

Assessment of stakeholder needs regarding geofencing in the transport system



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Summary

This report is the result of a study of the challenges and needs of stakeholders in the transport system which could be met by geofencing services. It describes the problems and requirements of stakeholders from different transport sectors as well as various geofencing applications that are wanted by these stakeholders. The analysis also goes into the challenges regarding the experience and knowledge of geofencing and potential business model structures. The needs analysis was initiated by the ongoing geofencing research and innovation programme in Sweden, funded by the Swedish Transport Administration and sets out to provide guidance for the research and innovation programme moving forwards. The study shows that there is a general agreement among the actors regarding the overall challenges, such as traffic safety, congestion, emissions and the transition to fossil-free transport. In addition, there are several individual challenges that are specifically connected to each category of stakeholder. Various geofencing applications are mentioned that can help overcome both the overall challenges relating to the traffic system and the problems specific to each case. However, several groups of stakeholders have relatively limited knowledge of the available geofencing services and the possibilities of the technology. In addition, there are problems in understanding geofencing, what it can do and how it will work. Furthermore, some stakeholders have little knowledge of the potential value of the technology. While some stakeholders believe that the technology has significant potential to overcome some of their challenges and meet their needs, there is still little demand for geofencing services and an unwillingness to pay for them. Many stakeholders think that geofencing should be part of contractual agreements between the buyers and sellers of transport services or that geofencing should be a standard feature of vehicles in order for it to be more widely used. At the same time, some stakeholders think that the provisions of contractual agreements are already too strict and that they should focus on performance rather than on which technology should be used. Therefore, there are still many difficulties relating to how or whether geofencing can become a viable service that will overcome their challenges and meet their needs.

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1. Background and purpose

The needs assessment was initiated by the ongoing geofencing research and innovation programme in Sweden, funded by the Swedish Transport Administration. There are many ongoing geofencing-related initiatives, some of which are explored in a research and innovation (R&I) context. However, a full and comprehensive overview of the needs of geofencing services on the market has not yet been carried out. Although development is progressing quickly and new services are being tested as part of various R&I projects, the full potential and use of geofencing can only be achieved by making the services available in an independent market.

The objective of the stakeholder assessment is to identify current challenges among traffic- and transport-related stakeholders, specify the geofencing functions wanted or needed by the stakeholders and evaluate the business solutions for geofencing. The following questions will be answered in the report:

1. Overall needs/challenges faced by the stakeholders interviewed which geofencing can help to resolve
2. Overall need for/interest in geofencing among the stakeholders interviewed

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.*

2. Methodology

The method used for the assessment is semi-structured interviews with selected organizations. A list of potential categories of stakeholder was created initially, covering all road transport modes where geofencing could be of interest or where geofencing could be part of a solution to an existing challenge. Organizations within each category were then identified through existing networks or available contacts. In total around 90 organizations were contacted for an interview, which in the end resulted in 46 semi-structured interviews with 40 different stakeholders. The selection process is presented in Table 1 below. The interviews were conducted with the help of an interview guide, which was sent to the participants prior to the interviews. The interviews were then held in a digital format, ranging from approximately 30 to 90 minutes in duration. The study was conducted throughout the period from June to October 2021.

Table 1. Stakeholder categories and type of organizations included in the study

Stakeholder category	Type of organization	Number of independent organizations	Number of interviews
Authorities	Local road authorities	3	6
	National road authorities	2	2
	Work environment authorities	1	1
	Law enforcement	1	1
Public transport	Public transport operators	2	3
	Public transport agencies	2	4
Freight transport	Freight transport operators/freight contractors	4	4
	Transport buyers	5	5
	Trade organization	1	1
Taxi/car and bike sharing and rental	Taxi operators	2	2
	Car rental/sharing companies	4	4
	Bike rental	1	1
	Buyer of taxi services	1	1
Enclosed or specified areas	Port and terminals	2	2
	Property owners	2	2
	Construction companies (contractors)	2	2
	Road work/site planners	1	1
Traffic safety & security	Knowledge centre	1	1
	Insurance companies	3	3

The report is structured as follows. In Chapter 2, the results from the interviews are presented for each stakeholder category. The chapter explores the needs of the stakeholders and the potential they believe that geofencing offers. In Chapter 3, the results are discussed in a broader perspective relating to the needs and challenges, how geofencing can meet certain requirements of the stakeholders and what functionalities are most relevant for the market. The report ends with a summary of the conclusions in Chapter 4.

This study focused mainly on Sweden, since the R&I programme is a nationally funded Swedish programme. The stakeholders and representatives of international companies that were interviewed were mainly Swedish and most discussions were conducted from a Swedish – and to some extent, European – perspective. Furthermore, there is a relatively small number of interviews for each type of organization. This is because some organizations that were contacted did not respond and because the study period was short.

3. Results

This chapter presents the results for each individual stakeholder category: authorities, public transport, freight transport, taxi/car and bike sharing and rental, enclosed or specified areas and traffic safety and security organizations.

3.1 Authorities

In this category there are four types of organizations: local road authorities, national road authorities, work environment authorities and law enforcement. Table 2 summarizes the results from the various authorities. Local road authorities include medium-sized and large cities (by Swedish standards), while the national road authorities consist of the Swedish Transport Administration and the Swedish Transport Agency. In Sweden, cities are responsible for local roads while the national road authorities are responsible for national roads. The last two types of organization are represented by the Swedish Work Environment Authority and the police, respectively.

Table 2. Results from authorities

Type of organization	Challenges/ needs	Knowledge/ experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Local road authorities	<ul style="list-style-type: none"> • Congestion • Traffic safety, e.g. speeding cars • Local environment (emissions and noise) • Attracting users back to public transport after the COVID-19 pandemic. • Disrupted accessibility due to ongoing infrastructure projects 	<ul style="list-style-type: none"> • One has worked with geofencing directly, e.g. pilot study regarding speed limit compliance for buses • Another has been involved in the geofencing programme since the start • All affected by it in relation to e-scooters 	<ul style="list-style-type: none"> • Speed restriction geofencing for buses • Dynamic environmental zones • Further restrictions for e-scooters (access, parking, speed) • Dynamic geofencing that adjusts to current needs and external factors • Directions for transit vehicles, to prevent them from entering the city centre • Mandatory geofencing for drivers convicted of speeding 	<ul style="list-style-type: none"> • Control traffic and increase traffic safety 	<ul style="list-style-type: none"> • Include geofencing as a requirement in procurements. Cities have a big role to play • Not all vehicles have to be geofenced. A small number can affect others
National road authorities	<ul style="list-style-type: none"> • Traffic safety • Accessibility for all • Directing traffic in densely populated areas • Routing of high-capacity vehicles 	<ul style="list-style-type: none"> • Extensive knowledge. Involved in several projects 	<ul style="list-style-type: none"> • Dynamic and smart geofencing zones. Zones that are adjusted to current needs and external factors (speed, environmental issues and access) 	<ul style="list-style-type: none"> • Control traffic and increase traffic safety • Improve accessibility and use of existing infrastructure • Safety for vulnerable road users 	<ul style="list-style-type: none"> • Market-driven. Road authorities should enable the market to develop geofencing services • Believe it is easier for commercial stakeholders to implement geofencing than for private road users
Work Environment Authority	<ul style="list-style-type: none"> • Worker safety. On-/off-site and transport • Human/machine interaction • Employees carrying out emergency work on roads particularly vulnerable 	<ul style="list-style-type: none"> • Aware of it. For instance, speed-restricted buses and in relation to the terror attack in Stockholm 	<ul style="list-style-type: none"> • Access control. Prevent vehicles/people from entering restricted areas • Speed restriction geofencing 	<ul style="list-style-type: none"> • Safety and security 	<ul style="list-style-type: none"> • How can geofencing be installed in all private cars? How to target foreign cars? Effects if not all cars are equipped?
Law enforcement	<ul style="list-style-type: none"> • Accessibility. Law enforcement vehicles must be able to pass without being hindered 	<ul style="list-style-type: none"> • Some knowledge. Not aware of any applications of geofencing in law enforcement today 	<ul style="list-style-type: none"> • Speed/access control. Prevent terrorist attacks • Dynamic zones. Permit needed to access specific areas • Vehicle automatically stops when drivers are not using their seat belt, have a heart attack etc. • Dynamic/moving geofencing zones, e.g. slow down cars in a car chase 	<ul style="list-style-type: none"> • Access control for cars, e-scooters, drones etc. • Prevent terrorist attacks 	<ul style="list-style-type: none"> • The police can make suggestions, but it is up to politicians and planners to lay down the rules

The road authorities, both local and national, have some experience of geofencing, either working with it or being involved with it in other ways. Their experiences differ slightly, but all the authorities interviewed take a positive approach to geofencing, mainly in relation to traffic safety and adjusting the speed of vehicles. Many authorities believe that geofencing can be used to control the speed and parking of e-scooters, to improve safety for users and to reduce the number of wrongly parked e-scooters. Access restriction is also mentioned by several respondents as a potential use of geofencing. Dynamic applications of geofencing are also of interest, where, for instance, zones can be defined depending on external factors such as the time of day or the number of people moving around in an area. The benefits include better control and management of traffic to increase accessibility and traffic safety, as well as to prevent potential terrorist attacks. There are various ideas about how to increase the use of geofencing. It could be included in public procurements for transport services provided to cities or in contracts for larger infrastructure projects that require a large amount of transport. Some also argue that it is easier to work with commercial road users than it is to approach private road users. This is because contractual agreements are a more effective tool than monetary incentives (in order to reach a larger group of customers). However, some respondents also stated that not all vehicles need geofencing, as there could already be positive effects from a smaller number of vehicles. This is mainly related to speed-related applications, where a geofenced vehicle will affect the speed of vehicles behind it.

3.2 Public transport

This category is represented by two types of organizations: public transport operators and public transport agencies. The latter are entities responsible for planning, developing and procuring public transport in a certain region. Public transport operators on the other hand are companies that provide the actual transport services. They own the vehicles and employ the drivers. A public transport agency usually procures services from several operators. Table 3 summarizes the results from stakeholders in the field of public transport.

Table 3. Results from public transport

Type of organization	Challenges/needs	Knowledge/experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Public transport operators	<ul style="list-style-type: none"> • Ensure buses do not exceed speed limits or deviate from route • Traffic safety on the route and at the depot • Delays caused by congestion 	<ul style="list-style-type: none"> • Familiar with it • Encountered it in different forums, such as Drive Sweden • Participated in a number of pilot studies, mainly focused on speed restrictions • Currently used on some bus routes, especially to control speed without the option to override 	<ul style="list-style-type: none"> • Speed restriction geofencing (also dynamic aspects, i.e. reducing speed in bad weather) • Ensure buses stay on their routes and avoid low tunnels etc. • Geofencing to reduce fuel consumption • Geofencing to increase safety and efficiency at the bus depot 	<ul style="list-style-type: none"> • Possibility of controlling vehicle speed • Increase safety, efficiency and punctuality 	<ul style="list-style-type: none"> • System must not be specific to certain makes of vehicle. Same functionality in all vehicles • Technical issues need to be solved first. Then economic and business cases • Geofencing needs to be properly tested as well as accepted by the drivers • There is a willingness to pay if the benefits are obvious. If not, it must be included as a requirement in public transport procurements and part of traffic regulations.
Public transport agencies	<ul style="list-style-type: none"> • Accessibility, make public transport more attractive for users • Congestion • Lack of information on traffic disruption • Traffic safety. Low tunnels, narrow streets and speeding are concerns 	<ul style="list-style-type: none"> • Familiar with it • Geofencing has been tested in Stockholm and in ElectriCity in Gothenburg • Currently used for information purposes, e.g. regarding low tunnels and narrow streets • Have advised cities regarding parking zones etc. for e-scooters 	<ul style="list-style-type: none"> • Speed restriction geofencing, e.g. around schools • Geofencing to warn/prevent drivers from approaching an obstacle, such as a low tunnel • Geofencing as a tool to automate information and decision flows, e.g. when disruption occurs or for traffic prioritization • Geofencing to prevent private cars from entering areas dedicated to public transport • Geofencing environmental zones. Automatic switch to electric mode 	<ul style="list-style-type: none"> • The option of controlling vehicle speed and/or access • Informing drivers about potential barriers and traffic congestion • Increased traffic safety and reduced disruption, making public transport more attractive for users 	<ul style="list-style-type: none"> • System integration issues need to be solved. Geofencing zones provided by different suppliers must work together and it must be possible for the different systems to share information • Should the public transport agency set up the geofencing zone in a way that allows all operators to use it or is it the individual operator's responsibility? • GNSS not currently accurate enough in all vehicles

In this category, the knowledge of and opinions on geofencing are quite similar. All interviewees take a positive approach to geofencing and have encountered it in one way or another. For instance, speed restriction geofencing has been tested in pilot studies on buses in urban environments. Regarding the benefits of geofencing and possible future use cases, the interviewees mention speed restriction and (route) directions as measures to improve traffic safety and to contribute to a sustainable work environment for the bus drivers.

Regarding how geofencing can be scaled up and reach a bigger market, many interviewees mention the challenges relating to system integration and explain that the technology used must not be specific to a certain make of vehicle. There needs to be some sort of standardization, in order to avoid obtaining systems from several suppliers and creating different geofencing zones/users that cannot communicate with each other. Furthermore, the interviewees point out that the technology needs to be properly tested and validated before implementation.

3.3 Freight transport

In this category there are three types of organizations: freight transport operators/freight contractors, transport buyers and trade organizations. Freight transport operators are carriers that provide transport services. Freight contractors act as middlemen for several smaller carriers, distributing assignments to their members. Both freight operators and contractors work closely with the drivers and have an influence on the vehicles used for transport assignments. Transport buyers are the organizations that pay for a transport service. They often require long-term contracts with freight operators which provide a certain type of transport. These contracts frequently contain a number of requirements concerning the performance or the code of conduct that freight operators need to adhere to. Some organizations can be both freight operators and transport buyers, meaning that they procure a certain percentage of their transport services, but they also have their own fleet of vehicles in operation. Trade organizations promote the interests of their members and influence policy, business development and education within the freight sector. Table 4 summarizes the results from the freight industry stakeholders.

Table 4. Results from freight industry stakeholders

Type of organization	Challenges/needs	Knowledge/ experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Freight transport operators/ freight contractors	<ul style="list-style-type: none"> • Shift to fossil-free transport • Organized crime (theft, stolen goods) • Too detailed requirements in (short) contracts • Accessibility in cities/congestion • Driver behaviour (some mention this, not all have problems with it) • Stress levels of drivers in urban areas 	<ul style="list-style-type: none"> • Some have a fair amount of knowledge and one is working with the concept in project form • One organization uses geofencing for positioning/ monitoring • Some have very little knowledge or have only heard of geofencing 	<ul style="list-style-type: none"> • Dynamic environmental zones (adjusted depending on time of day) • Help in route planning (dangerous goods) • Terminals (alarms, entry/access systems and security) • Speed restriction geofencing (also dynamic aspects, i.e. reducing speed in bad weather) • Access to environmental zones • Locking doors for off-peak deliveries • Be part of the transition toward more electrified vehicles • Dynamic road lanes depending on time of day • One organization sees no useful areas or value in geofencing 	<ul style="list-style-type: none"> • Some see no value in geofencing • Better work environment for drivers • Better PR (branding) • Help in following up requirements in contracts • Safety and security aspects 	<ul style="list-style-type: none"> • Geofencing should be a standard in vehicles • Customers have little interest in paying for these kinds of services, but include them in their requirements • The costs will end up being paid by consumers, who do not want their goods to become more expensive • Must be the same for all (if implemented in cities or regions) • Could be part of agreements/contracts to fulfil requirements for traffic safety • Could be part of certifications
Transport buyers	<ul style="list-style-type: none"> • Emissions • Slow development of alternative fuels • Safety/security • How to include speed requirements in contracts 	<ul style="list-style-type: none"> • Varied among the respondents 	<ul style="list-style-type: none"> • Speed adjustment (both urban and rural) • Speed adjustment in terminals • Access restrictions (to promote consolidation centres) 	<ul style="list-style-type: none"> • Better PR (branding) • Help in following up requirements in contracts • Traffic safety 	<ul style="list-style-type: none"> • Could cost more than people are willing to pay • If it contributes to business value, they are willing to pay for geofencing to be used by their transport operators • Geofencing should be standard across vehicles for fair competition
Trade organization	<ul style="list-style-type: none"> • Electrification of freight transport 	<ul style="list-style-type: none"> • Some knowledge, but limited 	<ul style="list-style-type: none"> • Ports and terminals • Assist in charging EVs (spot allocation and predictability) • Winds on bridges (possibly close bridges to high-sided vehicles if dangerous) 	<ul style="list-style-type: none"> • Help in following up requirements in contracts • Good PR • Could be used for certification for "sustainable transport" 	<ul style="list-style-type: none"> • Currently does not see any demand. • Sees that geofencing could be part of contractual requirements

In this stakeholder category there are varied responses. Some interviewees have experience of geofencing and some are fairly new to the concept. There are also different views about the benefits of geofencing and the areas of use. However, the challenges are fairly similar, regardless of the type of organization. Most mention challenges involving traffic safety, accessibility, the transition to electric mobility and the well-being of drivers. The transport operators also refer to problems with short-term and detailed contracts. Some transport buyers, however, mention the difficulties in including speed-related objectives in contracts and in following up requirements. This is often time-consuming and costly, which is why geofencing

could reduce the need for compliance checks for speed-related contractual requirements. When it comes to the areas of use for geofencing, there is also some disparity in the responses. Some see the value of the technology, for instance to introduce dynamic functions, assist in the transition to electric vehicles, help with routing, impose access restrictions on areas or road lanes and make ports and terminals safer. However, other respondents are sceptical about the value of geofencing, as one explains:

"You can do as much as you want with geofencing, but it must have benefits as well. I think you can come up with incredibly cool ideas that sound very good, which in practice and in reality do not really add any value."

Some explain that in the cities the streets are so narrow and congested that the drivers cannot exceed the speed limit even if they wanted to. However, others mention that speeding is a problem and that supportive systems such as Intelligent Speed Assistance (ISA) or geofencing could reduce the risk of vehicles being driven too fast, which has a negative impact on the company's brand. Some carry out manual checks on their drivers to see if they are complying with speed limits, which is expensive and not cost-effective. Transport buyers have a similar problem because they have to check whether their transport service providers are following speed restrictions. This is something that is rarely done, which is why geofencing could be a helpful tool. From the perspective of transport buyers, it could be useful to include geofencing in the contracts with the transport operators. This could also form part of the certification for more sustainable transport solutions, which would be good for branding. In a similar way to certification and labelling in the food industry, transport operators or trucks could be labelled if they use geofencing. This could be included in existing certifications, such as Fair Transport.

Regarding implementation, there is no significant demand for geofencing, although there is interest in the subject and the benefits of geofencing are considered to be significant. Most respondents mention that it ultimately depends on whether end-consumers are willing to pay more for commodities. Transport buyers are prepared to pay transport operators for using geofencing if it provides substantial value through branding or reduced costs. Among transport operators the interest is low, unless they are incentivized in some way, for instance if they are given access to certain areas or allowed to make off-peak deliveries. Otherwise geofencing needs to be standardized so that it is the same for all and there is no unfair competition.

3.4 Taxi/car and bike sharing and rental

In this category we have brought together taxi operators, which in turn include many smaller taxi companies with a significant variation in the number of vehicles. The category also includes both traditional car rental companies, car sharing companies and a company that allows people to share private cars. Furthermore, a bike rental supplier and a buyer of taxi services have been added to the category. Table 5 summarizes the results from stakeholders in the field of taxi/car and bike sharing and rental.

Table 5. Results from stakeholders in the field of taxi/car and bike sharing and rental

Type of organization	Challenges/needs	Knowledge/ experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Taxi operators	<ul style="list-style-type: none"> • Increased competition from other mobility solutions • Some unfair competition • Transition to electrification • Efficiency/access is a challenge but manageable • Unions have concerns about data collection • Traffic congestion creates stress for drivers 	<ul style="list-style-type: none"> • Good level of awareness. Familiarity with the technology, but less knowledge about what is available on the market • Positioning services, for instance to connect the order to the right vehicle and provide information about pickup times have been in use for a long time • Informative ISA service already in some of their vehicles 	<ul style="list-style-type: none"> • Reliable compliance with speed limits • Reducing speed in certain places, for instance outside schools • Possibility of allowing access to closed areas for some vehicles • Improved work environment for drivers 	<ul style="list-style-type: none"> • Definitely sees benefits without having evaluated the business case yet • Could contribute to good PR but that is not enough • The contractors (municipalities) decide which areas they want geofenced 	<ul style="list-style-type: none"> • Financial margins currently low. To add costs without getting something in return will probably not work • A standard for geofencing technology in vehicles to avoid unfair competition in procurements
Car rental/sharing companies	<ul style="list-style-type: none"> • Mobility challenges connected to automation and digitalization • New competition from other mobility services • Need to secure a good mobility solution for people of all ages and driver experience • Access to parking • Make sure vehicles are located where there is a need • Accidents and traffic incidents • Infrastructure for charging • More efficient administration, e.g. handling of congestion tax • Increase the attractiveness of sharing your vehicle • Lack of rules and standards etc. • GDPR is a showstopper for many position-based services. Customers need to give their consent to be able to use the positioning system 	<ul style="list-style-type: none"> • Some have thorough knowledge, others have not heard of it before • No services as of today in Sweden, but in other markets the technology is used to give support in complex traffic situations, for instance • Informative ISA service available for several years as part of the navigation system • In cities they keep track of demand or potential demand, i.e. where people are when they want a car, to be able to adjust the number of cars at the relevant depot. • Limited experience due to the lack of possibility of collecting data. 	<ul style="list-style-type: none"> • Safety and environmental factors are interesting areas • A lot of possibilities for services related to positioning, but not sure that limiting the speed is one of them • Find the car • Access/no access to areas • Additional services/information based on position, but it is important not to send the user information that might not be wanted • Parking for privately shared vehicles to promote sharing • Automated reporting of e.g. driving distance to make administration easier 	<ul style="list-style-type: none"> • Traffic safety • Environmental concerns (with environmental zones as well as increased car sharing) • More efficient administration • Increased attractiveness for customers • Better traffic flow 	<ul style="list-style-type: none"> • Companies might be interested in functions related to safe driving and be willing to pay • Different user functions could be part of differentiated pricing, but could also become a competitive edge

Bike rental	<ul style="list-style-type: none"> • Would like to be able to define the geofencing zones in more detail • Bicycles rented on fake credit cards • Bicycles stolen, destroyed or “thrown away” • Few areas available for new rental bike stations 	<ul style="list-style-type: none"> • Thorough knowledge • Geofencing is used in the current bike rental system 	<ul style="list-style-type: none"> • Geofencing used to detect/register that a bicycle is returned within a designated area • Discussions on how to further develop the use of geofencing, e.g. differentiate charges depending on location (city centre vs. suburb, for instance), define an entire street as an area where bicycles can be rented/returned etc. 	<ul style="list-style-type: none"> • Further development (including geofencing) to make the bike rental system more flexible and therefore more attractive to use 	
Buyer of taxi services	<ul style="list-style-type: none"> • Driver behaviour (speed) • Follow-up on agreements (currently manual) 	<ul style="list-style-type: none"> • Thorough knowledge, currently involved in a project testing geofencing 	<ul style="list-style-type: none"> • Speed adjustment, mainly in sensitive areas such as outside schools 	<ul style="list-style-type: none"> • Increased safety (speed limit compliance) • Reduced costs of check-ups • Increased sense of security for passengers (fewer complaints) 	<ul style="list-style-type: none"> • Geofencing as part of procurements or as one tool to fulfil vehicle performance requirements

In this category there is a wide variety of responses. Some interviewees have experience of geofencing and some have not heard about it before. However, those that have no knowledge of it have used position-based functions. In some cases where interviewees have a high level of awareness, they still know little about what is available on the market.

The General Data Protection Regulation (GDPR) and union views on driver integrity in relation to data collection are raised as a concern or even as a showstopper in some cases. Without customers’ consent, it is not possible to gather the data needed for some stakeholders’ potential use cases.

Safety and environmental perspectives are interesting areas for many of the stakeholders. Ensuring compliance with speed limits specifically in sensitive areas, such as outside schools, is seen as important. Taxi operators mainly see opportunities for improving the work environment for drivers. Other factors include improved access, better traffic flows, less traffic congestion etc. Car rental companies and car sharing companies identified additional possibilities for improving the customer experience and making administration systems more efficient, for instance by automating much of the manual work connected to renting a car, making sure vehicles are located where there is a need and providing support in unfamiliar traffic situations/places. Also in the bike rental business, geofencing-based functionalities could definitely contribute to improving the customer experience and, as a result, to increased usage. At the same time, these functions could resolve some of the problems, for instance stolen and destroyed bicycles.

Taxi operators express concerns about the added costs. The sector has low profit margins and a lot of competition. Additional costs without additional earnings will make the situation even harder. There is a need for a standard related to geofencing to prevent unfair competition, for example in procurements. In the car rental business, companies have identified possibilities for differentiated pricing based on additional functionalities for all customers. Business customers in particular might be willing to pay for some of the use cases. For the buyer of taxi services, geofencing is regarded as being part of the procurement process to fulfil vehicle performance requirements.

3.5 Enclosed or specified areas

This category of stakeholders includes organizations that are operating within enclosed or specified areas. This means, for instance, fenced areas, temporary geographically defined areas and specific landowners. The type of organizations included are ports and terminals, property owners, construction companies and road work planners. Ports and terminals are nodes within the transport system with a considerable amount of external traffic arriving and departing and also internal traffic. Property owners are responsible for specified areas and are interested in developing them. Construction companies are responsible for building new residential buildings or large infrastructure projects. Road work companies are responsible for planning, setting up and monitoring road works. Usually they are customers of large construction companies. Table 6 summarizes the results from stakeholders with enclosed or specified areas.

Table 6. Results from stakeholders with enclosed or specified areas.

Type of organization	Challenges/ needs	Knowledge/ experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Ports & terminals	<ul style="list-style-type: none"> Emissions Increasing vehicle volumes (need more efficient entry into the terminal and allocation of vehicles coming to the terminal) 	<ul style="list-style-type: none"> Different experiences among respondents. One with little knowledge, one with more experience from practical case of directing heavy traffic entering the port 	<ul style="list-style-type: none"> Directing vehicles entering the port and better/individual routing in the port 	<ul style="list-style-type: none"> One sees no value in relation to ports, the other sees significant benefits when entering the port. Reduce the amount of stops at entry (better entry flow and routing within the ports) 	<ul style="list-style-type: none"> As mentioned, one stakeholder has a case where geofencing is used. In this, the users pay for the service indirectly through their usage of the port (truck companies pay shipping companies for tickets who pay the port for usage). Introduction of the system has led to increased costs for shipping companies, but it has also simplified their operations

Property owners	<ul style="list-style-type: none"> • Building more low-cost housing • Safety and security in residential areas • Social sustainability, integration/segregation • Incorrectly parked cars and cars in areas they should not have access to 	<ul style="list-style-type: none"> • Some knowledge • Geofencing has not been tested or implemented 	<ul style="list-style-type: none"> • Control vehicle access without having to use physical barriers • Geofencing to increase safety when developing new houses, e.g. reduced speed close to schools 	<ul style="list-style-type: none"> • Increase safety • Ensure rules are complied with at a lower cost 	<ul style="list-style-type: none"> • Concerns on how geofencing can be implemented in a broader perspective. Should it be mandatory?
Construction companies (contractors)	<ul style="list-style-type: none"> • Working environment and safety. Height, dust and noise, human/machine interaction etc. • Avoid machines driving over boundaries or into restricted areas • Risk of collision with cyclists when entering/exiting construction site • Optimizing material supply in order to reduce the number of deliveries 	<ul style="list-style-type: none"> • Some knowledge • Geofencing has not been tested or implemented 	<ul style="list-style-type: none"> • Geofencing to avoid human/machine interaction. Relates to machines working on-site as well as delivery trucks. • Geofencing to inform incoming trucks about the construction site, e.g. location of loading/unloading zones • Geofencing to warn drivers/workers/pedestrians/cyclists • Geofencing to warn workers, drivers, pedestrians and cyclists of potential dangers • Speed restriction geofencing, e.g. when building close to schools 	<ul style="list-style-type: none"> • Reduce the number of accidents on site and relating to transport to/from site • Geofencing can result in a more efficient building process, e.g. by sending information to drivers before arrival 	<ul style="list-style-type: none"> • What technology should new machines have? What requirements should be specified when buying them? • Conditions may vary regarding who is responsible for the transport. Not certain that you can make demands
Road work/site planners	<ul style="list-style-type: none"> • Safety at road works. Safety when setting up road works • Ensure that drivers respect speed limits when passing road works • Informing drivers about upcoming road works 	<ul style="list-style-type: none"> • Thorough knowledge • Participates in a couple of studies. For instance, the Smart Urban Traffic Zones project. 	<ul style="list-style-type: none"> • Adjust regulations at road works depending on time of day • Informing/directing vehicles at road works 	<ul style="list-style-type: none"> • Increased safety, e.g. by informing drivers of upcoming road works or automatically reducing vehicle speed 	<ul style="list-style-type: none"> • Geofencing could be used to fulfil contractor safety requirements at road works • Regulations could help increase the use of geofencing

The enclosed or specified area category is relatively diverse, both with regard to the type of organization and also their responses. There are some similarities, for instance regarding safety within the areas. All of the stakeholders have some type of traffic within their areas of operation which always has an impact on safety. Collisions between heavy vehicles and vulnerable road users represent a high risk, especially in ports, construction sites and road works. The experience of geofencing also differs between the respondents in this category. Most have limited experience, but others have implemented geofencing in some way to control vehicles entering their specified area. The interest among the stakeholders lies mostly in controlling vehicles when they enter the enclosed or specified area to increase safety. For instance, vehicles reduce their speed when approaching a construction site or road works, especially if it is close to a school. Another example is a system to warn road users, pedestrians and cyclists about an upcoming construction site or road works. The respondents

also mention that there can be geofences with dynamic functions where lower speed restrictions for vehicles approaching construction sites and road works are only imposed when there are people working at the sites. Other benefits of geofencing could be that fewer physical barriers are needed in some areas.

As mentioned above in relation to implementation, one of the stakeholders interviewed (a port) has implemented a geofencing system. This involves the end-user (driver or transport company) paying for the technology as part of the cost of the ticket for the ferry. The shipping company in turn pays for using the port and a percentage of this fee also contributes to the cost of the geofencing technology. The geofencing system is considered to provide value for all the stakeholders involved (better port management, fewer stops, smoother entry to the port) and there is a demand for the service. Other types of organizations mention that geofencing should be standardized or that it could be part of procurement contracts. There is often a restricted budget for road works and therefore new technologies are sometimes neglected. However, lately interest has increased, which implies that solutions such as geofencing could be part of contracts in the foreseeable future.

3.6 Traffic safety and security

This category consists of organizations which are involved with traffic safety and security. Three insurance companies and one knowledge centre for traffic safety have been interviewed. The insurance companies provide insurance services and also education on traffic safety to both private and commercial customers. The knowledge centre in the study is a non-profit, independent organization that promotes traffic safety in Sweden. Table 7 summarizes the results from the organizations that work specifically with traffic safety.

Table 7. Results from stakeholders in the field of traffic safety

Type of organization	Challenges/needs	Knowledge/experience of geofencing	Area of interest for the use of geofencing	Benefits of geofencing	Implementation
Insurance companies	<ul style="list-style-type: none"> • Traffic safety (especially vulnerable road users) • Emissions • Accessibility • Car theft • Distractions while driving (phone etc.) • Speed of heavy goods vehicles (heavy goods vehicles are often involved in more serious accidents) 	<ul style="list-style-type: none"> • Some knowledge. Heard of it in relation to e-scooters, the terror attacks and speed adjustment • Some experience of working with GNSS-related voice activation outside schools (speed-related) 	<ul style="list-style-type: none"> • Most traffic safety-related applications (reducing speed in certain areas, especially where there are many vulnerable road users) • Dynamic functions could be valuable, for instance on the basis of data about where accidents often happen or weather data • Possibly to reduce emissions • Temporarily close roads or reduce speed at the scene of accidents to prevent secondary accidents 	<ul style="list-style-type: none"> • Increased traffic safety (also economic value) • PR benefits for users • Lower infrastructure costs (for instance installing speed bumps) • Reduced costs of damage (less risk of being involved in incident) 	<ul style="list-style-type: none"> • Do not think it could help to reduce insurance premiums (which are already low). Better opportunity in larger procurements for commercial stakeholders to include geofencing in contractual agreements • Geofencing needs to become a standard feature to be included in premium calculations • Premiums could be reduced if a driver is involved in fewer accidents (which geofencing could help with)

			<ul style="list-style-type: none"> • Increase compliance at road closures • Reduce risk of theft of rental cars 		
Knowledge centre	<ul style="list-style-type: none"> • Traffic safety (reduce vehicle speed, promote use of bicycle helmets and seat belts in cars) • Increase accessibility and safety for pedestrians and cyclists • Better monitoring of speed limits 	<ul style="list-style-type: none"> • Familiar with it. Discussions on how geofencing can be used to reduce speed in defined areas 	<ul style="list-style-type: none"> • Geofencing zones in which speed limits are “remotely” regulated • Using geofencing to inform and/or warn road users (cars, trucks, pedestrians, cyclists), for instance about potential dangers 	<ul style="list-style-type: none"> • Benefits related to traffic safety (fewer casualties/serious injuries in traffic accidents) 	<ul style="list-style-type: none"> • Concludes that widespread implementation will be a challenge (acceptance, only available in new cars, willingness to pay)

This category of stakeholders focuses mainly on traffic safety-related challenges, therefore most of the benefits and possible use cases for geofencing are linked to speed. There is a significant emphasis on vulnerable road users who are at risk when vehicles, especially heavy goods vehicles, are speeding. The knowledge and experience of geofencing is limited, although all the stakeholders have heard of it and have had some discussions about it internally. One stakeholder has run a pilot project where a GNSS voice changes to a child's voice when a road user is approaching a school, which is considered to be a type of geofencing application. The geofencing application of interest within this category is speed reduction in defined areas, primarily in areas with many vulnerable road users, close to sites of accidents to reduce the risk of secondary accidents and close to road works. Here dynamic functions could be beneficial, where the geofences and their requirements are defined on the basis of external factors, such as accidents, weather conditions or vulnerable road users in the area. Geofencing could also be used to warn road users of potential dangers ahead. The value of geofencing would include reducing the number of casualties and serious injuries in traffic accidents which would bring significant societal and economic benefits. It could also mean that fewer physical barriers are needed in the infrastructure, such as speed bumps, which have economic (reduced costs of building infrastructure), social (potential health risks when frequently driving over speed bumps) and environmental (less braking and acceleration) impacts. There could also be PR benefits for companies using geofencing, which would indicate that they are working to create a safer traffic environment. Other advantages mentioned are potential reductions in repair and insurance costs if vehicles are involved in fewer accidents as a result of geofencing.

With regard to implementation, the insurance companies are relatively unanimous in their view that geofencing in itself would not result in lower insurance costs unless it becomes a standardized safety feature, approved for instance by Euro NCAP. Geofencing as a stand-alone feature or add-on service will not lead to lower insurance premiums in Sweden, as the insurance premiums are already low. However, it could indirectly reduce the cost of insurance if it helps to prevent drivers from being involved in accidents, leading to a better record with the insurance company. But the lower cost is then not related to the vehicle or its technical specifications, but to driver behaviour. There is however an opportunity for larger fleets to reduce their insurance premiums, because in this case contracts are negotiated in a different

way from those with private road users. The stakeholders interviewed therefore believed that it will be more difficult to gain widespread acceptance of geofencing among private road users because of the lack of a real economic incentive.

4. Analysis

The analysis will compare the various stakeholder categories in relation to their challenges and needs, knowledge and experience, areas of interest for the use of geofencing and its benefits, as well as views on implementation and potential business models. It will evaluate the similarities and differences, general interest in geofencing and the challenges that need to be overcome to make geofencing more widely available and more attractive to use.

4.1 Challenges and needs

The overall challenges most frequently mentioned are the transition to fossil-free transport, traffic safety and congestion. These problems recur in all the stakeholder categories. Most of the remaining challenges and requirements are connected to the stakeholder's own area of operation, for instance freight companies that struggle with a shortage of drivers or car rental/sharing firms that are facing competition from alternative modes of transport. In several cases, the challenges faced by the authorities are in line with the potential use cases for geofencing. Speed is most often mentioned, with driver behaviour being a common reason for speeding. Speeding is also considered to be caused by the need to make up lost time as a result of congestion, unplanned events and tight deadlines for different assignments. Speeding is therefore the result of many external factors which affect the behaviour of drivers. Many interviewees mention the fact that this is a major issue in cities where vehicles interact with vulnerable road users. However, some respondents do not highlight problems with speeding in cities because of the narrow streets combined with the interaction with other modes of transport. Therefore, according to these respondents, speeding is more likely on major roads and ring roads. There is also some discussion about the challenges involved in including speed requirements in contractual agreements for transport buyers. Even though the contracts require transport service providers to follow existing laws and regulations, there are currently very few ways of checking whether these requirements are being met. The checks are often manual and only carried out occasionally or rely on other road users or passengers to report reckless driving.

Generally geofencing is mostly mentioned in relation to the challenges of traffic safety, environmental impacts and accessibility, which is in line with the overall challenges mentioned by the respondents in the study.

4.2 Knowledge and experience of geofencing

The levels of knowledge of geofencing vary among the stakeholders. The term is new to a few of them, but even in these cases they have used some kind of position-based service without making the direct connection to geofencing. Some stakeholders have even been involved in

geofencing studies or demonstrations. Others have developed functions that are already in use or have a lot of ideas about how geofencing could improve the customer experience and their business in the future.

Because of the divergence in the knowledge and experience of geofencing, there is no one single solution for increasing competence in this area. However, on the basis of the interviews a few areas have been identified that may improve the overall situation:

- Increased knowledge about the geofencing functionalities and tools that are currently available on the market and will be available in the near future.
- Information about how to manage the requirements of the GDPR and personal integrity and still be able to collect vehicle data
- Increased knowledge about future or expected requirements relating to procurement, for example

Identifying the relevant communication channels that will make it possible to reach out to all the stakeholders is an important but difficult task.

4.3 Benefits and areas of interest for the use of geofencing

The suggested applications for geofencing can be divided into three main categories: access control, speed restrictions and informational geofencing. With regard to access control, construction companies and the Work Environment Authority are interested in the possibilities of using geofencing to prevent workers/pedestrians and cars from entering areas where heavy machinery is operating, and therefore to help avoid accidents. This type of functionality is also mentioned by a public transport operator, which argues that geofencing could be used in a similar way to avoid accidents in bus depots.

Access control is also mentioned in relation to preventing vehicles from entering areas where they simply should not be. This type of functionality is brought up by a number of organizations. For instance, freight transport operators (among others) mention that geofencing can be used to manage access control for terminals, ports and other controlled/restricted areas. Furthermore, property owners suggest that geofencing can be used to restrict access to certain areas without having to use physical barriers. On a more detailed level, a public transport agency discussed the possibility of using geofencing to prevent cars from entering areas designated for buses (such as dedicated bus lanes). Also, the police reflected on whether geofencing could be used to stop vehicles from entering specific streets, which would make it possible to prevent terrorist attacks. In the context of access control, many organizations (mainly national road authorities) also suggest more dynamic geofencing applications, where, for instance, the requirements can be changed depending on the time of day, weather conditions etc.

Some organizations discuss the benefits of using geofencing in a variety of different ways in combination with environmental zones. In this case, a freight operator suggested that access to an environmental zone should only be granted to vehicles with certain specifications and explained that this can be controlled with geofencing. Other freight operators, along with public

transport agencies and national/local road authorities, proposed that geofencing can be used to automatically switch vehicles to electric mode when they enter an environmental zone.

Many organizations identified the possibility of deploying geofencing functionality to inform and/or warn the driver about certain conditions in a specific location or stretch of road. These could be locations where accidents frequently occur, such as an entry/exit road to a construction site or a road work site. These types of measures are suggested by a number of organizations, including construction companies, public transport agencies/operators, freight operators and insurance companies. A large number of organizations also see the benefits of using geofencing to give the driver directions. This could be on a larger scale, such as a local road authority's suggestion of giving directions to transit vehicles, to prevent them from driving through the city centre. A work site planner also suggested that vehicles could be redirected past road construction sites. On a more detailed level, a construction company discussed the benefits of using geofencing to inform drivers about loading/unloading zones on (larger) construction sites.

The most commonly discussed use of geofencing, suggested by almost all the stakeholders interviewed, relates to the technology for restricted vehicle speed. Here mandatory compliance with speed restrictions in close proximity to schools is suggested by, for instance, a property owner, a taxi operator and a construction company. Other specific areas for the use of speed restriction geofencing include terminals, as suggested by a transport buyer. Specifically with regard to public transport, a local road authority suggests speed limitations for buses. In addition to traffic safety considerations, it is pointed out that this will result in a better work environment with less stress for the drivers, as they do not have to catch up on lost time. The same benefits are mentioned by a taxi operator. Some organizations also discuss dynamic/smart geofencing zones. In this context, an insurance company mentions temporary barriers or reduced speeds at the scene of traffic accidents. Similar measures are discussed by, for instance, local and national road authorities, which also specify that the speed could vary depending on external factors such as weather conditions. Furthermore, the police speculate on whether some sort of mobile geofencing zone could be used in order to give police cars right of way, for example by slowing down cars close to the car that is being chased.

In addition to the measures referred to above, some specific applications relating to e-scooter and bike rental are mentioned or discussed by specific operators and local road authorities.

In summary, geofencing applications suggested and/or discussed during the interviews can be categorized as follows:

- Access control – avoid accidents
- Access control – restricted areas or parking
- Inform driver – warning
- Inform driver – directions
- Speed restriction
- Speed restriction (dynamic)

4.4 Implementation

Implementation of geofencing will be easier in commercial vehicles than in private vehicles. For commercial stakeholders, there could potentially be greater benefits from various geofencing services, such as reduced costs, PR advantages or other economic or operational incentives. Most stakeholders in the study mention that geofencing could be part of procurements, as a requirement to be fulfilled by the transport service providers. However, some transport service buyers mentioned that they do not want to include technological requirements in procurements, because it is the result that is important, not the means of achieving it. Excessively strict requirements in procurements can, according to some, place obstacles in the way of more sustainable solutions and long-term prospects. It is also clear that commercial transport service providers are operating their businesses on low margins and that any additional costs which do not generate direct benefits will be disregarded. Both freight and taxi companies mentioned that geofencing should be standardized to avoid unfair competition. Standardization can also help resolve potential issues regarding manufacturer-specific solutions which complicate the situation for firms with larger fleets. Furthermore, for geofencing to help reduce the costs of insurance, there is a need for a European standard, similar to the ISA. Therefore, it is expected to take some time before speed restriction geofencing is generally accepted and requested by vehicle buyers.

Ultimately it is the end-consumer who will pay in one form or another for transport operators to use geofencing. In one case, where a stakeholder is operating a geofencing solution in a specified area, the property owner has invested in the technology, but the cost trickles down to the tickets bought by the organizations affected by the technology. However, the system is considered to increase efficiency and productivity both for the provider and the users and therefore the solution is economically viable.

Another approach, mentioned by a couple of the stakeholders, is to incorporate geofencing into a certification or labelling scheme, similar to that used in the food and clothing industry to highlight fair trade or organic production. Making geofencing part of a certification or label could be a way to raise awareness among other road users and customers of increased vehicle safety, which would enhance the reputation of the business.

However, most categories regard the levels of demand to be relatively low, although many see the potential benefits of the technology. Therefore, to increase the demand for geofencing, it will be necessary to provide facts about the actual benefits of the service for the individual stakeholders and these benefits should preferably be measurable.

5. Concluding remarks

Following the analysis, there are a few factors to consider regarding the needs and challenges among the stakeholders in the Swedish transport system in relation to geofencing. For instance, there is a wide variety of knowledge and experience among the stakeholders interviewed, regardless of the type of transport. For some the term is new, but most of them have encountered or heard about it before and some have even participated in studies where

it has been tested. However, generally only a few have integrated geofencing services into their daily operations, although there are geofencing services available on the market. In several cases there is also a different understanding of geofencing and of whether and how the technology can be used to overcome current challenges and meet existing requirements. Therefore, there are different perceptions of the benefits of the technology and of how it could be integrated into existing business models. It is also noticeable that the advantages of geofencing are on different levels, with the benefits being generated for an individual, a customer, a fleet owner and/or society as a whole. This, of course, depends on which use case is being discussed, but it gives an indication of the many areas where geofencing can be used and the differences in the understanding of it.

Annex A - Questionnaire

Notes:

- All interviews were conducted in Swedish. The questions below are therefore a translation of the corresponding questions in Swedish.
- As mentioned above, the method used for the assessment was semi-structured interviews. Therefore, not all the questions were necessarily asked during all interviews.

Introductory questions

- Permission to record the interview.
- Role in the organization (background and responsibilities)

Needs

- Tell us about your business
- What challenges do you see regarding transport (speed, environment, accessibility etc.)?
- Are you working with these issues today? In what way?
- Do you work to ensure the quality of transport in terms of safety and the environment?
- What is your role in increasing transport quality in relation to safety and the environment?
- Are there other stakeholders that are relevant/responsible for increasing transport quality in relation to safety and the environment? What roles do they have? Do you interact with them? If so, in what way?
- Do you use and/or develop services intended to increase transport quality in relation to speed and the environment?
- Do you place any requirements on your transport services in relation to safety and the environment?
 - Do you follow up on these requirements? How do you do this?
 - Do you use technical tools for the follow-up? In what way do they contribute?
 - If not, are technical tools being considered for future use? What technical tools? How could they contribute?

- Do you see a need to impose stricter requirements on how vehicles are driven?
- Are these requirements included in procurements? In what way?
- Which stakeholders do you interact with in order to increase transport quality in relation to safety and the environment?
- In this context, what data is shared with other stakeholders? Which stakeholders? How?

Geofencing

- Do you work with connected vehicles/infrastructure today? What, in your opinion, are the primary areas of use for connected vehicles/infrastructure and digitalization in relation to speed, the environment and accessibility?
 - In what way?
 - If not, do you see any potential in connected vehicles/infrastructure?
- Are you familiar with the term/concept geofencing? [If not, the interviewer provides a brief description.]
 - Have you heard anything about the concept? What have you heard?
 - How do you define geofencing?
 - Is it used today, in one way or another? How does it work?
- Do you see possibilities for geofencing? Which benefits can it create? For whom?
- Do you see any potential disadvantages of geofencing?
- Can geofencing contribute to increased transport quality and compliance with requirements?
- Are there projects/initiatives related to geofencing or increased transport quality that you know of or are working on right now?
- How do you see your role regarding the development/implementation of geofencing?
- What differences will there be compared to the current situation if geofencing is used?

Implementation

- For transport buyers: Would you be prepared to pay more for a transport service if it included the use of geofencing or if it involved improved compliance with rules/requirements?
- For transporters: Would you be prepared to pay more for a vehicle equipped with geofencing technology?
- For other stakeholders: What is your view on a potential business model for geofencing based on your needs?

Conclusion

- Do you feel that there are questions we have missed?
- Is there something you would like to add?
- Is there anyone you think we should contact/interview?