have ISA advisory (see below) installed. ISA follow speed on traffic signs and are therefore static. The city was also interested in investigating dynamic speed limits through public procurement. The speed on traffic sign (static speed) works many times well (which ISA use), but sometimes there is a need to adapt the speed to actual conditions at a particular time and not use traffic signs (dynamic speed), for example during an event.

The city also had an ambition to be more proactive against speeding. The city wanted to investigate if speed control could be a part of an agreement and not as a part of violating speed legislation. The service trips cars today have for example cruise control, but the driver can choose to use this or not. The city has so far worked with education and training to bring about behavioural changes in the green vehicle drivers to respect speed limitations. This time the city also wanted to explore the limitations of "mandatory" speed limitation and driver acceptance.

There are two other needs for service travel. One is punctuality. The city concluded that geofencing could not be used to achieve this goal at this moment. The other one is reduced environmental impact through lower emissions. The city concluded that geofencing can be used to achieve this goal (lower speed = lower emission) but decided to not include it in the pilot.

7.1.2 The geofencing zones

With the help of traffic engineers, the city identified different zones that were suitable to be in the pilot, i.e., areas around frequently visited schools or activity centres. The city also decides about suitable maximum speed for the different areas. For example, it could be an area where there was a need for reduced speed, but traditional methods of reducing speed (speed bumps) were not suitable as these would prevent emergency vehicles. Another area selected was intersections with hidden visibility. One problem was that the city didn't know which route the driver would choose. Another problem was the right size of the zone.

[21] Sven-Thomas Graupner et al (2024) Report on the Acceptance Evaluation for the Geofencing Use Case Study in Gothenburg

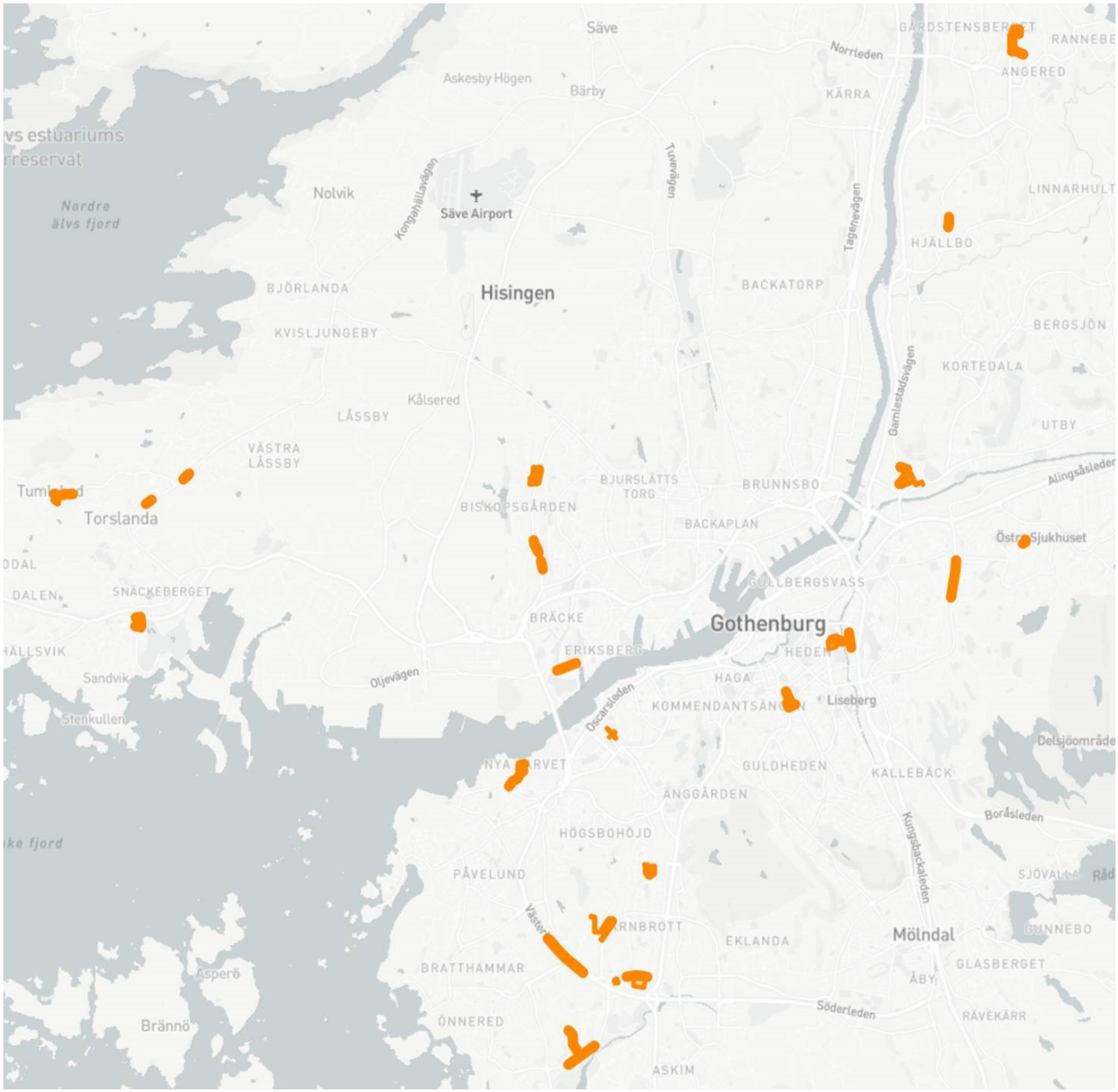

Fig 2. A map showing the geofencing zones in the pilot.

Fig 3. A map showing what an individual zone would look like.

7.1.3 Map and analyze the market regarding geofencing

In the Public Procurement Act there is no exhaustive definition of market research. Market research is done by collecting all available information on the market which the contracting entity can obtain and assimilate at the planning stage. Commonly used methods to gain information are dialogue with suppliers about the object and how it is described or invite the suppliers to do a demonstration.
Geofencing can be installed by the manufacture of the vehicles for different purposes. BMW offers something called BMW eDrive zone. This means that a hybrid car automatically switches to electric power when the car enters an environmental zone. But there are no passenger car manufacturers, at this moment, that offer geofencing to control vehicle speed.

Since the cars to be used in the pilot had already been procured, the geofencing technology needed to be procured separately from a 3rd party provider and retrofitted into the cars. Challenges for the city are that the vehicle fleet consists of different model years and brands. They are used at the same time and must work together based on the chosen solution. Moreover, it is not high premium brands in the fleet, which normally offer more advanced technical solutions early on. The type of vehicle used for service trips is not normally at the forefront of technology. The vehicles used by service trips also need to be able to take wheelchairs on board and need to be equipped with stair climbing. The choice of vehicle brand is therefore limited. Many vehicles in the existing fleet are converted WV Caddy.

The city of Gothenburg therefor investigated and contacted 3rd party suppliers of geofencing equipment. The Department of Service trips already from start know one Swedish 3rd party reseller of geofencing which was approached. Through the network of project partners, a reseller from another country within EU was also identified and approached. The price indication from the suppliers indicated that a direct procurement was possible as the amount was below 700 000 SEK.

The city could have used the platform developed in DIZ2 project (see above) to create and mediate the zones. But the platform requires the receiver to be able to receive the zones in the DATEX II format and covert/adopt them to their zone management/fleet management system. The city decided that this would be too complex and too many uncertainties to handle in the pilot.

7.1.4 Alternatives to geofencing

A part of the market investigation is to understand alternatives to geofencing. The goal of phase one is to set requirements for the procurement like deciding on functional requirements. However, because functional requirements are not specific to a particular technology, a supplier can meet the functional requirements with non-geofencing technologies and what might be a surprise for the buying organization.

There are alternatives to geofencing, which also regulates vehicle speed, especially Advanced Driver Assistance Systems (ADAS) and Intelligent Speed Assistance (ISA). The vehicles used for service trips already have ISA (advisory) and ADAS installed. ISA and ADAS accompany the vehicles from start and, so to speak, are included in the procurement without the city having to pay extra for it. In a procurement there are no "extra" funds, but every coin counts. If taking money in the procurement to

buy geofencing, another need may stand back. This in turn means that the alternatives to geofencing need to be evaluated to justify why the city should invest in geofencing.

ISA will become mandatory for all new motor vehicles sold from July 2024.[22] ISA is an advanced safety system that prevents vehicles from exceeding the speed limit. There are different types of ISA, and the manufacturer can choose which ISA to include in the vehicle. Some ISA only warn the drivers when they are going over the speed limit and leave it up to the drivers to enforce the speed limit or not (advisory). Some ISA solution can control the car and allow the vehicle to adjust its speed to adhere to the speed limit. All ISA system have in common that the driver can choose to disconnect these.
ADAS is a different solution that assist drivers in driving and parking functions. One of the solutions is Adaptive Cruise Control. Adaptive Cruise Control can control the cars speed, but the driver can choose not to use the technique.

The city concluded that ISA and ADAS were not alternatives to geofencing. They can both be disengaged by the driver easily without data being collected about this. ISA adopts to regulated speed at traffic signs. The city wanted to test dynamic traffic rules (time, place, and situation allowing lower speed than signposted), and ISA cannot offer that because it always uses static signposted speed. But the city also sees other advantages with geofencing like the possibility to manage a fleet of vehicles and send messages to drivers. Geofencing also allows for the ability to control the drivetrain or other functionality. ISA and ADAS cannot do this.

7.1.5 Map and analyze risks

The phase one includes conducting a risk analysis. This means identifying what the risks are, what their consequences are, and the likelihood of them occurring.

Vehicle insurance and warranty (3rd party equipment)

Installing 3rd party equipment in an existing vehicle on the market may come at some risks. Geofencing is not a standardized technology and can be installed in different ways. The vehicles used in the pilot

[22] Commission delegated regulation (EU) 2021/1958 of 23 June 2021 supplementing Regulation (EU) 2019/2144 of the European Parliament and of the Council by laying down detailed rules concerning the specific test procedures and technical requirements for the type-approval of motor vehicles with regard to their intelligent speed assistance systems and for the type-approval of those systems as separate technical units and amending Annex II to that Regulation.

have all insurance. In addition, vehicle manufacturers offer guarantees regarding the vehicles. During the warranty period, the seller is responsible for the function of the car or a certain feature of the vehicle. The seller can setup rules for the warranty to apply, for example, that the car is serviced regularly. The warranty does not apply to defects caused by the buyer to the vehicle by using the vehicle abnormally or that special measures have been taking such as rebuilding or modification of the vehicle if they cause the defaults of the vehicle.

The city checked with the vehicle manufacture that the additional technical solution regarding geofencing would not affect the insurance or warranty of the vehicles.
No insurance claims were made during the pilot.

Driver privacy and access to data

The city identified early on that there was a risk in collecting data on driver and crime (speeding) and spend a lot of time solving this problem. According to Art. 10 GDPR (see above), an authority shall collect personal data on crime if it is necessary for the performance of its tasks. The City of Stockholm had previously considered collecting data on speed violations from their employees when they used the city's cars for work. The Swedish Authority for Privacy Protection advised the city not to proceed with the plans as it was not the task of the municipality to monitor employee speed violations. The city of Gothenburg was also not interested in data on individual drivers but wanted information on speed violations at an aggregated level. The challenge was that aggregated speed violation data starts as driver-level personal data. One of the solutions was that the city would never have direct contact with the drivers during the pilot, but only with their employers/operators. The employers acted as a filter vis-à-vis the city. The city never knew who was driving the vehicles. This, in turn, had consequences for the pilot's implementation.

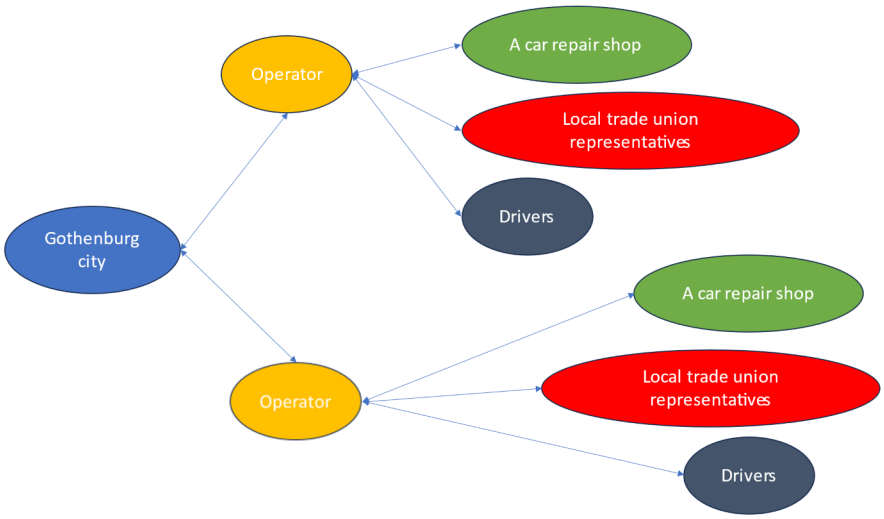

Fig 5. A picture illustrating how communication was done in the pilot. The picture shows who are in contact with whom.

7.2 Phase two – Carry out the public procurement

Phase 2 includes, among other things, producing procurement documents, advertising, examining, and evaluating received tenders. A decision must be made on which supplier has won the procurement and agreements must be signed. Normally this phase is time consuming.

In this part, the city needed to work in two stages. One part was about the geofencing equipment, and one part was about getting access to the vehicles that should be equipped with geofencing in the pilot. As mentioned above a former manager was interested in geofencing and had included it in the public procurement already from 2016. The procurement stated that the operators must provide vehicles and drivers to the geofencing pilot.

> *X.X. Geofencing*
>
> *Geofencing is a digital, geographical zone where connected vehicles can be controlled in different ways. Gothenburg City, Traffic offices follow the development of the technology geofencing and intend to test and use in the long term this technique. In order to develop geofencing and test areas of use, the Traffic Office sees opportunities to test geofencing on existing vehicles in this agreement. This means that the carrier must: make their vehicles available for geofencing testing.*

The traffic office reimburses the carrier for the additional costs incurred in connection with the tests. The costs may include, for example, equipment and installation of equipment in the vehicle. When selecting vehicles to carry out assignments under this agreement, carriers shall give priority to vehicles that allows the technology geofencing.

X.X Speed compliance

The transport company must work with preventive measures to ensure that speed compliance is maintained for the vehicles operating in this Agreement. At the request of the Transport Office, the Transport Company shall provide a summary statistic on the speed enforcement of vehicles and measures taken to reduce speed violations.

The cost of participating in the pilot was negligible in comparison to the value of the entire framework agreement.

Another new traditional four-year (2022-2026) frame agreement was made during the project, but the amendments looked the same.

What remained for the city to procure was the geofencing technology through a direct public procurement from a 3rd party supplier (reseller). The city needed to procure two parts; one part that consisted of a map system where zones could be drawn and communicated to the vehicles (platform and a tablet), one part that consisted of physical equipment in the vehicles (speed box). The two parts should communicate digitally with each other. The city of Gothenburg contacted the two resellers identified and described very broadly what the city was interested in procuring: “Digital service including equipment for the application of geofencing, which means limiting the speed at which 20 vehicles performing missions for service trips can be driven within specified zones. Test run within the framework of externally funded research project GeoSence." The resellers were asked to give a bid. They provided two different solutions. One of the suppliers was significantly more expensive and the city chose to go ahead with the cheaper option. In December 2021 the city decided to lease the two parts from the Swedish supplier, which is leasing cost per week and vehicle during the trials. The 3rd supplier who won the tender, in turn, hired two subcontractors.

During the spring of 2022, the city discovered that the solution did not work as expected. The city test-drove a vehicle with equipment that they intended to lease. The problem was that the latency was too

big. The vehicle didn't react fast enough to enter a zone. Human-machine interface was not good enough either. The equipment could only emit beeps, but not spoken text. The reseller found a new subcontractor for the platform.

7.3 Phase three – Realize and follow-up the public procurement

In phase 3 implementation of the public procurement is in focus. During this phase the pilot will be carried out. Another important task, in this phase, is to evaluate and follow up the public procurement. Has the reseller delivered what was requested? What has the city learned from the pilot about geofencing?

7.3.1 Implementation of the pilot

The pilot was carried out between August to December 2022. The pilot was designed as follows:

1. Baseline: speed registration in the background in the geofenced zone. The user interface (the tablet) was not used active (3 weeks, 15 vehicles)
2. Speed information in low-speed zones to the driver (3 weeks, 15 vehicles)
3. Same information to the driver as in phase 2 but with normal throttle application the speed did not increase ("mandatory throttle impact"). The driver could exceed the speed limit by flooring the pedal. If this happened, it was recorded for follow-up. (2 weeks, 6 vehicles)

The equipment that was installed in the vehicles was tasked to support the drivers not to override the speed limit in these zones. The driver had a tablet in the vehicle where the map of the geofencing zone was displayed. On the map, there was information about the zone, vehicle speed and the target speed for the current zone. There was also information about the next zone to enter, the speed for that zone and the distance to that zone. The driver was also given a read-out message before entering the zone "You are approaching a 30 zone". When the drivers were outside of a geofencing zone the tablet showed the regulated speed and the vehicle speed. Before the pilot started the drivers were also informed about the pilot.

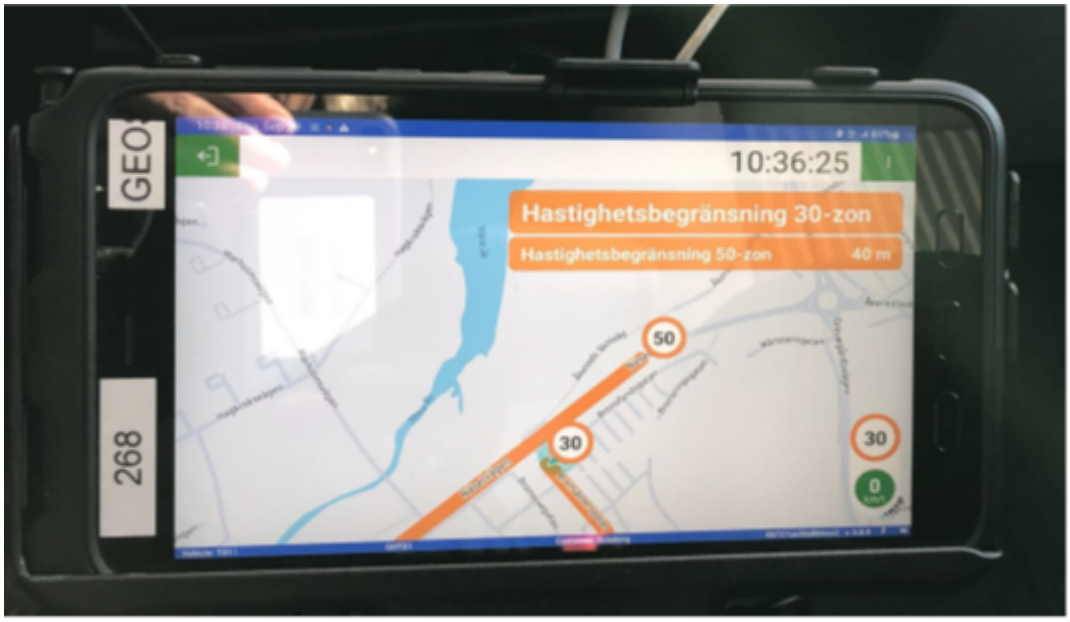

Fig 4. A picture of the driver´s view of the tablet inside the car. Photographer is Malin Stoldt.

Originally, the pilot was supposed to start in the spring of 2022, but a number of problems occurred that delayed the start.

The city of Gothenburg had previous decided about where to locate the geofencing zones. The next step was to get that information into the digital map in the platform. During the pilot, the city concluded that the zones were in the right place and the same for all cars in the platform. The problem was to get the zones right in combination with individual cars. It turned out that the vehicles behaved differently depending on the model year and engine model. The problem was the speed box, not the zones as such. The higher the speed in the zone, the greater the deviation (between programmed speed an actual speed). The speed box needed to bet installed correctly and calibrated. One solution did not suit everyone, but the zones needed to be fixed vehicle by vehicle, which took a lot of time. In practice, it was done so that one employee from the city “clicked out” zones in the digital map´s system and filled in information about several attributes for each zone. In addition, the employee, also had to create so-called triggers. The rule for the zone was associated with the trigger. A zone had many triggers. It was important to set triggers at each point entering the zone, otherwise the vehicle and the driver would not know what was going on. Another problem was that the map provider continued to develop its system (which is used in web browsers) continuously, so there were several upgrades during the pilot. A good thing with this was that the city could influence the development of the zone and trigger management. In conclusion a lot of

trial and error with zone management had to be done but the support from map provider was good. The design and troubleshooting of the zones took many more hours than expected for the city.

The city could not have direct contact with the drivers (due to GDPR reasons, see above) regarding whether the speed box behaved as supposed to do. Instead, the city needed to have the operators/employers as an intermediary. It took a long time to get things right.

The city also wanted the drivers to receive an audible signal when a zone border was crossed. It soon turned out that the drivers did not understand what the beep meant. The city then wanted to use a device that played a pre-recorded message to the drivers so that it would be clear to them what was going on in the zone. The problem was that there was a long delivery time on such a device. The city was therefore unable to proceed with this.

There were also some problems with the installation of speed boxes as such e.g., the importance of disconnecting cruise control. This was discovered in the third part of the pilot. First, the subcontractor of the speed boxes sent information to the ordinary auto repair shop used by the transport companies about how to install them. But in the end, it turned out that the speed boxes were misconfigured. Drivers were able to easily override the automatic speed regulation by using cruise control. The car mechanics had not understood the purpose of why the equipment was installed and the desired result. In the end the subcontractor sent their own car repairer to do the installation of the speed boxes. It was difficult to schedule the vehicles for this and the pilot run out of time and budget. This explains the difference in the number of vehicles between points 2 and 3 above. Some equipment was also stolen during the pilot.

7.3.2 Learnings from pilot – experience and evaluations

The city of Gothenburg has evaluated the pilot. This is what the city has learned:

Things that could have worked better in the pilot

Driver´s right to privacy has been a challenge in the pilot. Due to GDPR reasons the city didn't want to receive personal data about the drivers. The city didn't want i.e. to receive data about drivers´ speed violations. Instead, the researcher in the project collected data from the fleet management system. The researchers then provided the city with aggregated data about the drivers. But this solution had the

disadvantage that the city could not communicate directly with individual drivers, but always had to go through the employer/operator. This took time and led to information loss. This also made it difficult to troubleshoot technical problems then the system didn't behave as expected. Some of the original zones there also located in streets not used by the drivers. It took time to understand which streets the drivers used regularly. Lessons learned is that direct communication with drivers during pilot is preferable after all.

The city opted for a 3rd party solution, which in turn means that additional equipment is installed in the vehicles. The drivers were given an extra screen to keep an eye on. Splitting drivers' attention can reduce road safety. At the beginning of the pilot, screens were important for the drivers to learn what rules applied there. When the drivers knew this, the screens became less important.

As mentioned above, equipment and zones have also been a challenge in the pilot. There were also "ghost zones". They did not show up in the platform, but the vehicle could not increase speed in certain areas. In these areas the city had not set up geofencing zones. Lessons learned is that the technique needs to be verified before installing in all vehicles and it is not mature enough at this moment. It would have been easier if the technology had been standardized or type approved.

The city needs to be involved and experience the technology first-hand. The city needs to test drive more itself and understand how the vehicles behave. The city needs to know the exact vehicle details as installation of the retrofitted equipment is done on an individual level. General solutions do not work which makes it more troublesome to scale. Cooperation between all actors involved needs to be close and deep. The chosen geofencing solution tested in the pilot was not good enough as a driver-supporting technology at this moment.

Things that worked fine in the pilot

The city received a lot of high-quality data registered from the trips. The data is very useful for research and analysis. The equipment as such worked well in the end. The 3rd party suppliers where very helpful and engaged in the pilot.

The city´s advice to other cities that want to procure geofencing

Here is a list of advice for others who want to try geofencing:

1. We know that vehicle type, engine type, etc. affect the choice of equipment and its calibration. Therefore, have an early dialogue with suppliers about what suits your mixed fleet and what is required to achieve the goals you have with geofencing.
2. Test drive the variants offered.
3. Make sure that each vehicle variant is tested in all zones before all vehicles have the geofencing technology installed, so that adjustments can be made easily.
4. Ride with/drive yourself to understand the user experience of the configuration of «your» vehicles.
5. Have direct contact with drivers.
6. Ensure that trade union representatives at all levels are sufficiently informed and positive.
7. If doing a research project - consider including equipment contractors in the project application so that they receive (some) external funding for their participation and are not dependent on the city paying them.

8. Discussion

In this chapter the authors of this report will share their insights, advice and lessons learned from the pilot.

8.1 Technical challenges

The city's challenge is that geofencing is not type-approved or standardized. There is also no vehicle manufacturer that offers geofencing from the start. Unlike ISA, which accompanies the car from the beginning, the city cannot get geofencing into the bargain when they procure vehicles trips. If geofencing was installed already at the factory (like ISA) it would be easier to do public procurement including

geofencing. However, it is not likely that active geofencing will be a standard solution in cars in this segment for the coming years unless there will be legal requirements and/or if the customers are asking for it (market demand).

The city's alternative is thus to choose to retrofit geofencing in the vehicles. The next challenge for the city will be that the vehicle fleet consists of mixed vehicles with different origins. This makes it difficult for the city to procure a geofencing solution that works for all the vehicles. There is no “plug & play solution” yet and the 3rd party solution that is being used in the pilot has been developed during the testing phase. The city ends up in individual solutions with a lot of work to get the technique to work in each individual car. There is also a lack of knowledge about retrofitted equipment at car repair shops, which also contributes to it being difficult to scale up the technology since geofencing needs to be retrofitted. When it comes to public procurement, it is also not enough that one or two manufacturers offers geofencing because the city wants to get several options to choose from.

Our conclusion is that the current state of geofencing technology is not ready for a full-scale commercial introduction yet. More pilots are needed to let the technology grow.

8.2 Organizational challenges

8.2.1 Need for a change in the way of working

This project and report are about geofencing. It is logical that the project aims for testing a geofencing solution. But it is also important to start at the right end. The city already 2014 decided that geofencing was something to explore. It is unclear why the city back then made this decision. In our pilot, the city first decided on the technology to use and then determined functional requirements. In this way the technology ruled and not needs. We believe that it is better to do the opposite. Start by analysing the needs and then derive functional requirements. Then suppliers can evaluate if their technical solution can meet the functional requirements.

If the city wants to continue working with geofencing, more actors need to be involved, both internally and externally. Internally, geofencing needs to be integrated with those working with traffic regulations to reach the potential of dynamic speed and zones. The city also needs to focus more externally to learn

from others' experience of geofencing and spread its own good examples, simply creating collaborative spaces.

8.2.2 Level of acceptance vs level of impact

One conclusion is that it was difficult to work with quality follow-up in this public procurement when it came to speed. The city sees public procurement as a way to combat speeding violations on an aggregated level. Normally, the city has many opportunities to follow up a procurement and quality assurance through, for example, monthly meetings with operators, customer surveys and spot checks. Instead of using geofence to regulate the speed for a few specific cars in the system, an alternative could be to lower the speed in these sensitive areas for all traffic and have new traffic signs in the traffic environment, i.e. permanent and variable traffic signs. The city could also use other alternatives to geofencing like ISA. Regarding ISA, there is a standard in place and depending on the requirement level almost the same result as through active geofencing could be achieved. In the pilot, the geofenced cars were driving at a lower speed than the rest of the traffic. That could be a risk for irritation and a traffic safety risk if other cars decide to overtake in sensitive areas. Then the goal is not fulfilled, but rather the opposite.

In the public procurement, the city must balance two different factors. One factor is to choose the best technology that impact speed. The other factor is about user (driver) acceptance. Drivers tend to like solutions that are not forced upon them, but if the use of a solution is voluntary, there is a risk that the solution will not be used by drivers. To conclude, the challenge is level of acceptance vs level of impact and how does a city evaluate what solutions/combination that should be used.

8.2.3 Data about driver behaviour and privacy might be an issue

In simple terms, there are three types of data: data that must be collected according to law, such as driving and rest times, data on crimes and “nice to have” data.

Speed control is important for the city. The idea is, if the city can control vehicle speed by using public procurement, it will have a total impact on the traffic flow in the city. If speed is a part of the public procurement the city also thinks that this is a way to reach dynamic speed control where necessary in the city. The city´s ambition is therefor to make speed control a part of the public procurement

agreement. The city´s ambition is to have clauses in the agreement that says that equipment that controls the vehicle´s speed (like geofencing) should always be activated. If the driver turns off the system, data about this must be reported to the city from the operator. This data collection is intended to be used as a quality follow-up of the agreement. This is not done in the current agreement on driver level.

The problem is that the city´s wish to collect data about driver behaviour might infringe the drivers right to privacy according to GDPR. To know if the system is activated or not, the data collection must be made on an individual driver level by the employer/operator and later converted to aggregated data by the operator. Data about geofencing is activated or not in the vehicle is not data about crime. It is more in the category "nice to have data" about driver behaviour. Similarly, "nice to have data" can be found in public procurement regarding vehicle energy consumption. The Swedish Authority for Privacy Protection has decided on a case where the agency investigated whether it is permissible for an employer to collect data on how much energy an individual driver uses.[23] The employer's motivation for collecting data on eco-driving is that, among other things, the public procurement agreement requires this. The legal ground was weight on interest. The privacy agency ruled that it was ok to collect that data. It was a legitimate interest to reduce emissions from fuels, the processing of personal data was necessary to reduce emissions and that the goal of reducing the environmental impact is something that benefits society as a whole.

In the Gothenburg case you could argue that it is a legitim interest to know if geofencing is activated or not considering that passengers belong to a vulnerable group and that the society at large wants to protect this group. The question then becomes whether there are other alternatives that give equally good results and that do not infringe on the drivers' privacy.

There is also another case where the question is whether an employer can collect data on the speed of the vehicle in a geofencing zone. The answer is yes, but the employer needs a permission to do so from the Swedish Authority for Privacy Protection.[24] In this case it took 1,5 years to get the permission.

[23] Integritetsskyddsmyndigheten, Beslut efter tillsyn enligt dataskyddsförordningen – Nobina Europé AB, IMY-2022-6656, 2023-12-04

[24] Integritetsskyddsmyndigheten, Beslut om tillstånd att behandla personuppgifter om lagöverträdelser, DI-2022-253, 2023-06-02

In summary, if the city has a clause in the contract that speed enforcement technology is to be used by the driver, there also needs to be a legal possibility for operators to be able to collect data on whether the equipment is activated or not or maybe even data about speeding. In this part, the work of the Swedish Authority for Privacy Protection needs to be closely monitored.

8.3 Business-related challenges

8.3.1 Strategical decision about IT-solutions

In the direct public procurement, the city bought two parts; one part that consisted of a map system where zones could be drawn and communicated to the vehicles (platform and a tablet), one part that consisted of physical equipment in the vehicles (speed box). But the question is, maybe the city should develop the platform itself? The city already developed a platform and communicated rules to vehicles in the project Diz2. So far, the city has taken various roles in research projects. In the short run it is a good thing to explore and learn more, but in the end the city needs to decide the following: How large of a role should the municipality take in the geofencing solution regarding IT solutions? There are many different layers, and it should be a strategic decision how deeply involved the municipality is in the technical IT-solution.

- Should the IT-platform be in-house, or should it be a 3rd party solution? Are there any scaling benefits using a platform inhouse?
- What about costs, administration, and resources for a long-time in-house service?
- In the procurement of transport for service travel maybe a service for follow-up deviations from the agreed speed in certain geofenced areas should be asked for. In the sourcing process the municipality could also demand driver support to make it easy for the drivers to reach the agreed speed in certain geographical zones.

The role of the municipality regarding the data collection is important to clarify. Will the municipality have access to data or just a service on aggregated level? What information is useful for the municipality? Maybe it is only deviations from the business agreement that should be followed up by the municipality? Is it necessary for the municipality to have direct contact with the driver if a system is up running? (During a test phase it might be good to troubleshoot).

The city has plan to test geofencing on their own vehicles and not as today when it is a geofenced transport that is being procured. The answers to the questions above may differ whether the city buys a vehicle or a transport. If vehicles are geofenced – will it be more interesting for the city to move towards a more integrated, IT-system?

8.3.2 Who is responsible for ensuring that the vehicles do the right thing?

Ahead of future procurements, the city needs to decide who does what in the public procurement. In this part, it is mainly about determining what is the city´s task. Traditionally, it is the city that decides on and makes traffic rules public. Then it is up to the drivers to execute this to the best of his/her ability. In the pilot, these boundaries became blurred as the city "clicked out" zones and took responsibility to make sur that the cars behaved as they there supposed to do in the zones. This took a lot of time. In an earlier project (DIZ2) the city only published the rules in their platform and the vehicle manufacture made sure that the vehicle behaved correctly. The question is – who is responsible to make sure that the vehicles do that they are supposed to do?
For the city there are advantages with doing the job. There are standard tools that can be used to build the solution, provided that the city has access to expertise. It keeps costs down, allows for rapid changes and development (not dependent on supplier development cycle). It also brings great opportunities for the city to have own influence and adaptions. The disadvantages are the opposite. The city is dependent on one´s own skills. Risks are that other things have a higher priority and that development in not done at the pace needed.

Maybe it is too early to decide about who does what and more pilots are needed. The development of the geofencing technique is still ongoing. Geofencing could in the future be included in a fleet management system or special systems will be procured for zone management. Another track could be that learnings from e-scooters about how their geofencing is done could link to all kinds of vehicles.
If the city decides that the right thing to do is to publish rules and that it is the operator's responsibility to make sure that vehicles behave as they are supposed to do and this is followed up in a self-monitoring program, it might lead to another problem. How can an operator calculate about this job and give a bid? This is a risk for the operators.

9. Future works

As the technique is not ready to scale up at this moment, more pilots are needed. The city of Gothenburg will continue their work with geofencing. More larger pilots are expected the coming years. The city would like to learn more about i.e., geofencing equipment, driver assistance, and develop their internal work processes. One thing to explore would be to investigate if it is possible to geofence individual journeys within special transport service. But we would also like to recommend the city to explore alternatives to geofencing and learn more about the best way to reach the city´s goal.

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