# The City of Gothenburg and Geofencing

## The story of Special Transport Services

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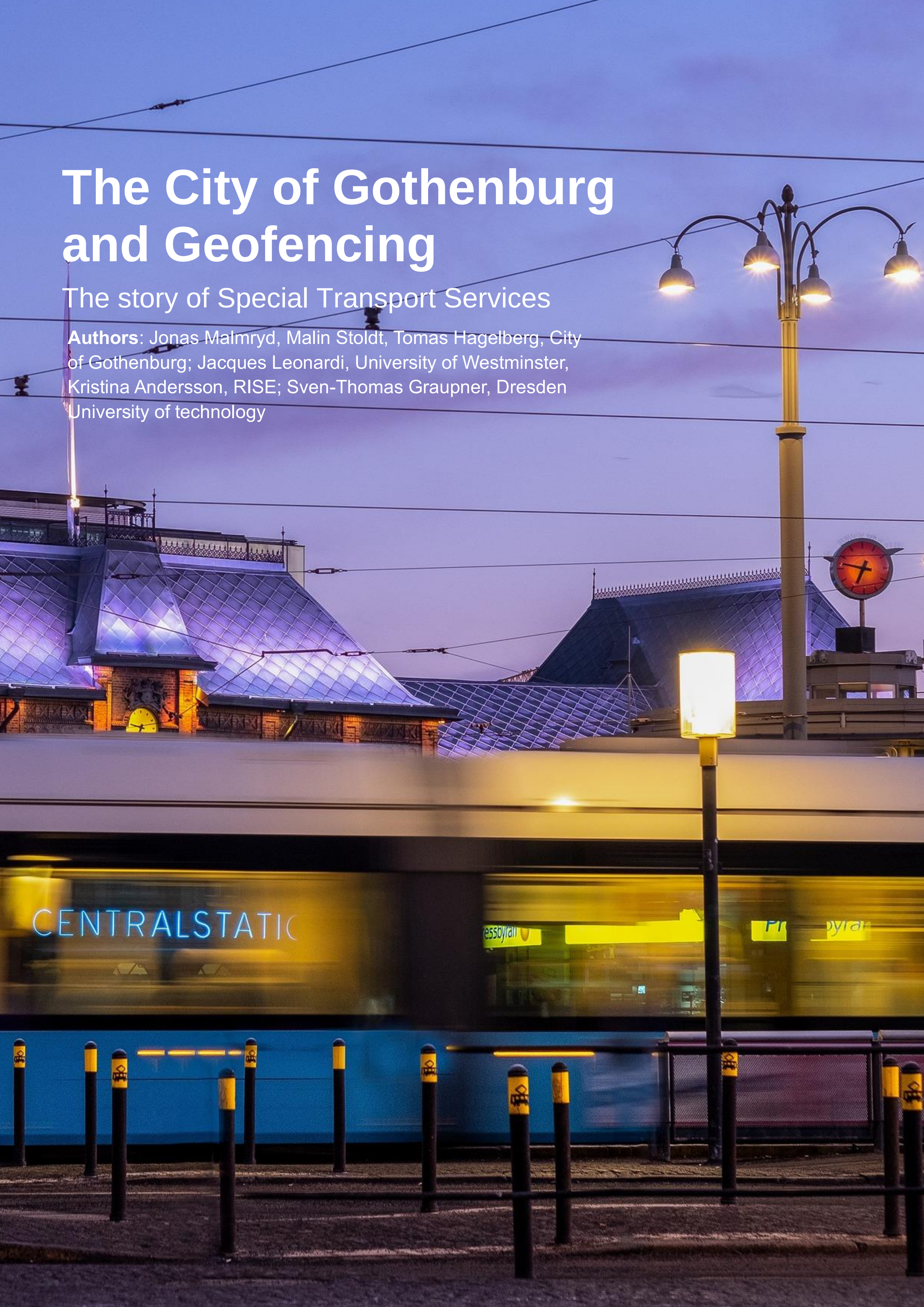


# TABLE OF CONTENTS

## INTRODUCTION

This use case addresses geofencing in public procurement, i.e., how to describe requirements for geofencing functionality and how to follow up compliance to the requirements stated in the contract between the city and a traffic operator. The aim is to ensure that speed limits are being respected especially around areas where vulnerable road users are e.g., nearby schools. Tests have been conducted with vehicles for Special Transport Services, which serve people with disabilities.

Speed control zones were set up with different speed limits: some with the regulated speed and some with speed lower than the regulated speed. Geofences were integrated in the traffic operators fleet management system. As this use case involved an existing fleet of vehicles, this system had to be retrofitted. Equipment was installed in the vehicles to support the drivers not to override the set speed limit in these zones. The demonstration enabled user studies to evaluate drivers' experience while approaching, going through and exiting multiple geofenced zones.

**What are service trips (special transport services)?**

Service trips are for travellers who have difficulties travelling with ordinary public transport (e.g., a child with special needs travelling to school or an elderly or disabled person travelling to a meeting).

## CITY BACKGROUND AND MOTIVATION

The city of Gothenburg is Sweden's second largest city. It has a strategic position by the sea and harbours Scandinavia's largest port. The city is growing substantially and the competition for city space is hard. In the early 1990s, Gothenburg city was considered to have the most dangerous traffic situation in Sweden. The city realised that something had to be done about the situation. Ever since, Gothenburg have been working actively with traffic safety. In 2022, Gothenburg was selected as one of Europe's 100 climate-neutral and smart cities. Altogether, this sets demands for new ways of traffic planning and traffic management.

Traffic safety has a large dependency on speed. The higher the speed and the heavier the vehicle, the higher the risk for incidents and the more severe the injuries. The City of Gothenburg has an ambition to include geofencing functionality in public procurement to get better speed compliance for fleets and transport services that are used by the city. Within GeoSence, a case study has been conducted by retrofitting some of the vehicles that are used for special transport services. Drivers' behaviour and acceptance have been evaluated

### Status quo on Special Transport services

Special Transport Services is a department within the Urban Environment Administration in Gothenburg. The department offers public transport services to passenger groups with special needs, i.e., trips to daily activities for people with functional limitations or cognitive disabilities and school trips for children with special needs.

## The Special Transport Services is a part of public transport

A certain permission is needed for using the special transport services. The trips must be booked in advance, either by calling the ordering central or by using a web page or a mobile application. The special transport service may also be used by city employees for certain work trips/missions.

Every year, more than a million special transport trips are made. The mission is to offer safe and secure trips, which is followed up regularly in customer surveys.

## The fleet vehicles

The fleet of vehicles is divided into two parts:

- **Traffic operators that are specialised in this kind of trips**. Three companies are contracted. This part represents approximately 85 % of the overall contract sum. The operators are contracted to be available a certain amount of time every week/day. They get paid for this time, regardless of how many trips they conduct. These vehicles are painted green and have a special striping and information on the sides of the vehicles. There are 243 vehicles, of which 106 vehicles are fitted for wheelchairs and 137 are ordinary passenger cars. 73 of the passenger cars are pure electric.

- **Ordinary taxis**, which amplifies the ordinary fleet at peaks/periods of higher demand. The taxi companies are paid per trip. Two companies are contracted.

Public procurement for a new contract period of 5 years was made in late 2020.The contract sum is around 1,5 billion SEK (150 million EUR). The new contracts came into force in February 2022.

The fleet consists of electric vehicles, biogas- and HVO100-driven vehicles.

## Systems for Intelligent Speed Adaptation (ISA)

The traffic operators use ISA systems that **inform** the driver of the speed. The national road data base is the source for the legal speed data. The ISA-systems log the actual speed for each vehicle.

Different operators use different ISA systems. If there are customer complaints, the city of Gothenburg can ask the operator about details for the trip, i.e., data registered in the operator's ISA system. The city of Gothenburg does not have access to any other data registered in the operators' ISA systems.

## Complaints

Some passengers complain about the speed, that the driver speeds and/or goes to fast. Because of that, the trip does not feel safe and secure.

Complaints per year:

- 2018: 54
- 2019: 31
- 2020: 20 (fewer trips than normal were made due to covid)
- 2021: 17

- 2022: 42 (Due to a terminated agreement, a lot of new drivers had to be introduced in a short time period, likely resulting in more complaints)

This is a very small number of complaints considering that a million trips are made every year, but it is necessary to bear in mind that not all thoughts/comments regarding a trip result in a complaint. The city has a dialogue on a regular basis with associations that represent the passengers (for example the national association for visually impaired) and they convey their members experiences of using the Special Transport Services.

The city also gets complaints from individual citizens. The green-painted cars are easy to recognise and the public notices their driving behaviour (for example speeding). It gives the city a bad reputation.

Each complaint is forwarded to the appropriate operator, mandating internal measures. In the event of recurrent complaints involving the same driver, the city may necessitate a customised action plan and subsequent follow-up by the operator.

## Hypothesis – problem cause

In the project, the following has been discussed:

- The driver's support to not override the speed limit is not good enough.
- The drivers may feel stress to be on time or to be able to handle as many trips as possible (depending on which business model the contracted company/operator uses).

## Motivation: safe and secure trips in special transport services

**What the city of Gothenburg wanted**

- Safe and secure travel for customers. Customers are particularly vulnerable due to their disabilities.
- Safe and secure travel for other road users. Improve the traffic situation in general.
- Driver assistance. Help the driver to increase the quality of the journey (e.g., drive legally).

The motivation was in other words to meet the city's ambition to get better speed compliance for fleets and transport services that are used by the city. The city wants to investigate what kind of functionality that can give better support for the drivers to keep the speed. The traffic operators are interested in helping the drivers keeping the speed. This could mean less damage and wear of the vehicles, which in turn would decrease costs and increase safety in operation.

The city wants to have the possibility to set lower speed than regulated at certain areas/parts of the roads, for example where there are complaints and where there is a higher risk for incidents. Through GeoSence the city wants to test/validate if the geofencing technique supports the mission to achieve safe and secure trips (by complying to speed regulations) and is accepted by the drivers. The city also wants to learn what is needed to implement geofences for special transport services.

## What the Special Transport Services department wished to get more knowledge about

1. Can temporary/dynamic speed recommendations, lower than legally regulated, be used to support the driver in driving in a way that the travellers find safe and secure?
2. What drivers' support is needed to make it easier to comply with recommended speed (i.e., lower than legally regulated)?
3. What routines and ways of working must be established to use geofencing in daily operations? From the purchaser's point of view (the Urban Transport Administration) and from the providers' (the traffic operators)?

## Mandate

The Urban Transport Administration does not have mandate to handle or prosecute speed violation. Only the Swedish police authority is authorised to do that.

Topics addressed in the GeoSence project

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

# Use case in Gothenburg: Special transport services

Passengers with need for special transport services belongs to a vulnerable group. The case study investigates how public procurement can be used to ensure that speed limits always are respected and thereby strengthens the passengers' right to safe transport.

If possible, the city wants to avoid forcing the drivers to speed compliance. That is why the city in GeoSence would like to evaluate the drivers' experiences and behaviour when combining optional ISA for regulated speed (i.e., information about the legal speed) with mandatory ISA for the test areas with contracted speed (i.e., geofences).

Special transport services (Färdtjänst in Swedish) are a kind of public transport for travellers that have difficulties to travel with ordinary public transport. It includes school transport for children with special needs. To use Special Transport Services, you need a permission.

It is also important to analyse if the drivers accelerate after passing a mandatory geofence to make up for possible time loss.

**Case study focus**

How to describe requirements for geofencing functionality when procuring transport services in order to achieve higher speed compliance, but without unnecessary limiting the "freedom" of the driver.

**Hypothesis**

The driver accelerates above regulated speed after passing a "mandatory" low-speed zone

**Case design**

Compare user behaviour and user experience during three phases

**Test period:** August – December 2022

1. Baseline: logging of speed in low-speed zones (but without informing the user) (3 weeks, 15 vehicles)
2. Speed information in low-speed zones (2 weeks, 13 vehicles)
3. Speed information and "throttle impact" ("mandatory") in low speed zones (2 weeks, 6 vehicles)

Web survey to drivers before and after the trials.

## Process

The main stakeholders involved in the Gothenburg case were the city authority, the Urban Environment Administration ( previously named the Urban Transport Administration), procured special transport service provider, third-party service provider of hardware and software to enable geofencing in piloted vehicles and research partners. Additional stakeholders that were involved to a lower extent, but had influence on the pilot, were legal expertise and the union representing the drivers and the police.

The city authority had the role of managing the project by determining goals and objectives (in collaboration with involved stakeholders) and to coordinate all stakeholders in that direction. The city authority is also the procurer of the special transport services and the hardware and software services to enable geofencing, hence representatives are managing several different stakeholders with different objectives.

The process was initiated in 2021 by defining the reason for using geofencing, establish this with the transport service providers, identifying reasonable road stretches to be geofenced and deciding on technical solutions for enabling the pilot.

The pilot was initiated in the Autumn 2022, more than a year after initiated organising and planning. Preparations, executions and follow-ups were made in coherence with the other stakeholders involved in the pilot.

Although a successful pilot, there were some challenges in coordinating the stakeholders. This mainly related to effective communication between the drivers and the third-party service provider of software and hardware to enable geofencing. This was solved by excluding middlemen who had less interest in the pilot.

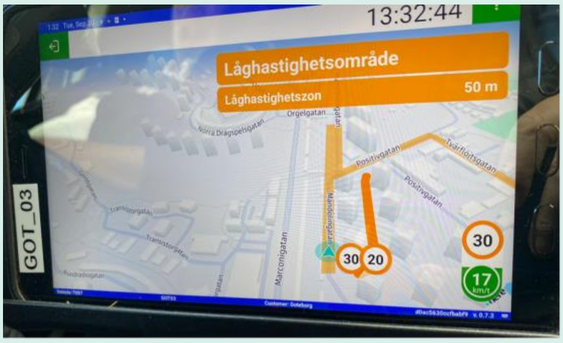
Many improvements on useability, technical accuracy and functionality could be made during the pilot in the autumn of 2022.

## Implementation

16 vehicles were equipped with speed limiters and a tablet. Geofenced areas were set up in a fleet management system that impacted the vehicles. An app installed in the tablet informed each driver visually and audially of the current speed when entering a geofenced area.

The vehicle equipment and access to the fleet management system were leased from a 3rd party supplier and used in the test vehicles during the test period.

For this use case a modular system consisting of software and hardware components (provided by SkanTech and Lingaard-Pedersen) was used. It included a tablet device with an android based navigation app, a speed limiter device, a break relay device and cables connecting the components. Maps and geofencing information were stored locally on the tablet, which enabled the system to function without constant mobile connection. The navigation app then communicated with a geofencing management system via mobile network and allowed for remote updates of geofencing and other software/data adjustments. Driving data was recorded and stored locally, then uploaded to the geofencing management system when mobile connection was available.




## Impacts of the Gothenburg trial

**Impact assessment categories** are based on interviews, local data, information & statements from municipality & service providers.

### Overall impact of the trial

The city assesses the acceptance results to be **reasonable**. When considering the technical issues, one could say they are good. Going forward they don't see the acceptance as a game stopper.

There are also indications that the **geofencing solutions are promising in regulating speed**, and there did not seem to be compensatory speeding outside of the zones. However, the **results were limited** due to the challenges faced with setting up the technical solution, mainly due to a lack of communication with the end user (due to GDPR).

## Behavioural change

Driving behaviour during the use case study was analysed to evaluate the impact of the geofencing based ISA solutions and the compliance with the speed regulation. Driving data was collected second-wise from all equipped vehicles. This included GPS location, vehicle speed, geofence and speed limit information, and other system status information. The analysis of driving data, focused on three research questions.

### Research questions

Is the retrofitted ISA effective for reducing speeding within low-speed zones?

Which ISA variant (informative or mandatory) is more effective for speed reduction?

Does it lead to compensatory driving behaviour (speeding) outside low-speed zones?

To answer the research questions, two indicators of speed and speeding were analysed: The average vehicle speed when driving within the low-speed zone, and the amount of time speeding within the low-speed zone.

Concerning the first research question, findings are that average speed was highest in the Baseline, (about 3.9 km/h below the zone speed limit) and lowest in the mandatory ISA condition (about 4.8

km/h below zone speed limits) with informative ISA in between (4.4 km/h below zone speed limit), but there was no statistical difference between the three study conditions.

For the indicator Amount of speeding, the largest percentage (28 %) was found in the baseline and the smallest in the mandatory ISA condition (11 %), with the informative condition in between. The amount of speeding was significantly higher in the baseline compared to the mandatory condition, but did not statistically differ between baseline and informative system.

**Hence, the retrofitted ISA was only partially effective to reliably reduce the speeding.**

Concerning the second research question, there was no statistical difference between informative and mandatory ISA for both indicators.

**Conclusions are that none of the two ISA systems was more effective than the other to reduce speed and speeding within the low-speed zone.**

To answer the third question, the speed and speeding for a short period of time (1-3 minutes) directly after leaving a low-speed zone, was analysed. The analysis of driving data did not indicate an increased speed or amount of speeding in the ISA conditions compared to the baseline.

**Hence, there was no evidence for compensatory increase in speed and speeding after leaving a low-speed zones.**

To summarise, the analysis of driving data for the Gothenburg use case showed only limited evidence that the ISA system can support the driver effectively to reduce speeding. If at all, a reduction in speeding was found for the mandatory ISA system. However, mandatory ISA systems, that automatically reduce the vehicles speed and thus restrict the freedom how to drive, has been reported to be less accepted by drivers in the previous research related to acceptance of ISA. It is also the less preferred solution for the city, since it rather wants to implement a solution that supports and does not restrict driver behaviour.

There are a number of limitations in the study design that may have contributed to these findings. Firstly, only a small number of vehicles and drivers participated in the study. Secondly, which zones were visited and how often was highly variable among these participants. The low-speed-zones were relatively small, thus affecting driver's behaviour only in a fraction of the time of their professional driving.

At some of the chosen low-speed-zones, constructional speed reduction measures (speed bumps, recommended speed signs, street narrowing) were already in place, generally reducing opportunities to speed. All these factors may have contributed to the fact that in the current case study the effects achieved in reducing speeding offences in the slow zones were lower than expected, especially when using the ISA information system.

## ACCEPTANCE SURVEY

The analysis of acceptance was another important aspect for the evaluation. Two main questions guided the acceptance analysis.

## Research questions

1. Which ISA system is preferred by the drivers?
2. What are the main factors influencing acceptance and preferences of use for the geofencing based ISA system?

Acceptance of the introduced traffic measure and for the tested technical system was evaluated with a quantitative online survey before and after the use case period. The general concept for the acceptance survey was developed based on previous findings related to acceptance for driving assistance and speed assistance systems and more broadly acceptance for traffic measures to increase traffic safety and avoid speeding.

The survey was split into two parts, one conducted before and one after the use case study. The survey at the beginning was used to get a better understanding about the sample of participating drivers, including their prior opinions and attitudes about traffic safety and speeding, their prior experiences and opinions of ISA systems, their expectations concerning efficiency and effectivity for the planned traffic safety measure and their intentions to use the system and to comply with the introduced regulation during the use case.

The second part focused on the experience during the use case. The acceptance evaluation focused on three different aspects of the use case implementation: the specific retrofitted ISA system variant, the specific traffic safety measure, i.e., the implementation of speed limits that are lower than the officially speed regulation, and lastly, the application of geofencing as a tool (for an authority) to implement the regulation. As a proxy of acceptance of the tested retrofitted ISA system, preference ratings were used for using one of the two tested ISA system variants and for the intentions to use it in future. The other two aspects were assessed with several judgements focusing on the perception and understanding of geofenced zones and geofencing as a tool for authorities as well as the perception and acceptance for the speed limits.

According to previous research, acceptance of driving assistance functions is influenced by several factors. The most important factors were also addressed in the survey, including the ease of use of the system, its perceived effectivity and usefulness, trust (relates to reliability and validity of the system behaviour, information and function but also to data privacy and security), experience of certain traffic related risks (i.e. close following or risky overtaking), concerns related to job performance, as well as the perceived workload.

Due to the technical problems encountered during the use case, some questions were added to obtain information on how the ISA system was actually used, what kind of malfunction occurred during the study, and how participants judged the organisational aspects of the use case implementation.

## Results

Eight participants each took part in the surveys before and after the use case study. Results of the survey's questions on acceptance and influencing factors revealed the following:

**Participants reported no clear preference for using the retrofitted ISA system**, i.e., 50 % preferred not to use the system, and each 25 % expressed a preference for either the informative or the mandatory ISA system. Acceptance judgments did improve only marginally, if the system would be better integrated with already available assistance functions in the vehicle.

**Speed limits for low-speed zones were found acceptable by more than a half (62.5 %) and were rated more often an advantage than a disadvantage** (37.5 % vs 12.5 % but 50 % expressed neural opinion).

**Zone speed limits in line with the official regulated speed limit were found more acceptable than lower ones,** and lower speed limits were accepted better on roads with higher compared to lower regulated speed (>60 km/h vs <=50 km/h.

However, survey's answers also revealed that the **participants had difficulties to understand the objectives and why the speed limits were introduced in the low-speed zones.** They also rather disagreed that the zones were helpful to improve traffic safety or located at places that were vulnerable for safety. Most participants considered speed limits a good method for safety improvements only, if most or all vehicles had to comply with them.

**Concerning geofencing as technology, participants rather disagreed that it is a flexible tool to improve traffic safety** and that it could be is useful to implement group selective speed limits. However, they valued its potential to introduce temporally valid speed limits within zones.

What factors influenced these acceptance perceptions? On one hand, the answers revealed slightly positive judgements regarding aspects of perceived usefulness (especially towards the aspects passenger safety, safety of driving in the zone, and compliance with speed limits in the zone). Furthermore, respondents' answers did not indicate an increase of risky traffic related situations. Workload was not reported to be increased substantially either.

On the other hand, some aspects received negative evaluations. Most importantly, there were rather **negative trending evaluations for ease of use and trust.** In particular, answers indicated battery charging issues, GPS accuracy issues (which led to zone detection errors) and problems with the overriding the automatic speed limiter. Respondents also reported low levels of trust for the behaviour of the system, its functioning, and the data security of the system. Only one respondent provided a positive evaluation once for these trust related questions, indicating an overall low level of trust.

Referring to the research question on which system is preferred, the acceptance analysis did not uncover a clear pattern. However, in the pre-study questionnaire only two of eight participants stated that they had used ISA for professional driving before, and this only sometimes. On one side, the fact that 50 % would prefer to use the retrofitted ISA system in future can be therefore interpreted as improved usage intention.

Perhaps, providing support on speed limits in certain areas only (such as in low-speed zones) receives a better acceptance than when such information and warnings are provided on every location and instance. On the other side, it remains unclear how sustainable and long-lasting this choice would be, as some research has shown that active ISA usage decrease over time. The present finding also contrasts with earlier research, in which a preference for informative compared to mandatory ISA was found.

During the use case, there were some technical problems, partly due to a faulty installation of the retrofitted ISA. This probably has contributed to negative judgments and prevented that the solution reached its full potential. Many of these short-comings could have been avoided, and technical aspects of the geofencing technology are expected to improve in the next years.

While this may help to mitigate some acceptance issues, it remains unclear whether it will be sufficient to achieve better behavioural compliance with stricter speed limits when using an informative ISA system, which is the city's preferred solution as a supporting technology, but was not effective in the current use case. Further research is needed to clarify this and to find solutions that will improve compliance for such safety measures and offer improved technical support systems.

## SUSTAINABILITY RATING OF CASES

### Main impact findings for Gothenburg

**Effectiveness:** For the solution aiming at counteracting speeding in sensitive area in Gothenburg, the main effectiveness was considered medium high, as the application was used to influence driver behaviour towards lower speed than the regulated speed.

**Sustainability:** As can be seen in Figure 1, Impacts were valued the most favourably for technology economy, improved parking behaviour and improved traffic control.

For the Assessment of Strength, Weaknesses, Opportunities and Threats, the main opportunity would be to further develop the technology elements to better integrate it into the vehicle systems.

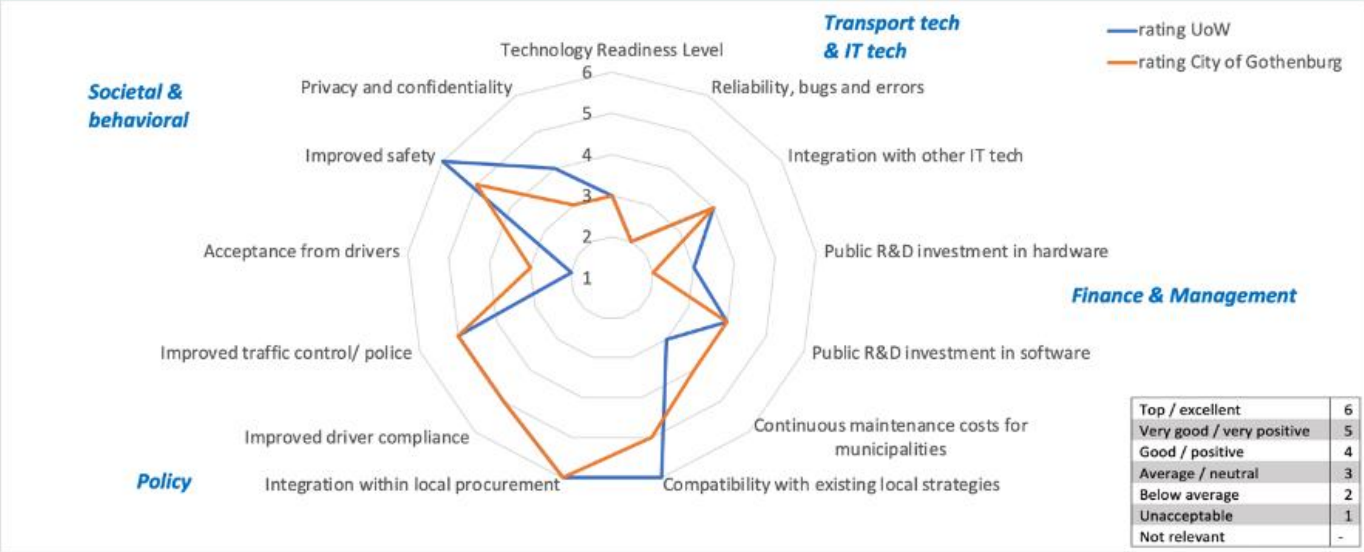



*Figure 1: Gothenburg impact assessment: sustainability rating of cases*

## LESSONS LEARNED

### Recommendations

- Take control of the process (exclude middlemen)
- Plan for potential conflicts – resource-demanding but rewarding

### Equipment & zones

- Information about vehicle model, year & motor type is needed to correctly calibrate the equipment.
- Equipment was not correctly installed in some of the cars. The cruise controller could be used to override zone speed.
- Lower speed than expected in the zones. The higher the speed, the larger the deviation (62 km/h in 70 km/h zone).
- There were some ”ghost zones” – zones in areas where we had NOT set up zones.

VERIFY BEFORE INSTALLING ALL VEHICLES

### Barriers

- Low participation/commitment among participating drivers
- Difficulty in “owning” the pilot process
    - Coordinating several actors with different objectives
- No direct contact with end users
    - Missing feedback on why something was not working with geofencing application
    - Managers with low commitment or knowledge

## PLANS FOR THE FUTURE

At the moment, there are no plans for future geofencing activities in Gothenburg. The city identifies a need to learn more about the effects of mandatory ISA roll outs, and how that will affect the speeding behaviour overall. The city also think that it might be less complicated to implement similar solutions in heavy trucks (where the geofencing maturity within the vehicles is a little bit ahead), instead of cars. Heavy trucks are also a greater risk to VRUs and create more wear and tear on the infrastructure. So the payoff would be bigger.

## REFERENCES/MORE INFORMATION

Further details on results and findings relating to the Gothenburg Use case can be found in documents available at the project web site[1].


[1] https://closer.lindholmen.se/en/geosence