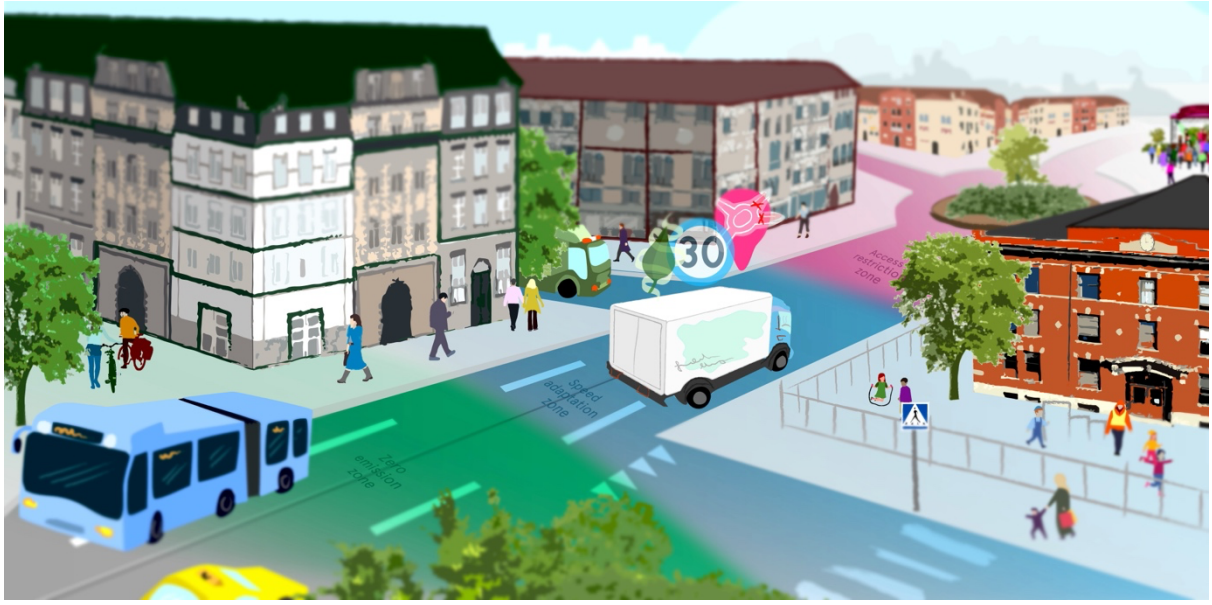
CLOSER

Report on market analysis – geofencing-based services in road transport



Summary

This report is the result of a study on the commercial market for geofencing services for road transport applications. It presents existing geofencing services on the market today and shows how the market for geofencing services will potentially develop over the next five to ten years. The market analysis conducted was initiated by the ongoing geofencing research and innovation programme in Sweden, funded by the Swedish transport administration; it sets out to guide the research and innovation programme on its agenda moving forwards. The study shows that in various ways, geofencing is becoming more common as a service in transport-related applications, particularly in terms of increasing the performance of vehicles that form part of fleet management systems. New geofencing applications that affect the vehicle's characteristics, such as the speed and switch of powertrains in PHEV vehicles, are currently being developed and deployed on the market. Use of these geofencing services is expected to increase over forthcoming years, as a result of an increased awareness of traffic safety issues, and lower or zero emission zones being implemented in European cities. Challenges in development mostly relate to more dynamic functions, where the characteristics of a zone may change depending on external data inputs, and where geofences may potentially be designed by actors other than the service provider or service user. Legal queries and data security are the primary challenges presented by these functions and require close collaboration between different actors.

Index

Summary 1
1. Introduction 3
1.1 Limitations 4
2. Available geofencing services 5
2.1 Trucks and vans 5
2.2 Buses 7
2.3 Personal vehicles 8
2.4 Third-party service providers 10
2.5 Discussion on available geofencing services 12
3. Future applications 12
3.1 Trucks and vans 13
3.2 Buses 14
3.3 Personal vehicles 15
3.4 Third-party service providers 15
3.5 Discussion on future applications 15
4. Challenges and restrictions for geofencing 17
5. Conclusions 18
6. References 19

1. Introduction

The present market analysis was initiated by the ongoing geofencing research and innovation programme in Sweden, funded by the Swedish transport administration. The background is that there are many ongoing geofencing-related initiatives, many of which are explored in an R&I context. However, there has not been a full and comprehensive overview of the existing geofencing services on the market. 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 depends on service distribution in an independent market.

Geofencing is defined as the delineation of a geographical zone by a geolocated virtual perimeter, which automatically detects when tracked mobile units (such as phones and vehicles, etc.,) enter or exit these areas, with the help of geopositioning (GNSS/GPS) (Reclus, 2013). For transport related applications, this means that a virtual perimeter detects when a vehicle – or other road user – enters or exits a geographically defined area and triggers some kind of action in or outside the vehicle, such as a toll payment, switch of powertrain in a hybrid vehicle, a warning signal or speed adjustment (Foss et al., 2019). In this report, geofencing services are divided into three categories:

1. **Steering/controlling**: whereby a vehicle automatically changes characteristics when entering or exiting a pre-defined geofence. The geofence and its attributes can be defined by the service provider, a customer or by other actors who can construct geofences in an integrated interface – usually provided by the service provider. Today, most of these steering or controlling features can be overridden by the driver.
2. **Informative**: whereby the driver receives information of some sort through an interface when the vehicle enters or exits a pre-defined geofence. There is no action or change in the vehicle.
3. **Performance based**: geofencing services that focus on vehicle and driving performance to optimise operations and up-time. These are mainly based on data extracted from vehicles.

The purpose of this market analysis was to identify existing geofencing services available on the market in the road transport sector today, in order to investigate the underlying business models for these services and determine how the market for geofencing services will develop over the next five to ten years. Furthermore, this report aims to guide the research and innovation programme on its agenda moving forwards, to identify which areas to focus on for broader use of geofencing, and to find measures for implementation and market incentives.

The method employed to conduct the market analysis mainly consisted of semi-structured interviews with selected companies. The semi-structured 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 30-90 minutes in duration. The study was conducted throughout the period from mid-December to mid-March, 2020-2021. The companies that participated in the interview study are shown in Table 1. It was not possible to interview all service providers on the market, owing to time restrictions. However, some additional data regarding geofencing services has been collected from various

service providers' websites. As such, information on geofencing services available through some additional service providers is included in Chapter 2.

Table 1. Companies interviewed in the study

Type of service provider	**Companies**
Truck and van manufacturers	Volvo Group, Scania, Volkswagen, MAN
Bus manufacturers	Volvo Group, Scania, MAN
Personal vehicle manufacturers	Stellantis, Tesla, Volvo Cars, BMW, NEVS
Third-party service manufacturers	KG Knutsson, AddSecure, Consenz
Transport service manufacturers	Einride
Map service manufacturers	Here, TomTom

The report is structured as follows: In Chapter 2, the geofencing services available on the market for the various modes of transport considered are displayed. This chapter explores certain aspects of the technical requirements and business models that these services require. More future services and applications are explored in Chapter 3. Because these are regarded as potential future services, a certain level of discretion was required, and as such, no company names or affiliations are mentioned. Chapter 4 deals with potential challenges and restrictions for developing and deploying geofencing. The report ends with some summarising conclusions in Chapter 5.

1.1 Limitations

This study focussed mainly on Sweden, since the R&I programme is a Swedish nationally funded program. The actors 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. International laws or regulations cannot, however, be neglected when developing geofencing, and many of the actors interviewed operate on a global market, which was also reflected in the interviews. A relatively small number of service providers were also included in the analysis. This can be attributed to several factors, such as restrictions on resources, some companies declining to participate and a lack of contacts for some companies. Furthermore, the study focuses on geofencing services offered to end customers and thus excludes potential suppliers to the geofencing service providers. The suppliers could, for instance, include companies that provide software and other interfaces for designing geofences. The selection of which companies to include in the study depends on the project group's own reflections, and therefore, some relevant organisations may have been excluded from the selection process. Furthermore, the definition or understanding of geofencing may vary across respondents, and there is thus a risk that respondents may exclude services or applications that in some cases, could depend on geofencing technology.

2. Available geofencing services

This section explores the geofencing services available on the market today. It shows what is available, which type of road vehicle the services are available for and the technology used, in addition to giving a conceptual overview of different business models. The services available for all vehicle types are summarised in Table 2. The sub-chapters then go into more detail on the different vehicle types: trucks/vans, buses and personal vehicles. There is also a section for services provided by third-party service providers, and finally, a general discussion on the services available on the market.

Table 2. Summary of geofencing services available for different types of vehicles

Type of service	**Applications**	**Available for**	**Offered by**
Steering/controlling	Speed and propulsion	Trucks/vans, buses and personal vehicles	Scania, Volvo Group, BMW, KG Knutsson, Ford, Stellantis
Informative (data to vehicle/mobile device)	Speed and propulsion	Trucks/vans, buses and personal vehicles	Scania, Volvo Group, Here, TomTom, BMW, Mercedes, Porsche, Audi, Nissan, Hyundai
Performance-based (data collection from vehicle)	Positioning, notification, driving pattern, electric propulsion optimisation	Lorries/vans, buses and personal vehicles	MAN, Scania, Volvo Group, Volkswagen, BMW, Volvo Cars, Einride, AddSecure, DAF
Other services	Toll payment	Vans	Volkswagen

2.1 Trucks and vans

There are some geofencing services available on the market in the haulage industry, which includes all vehicles used to provide goods transport services. These are summarised in Table 3 below.

Table 3. Geofencing services available for lorries and vans.

	Geofencing service	**Available since**	**Business model**
MAN	Performance-based: - position - notification - driving pattern	2018	Geofencing as an additional service for a starter pack that is included upon purchasing a vehicle. Subscription per day

Scania	Steering and informative - speed - emissions - noise Performance-based - position - notification - driving pattern	2018 (possible to update vehicles from 2016 with hardware and software)	Subscription per month
Volvo group	Performance-based - position - notification - driving pattern	At least from 2013	Subscription
Volkswagen	Performance-based - road tolls - driving journals - positioning	Possible to retrofit	Cost for installation Subscription (for 36 months)
DAF (DAF, 2020)	Performance-based - position - notification - driving pattern	N/A	N/A
Ford (Ford, 2020)	Steering - propulsion	2020	TBD
Stellantis	Steering - propulsion will be available soon	Tests with Jeep Renegade ongoing in Italy	Being developed for all or most of the brands within Stellantis.

The geofencing services available for all truck and van manufacturers are based on information obtained from the vehicles on positioning, notifications on passages or diversion from routes and driving patterns in various locations. Of the companies interviewed, only one offers steering services, whereby a zone and desired vehicle characteristics (speed and propulsion) can be specified by a customer using fleet management software, before being sent to a vehicle with a telematic solution. The speed attribute service means that a vehicle cannot accelerate over a specified limit – not that the vehicle actively breaks to reduce its speed to the specified limit. It is possible for drivers to override this function.

Geofencing services are new to most service providers. They have been developed and deployed quickly over the past five years. Most vehicles from 2018 onwards are geofencing

enabled, for either informative or steering services. All new vehicles produced by the manufacturers interviewed are connected to a fleet management system that makes it possible to transfer data to and from vehicles. The most common data distribution method is via a telematic solution with a SIM-card.

The most common business model is a subscription service. In several cases, geofencing services are included in the internal fleet management services provided by the vehicle manufacturers. In some cases, geofencing services are offered as an add-on, and as such, constitute an additional cost on top of the basic fleet management service amount. However, now, demand for these kinds of services is low. In most cases, this is because customers cannot visualise the financial gains that these services could offer and tend to prioritise services related to fleet management and vehicle maintenance and performance instead.

2.2 Buses

There are some geofencing services available on the market for the bus industry. These are summarised in Table 4 below.

Table 4. Geofencing services available for buses.

	Geofencing service	**Available since**	**Business model**
MAN	Performance-based: - position - notification - driving patterns	2020	Geofencing as an additional service for a starter pack that is included upon purchasing a vehicle. Subscription per day
Scania	Steering and informative - speed - emissions - noise Performance-based - position - notification - driving patterns	2018 (possible to update vehicles from 2016 with hardware and software)	Subscription per month
Volvo Group	Steering - safety zone - silent zone - zero emission zone Informative to help the driver to drive more economically and safely	At least from 2013	Subscription

Geofencing is in some way available across all the manufacturers interviewed. All of them have an informative geofencing system, aiming to aid both the driver and the fleet manager

upon giving them greater control over vehicles. Two of the bus manufacturers offer steering geofencing functions, whereby the customer can define zones and set the criteria within those zones. Volvo is also involved in the R&I project, Digitized Infrastructure Zones (2019-2021) "DIZ2", financed by Skyltfonden, which looks at interfaces that city authorities can potentially use to define geofences to be distributed to buses. Interviews with the manufacturers revealed a higher demand for geofencing applications for buses than for lorries and vans. This is due to cities setting higher public procurement requirements, decreased maintenance costs and a better work environment for drivers. Speed was the application most discussed, as many buses manufactured today are fully electric, whereas geofencing for the driveline is not needed. Fully electric buses are expected to be the only buses used soon, at least in urban environments. Steering functionalities for speed in buses work in such a way that drivers cannot accelerate once they have entered the zone. Today, there is no active braking, and it is unclear whether this is something that manufacturers or customers might want, owing to safety concerns.

Over the past 10 years, most buses have been connected in some way, with geofencing being available since 2013. However, it has most commonly been deployed within the past couple of years. Similar to the case for trucks and vans, geofencing services are made available via a subscription to the service, through the manufacturers' internal fleet management platforms.

2.3 Personal vehicles

Some geofencing services are already available on the market for personal vehicles – some at the test or demo stage. These are summarised in Table 5 below.

Table 5. Geofencing services available for personal vehicles.

	Geofencing service	**Available since**	**Business model**
Stellantis	Steering - propulsion will be available soon	Tests with Jeep Renegade ongoing in Italy	Being developed for all or most of the brands within Stellantis.
Tesla	N/A – Strategy to avoid vehicle limitations based on geofences, instead focus on increasing vehicle autonomy.	All models connected except Roadster between 2008-2012)	N/A
Volvo Cars	Steering of speed and propulsion demonstrated in tests and pilots. Customers can create speed limitations on their own.	Steering functions have only been part of tests and pilots.	Developed based on higher demand from customers.

	Informative - positioning - speed Performance-based - positioning	All vehicles have been connected for many years.	
BMW	Steering - e-zone; automatic change to electric propulsion (driver can override) Informative - speed (based on road signs) Performance-based - positioning	2019 e-zones 2013 all vehicles connected	E-charging incentives programme (BMW points).
NEVS	N/A – Geofencing technology will play a key role in supporting the early introduction of autonomous vehicles, since approval for driverless vehicles will most likely be limited to specific geographical areas and roads.	Tests	TBD
Mercedes	Informative - positioning - speed	Available for all models. Introduction year unknown.	Subscription 1-3 years
Porsche	Informative - positioning - speed	Available for all models. Introduction year unknown.	Subscription 1-2 years
Audi	Informative - positioning - speed	Available for all models. Introduction year unknown.	Included in Audi connect CARE
Nissan	Informative - positioning - speed	Available for all models. Introduction year unknown.	Subscription
Hyundai	Informative - positioning	Available for all models. Introduction year unknown.	Subscription

Geofencing services are, or will soon, be available for most passenger vehicles. The initial focus is on steering the driveline in hybrids to force or suggest full electric drive-in emission-free city zones. Route information in the navigation system, when available, is also used in some cases, to optimise battery usage, to enable emission-free driving when an emission zone is part of the route. Incentives like access to these zones – and/or lower costs to do so – drive development. Being regarded as a company with innovative solutions and concern for the environment is also considered a significant driving factor behind this development.

Speed limits are usually identified by means of a camera that can identify road signs, although this information is often available through GPS positioning and the connected map system used as well. Drivers then have the option of setting the speed assist system to limit speed accordingly. Many of the participants interviewed showed interest in participating in tests for limiting speed using geofencing technology soon.

Many personal vehicle manufacturers also have an app where the owner can set a speed limit for their vehicle. In some cases, the speed limit is also connected to a geographical area, but in most cases, remains separate, at least for now. Unlike Volvo's Care Key, it's still possible to exceed the speed limit – but the owner receives a notification about the event. In some cases, this functionality is included for free, whereas in other cases, it is an add-on subscription service.

A similar service is the Geofencing service that Mercedes offers as part of its Vehicle Monitoring Package (Mercedes-Benz, 2021), whereby drivers can use the Mercedes me Portal to define a geographical area in which the car is free to move. As soon as the car leaves or enters this area, the owner will be informed via email. Several other personal vehicle manufacturers offer similar services, for instance Porsche, Audi, Nissan and Hyundai.

Some brands send vehicle positioning information to their cloud solution – which can be accessed by the vehicle user – continuously. In contrast, others only send positioning information when the vehicle isn't moving. The latter is expressed as a safety and/or personal confidentiality concern, rather than a technical limitation.

Most vehicles manufactured today are connected and have been for several years. However, it is very often the case that older vehicles do not have the possibility to be updated with the new functionalities required, owing to hardware and software backward compatibility.

2.4 Third-party service providers

For the actors that we categorise as third-party service providers and transport service providers, there are some geofencing services available on the market. These are summarised in Table 6.

Table 6. Summary of geofencing services available from third-party service providers

	Geofencing service	**Available since**	**Business model**
Einride	"Access" (vehicles cannot go beyond predetermined routes)	Since the start of 2016 (public roads 2018)	Offers a transport service – not specific in-vehicle services.
KG Knutsson	Steering - speed Informative - speed (ISA) in combination with driving journal	Retrofit solution in a proof of concept (primarily for buses)	Subscription per month
AddSecure (prev. Vehco)	Performance-based - speed - driving patterns - position	Retrofit solution for lorries and trailers.	Subscription per month
Here	Informative - speed - road works - congestion and other traffic situation services	n/a	- Per million data transaction - Licence fee per vehicle - Subscription (per month or year)
TomTom	Informative - Speed - Road works - Congestion and other traffic situation services	n/a	- Per million data transaction - Licence fee per vehicle - Subscription (per month or year)
Consenz	Still in the prototype stage. Focus on bringing connected services and solutions to "non-connected" vehicles.	Retrofit solution primarily focused on passenger vehicles with OBD connectors.	TBD

The most common services are informative applications, whereby drivers receive a message informing them of current speed or other relevant information for a certain stretch of road. The map service providers, such as Here and TomTom, are focusing particularly on these services, as their business models depend on creating easy trips and better routes for drivers. The map service providers also sell their services to vehicle manufacturers, and thus play an essential role in the development of geofencing services by vehicle manufacturers. The data to be distributed on speed or other obstacles is collected by means of crowdsourcing from their own service users or from national road data banks.

Two of the service providers interviewed have more in-vehicle adaptation. Einride, which identifies itself as a transport service provider, has geofencing not as an individual service, but as a part of providing efficient transport solutions for its customers. It forms part of the development of future autonomous (self-driving) vehicles, and today, mostly focuses on route guidance, meaning that vehicles cannot go outside a specified route. The only service provider in the study that offers a steering application on speed is KG Knutsson, which is developing the application in a proof of concept with a bus operator. This allows customers to determine speed on certain stretches of road and within bus terminals, so that the bus does not exceed a certain speed limit. Their retrofit solution can be installed in vehicles from different vehicle manufacturers, which is beneficial if the operator has a larger mixed fleet, in which some of the vehicles are perhaps not so new that they have pre-installed geofencing services. This service also allows the fleet manager to operate the geofences from one single interface for all vehicles. The service is applicable for speed; other applications, such as forced powertrain, are viewed with greater difficulty, given that they involve greater infringement on vehicles.

2.5 Discussion on available geofencing services

The market analysis shows that geofencing is available in some way or another across most of the vehicle manufacturers and service providers. The most common services are performance-based services that transfer data from the vehicle to a fleet manager to optimise operations and maintenance, and informative services based on data sent to the vehicle regarding a geofencing zone and its attributes. In the latter case, drivers must make decide whether to follow or ignore zone information. Performance-based geofencing services are more common in heavy and commercial vehicles, where data from the vehicle on position and driver behaviour is used to optimise a fleet. Steering geofencing services are becoming more common, both in commercial and private vehicles, and have evolved over the last few years. Many of the services are developed and deployed within projects and initiatives and drivers usually have an override option. Most of the actors interviewed see that geofencing has potential and recognise that the demand for these services will increase in the future. However, some actors will not focus on developing geofencing, as they prioritise other areas of development, such as autonomous driving and vehicle maintenance and optimisation.

3.Future applications

The study included questions on future applications that participants either envisaged or were already developing. For corporate confidentiality reasons, it is not possible to portray which manufacturer or service provider is developing which service, or to say which technical developments are the prominent for geofencing. There were also restrictions in terms of what the respondents could communicate during the interviews, so the results presented below are more generic and anonymous. The outline presented is like that of the previous chapter, where the results for each vehicle type and service provider are displayed first, followed by a general discussion.

3.1 Trucks and vans

Most of the vehicle manufacturers interviewed consider geofencing to be important in terms of speed, emissions, noise, and access, in some cases considering them to be inevitable in future intelligent transport systems. Today, a couple of the actors are involved in R&I projects looking at new possible applications. The consensus is that geofencing could not only contribute to safer and more attractive cities, but could also assist drivers in their work, making it more difficult to make an error in traffic and reducing damage to vehicles.

Now demand for geofencing services is low among truck and van customers. However, this is predicted to change in forthcoming years, as one respondent explained:

> *"It's not going to be available next week, but when demand is high enough, it will be available, and it [the demand] is increasing all the time".*

The reason behind this increased demand is a combination of traffic safety concerns, fuel consumption, wear and maintenance costs. At the same time, other respondents indicated that there may be a lack of awareness about geofencing technology and its potential:

> *"Then I think, like... I think that perhaps people don't know that it's possible [speed related geofencing] – that it exists. I haven't been asked many questions about it before…"*

Other future applications of geofencing might include road status safety features, whereby vehicles or roadside units and sensors could send information to vehicles regarding wind conditions or slippery roads, for example, thus enabling them to reduce speed accordingly. However, this is not something that is being developed now. Rather, potential areas of use have been identified. These applications do imply high speed and trusted data sharing across different actors, which complicates development and deployment. However, these potential uses are still considered informative, and do not steer or affect the characteristics of the vehicle, as one of the respondents suggested:

> *"That type of communication between vehicles and vehicles – and between vehicles and infrastructure and road signs and so on – will come in a number of years. By then, you'd get much more reliable information about what's happening on the road ahead. But like I said, it's still just information to the driver".*

Beyond this, the areas of geofencing use most frequently mentioned by the respondents were related to fleet management optimisation – meaning the right vehicle for the right assignment within an allocated area. One respondent pointed out that the geofencing features that they develop are primarily focused on their customers' needs, since they are the ones operating the vehicles. It is possible that after that, new services could emerge that look to a more holistic ecosystem, going beyond customer needs to also consider the needs of local or national authorities, or of customers' customers – such as transport service purchasers, for instance.

Furthermore, expectations on driving the development of different geofencing solutions differ across truck and van manufacturers. Some respondents mentioned that development is demand-driven, in that customers ask for more applications that could increase safety and hybrid powertrain change in designated areas in which geofencing could assist. Other respondents mentioned that the development of geofencing is more policy driven, where new and stricter policies from local or national authorities on speed adaptation and forcing electric drive-in urban areas will be the driving factor for development and deployment.

Most respondents from the truck and van manufacturers included in the study stated that technology is not a primary concern in terms of developing different geofencing services. Some mention that they could develop several geofencing functions within a short frame of time if demand for them increases and customers ask for them. These services are largely like services that are currently available, where customers can draw geofences and define the vehicle's characteristics. Services that involve sharing data with other actors, such as road authorities or other manufacturers, will take much longer to develop. The timeframe differs across the manufacturers interviewed and ranges from 5-15 years for the more advanced services that involve several actors, indicating much uncertainty.

3.2 Buses

The manufacturers interviewed all see geofencing as inevitable in future traffic development for increased safety. Most have already developed geofencing services and have them available on the market. A couple of the manufacturers believe that more dynamic functions will be more common in the future, with city authorities able to play a more central role in development and deployment. This could mean geofencing zones at schools or events. As customers, cities usually set stricter requirements for buses, although they also facilitate faster development, meaning that more new use cases emerge.

> *"It is possible to do a lot with this type of service, but this is based on the desire to limit the vehicles in terms of their position within a geographical area. You can do a lot – but you should not do everything".*

Some potential services mentioned depend on data sharing between different actors – both public authorities and private organisations. This makes it more difficult to develop these services, even though they could have a high impact on road safety.

> *"Say that it's very windy. You could, for example, have a meter somewhere that senses the wind and sends a signal to your bus. Or say that there's black ice somewhere. You have a cold sensor that sends information to a zone and so on".*

Development in the bus industry is driven by requirements set by city authorities in public procurements. As such, demand is currently higher in this sector than it is for other types of vehicles. New interfaces for designing and operating geofences are developed and deployed. Better technology for positioning, trusted data sharing between actors and connected systems and sensors within vehicles can contribute to new use cases.

3.3 Personal vehicles

Most of the personal vehicle manufacturers interviewed see geofencing – in terms of speed, emissions, noise and access – as an important part of the future intelligent transport system. The technologies required are already available, but demand is still low, therefore limiting market availability. As one respondent expressed:

> *"The technology and data is available in vehicles. The reason why it hasn't been made available as a service is lack of demand. If demand for these vehicles were to increase, the service could be put on the market very soon".*

Several of the respondents also specifically mentioned that the introduction of autonomous vehicles will be highly dependent on geofencing technologies, as mentioned by one respondent:

> *"It's a mandatory part of an autonomous transport system, and also, the possibility of introducing such systems into a stepwise approach. The operational design domain (ODD) to indicate where the automated driving system can operate safely will be based on geofencing technologies".*

3.4 Third-party service providers

Most third-party service providers in the study are new to geofencing, with the exception of informative geofencing for optimising vehicle fleet usage, which has been around in various forms for a couple of decades. Existing steering solutions are mostly in the pilot phase, with the potential of becoming future commercial services. The market for these consists of fleets made up of different vehicles, where a retrofit solution and a single customer interface simplify usage. However, some more dynamic use cases dependent on external information could be of interest:

> *"And we're particularly looking into pollution issues and closing parts of the street, depending on the level of pollution on a certain day. All of this is possible in the future".*

Most of the actors interviewed focussed on vehicle performance for future applications. This includes transport planning features, optimising driving behaviour and optimising power distribution in vehicles, depending on road features and characteristics. This is more eminent for electric vehicles, to optimise battery usage.

3.5 Discussion on future applications

It is difficult for the manufacturers and service providers to talk too much about future services owing to confidentiality. Many actors are also new to geofencing and its possibilities, with the exception of fleet management and vehicle maintenance services. As such, most answers regarding future services and applications are speculative. Most respondents see a future potential for geofencing, in terms of both optimising vehicle use and steering functionalities. It is considered to have great potential for the environment and road safety, and many mention

functions that could be considered dynamic, where roads, speeds and powertrains could be adjusted based on external data sources. Mentioned examples of this include reducing speed when it is windy, when roads are slippery or when there are many vulnerable road users in a specific area, forcing electric drive when air quality is bad and restricting access to roads when there are road works or accidents.

Technical development is not a major concern for future applications; it is more demand that affects deployment. Most service providers acknowledge that they have the technical capability to provide more geofencing services if customers want them. Difficulties lie primarily in data quality and trust when sharing data, as well as legal requirements.

During the interviews, there were some discussions on the roles that city or road authorities will play in future traffic management, also in relation to geofencing, as shown by the following quotes:

> *"So, I think a lot of cities might see it as a way of completely orchestrating and enforcing rules in their cities and actually giving time slots to people, so we hear these ideas when talking about future research projects".*

> *"...if I look at buses, they [cities] are interested in using geofencing functionality to limit vehicle accessibility in cities, for example. I can see that there is an interest in introducing environmental zones and restricting emissions, like they do in Europe, for example".*

Others mention that stricter regulations in cities are inevitable for reducing emissions and increasing road safety in urban areas. Geofencing is one way to work with these regulations, but cities don't necessarily have to be the ones defining the geofences. The role that cities will play in development is therefore unclear among the respondents.

Several respondents mentioned intelligent speed assistance (ISA) to control speed in the near future. As a result of new EU rules, ISA systems will soon become standard in all new cars within the EU (from 6 July 2022 for new types and from 7 July 2024 for all new vehicles) (European Parliament and Council, 2019). ISA can work in different ways: (1) camera-based traffic sign recognition systems in vehicles detect the current speed limit by reading road signs; (2) the vehicle obtains information by matching the position of the vehicle against, for example, a map database with information on speed limits; or (3) a combination of both. Some map service providers regard the first solution as challenging, since in many countries, road signs are difficult to read, and different weather conditions can make it difficult for sensors and cameras to read them. Moreover, positioning solutions require all speeds to be digitised and to correlate with road sign position. Crowdsourcing could potentially help with this, and many map service providers already work in this way.

When thinking about geofencing from a longer-term perspective, some actors mentioned that geofencing is mandatory for independent driving. They do not specify which

functions or applications but feel that geofencing could prove useful in terms of guiding vehicles and ensuring safety and good vehicle positioning and behaviour in certain areas.

4. Challenges and restrictions for geofencing

This chapter goes through some of the main challenges presented when developing and deploying geofencing. These challenges are relevant to both current and future applications.

Many respondents mentioned data sharing as an obstacle, mainly for future applications. If geofences are designed based on external factors, such as accidents, road closures, high air pollution, etc., then this data needs to be validated and shared by trustworthy sources. This is particularly important if several actors can design geofences:

> *"Especially in the future if there are other systems that come in and create automatic geofences that appear as a result of something that has happened and then a car's speed is regulated… what consequences does it have and who is responsible if that geofence that appeared should not have been there? What if there was a bug in some system?"*

Some mention that this function needs to be included in the existing national database, regardless of whether local or national roads are concerned. A national access point (NAP) could be a potential solution for standardised data sharing, upon facilitating access to – and enabling easy exchange and reuse of – transport-related data and geofences. As one respondent mentioned:

> *"I think we need to develop the concept of a national data access point. Because it won't work if you distribute it too much. Should we connect to one data point when driving in Gothenburg and to another when driving in Jönköping? That's not sustainable. It must be collected and there must be a party responsible for ensuring that the access point is available, and that the information presented is correct".*

Several actors involved in the study mention the importance of ensuring that the information presented or distributed is correct. One significant aspect is making sure that data is correct and correlates with the physical reality. For instance, one respondent mentioned the importance of making sure that the design of a geofence only affects vehicles on the road that it is meant to affect – not roads going over or under the specified road. Another example is making sure that the digital version of a traffic regulation, which service providers can build geofencing services on, is correct and correlates with the position and sign in physical reality. From a technical perspective, however, service providers do not currently consider this to be a challenge. For most actors, the technology is already available or can be developed or acquired quickly. None of the actors mention that steering, informative or performance-based services depend on advanced technology and do not require fast speed data exchange through 5G or Dedicated Short-Range Communications (DSRC).

Another challenge that is often mentioned is legal queries. Questions regarding who can affect a vehicle's characteristics and how fast a vehicle can reduce its speed when approaching or entering a speed zone for instance, need to be investigated. Furthermore, there are some uncertainties to be resolved before geofencing can be procured, especially in terms of whether the driver should always be able to override a steering geofence.

5. Conclusions

The purpose of this report has been to identify existing geofencing services on the market, to investigate the underlying business models for these services and to determine how the market for geofencing services will develop over the next five to ten years.

Informative and performance-based geofencing services are the most common. At the moment, most commercial vehicle customers request geofencing services for fleet management or maintenance, for example positioning and vehicle performance services. There are some third-party service providers that provide similar services to those offered by vehicle manufacturers, often with a similar purpose, but with the aim of simplifying operations for fleet managers with many different vehicles of different brands. Increasing awareness of safety implications, optimised fuel consumption and increased use of hybrid vehicles could increase demand for other kinds of geofencing services soon. For personal vehicles, geofencing as a technology is becoming more common and several services have been deployed over the past few years, often regarding the powertrain shift in PHEV vehicles. This is mainly due to the current European development of introducing low or zero emission zones within cities. Steering or controlling geofencing services are becoming more common, where all services – with a few exceptions – have an override function allowing the driver to ignore or reverse the action that the geofence activates in the vehicle.

Future applications over the next 5-10 years remain rather uncertain and are difficult to predict, partly because respondents were restricted in the answers they could give, as a result of business confidentiality. It is also unclear how high/low demand will be and if there will be national or international regulations that may accelerate the development and use of geofencing for traffic management purposes. This is mainly relevant for steering geofencing services, whereby geofences can be designed by external actors – and not by the service user themselves, as most services function at the moment. It must also be noted that currently, vehicle manufacturers are mainly focussed on other areas of development, such as the transition to electric vehicles and autonomous driving. Geofencing is sometimes regarded as an enabling technology within these fields – but in most cases, it is not seen as a main area of development. Furthermore, there is a certain difference in opinion among service providers in terms of how the transport system will develop. Some predict that cities and authorities will have more influence on traffic and be more active in managing traffic. Cities and authorities designing and deploying geofences could be one aspect of that. Others believe that cities and authorities will not have any more influence than they do today, but think that they will provide relevant data, which service providers can then use to develop certain services in relation to speed, environment and accessibility.

This report also aimed to guide the research and innovation programme on its agenda moving forwards, to identify which areas to focus on for broader geofencing use to find measures for implementation and market incentives. Today, geofencing services are developed and deployed by market incentives, meaning that there must be a demand for those specific geofencing services in order for them to be developed. There are no regulations that require geofencing to be embedded in vehicles. At the moment, the services most frequently requested by users are performance-based and informative geofencing. These services are less complex, especially from a legal perspective. For steering and controlling geofencing services, it is more complex – the R&I programme should focus more on these applications. It is also possible to conclude that potential future applications require more data sharing between different actors, adding to the complexity. Continuous collaboration between different actors is essential, especially if geofences are designed and deployed by external actors rather than by service providers or service users. This implies data sharing, data quality and incentives for using steering or controlling geofencing.

It is also important to highlight that there may be more use cases for geofencing than those mentioned in this report. A study within the R&I programme that looks into needs and demand for geofencing is ongoing and a report is expected to be released in autumn 2021.

6. References

DAF (2020) DAF Connect Brochure - More profitability through more insight. Available at: https://www.daf.com/en/news-and-media/daf-document-library [2021-06-15]

European Parliament and Council (2019) Document 32019R2144. Available at: https://eur-lex.europa.eu/eli/reg/2019/2144/oj [2021-06-21]

Ford (2020) New geofencing tech supports cleaner air in cities. Available at: https://www.ford.co.uk/experience-ford/ford-blog/geofencing [2021-06-15]

Foss, T., Seter, H. and Arnesen, P. (2019) Geofencing for smart urban mobility. Summarizing the main findings of Work Package 1, SINTEF Building and Infrastructure/Mobility and Economics. Trondheim: SINTEF Byggforsk, ISBN 978-82-14-06852-8

Hyundai Bluelink Connectivity. Available at: https://www.hyundai.com/eu/about-hyundai/our-cars/bluelink-connectivity.html [2021-06-21]

Manage your Audi from your smartphone with the myAudi App. Available at: https://www.audiusa.com/us/web/en/myaudi/apps.html [2021-06-28]

Mercedes-Benz (2021) Safety and Service - Vehicle Monitoring. Available at:

https://shop.mercedes-benz.com/en-gb/connect/pdp/Vehicle-Monitoring/530?variantCode=QEV111AG2UNB&isInitialTransition=1 [2021-06-17]

Nissan Connect services. Available at: https://www.nissan.se/agande/nissan-infotainmentsystem/nissanconnects-tjanster.html [2021-06-28]

Porsche Classic Vehicle Tracking System. Available at: https://www.porsche.com/international/accessoriesandservice/classic/genuineparts/producthighlights/classic-vts/ [2021-06-28]

Reclus, F. (2013) 'Geofencing' in Bakhouya, M., Gaber, J., Wack, M. and Nait-Sidi-Moh, A., eds., *Geopositioning and Mobility* [eBook], 1st ed., John Wiley & Sons, Incorporated, 127-154.

Skyltfonden (2019) Digitized Infrastructure Zones Available at: https://goteborg.se/wps/portal/enhetssida/Innovation-och-utveckling-far-framtidens-mobilitet-i-Gateborg/Digitaliserade-infrastrukturzoner

Volvo Cars introduces Care Key as standard on all cars for safe car sharing. Available at: https://www.media.volvocars.com/global/en-gb/media/pressreleases/250013/volvo-cars-introduces-care-key-as-standard-on-all-cars-for-safe-car-sharing [2021-06-19]