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Report

Geofencing for smart urban mobility

Summarizing the main findings of Work Package 1

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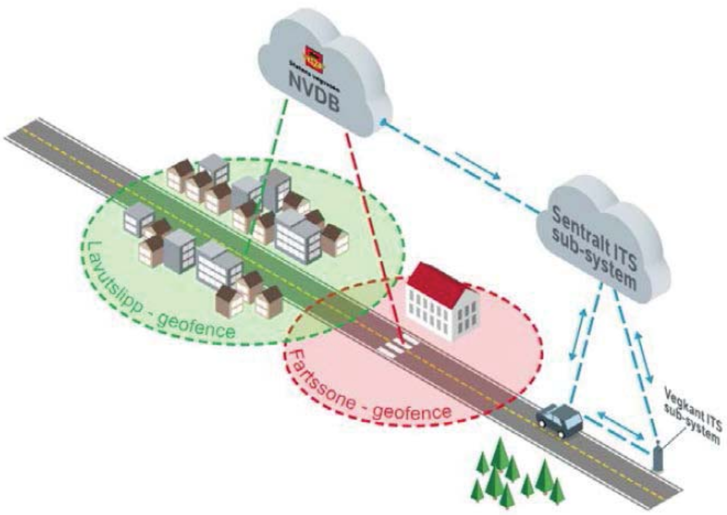

SINTEF Building and Infrastructure
Digitalization in Transport

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ABSTRACT

Abstract heading

Norwegian cities are heavily affected by car traffic, which brings major challenges related to efficiency, safety and the environment. In GeoSUM cooperative ITS and geofencing will be used to develop new tools to meet these challenges. Using geofencing, digital zones is defined on a map and specific rules inside these zones can be transmitted directly to the vehicles. This technology is a prerequisite for the future transport system, for instance to make automatic driving a reality. This report sums up the finding from workplace 1 of the GeoSUM project. In short, it contains a comprehensive literature study, reflections on standardisation, functionality of the related ITS-services, public-private collaboration, Business and management models and privacy considerations. Please note that some of the notes included in this project might change during the rest of the project period, and that updates may occur.

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1 Introduction

Many Norwegian cities struggle with negative effects from car traffic in their urban environment. Urban environment agreements were presented in the National transport plan 2014-2023 to ensure a more holistic policy on spatial planning and transport in city environments. These are agreements between the cities and the central authorities. Zero growth in car traffic in city environments is a central goal in these agreements, a goal based on the Climate settlement from 2012. Any growth in transport should be done using public transport, cycling or walking. In 2015 the City development agreements followed, where cities, regional and central authorities formalized their collaboration on spatial planning in cities.

Despite these efforts, car traffic is still a problematic aspect in many urban environments in Norway, and new measures and policies are desirable. An additional complicating factor is the extensive and costly physical infrastructure that is necessary for controlling and managing the car traffic in urban areas. However, the limit has been reached for what is possible with the physical infrastructure at the roadside without exceeding the mobility of the population. New measures and means are therefore necessary and new technologies open innovative possibilities. In the GeoSUM project we will use geofence technology to develop new tools to meet these challenges by connecting vehicles with C-ITS and help develop new ITS services for traffic management and road information. The concept is described in Figure 1.

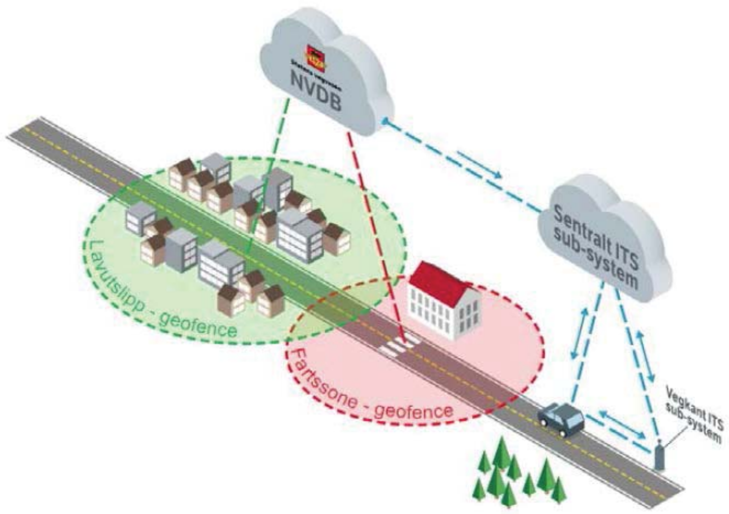

Figure 1 The concept of the GeoSUM project – using geofence technology and C-ITS to develop new tools for traffic management and road information.

When using geofence technology one uses digital zones defined on a map, and directly transmit these zones to vehicles. With geofencing, appropriate actions can quickly be taken to control and inform traffic, without the need for expensive and rigid infrastructure, such as a tollgate. The number of other applications within the field of transportation is for this technology is numerous; provide warnings about accidents and challenging road conditions, access control, collect payment for parking, or differentiate tolling between different road users (buses, private cars, heavy vehicles, and so on).

In GeoSUM, we will pilot two ITS services benefitting from geo-fencing, also described in Figure 2: 1) differentiated road usage fee in low emission zones as part of rapidly improving air quality in cities and 2) automated speed adaption around schools to improve traffic safety in these particularly vulnerable areas. Reducing speed in areas around schools is one of the two applications that will be piloted in the GeoSUM project. First and foremost, this has a safety impact: the speed is reduced around schools. The other application of geofence technology in this project is a low emission zone where the vehicle itself transmit relevant data, such as kilometres driven, to achieve a more differentiated and fairer road tolling. Such low emission zones can be used as a mean to quickly reduce the air pollution in city centres, by rewarding use of low and zero emission fuels, and vice versa, charge a higher fee for use of high emission fuels. In this pilot, hybrid vehicles are particularly interesting since they can be forced to run on electricity within a low emission zone, and thereby be given a lower fee.

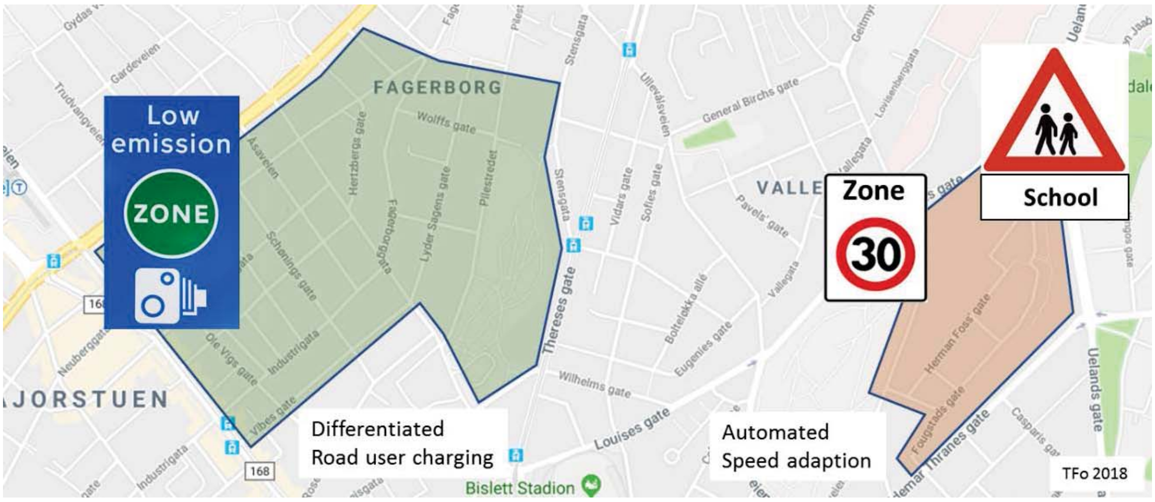

Figure 2: Scope of research project

The pilots in GeoSUM will be carried out in operational city traffic, where the vehicle fleet will consist of both vehicles with built-in C-ITS from factory and vehicle with a refitted ITS station in vehicles.
By combining C-ITS and Geofence, road authorities and road operators can develop powerful, efficient and dynamic tools that can be used to influence and inform vehicles in areas defined by geofencing. New traffic control measures can then quickly be established and changed both in time and space without the need for costly and time-consuming development of physical infrastructure along the road.

The partners in this project consists of the Norwegian Public Roads Administration (NPRA), which also is the project owner, while the private partners are the car manufacturer, Volvo, and the supplier of ITS-stations, Q-Free. SINTEF and NTNU are the research partners. The two pilots in the GeoSUM project are operated by the NPRA Regions, while the NPRA Directorate has the overarching responsibility for collecting experiences and learning from the pilots. In GeoSUM, NPRA Region Midt is the operating region for both the pilots. This is a reflection of a larger trend within the NPRA where the regions are assuming responsibility for tasks that previously were the Directorate's responsibility.

The private actors supply the two pilots with the in-vehicle technology for testing geofencing, where Volvo and Q-Free represent two different technical solutions. Volvo has a solution for C-ITS integrated in the vehicle through software, while Q-Free has a retro-fit solution where an ITS-station is to be installed in the car.

GeoSUM is a project financed by the Norwegian Research Council through the Transport 2025 program, and is an innovation project in public sector. The Norwegian Public Roads is the project owner, SINTEF and NTNU are research partners, and Volvo and Q-Free are industry partners. Public-private collaboration is in focus when developing these services.

Geofencing is a technology already in use, for instance providing information to smartphone within a defined area. However, within the field of transport controlling and information, this technology represents a major innovation both nationally and internationally.

This report summarizes the first main findings in the project, that is the findings made in work package 1. This report includes four main aspects:

1) **A state-of-the-art study (SOTA):** The main purpose of the SOTA is to map the different use cases for geofence in the transport sector. We include both published articles in peer review journals and conference papers, and other forms for non-published material.
2) **ITS services and standardization**: This activity describes the ITS services that can be included in the two use cases of this project: speed zones and low emission zones. This includes developing a system architecture that supports both an integrated solution in vehicles and a retrofit solution.
3) **Private-public partnership**: This activity will map roles and responsibilities for the two use cases by conducting interviews with the Public Roads Administration, Volvo and Q-Free. It also suggests a value network for the services.
4) **Privacy**: The main purpose of this activity is addressing the major challenge of securing the right to privacy for individuals. This can be solved by early searching for solutions for privacy by design.

This report summarizes the first findings made in the GeoSUM project and summarizes the work conducted through 2018. It is important that we highlight that these are early results and that adjustments will come. Still, the results are important as a foundation for the rest of the project and are therefore also critical to document. An example here is the documentation of the standardizing process, which will continue to be addressed through the entire project period.

2 State of the art study

Petter Arnesen and Hanne Seter

2.1 Introduction

The main aim of the GeoSUM project is to use geofence technology to develop new tools and measures for informing and controlling road users. One of the first activities in this project is to conduct a mapping of the "state of the art" (SOTA) of geofencing used for traffic purposes. This memo consists of two main parts: first, it conducts a literature review of the available scientific research on traffic related geofence, and second, it gives a brief overview of the most relevant use cases.

In the scientific literature review we find that some papers focus only on a technical validation, but the majority of papers focus on a use case. The use cases are traffic intersections, animal detection, HGV and cargo control, border crossings, terminals, safety, tolling, pedestrian assistant system, fleet management, preventing auto theft, travel behaviour and parking.

In the overview of the most relevant use cases we review the most common urban vehicle access regulations that have been implemented, and we focus specifically on low emission zones (LEZ) and how these are implemented in European cities. A variety of different designs are used, but many LEZ are enforced through stickers and badges, while some cities use automatic number-plate recognition (ANPR). No cities are documented to use geofence as a technique to implement LEZ.

2.2 Methodology of scientific literature review

A systematic literature review was conducted to retrieve relevant scientific papers (Colicchia & Strozzi, 2012). Firstly, a brainstorm was conducted with several transport researchers to identify relevant keywords and databases. The search words were divided into two groups, one group only to be used when searching in transport-related databases, and a second group to be used together with the first group when searching in more general databases**.** The search terms in the first group was: geofenc*, geo-fenc*, virtual zone, virtual fenc* and virtual gantry. The search terms in the second group was: transport* and vehicle. The transport-related databases in use where TRID, ERTIGO ITS-library where only papers older than 2005 was included. Counting, the number of 10 searches was conducted in these two databases resulting in more than 70 unique papers.

Additionally, we used the more general databases Web of Science and Google Scholar, giving 20 more entries to search for. For Web of Science, we restricted to result to only include papers no older than 2005, giving about 20 more unique papers. For Google Scholar we restricted each search to only include the 20 most relevant papers (as defined by Google) after 2012. In total this gave a little over 100 more unique papers to study. The Google search was defined somewhat differently because Google does not provide the option to both sort the results by time and restrict the returned papers to only include papers after a specified time. Since Google Scholar generally returns a lot more results than other databases, we restricted the returned papers to only be dated after 2012. Ideally, Google scholar should be avoided in structured literature search, however in this case we observed an important and significant amount of literature emerging from our search that was not found by the other databases.

In total 30 search was conducted in the general databases resulting in more than 190 papers to evaluate. Some of these papers was quickly deemed not relevant, through a title and abstract scan. For instance, many papers were written on geofencing towards the aerial research field, which is not directly relevant for our main purpose. In total 105 papers were reviewed in detail. After reading, 40 more papers were removed, mostly due to a very weak link to geofencing, for instance only mention geofencing once as a possible application of their work. The rest of the papers were removed because they were not papers about geofencing used for road traffic. In total, 62 papers were included in the more detailed review, 11 from TRID, 22 from ERTIGO, 8 from Web of Science and 21 from Google Scholar.

2.3 Summary of scientific literature review

In this section we briefly describe each of the papers deemed to be the most relevant for this review. We categorize the papers depending on whether they are papers only validating GPS technology or by the use-case they consider. Since we are interested to identify these use-cases, we pay special attention to this latter group of papers.

2.3.1 GPS technology validation

Several papers focus on improving GPS quality, and only mention geofencing as an application that would benefit from such increase in quality, e.g. Lanza, Gutierrez, and Schortmann (2009), Betaille, Peyret, and Ortiz (2014) and Peyret, Vigneau, and Betaille (2010). Of these, the latter paper properly considers GPS quality quantitatively for geofencing applications. The paper investigates increased geopositioning accuracy obtained by augmenting the GPS system with The European Geostationary Navigation Overlay Service (EGNOS) for road transport services. This paper investigates seven ITS-services, where five of them are geofence applications. The study concludes that EGNOS can make GPS accurate enough for use in the presented geofence applications. They use three types of geofencing techniques – virtual gantry, corridor and zone, as defined in standard ISO/TS 17575:2010[1]. Fattepur, Sharvani, and Huttanagoudar (2016) and the series of papers (Rodriguez Garzon & Deva, 2014), (Garzon, Deva, Pilz, & Medack, 2015) and (Garzon, Arbuzin, & Küpper, 2017) address several technical issues with GNSS technology and geofencing, including inaccuracies and battery life, however with limited experimental validation. Only the three latter papers include small studies with prototype implementation collecting data for validation.

2.3.2 Use cases

In this section of the memo we summarize the scientific literature in terms of use cases for geofence. Some few papers are presenting projects, such as the *Intellidrive* testbed in Michigan (Burkhard, 2009), where several use cases are included such as milage-based fee and bridge height warning (Nait-Sidi-Moh, Ait-Cheik-Bihi, Bakhouya, Gaber, & Wack, 2013) and (Suganthi, John, Shamil, Patel, & Student, 2018) presents location-based services and geofencing within the fields of transportation in general, with examples of applications, but with limited literature reviews on the subject.

2.3.2.1 Traffic at intersections

Wünsch, Bölling, von Dobschütz, and Mieth (2015) combine GPS data with map-matching and geofences to study traffic at intersections. Geofencing is used to identify GPS-trajectories going through intersections. This approach is also used by Li, Day, and Bullock (2016) where the same subject is studied, i.e. trajectories at intersections, and the result is compared to in-pavement loop detector data.

2.3.2.2 Animal detection

Schalk and Schalk (2012) use geofence to alert wildlife by audio and offer the driver an in-vehicle alert when wildlife is present when a vehicle is approaching. The paper reports a 90% reduction of wildlife vehicle collisions during the pilot period.

2.3.2.3 HGV and cargo control

Several studies suggest using sensors on cargo in combination with geofence to track cargo. Permala, Scholliers, and Ratnasila (2014) suggest using this system for estimated time of arrival services and alerts. Other studies use geofencing to inform about when a vehicle deviate from the route, for instance to direct hazardous goods from densely populated areas where accidents will have a great impact, and it is suggested to ensure door lock in certain areas as a theft prevention measure (Stefansson & Hagen, 2009). Several other studies also suggest using a deviation from a route or location as possible use cases for geofences (Brummond, 2008; Pollack, 2008; Torfeh'nezhad & Behrooz, 2004). In Mohamad, Mansor, Ahmad, Adnan, and Wali (2016) a system that uses geofencing to check whether a Halal-product carrier stops at designated or unknown locations is developed and verified. The carriers' speed and stopping time is used to identify stops, and geofences are used to check whether or not the stop is according to the planned route.
Reclus and Reed-Drouard (2009) suggest using geofencing to enforce heavy goods vehicle (HGV) regulations. The geofence is suggested to be used with the "predetermined zone" or "proximity with a point of interest" technique. These techniques compare the entity's position with a fixed-point reference and determine if it is inside the area. Brummond (2008) suggests that an operation centre could be responsible for formulating a response plan, which could include appropriate public safety agencies.

[1] ISO/TS 17575:2010 Electronic fee collection -- Application interface definition for autonomous systems

2.3.2.4 Border crossings

M. McCord et al. (2010) and more recently M. R. McCord, Brooks, Banach, and Carr (2017), aim at capturing the time required to complete various activities at international border crossings, such as approaching the boarder on a congested road, paying toll, undergoing custom inspection, and waiting in ques. Geofences are specified at strategic locations that delineate the beginnings and ends of activities of interest. Cross-border truck movements are also investigated in Gingerich, Maoh, and Anderson (2016), where data from two US-Canadian border crossings was collected using geofence. In particular, geofence was used to identify cross-border trips, and afterwards identifying the trip purpose and border-crossing time. A tracking and monitoring system for cargo at border crossings at international port of entry is suggested by Brosi (2012).

2.3.2.5 Terminals

Several studies investigate how geofence can be used to determine for instance time spent in terminals as well as arrival and departure notifications Neto, Fontana, and Dias (2010) explains how to use geofences at a port terminal to reduce transit time at the terminal. No empirical test is included in the paper. One study suggest using a geofence for giving a pre-arrival notification at ports when cargo is approaching, with the aim of increasing security and efficiency of the transport flows through a port (Nyquist Magnusson & Bergsten, 2008). An arrival notification system is also suggested by Stefansson, Lumsden, and Mirzabeiki (2009) and (Ploos van Amstel & Clermonts, 2013). (Tioga Group, 2011) present a data collection experiment on the port of NY-NJ, where a geofence was used to collect statistics of almost 2000 terminal visits from a truck company during a one-month period. Comments on issues with inaccuracies due to the carrier's truck central being close to port. (Wilson & Vincent, 2008) tracks the movements of waste collection vehicles at transfer stations. The geofence is used to determine the amount of time each truck spent on different activities in the transfer station. This information is used to make recommendations concerning where the main delays are located (Wilson & Vincent, 2008).

2.3.2.6 Safety

Raza (2017) use a combination of Internet of Things (IoT), micro location and geofencing to discourage mobile use while driving. Communication is established by pairing the mobile phone with an in-vehicle black box, within a given geofence. It is suggested that this could be used to alert the driver, help crash site forensics, or be important information for issuing a driver insurance premium system. Another use case for safety is found in Noei, Santana, Sargolzaei, and Noei (2014), where it is suggested and simulated that an emergency vehicle entering the area/geofence around a traffic light is guaranteed a green light.

2.3.2.7 Tolling

Several studies use the geofencing technique on the tolling use case. Nagothu (2016) suggests an architecture of how to use geofences for tolling purposes by using GPS by giving latitude and longitude of the corner of the toll plaza. Each vehicle is identified uniquely by SIM or GPRS, and the vehicle's owner is notified by SMS or email about the fee. No empirical test is included in this paper

Pierce (2011) suggests a mileage-based user fee application from the road user pricing world, where the combination of on-board units (OBU) and geofence could be used to establish fees or locations where the fees change. No empirical testing is included in the paper.

The paper Matheson and Smith (2008) suggests a framework for Time Distance Place (TDP) charging of road pricing. A geofence can be used to identify the geographical boundaries. Any vehicle falling within the distance charging scheme rules will thus be charged when travelling within the zone. No empirical test geofence was however performed.

The lack of empirical testing is true also for Koch (2006), COSMEN-SCHORTMANN and MARTINEZ-OLAGUEE (2007), ZHOU, CONCHA, YU, and RONG (2007), Rajnoch (2007), Lykkja, Løland, Bang Huseby, and Søråsen (2013) and Furan (2008) where algorithms, architecture, requirements and methods for tolling with geofences is presented. However, no empirical test of geofence, other that GPS accuracy test drives. Duchâteau, Capelle, et al. (2014) does technical field test on GPS accuracy for road tolling with virtual gantries, while challenges with respect to implementations of such systems is discussed in Duchâteau, Leblan, Capelle, and Peyret (2014).

Walker et al. (2009) are testing charging using two geofences in the city of Swindon, UK. An inner and outer charging zones is defined, and through an OBU the driver is alerted of which zone he/she are in (with a solid light) and in proximity of (with a blinking light).

Sorasen and Lykkja (2012) provides an overview of using GNSS technology for road user charging, including tolling schemes, enforcement regimes and an overview of deployed and planned GNSS tolling systems. Concludes that such systems mostly is considered for heavy goods vehicles. (Schindler) presents in detail the Slovakian tolling system with virtual gantries implemented in Slovakia.

2.3.2.8 Pedestrian assistant system

Several studies suggest using geofence for pedestrian assistant system, particularly for pedestrians with mental disabilities. One empirical study aims at determining a suitable GPS sampling rate for movement of (cognitively impaired) pedestrians. The study suggests to use geofences for "being lost" alerts (Schneider, Zutz, Rehrl, Brunauer, & Gröchenig, 2016). Neven et al. (2017) also investigate how a monitoring tool can support persons with intellectual disabilities when travelling. By using a geofence one can monitor if the user stays within a predefined zone. Architectures and technical tests of such systems are also provided in Tarnauca, Puiu, Nechifor, and Comnac (2013).

2.3.2.9 Fleet management

Aloquili, Elbanna, and Al-Azizi (2009) apply geofencing to an automatic vehicle location tracking system based on real coordinates aiming at increased security and safety to the fleet of vehicles. The study runs a system validation by observing the vehicles' real positions at specific points and comparing this to the tracking system; the accuracy is almost 95%.

Oliveira, Noguez, Costa, Barbosa, and Prado (2013) track cargo and present real-time information about its whereabouts during a travel. Using this information, the study presents an automatic travel management to initialize and finish travels without user interaction. Geofencing is used to control the travel by using a geofence technique called "Route Adherence".

Oliveira, Cardoso, Barbosa, da Costa, and Prado (2015) use geofencing for logistics management. The study suggests a system for automatic delivery management, without any user interaction, as well as a mechanism to detect inconsistencies at real-time. The prototype developed can also monitor detours in planned routes and deals with alarms notifications using mobile devices. Automatic delivery management arguably reduce logistic costs and the cargo safety is increased.

The next study generates an estimated time of arrival system for busses in the city of Chennai in India (Hopfel, 2010). 600 buses were equipped. Pre-defined geofences are used to detect the average speed travelled so far, measure the distance to the next bus stop, take the current traffic condition into account and calculate the assumed time of arrival. The study finds that the estimated time of arrival is predicted with an average deviation of +/- one minute. Information is made available at the bus stop and on a web portal.

Kasture, Gandhi, Gundawar, and Kulkarni (2014) and Nasui, Cernian, Sgarciu, and Carstoiu (2014) presents a system and application where geofences can be defined by the end-user and then notified when a vehicle enters and leaves those areas. Of the two, only Nasui et al. (2014) have an actual developed system. Agustine, Pangaliela, and Pranjoto (2016) design a system where a fleet owner is alerted by vehicles leaving predefined geofences. The owner is, through a microcontroller, given the option to give commands to the vehicle, such as turning of the engine.

2.3.2.10 Preventing auto theft

Tarun and Radhika (2014), Dalai (2013), Bavya and Mohanamurali (2014) and Karim and Singh (2013) proposes to use user defined geofences to alert owner if the vehicle leaves a defined area. However, only the architecture of such a system is presented.

2.3.2.11 Travel behaviour

Bone, Kenbeek, Kato, and Bartruff (2015) used geofencing and a smartphone application to collect data about bus trips in the public transport system in Oregon. Both the technical and user behaviour differences between using an application based on geofencing and a Bluetooth approach are evaluated.

2.3.2.12 Parking

Rinne, Törmä, and Kratinov (2014) presents and demonstrate a parking lot surveillance system using geofence and activity recognition. The application is to give users information of about available parking and mark a parking lot as full if for instance a vehicle drives in and out of the parking lot. If the mobile unites leave by foot, the parking lot is assumed to be non-full.

2.3.3 Summarising the scientific literature

Geofence has been applied to several use cases within the transport sector, and the papers show a large variety in terms of scope. This confirms that the use of geofence has a major potential for supporting a host of different use cases within the transport sector.

Three critical limitations with the current literature should be highlighted: first, a majority of the studies do not present the reader with an explanation of how and why the technology should lead to effects. In terms of implementing new technology, studies that clearly give indications of effects are a necessity, as stakeholders should be reluctant to invest in a large-scale implementation without well-documented effects in terms of user acceptance, increased safety, economic gain etc. If we do not understand why we get the results we do it is also highly problematic to give policy recommendations for real-life implementation. This can lead to poor decisions about technology adoption by policy makers (Dyba, Kitchenham, & Jorgensen, 2005).

The second limitation is that most of the papers is not published. Publication through peer-review often represents an indication of high quality. For instance, peer-review journal publications have a much higher standard for publication than, for instance the ITS-world conference, or the simply uploading a report or note online.

The third limitation with the scientific literature today is that there are few pilots and large-scale implementations. This means that few studies base their conclusions on empirical data that could be expected to be representative for other contexts. Many studies aim at developing concepts where geofences could be used, but very few studies have collected empirical data from real-life experiments.

2.4 Urban Vehicle Access Regulations: Implemented use cases

A host of entry restrictions or access regulations for vehicles already exist in urban areas, where the most common is perhaps pedestrian zones which exist in some form in almost every town. In general, one can divide urban access regulations into three main types of scheme: i) low emission zones where access is regulated in terms of the vehicles emissions, ii) urban road tolls where access is regulated by payment, iii) major access regulation schemes where access is regulated by other requirements. Access regulations can be by vehicle type (e.g. car or lorry), vehicle weight (e.g. over 3,5 tonnes), by type of trip (e.g. delivery), or by driver (e.g. resident).

The European Commission (Ricci, 2017) has developed a report on urban vehicle access regulations. In general, the European Commission divides motivations for adopting such regulations into three main areas:

i) Environmental aims: implementation of low emission zones is an example of addressing environmental goals, where cities decide to regulate vehicle access in order to tackle the vehicles non-compliance with EU air quality limit values for particulate matter and nitrogen dioxide.
ii) Reducing congestions, as in the case of Milan or London, in which the key target is to reduce congestion, improve air quality and urban accessibility and/or to foster the development of alternative transport modes and the use of cleaner and more energy efficient vehicles.
iii) Raising revenues, as in the Norwegian urban tolling system, for which funding road construction from toll revenue has been practice for over 70 years.

The report of the European Commission highlights that there is a general lack of understanding of access regulations, their implementation and their effectiveness (Ricci, 2017). This statement supports our findings from the scientific literature review.

Several European cities have vehicle entry regulations, depending on vehicle emission standards, payment or vehicle type, etc. A description of these can be found on the following page:
http://urbanaccessregulations.eu/ , se also Figure 3

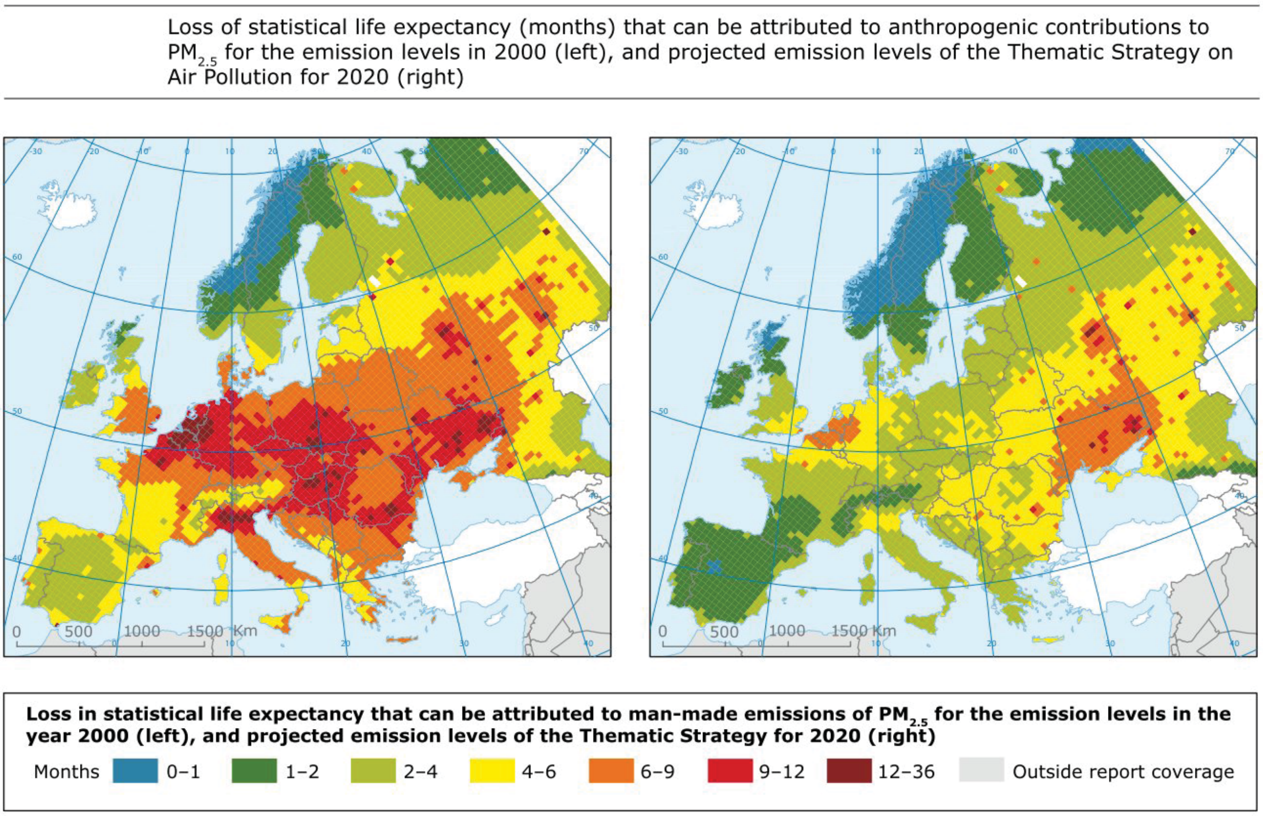

Figure 3: Source: Urban Access Regulations (see http://urbanaccessregulations.eu/low-emission-zones-main)

2.5 Low Emission Zones (LEZ)

Low emissions zone is by far the most common use case (if one does not include pedestrian zones) of urban vehicle access regulations and is therefore given particular focus this memo. Low emissions zones are also particularly relevant from a policy point of view and represent areas — usually within urban areas —with various restrictions on the operation of more polluting, typically older vehicles. Cities and governments have been adopting LEZ as a measure to reduce ambient exposures to air pollution, to meet the EU Air Quality Standards. The EU's air quality directives (2008/50/EC and 2004/107/EC) set pollutant concentrations thresholds that shall not be exceeded in a given period of time. These two Directives provide the current framework for the control of ambient concentrations of air pollution in the EU.

The European Union regulates emissions of GHGs from most vehicle types through European emission standards. European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. The development has consisted of several stages, and the stages are typically referred to as Euro 1, Euro 2, Euro 3, Euro 4, Euro 5 and Euro 6. The aim of Euro emissions standards is to reduce the levels of harmful exhaust emissions, chiefly: Nitrogen oxides (NOx), Carbon monoxide (CO), Hydrocarbons (HC) and Particulate matter (PM). The LEZ are implemented in a variety of different ways. These are reviewed below.

2.6 Low Emission Zones in European cities

2.6.1 The UK

Where: London
When: First phase 2008, second phase from 2019 called the Ultra Low Emission Zone.
Description: Low Emission Zone (LEZ) for heavy diesel vehicles. The LEZ covers most of Greater London and is in operation 24 hours a day, every day of the year. From 8 April 2019 new, tighter emission standards – so-called Ultra Low Emission Zone (ULEZ) standards - will affect petrol and diesel vehicles (including cars) in central London.
Who: Mainly HGV and other vehicles above 3500 kg.
Monitoring system: Automatic Number Plate Reading Cameras (ANPR)
Source: https://tfl.gov.uk/modes/driving/low-emission-zone

Other UK cities: Oxford: LEZ for public transport buses (2014). Brighton: LEZ for public transport buses (2015). Norwich: LEZ for public transport buses. Nottingham: LEZ for public transport buses.

2.6.2 Belgium

Where: Antwerp
When: 2017
Description: the entire city centre of Antwerp and part of Linkeroever are a Low Emission Zone (LEZ). Only Diesel vehicles above Euro 3/III norm and Petrol vehicles above Euro 1/I norm will be allowed to enter the LEZ.
Monitoring system: Automatic Number Plate Reading Cameras (ANPR)
Source: https://www.slimnaarantwerpen.be/en/LEZ

Where: Brussels – capital region
When: 2018
Description: The entire territory of the Brussels-Capital Region is covered by the LEZ (all 19 municipalities), although the Ring (R0) is not affected. A transition period is planned to run the first 8 months of 2018 - during which only warnings will be sent. In 2018, the only vehicles which will not be allowed to drive in Brussels are EURO 1-standard diesel vehicles or vehicles without a EURO standard (pre-Euro standards). A gradual extension is planned.
Monitoring system: Automatic Number Plate Reading Cameras (ANPR)
Source: https://lez.brussels/en

2.6.3 Germany

Where: Berlin
When: 2008
Description: The environmental zone covers the centre of Berlin inside the S-Bahn ring ("Großer Hundekopf"). Only low-emission vehicles are allowed into Berlin's environmental zone in order to reduce air pollution caused by diesel soot (particulate matter) and nitrogen oxides. A green sticker is required in order to drive within the environmental zone.
Monitoring system: Stickers in vehicles
Source: https://www.berlin.de/senuvk/umwelt/luftqualitaet/umweltzone/en/fahrzeug_plakette.shtml

Several German cities have LEZ, and a sticker in the vehicle is required to drive in the LEZ: Dortmund, Dusseldorf, Karlsruhe, Bremen, and several more.

2.6.4 Netherlands

Where: Rotterdam
When: 2016
Description: You are not allowed to enter the LEZ Rotterdam with a van or passenger car on gasoline with a registration date before 1 January 1992. For diesel vehicles a registration of 1 January 2001 applies. From 2018, this environmental requirement for diesel vehicles will be tightened to 1 January 2005.
Monitoring system: Cameras
Source: https://www.cityguiderotterdam.com/travel/getting-there/car-and-motorbike/

Where: Amsterdam
When: Amsterdam introduced a Low Emission Zone for lorries >3.5t on the 9th October 2008. 1 January 2018 Amsterdam has introduced a Low Emission Zone for mopeds, taxis and tour buses.
Description: Lorries >3.5T, delivery vans, mopeds, buses, coaches, camper vans.
Monitoring system: Cameras

2.6.5 Other LEZ in Europe

A summary of other LEZ across Europe can be found on the following page:
http://urbanaccessregulations.eu/

2.6.6 Summarising low emission zones

Low emissions zones are already implemented in several European cities, and the number is increasing as a response to demands of air quality. The most common technical solution is ANPR, except from manual systems based on stickers and tags. However, none of the cities use geofence technology as a tool for implementing low emission zones. This supports the findings made in the scientific literature review where we found that very few of the papers have gathered and analysed empirical data. Geofence technology has so far been on the concept phase within the transport sector.

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3 ITS services and standardization

Trond Foss

This chapter includes an overview of a general ICT architecture using relevant standards, and it describes how the ICT architectures can be designed for the speed zoning pilot and for the emission zone pilot.

3.1 Introduction: ICT architecture

The objective of this memo is to be a starting point for the development of the C-ITS architecture that will be the technical and functional platform for the two pilots in the R&D project GeoSUM[2]. The project will develop and test two ITS services: 1) Air-quality traffic management[3] and 2) Speed control in zones with vulnerable users[4]. The air-quality traffic management will be related to Low Emissions Zones (LEZ) and how to combine geofencing with management of vehicle energy for hybrid cars and how to implement differentiated road user charging for vehicles with different types of vehicle energy, e.g. diesel and electricity. The speed control will be related to automated speed control and information to drivers entering a zone with reduced speed (30 km/h) close to Primary and Lower Secondary schools.

The pilots will be carried through based on two different enterprise, technical and functional approaches. One approach will be based on a solution by the car industry partner Volvo and the other approach will be based on a solution provided by the ITS industry partner Q-Free. The two approaches are to be compared and a crucial prerequisite for the comparison will be that the two approaches are based on the same C-ITS architecture or at least ICT architectures that are comparable. The main purpose and scope of this memo is to establish a template for a C-ITS architecture that could be used by both Volvo and Q-Free.

[2] Geofencing for smart urban mobility
[3] ISO 14813-1 service: Air-quality-based road transport management
[4] ISO 14813-1 service: Variant of the ITS service Automated highway operation

3.2 The four main object in C-ITS

ITS service provision is in most cases supported by C-ITS. By C-ITS is meant a subset of overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems [1].

There are four main objects that are found in almost every C-ITS architecture, see Figure 4. The vehicle and the ITS equipment installed or integrated in the vehicle used by the ITS service user is the first one as C-ITS is very often related to the vehicle. Many ITS services are supported by the Vehicle ITS equipment and the co-operation with other Vehicle ITS equipment, as well as ITS equipment installed along the road infrastructure, in this case the Roadside ITS equipment. ITS services supported by C-ITS also very often include one or more central ITS systems, e.g. traffic management centres (TMCs) and data collection, storage and handling systems, e.g. cloud services. Finally, the ITS service user may have some personal ITS equipment, e.g. a smartphone or tablet, that could be used when benefitting from an ITS service, e.g. traveller information. The User ITS equipment could be connected to a vehicle when the user is inside the vehicle, e.g. a private car or bus, or it could be operating in a stand-alone mode connected to the telecom networks or local wi-fi networks.

Figure 4: The four main objects in C-ITS architecture

The provision of ITS services must be supported by communication services as C-ITS implies communication and co-operation between the objects in the C-ITS infrastructure. Hence, as shown in Figure 5, the four main objects are supported by communication systems. The communication services may vary from short-range communication like DSRC[5], Blue-tooth and Wi-fi to long-range communication like 3G, 4G and future 5G.

Two other types of services are also crucial: security services and geolocation services that are delivered by security systems and geolocation systems, e.g. Global Navigation Satellite Systems (GNSS) like GPS or Galileo and geolocation systems installed on the ground, e.g. location systems installed in 'city valleys' and tunnels.

[5] Dedicated Short Range communication at 5,8 GHz, e.g. used in European tolling systems

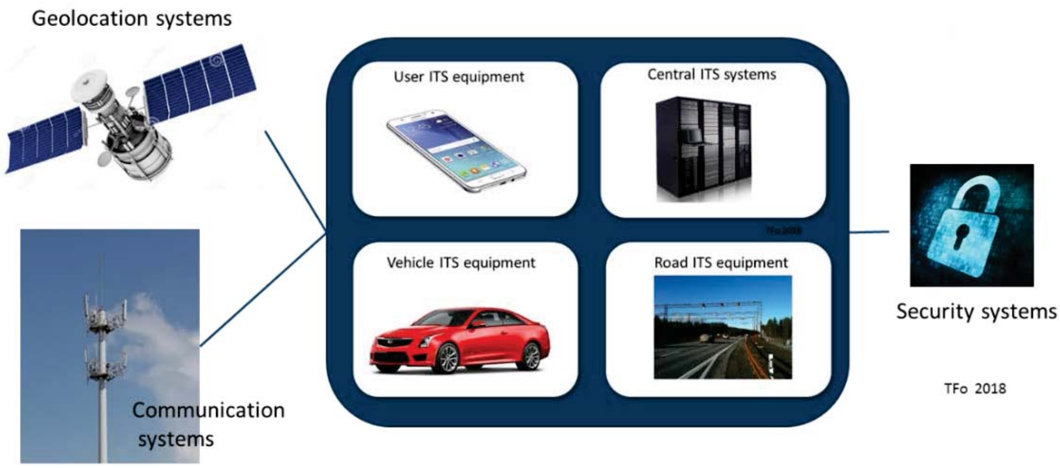

Figure 5: External services supporting ITS service provision

3.3 The four main objects in ISO C-ITS architecture

The four main objects in Figure 4 are defined in [2] where they are called ITS sub-systems, see Figure 6.

The core of each sub-system is the ITS station (ITS-S). The Vehicle ITS-S is connected to external systems like in-vehicle proprietary ICT-systems (CAN bus and Electronic Control Units (ECU)), see Figure 7, and the Roadside ITS-station is connected to roadside sensors, signs and signals. A suite of C-ITS standards defines the communication types, data, messages etc between the ITS stations. The interfaces between the Vehicle ITS stations (V2V) and Vehicle – Roadside stations (V2I) has the highest priority concerning the development of C-ITS standards. The Cooperative Awareness Message (CAM) is a typical example on a very important and standardised C-ITS message communication between vehicles.

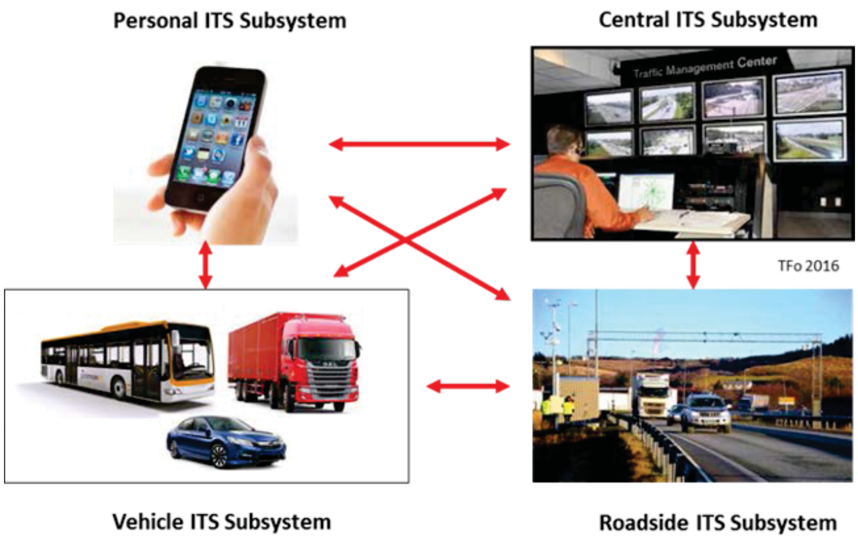

Figure 6: Four ITS sub-systems defined in ISO 21217

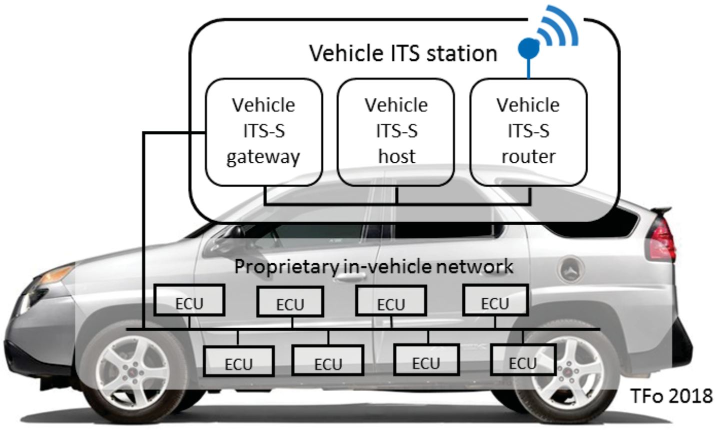

Figure 7: Vehicle ITS sub-system

3.4 Objects and ITS stations in the GeoSUM project

Figure 8 shows two different solutions for supporting the ITS services. The Volvo solution is based on the Volvo integrated C-ITS unit and the Q-Free solution is based on a retrofit Vehicle ITS-station. The Volvo unit will communicate with the Volvo back-office system and the Q-Free Vehicle ITS-station will communicate with the Q-Free Central ITS-station. Both back-office systems will communicate with the back-office system of Norwegian Public Roads Administration that is assumed to be the ITS service provider. The NPRA back-office system includes amongst others the National Road Data Storage (NVDB). The ITS service user will have access to his/her ITS service usage data fulfilling the privacy requirement on users right to access and read personal data.

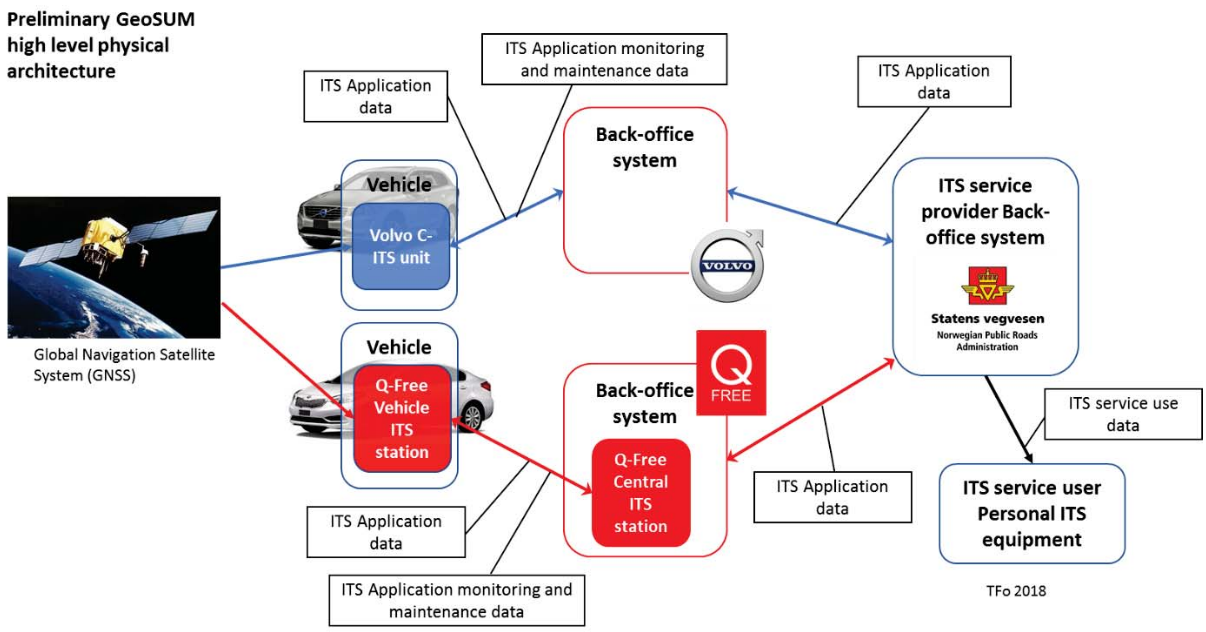

Figure 8: Objects, ITS stations and major information flows

There will be two major sets of information flows (messages):

- *ITS application data* will include the relevant ITS application data, e.g. maps and/or geofence zones, sent from the ITS service provider to the ITS service provider agent. Volvo and Q-Free will be ITS service provider agents as they are acting on behalf of the ITS service provider in providing the ITS service to the ITS service user, which in this case is the vehicle owner and/or driver depending on the service. In the opposite direction there will be ITS service usage data that will include personal data, e.g. vehicle registration number, speed and geolocation data.
- *ITS application monitoring and maintenance data* which will be data needed for the continuous monitoring and maintenance of the two ITS applications. The data flows will not include any personal data.

3.5 References

[1] ISO/TR 17465-1:2014 Intelligent transport systems -- Cooperative ITS -- Part 1: Terms and definitions

[2] ISO 21217:2014 Intelligent transport systems -- Communications access for land mobiles (CALM) -- Architecture

4 Private-public partnership

This chapter maps the roles and responsibilities of the actors involved in the two GeoSUM pilots, as well as the value network for each. We also include a section where we discuss the business and management models for the private and public actors involved in the project.

4.1 Introduction: Roles and value network in GeoSUM

Trond Foss

An ICT system architecture can be described by a set of different viewpoints[6]:

- The *enterprise viewpoint*, which focuses on the purpose, scope and policies for the system. It describes the business requirements and how to meet them. It also describes the roles or stakeholders that are linked and/or related to the use of the ICT system.
- The *information viewpoint*, which focuses on the semantics of the information and the information processing performed.
- The *computational viewpoint*, which enables distribution through functional decomposition on the system into objects which interact at interfaces. It describes the functionality provided by the system and its functional decomposition. A typical example on computational viewpoint in ICT systems supporting the provision of ITS services, are the four ITS sub-domains defined in ISO 21217:2014 Intelligent transport systems.
- The *engineering viewpoint*, which focuses on the mechanisms and functions required to support distributed interactions between objects in the system.

[6] Reference Model of Open Distributed Processing (RM-ODP) is a reference model in computer science, which provides a co-ordinating framework for the standardization of open distributed processing (ODP). See ITU-T Rec. X.901-X.904 and ISO/IEC 10746.

- The *technology viewpoint*, which focuses on the choice of technology of the system.

4.2 The enterprise viewpoint in GeoSUM

4.2.1 Roles related to the ITS service

The enterprise viewpoint is often described by a role and responsibility model. Figure 9 shows a generic role model for the provision of ITS services. The model is based on the ARKTRANS reference framework for ITS (Natvig, M. et al, 2009). In ARKTRANS the whole transport domain has been divided into 5 sub-domains representing groups of roles and responsibilities that are logically linked together either through their responsibilities or their business cases or a combination of both. Some of the sub-domains have further been divided in sub sub-domains. The ARKTRANS role model is related to transport services but the role model in Figure 9 has been transformed to ITS services to better reflect the ITS domain.

The domain called *ITS service demand* covers all roles that define and request ITS services. The domain covers the main role *ITS service user*, i.e. the person, organisation, company or authority that defines the ITS service, benefits from it and if required, pay for the ITS service. In this case it will be the user of the ITS services provided by the GeoSUM pilots, i.e. the driver of the vehicle. The short form often used is just User.

The *ITS service provision domain* covers two roles: the *ITS service manager* and the *ITS service operator*. The ITS service manager is the role that has the interface to the ITS service user including the ITS service description as a response to the ITS service user requirements, implicit or explicit contracts between the ITS service manager and ITS service user and handling of claims and payments for the ITS service. The ITS service manager also has an interface to the role ITS service operator (not shown in Figure 9).

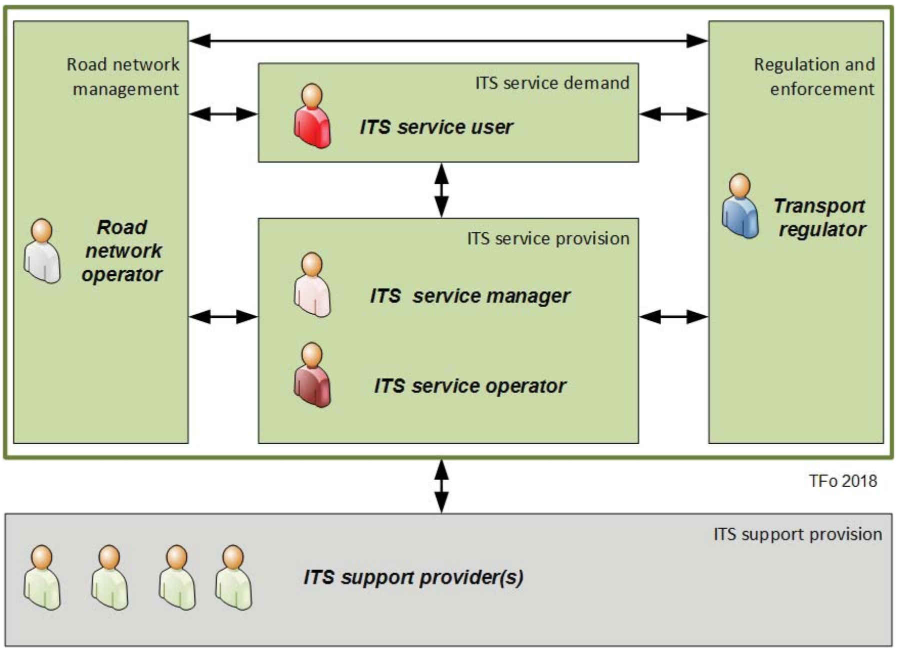

Figure 9: Roles in ITS service provision

The *ITS service operator* is the role that carries out the ITS service and delivers the ITS service to the User. A typical example is Google Maps providing the ITS service Traffic and Road information to drivers or fleet managers. Another example is an app developer providing the traveller on a bus-stop with on-line information about arriving buses. The role ITS service operator has an interface to the ITS service manager that has requested the services offered by the ITS service operator. It has also an interface to the ITS service user that should carry any type of proof that the user has access to the ITS service the user has purchased from the ITS service manager in those cases where the ITS service is not a public one and free of charge. A typical example is an electronic ticket stored on an electronic ticket media where the ticket is the proof of access to public transport.

The three roles ITS service user, ITS service manager and ITS service operator are the core roles in the value network for the provision of ITS services as shown in Figure 10.

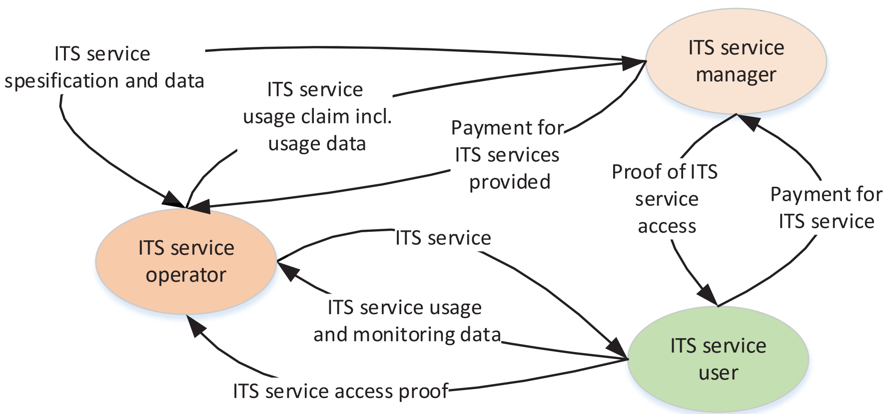

Figure 10: Core roles in ITS service provision

The ITS service user has an implicit or explicit contract with the ITS service manager describing the ITS service that the ITS service user has access to. In some cases, the ITS service is free of charge and in some cases the ITS service user has to pay for it, e.g. a fee for the use of service every time it is used or a subscription valid for 1, 6 or 12 months (value flow: *Payment for ITS service*). In those cases where there is a payment involved, there is a need for the ITS service user to have a proof of access to the service (value flow: *Proof of ITS service access*) enabling the ITS service operator to control the access and to charge the ITS service manager for the ITS service provided. However, in some cases where the ITS service is free of charge there could also be a need for a proof of access just enabling the ITS service operator to check that the ITS service user has the required service rights.

The ITS service manager will forward the ITS service specification to the ITS service operator that will deliver the ITS service (value flow: *ITS service specification and data*).

<u>Example</u>
The road operator (*ITS service manager*) could define a traffic information service to be delivered to the road users based on the data the road operator collects from sensors in his road network. The provision of the service is outsourced to a private company (ITS service operator) providing any road user with an app that supports the road user with on-line traffic information and road status (value flow: *ITS service*).

The ITS service operator provides the ITS service to the user (value flow: *ITS service*) against the ITS service rights (value flow: *ITS service access proof*). The ITS service operator collects the information he needs for the ITS service usage and the monitoring of the service delivery, e.g. functionality and quality (value flow: *ITS service usage and monitoring data*). Based on the delivery of the ITS service, the ITS service operator forwards a claim to the ITS service manager that has the contractual, financial and responsibility relationship with the ITS service user (value flow: *ITS service usage claim incl. usage data*).

The ITS service manager controls the claim, stores the data for his own use and analysis and pay the ITS service operator for the service provided (value flow: *Payment for ITS services provided*).

In many cases the ITS service manager and the ITS service operator are the same legal entity. In that case they will also be called an *ITS service provider*. The Norwegian Public Road Administration (NPRA) is an example on an ITS service provider where NPRA is both the interface to the user concerning the user requirement to the ITS service, e.g. Traffic information, while at the same time being the entity that provides the Traffic information by Variable Message Signs (VMS), webservices and mobile phone apps.

The ITS support provision domain covers roles that provide support services to the roles in the other four sub-domains. A generic name for these roles is ITS support provider. ICT service provider is a typical example, and payment service provider is another typical example. The actors fulfilling the roles will very often have specific names reflecting their services, e.g. Payment service provider (PSP).

The *Regulation and enforcement* domain covers all roles that establishes laws and regulations governing the Intelligent transport systems, publish information about the laws and regulations to the ITS service users and involved actors, collects information about the use of the ITS services and enforce the laws and regulations. A public road administration and Ministry of Transport are typical examples. The role Transport regulator covers all actors involved in the regulation and enforcement of an intelligent transport system, e.g. Data inspectorates.

The *Road network management* covers all roles that manage and operate the road system infrastructure and that controls the road system capacity. The role Road network operator covers all actors involved in the management and operation of a road network. This also includes the responsibility for the implementation and operation of the Roadside ITS equipment.

4.2.2 Controlled zone Manager

The draft standard *ITS – Urban-ITS – 'Controlled zone' management using C-ITS* defines the ITS relevant concept called geofencing. A controlled zone (CZ) is defined as a physical area for which access conditions are applicable. The physical area is described using the standard called *ITS – Co-operative ITS – Local dynamic map*.

The GeoSUM project includes the Controlled Zone access "prohibited for CZ users (vehicle) with given properties". Access is given to the vehicles that fulfil the requirement on vehicle properties, e.g. total weight less than 7,5 tonn. Fulfilling appropriate exemptions may also give access to the zone. In the GeoSUM project there will be the following exemptions:

ITS service: Air-quality traffic management

- A hybrid vehicle can enter and operate within the CZ but only in a 'no emission mode', i.e. in an electric mode
- A fossil-fuelled vehicle can enter and operate within the CZ after having paid a CZ fee

ITS-service: Automatic speed adaption

- A vehicle can enter and operate within the CZ if the vehicle automatically prevents the driver to drive with a speed above the speed limit, in this case 30 km/h.
- In the GeoSUM project a vehicle may also enter and operate within the CZ if the drivers are warned in a secure and appropriate way when approaching the CZ and if the drivers are reminded by the

speed limit in the CZ by audio-visual messages on-board the vehicle in case the driver exceeds the speed limit.

The draft standard *ITS – Urban-ITS – 'Controlled zone'* defines a role called CZ Manager. The main responsibilities of a CZ Manager are to identify a CZ and to achieve control of it. Further, the main responsibilities include disseminating information on existence of its CZs and the related conditions such that potential road users are informed in due time about restrictions to access the CZ. In many cases the CZ Manager and the ITS service provider will be the same legal entity, e.g. a road network operator.

4.3 The value network for the GeoSUM ITS services

Figure 11 shows the high-level value network for the ITS services provided in the GeoSUM project. The value network includes 4 of the roles in Figure 9 and the CZ manager described in 4.2.2. The roles Transport regulator and Road network operator roles are not relevant in the GeoSUM case as their responsibilities are implicit in the responsibilities of the role CZ Manager which in this case is the Norwegian Public Roads Administration (NPRA).

The *ITS service user* will be the driver of the vehicle driving in the controlled zone where one of following ITS services is implemented:

- Air-quality traffic management
- Speed control in zones with vulnerable users

Both services give CZ access to the vehicles fulfilling the CZ access conditions defined in 4.2.2. The services will be provided either to the vehicle itself (controlled vehicle energy source or controlled speed) or via the HMI interface to the driver (information/warnings to the driver). This is why the vehicle and HMI interface are included in the Figure 11.

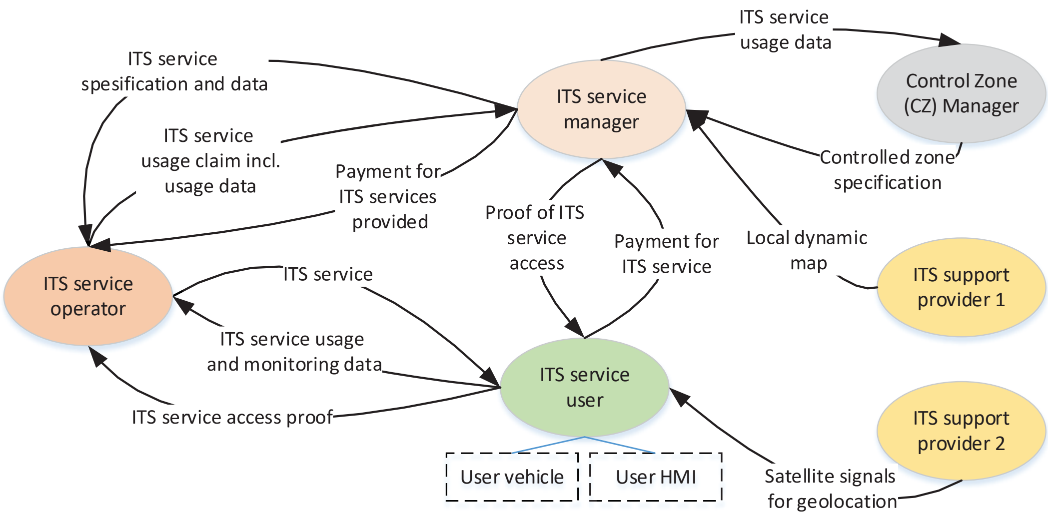

Figure 11: High-level value network for the GeoSUM ITS services

The *Control Zone (CZ) Manager* will define the CZ and its access conditions (Value flow: *Controlled zone specification*). In GeoSUM these will be the access conditions and exemptions described in 4.2.2. and the specification of the CZ area. The CZ access conditions and CZ area data will be provided to the *ITS service manager* who is responsible for the interface to the ITS service user in line with the generic role and responsibilities model described in 4.2.1. In return the CZ manager will receive information about the ITS service usage (Value flow: *ITS service usage data*). The ITS support provider 1 will provide the Local dynamic map (LDM) (value flow: Local dynamic map) to the ITS service manager who will forward the data to the ITS service operator as part of the value flow *ITS specification and data*. The ITS support provider 2 will provide satellite signals needed by the ITS service user equipment to localize the vehicle in relation to the CZ area (value flow: *Satellite signals for geolocation*).

In some cases, the ITS service user has some kind of proof of access to the service as shown in Figure 11. E.g. for a tolled road EFC service this would be a pointer to the contract between the EFC service provider and the user. The pointer (unique ID) will be stored in the On-Board Equipment used for the EFC service and presented to the Toll operator at the charging points. For the services in GeoSUM pilot this is not specified but in a real-life implementation such proof of access could be sent from the vehicle to the ITS service operator who is also in charge of the enforcement of users entering the CZ while violating the CZ access conditions. The proof of access will ensure that ITS service user has access to the CZ, e.g. by opening barriers or not taking and storing pictures of the user (vehicle) for later enforcement. There is also a value flow called Payment for ITS service. In the GeoSUM pilot there will be a virtual fee for the fossil-fuelled vehicle that is allowed to enter and operate within the CZ after having paid a CZ fee.

The *ITS service operator* is the entity that provides the ITS service to the ITS service user. The ITS service operator will receive a specification of the ITS service to be provided. In a real-world implementation of the ITS service there will be a service usage claim from the ITS service operator to the ITS service manager. The claim will also include usage data as a proof of usage of the service. There will be a payment value flow from the ITS service manager to the ITS service operator refunding the proof of usage records that are accepted.

4.4 Introduction: Business and management models

Hanne Seter and Petter Arnesen

Today's traffic management system is not based on a dynamic approach: individual vehicle behavior is not available to the traffic management centers (TMC), and traffic control strategies do not address individual road users. Private actors have an important role in collecting various data and have access to in-vehicle devices. In this view, what happens inside the vehicle is the domain of private actors, while what happens outside the vehicle is the domain of public actors. Today there is little or no exchange of information between these two domains.

To move towards a dynamic traffic management system, one must agree on a set of common interfaces, principles and business models to facilitate the exchange of data between vehicles and the TMCs. A dynamic traffic management system could be a win-win system for all stakeholders: Traffic managers can reduce congestion and emissions and improve traffic management. Road users could avoid congestion, receive more relevant information, and achieve better safety. The private service providers could provide more and better services to their customers.

A dynamic traffic management system is desirable due to the many benefits of the stakeholders, but it also raises many questions. Can road authorities regulate service provision in an open market? Will a dynamic traffic management system override individual's freedom of choice and right to privacy? Why should the road authorities facilitate improvement of quality of services provided by private actors? How can the private actors provide added value to the road authorities, while still enabling competing business models?

This note is a part of the research project GeoSUM and contributes to mapping the public and private actors' expectations and responsibilities when cooperating on ITS[7]-services. The note summarizes and discusses the main findings after the initial data collection on roles, business- and management models.

4.4.1 Methods

We based our data collection on in-depth qualitative interviews. We conducted semi-structured interviews to acquire in-depth knowledge of how the private and public actors perceive their role and responsibilities when developing ITS-services, and how business and management models can be developed. We conducted four interviews, two with representatives from Volvo and Q-Free, and two with the NPRA. Semi-structured interviews were the preferred method of initial data collection since there is not much pre-existing knowledge on the issue. The information collected from interviews is suited for answering the main subjects because we are interested in the subjective opinions of the respondents, or their lived experiences (Tjora, 2010). Although the opinions of the respondents are to some extent subjective, for simplicity we have written the analysis as though the information represent their employer. We recognize that this may not always be true, although we believe that the respondents chosen in this study holds position within their organization that makes them capable of representing their organization and not just their subjective opinion. In addition, the information gathered through the interviews is supplemented with relevant literature and other documents. We developed an interview guide that revolved around our two main subjects concerning i) roles and responsibilities, and ii) business and management models. We based our selection of respondents on a strategic selection where the companies and organizations themselves appointed the most suited candidates based on the main topics in the interview guide.

4.4.2 Norwegian Public Roads Administration (NPRA)

The overarching goal of the NPRA is to meet policy objectives: the population should receive the main benefits of the implementation. The NPRA is the authority and regulating body within the road transport system. NPRA has the overarching responsibility for environment and climate, safety and efficiency within the road transport sector, as stated in the National Transport Plan (Samferdselsdepartementet, 2016-2017). If the NPRA decides to use geofencing as a tool, this could for instance help achieving goals reducing greenhouse gas emissions levels. It is important that the selected use cases are the use cases that gives most benefit. For the NPRA it is important that benefit and societal impact is the goal of any pilot, not just testing technology.

Several questions arise during the interviews concerning the role and responsibilities of the NPRA in a world where digitalization and automation are emerging. One major question concerns NPRAs role as a regulating body in the digitalized transport sector. These questions are currently receiving much attention in the NPRA, for instance in the 2018 ITS strategy (Vegdirektoratet, 2018), but it is an ongoing discussion with many unresolved issues. In the ITS strategy it is stated that "the NPRA shall be a leading actor in developing legislation, regulations and guidance for ITS". On the one side, being a regulating body is a familiar role for the NPRA, but in the interviews it is stated that the new technology and digitalization is challenging the familiar role. Technology is particularly challenging because it develops rapidly, which requires the NPRA to change faster than what has been necessary in the past. However, technology is enabling a wide variety of new and powerful solutions which makes these changes potentially very useful for the society at large. The technology forces the NPRA to reevaluate their role as a regulating body and brings forward normative questions concerning what role the NPRA *should* have as a public administrative unit?

Another major question about the consequences of new technology concerns data. In the past the NPRA collected its own data, and there were not many alternatives in terms of suppliers of data. Today a host of

[7] Intelligent Transport System

actors are collecting data, including car manufacturers, navigation system suppliers, telecom operators and specialized service providers. Data from Volvo and Q-Free are examples here. Furthermore, to enjoy the full benefits of these data they would have to be combined. This introduces questions concerning who owns which data, who has the right to access the various kinds of data, and requirements concerning data amount and quality. This major challenge is also identified by the SOCRATES project (Koller-Matschke, 2018). In the ITS strategy the NPRA states that "the NPRA shall be a professional owner and distributor of digital road- and traffic data" (Vegdirektoratet, 2018). But how should this be organized?

The discussions within the NPRA concerning data also include discussions with other regulatory bodies, such as clarifying the responsibilities with the Norwegian Communications Authority. Who will be responsible for the digital infrastructure? Who shall develop, manage and maintain the digital infrastructure? Another example is that within cities there are many different bodies of authority that could have responsibility for transport. There is a strong need for a system that is based on standards. If everybody uses their separate systems, the benefit will be harder to realize. Such issues are currently unresolved, as well as many other questions concerning responsibilities in a digitalized transport system.

Piloting new technology is an important instrument for the NPRA, a point that is also brought forward by the ITS strategy. A major challenge is that pilots are usually much less complicated to set up than real-life implementation is. For the NPRA it is important that the pilots are run in development stages, and that the final stage is as close as possible to real-life implementation. This includes that both the public and the private actors in the end need to experience benefits from the technology being piloted. This is necessary to ensure real-life implementation. The NPRA to some extent has a role in facilitating so that private actors can experience business opportunities, this is particularly relevant for organizing pilots. It is not enough for the NPRA to be a part of a pilot and then hope that the technology will be used when the pilot is over. Another important aspect for pilots is knowledge about the impacts of the technology: "Before one can move on to implementation it is critical to have documentation of the impacts from the pilots". The NPRA as the authority on road transport must know that the technology in the pilot gives the desired societal impacts.

Even though the NPRA is open for more facilitation and cooperation with private actors, they do not believe that developing technology is a responsibility for themselves. This means that the vehicle and the ITS equipment installed or integrated in the vehicle by the ITS service user is not a responsibility of the NPRA. Still, the NPRA highlights in the interviews that it is crucial that they have knowledge about technologies. As a buyer of technology and being the actor that develops the technical requirements, they must have knowledge about how the technology works and how the ITS service should be implemented in real-life. This requires the NPRA to be a capable counterpart. To meet this new demand, the NPRA need to develop competence concerning digitalization that before has been outside their scope. Competence on digitalization therefore needs to be more integrated in the various departments than before. Another aspect is that the NPRA could be better at using the innovative procurement regulations that are more concerned with communication and cooperation. On this area it is possible for the NPRA to be more offensive.

The Directorate is responsible for involvement of the various departments within its own organization. One challenge with the GeoSUM project is that the project is interesting for many of the departments within the Directorate. The various departments have different use cases that might be interesting for geofence technology, use cases that are not necessarily a part of the GeoSUM project. Informing all relevant departments is therefore important to identify new use cases where the geofence technology could be a part of the solution. The pilot on speed limits exemplifies a subject that could be interesting for many different departments within the NPRA.

Even though geofencing is interesting for many departments within the Directorate, possible local authorities, or others, it is likely that the Directorate will be the institution responsible for at least some aspects of the digital infrastructure, exemplified here by the Norwegian Road Data Bank (NVDB) that today have the responsibility of digital road. This responsibility should continue to be administrated by the national authority, because the digital infrastructure cannot have local variations. In comparison, some local variations can be and is accepted with the physical infrastructure today. This could mean that when C-ITS and digitalization continue to develop, the NPRA must be organized in a different way than what it is today.

4.4.3 Q-Free and Volvo

An important responsibility that is brought forward in the interviews by the private actors is the execution of the pilots: Q-Free states that they "have a large responsibility in the project for planning, facilitating and carrying out the two pilots." With 35 years of experience from tolling Q-Free has relevant experiences that can be employed also to other use cases. The tolling platform can be used to develop innovations and new collaborations. Volvo also highlight their responsibility in the GeoSUM project for the pilots, and particularly for testing the integrated technology in the vehicle. At the same time, they also highlight the collaboration with Q-Free and the retrofit-solution. Traditionally there has not been much cooperation between car manufacturers and suppliers of ITS-stations. Both are however providing and receiving data and it is therefore interesting to cooperate. One could envision a recent future where vehicles that are not equipped with connectivity can be provided with an ITS-station. It is important that the project tests how well these two solutions work in real life. To meet the expectations of the road authorities it is important also to think one step further than the pilots.

Particularly important for the private actors are discussions concerning data, and the necessary interface for exchange of data. Previously, collaborations between the car industry and suppliers of ITS-stations have been few, although Q-Free has had collaborations with both Volvo and Tesla before. The private actors should together be responsible for "ensuring proper data quality, and relevant data." The development of C-ITS is at an early stage, and so far, the focus for the private actors has been developing the technology. Now the focus is turning to how the data from the car and the ITS-station will interact with other types of data and with this create new opportunities. Data quality and data sharing is highlighted as an important aspect that the GeoSUM project should help address because this is a problematic aspect today. This is not surprising since solving such issues requires cooperation with other private actors, as well as public actors. The public actors provide some important framework conditions for the private actors such as national legislation and regulations, as well as European legislation and standards. However, lack of accessible data and lack of standardization of data are also highlighted as main barriers in the SOCRATES project (Koller-Matschke, 2018).

When the private actors are dependent on public actors and framework conditions, it becomes clear that implementation of the services depends heavily on what happens in terms of regulation and legislation. "Legislation ensures that the whole industry must follow the same rules." Standardization is in this way particularly important to even out the playing field. Standardization could be an enabler of implementation since standards set requirements for the technological system, giving the private actors guidelines on how the technology should be developed and used.

A cooperation between the car industry and suppliers of ITS-stations is also important because one must ensure that the two technological solutions are well suited for the end user. Even though the two private actors might be competitors in the same market, it is perhaps more likely that the future of ITS will include a co-existence of many different technologies and actors. Within the GeoSUM project one can discuss different solutions and perhaps also discuss APIs and interface for sharing data. Many technical components are so-called "ready for C-ITS", but this requires the components to co-exist and be interoperable with other devices. Traditionally, interoperability between devices is problematic for instance due to the difficulties of sharing data.

A critical factor for succeeding with cooperation is trust, which often requires the actors to cooperate over a longer period. This statement is also supported by the literature on private-public partnership (PPP) which highlights that trust is a vital determinant of value creation in uncertain situations as it entails a level of faith in the trustworthiness of the other party (Chung & Hensher, 2018). For Volvo the triple helix cooperation is a rather new type of cooperation. However, they believe that the development of C-ITS requires more cooperation and more involvement with the authorities. The EU-project Nordic Way was important for documenting what is possible from a technical point of view. GeoSUM will go one step further and investigate what steps needs to be taken to make this work in real-life. In a new market a valuable approach is developing solutions together with customers. From a commercial side this approach ensures that the customer is pleased, but it also increases the societal benefits. If one develops a great product, but it is not possible to mass-produce, and no one is interested in buying the product, then the great product is no good. When developing solutions together with the customer this increases the quality of the requirements specification.

Turning to the issue of business models, geofencing is a technology that could be a part of several use cases. Q-Free is explicit on that the future will require new business models. Furthermore, one can see that new actors are emerging in the market. Technology is developing more rapidly than before, and is no longer the main obstacle. Today the focus is turning toward developing services, while there is less focus on developing software and hardware. According to the SOCRATES project a barrier to realization of dynamic traffic management is that there is no clear return of investment for actors (Koller-Matschke, 2018). Any investments of technical infrastructure and provision of data and information need an economic justification. Even though both Volvo and Q-Free has clear visions about developing business areas where they use the geofence technology, they do at some point in time have to justify their investment in terms of economic returns.

4.4.4 Highlights

Both the public and private actors of GeoSUM highlights the importance of testing new technology through pilots. The NPRA are clear on their role in terms of not developing technology, but rather focus on facilitation and arrangement of possibilities for private actors to make profitable markets within ITS. The private actors agree on this setup and highlights their need for the NPRA to set legislation so that the framework conditions on which they develop their business within are clear and fair. There is also a strong need for standardization.

Geofencing is seen to be a technology of great potential, both for achieving societal benefits and for creating new markets, however many prerequisites, such as data sharing, legislation, return of investment and privacy, must still be defined and resolved before obtaining a sustainable system for dynamic traffic management. For the GeoSUM project it is important to start to address some of these unresolved issues, particularly in terms of data sharing.

4.5 References

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5 Privacy

Trond Foss

This chapter includes an overview of the main challenges concerning privacy and the main principles guiding the processing of person data.

5.1 Introduction: Privacy

The purpose of the memo is to describe the privacy challenges following the two ITS services that will be piloted in the project. The challenges will further be used for defining measures that will reduce the privacy risk level to an acceptable level and ensure that the collection and processing of personal data is according to the General Data Protection Regulation (GDPR) [1].

5.2 Definitions

In this memo the following definitions apply:

Term	Definition
Data controller	The natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data [1].
Data processor	The natural or legal person, public authority, agency or other body which process personal data on behalf of the controller [1].
Personal data	Any information relating to an identified or identifiable natural person (data subject); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person [1].
Processing	Any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaption or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction [1].

5.3 Principles relating to the processing of personal data in GeoSUM

5.3.1 Introduction

The GDPR *Article 5 Principles relating to processing of personal data*, [1], states six principles that shall be the basis for the processing of personal data:

- Lawfulness, fairness and transparency
- Specified, explicit and legitimate purposes, 'purpose limitation'

- Adequate, relevant and limited, 'data minimisation'
- Accurate and kept up to date, 'accuracy'
- Storage of data is limited in time, 'storage limitation'
- Security, i.e. confidentiality and integrity

The six principles are addressed in the following text.

5.3.2 Lawfulness, fairness and transparency

The two ITS services that will be piloted in the project are both based on collection and processing of geolocation data and vehicle related data that are considered as personal data. The GDPR, Article 6 Lawfulness of processing, requires that the processing shall be lawful only if and to the extent that at least one of six requirements is fulfilled. The following applies for the GeoSUM project ITS services:

- *Consent*. The data subjects involved in the project will give their consent to the processing of their personal data for the purposes defined in the ITS services. The data subject is in this case the owner of the vehicle and the consent will also include an obligation for the owner to inform any other driver of the vehicle that personal data are collected and processed.
- *Public interest task*. The collection and processing of personal data is necessary for the ITS services provided by the transport authorities in their responsibilities and tasks related to safe and environmental friendly traffic management in cities.

The term fairness is not defined in GDPR and only used once in the regulation. However, in case of the ITS services there will always be a fair handling of the ITS service users concerning data collection and processing. All users will be handled equally with no exceptions, e.g. no exceptions due to vehicle type or vehicle owner.

The principle of transparency will be followed in the ITS services. The ITS service users will have an easy access to the data collected in a way that enables the users to easily understand which data that are collected, how they are processed and why they are processed. The access will also enable the user to control that they are handled in a fair way.

Privacy requirements

System and pilot requirements following the principle of lawfulness, fairness and transparency are:

Privacy req. [1]: The vehicle owner and vehicle user(s) shall give their consent to the processing of personal data used in the pilot.

Privacy req. [2]: Any user of the ITS service, e.g. the vehicle owner and vehicle user(s) shall have an easy access to the data that are processed enabling them to monitor which data that are collected and how they are processed.

5.3.3 Specified, explicit and legitimate purposes (purpose limitation)

The Road network operator will in most cases be the provider of the ITS service related to Automatic speed adaption. This implies that the road network operator will specify the purpose of the ITS service and the personal data processed as part of the ITS service provision. The road network operator will then per definition be the data controller.

For the ITS service related to road user charging it is not so evident who will be the ITS service provider. Ordinary tolling of Norwegian roads is performed by toll companies and the road network operator (Norwegian Public Roads administration) is just involved as the owner of the roadside systems and responsible for the operation of the national toll collection central system. An assumption concerning road user charging is that the Norwegian Public Roads Administration (NPRA) will not be the provider of the ITS service but it will act as a transport regulator.

Concerning the pilots, the assumption so far is that the Norwegian Public Roads administration (NPRA) will be the data collector and ensure that the data collected and processed will not be processed for other purposes other than archiving, scientific research or statistical purposes without violating the initial purpose defined in the ITS services.

The role and responsibility model to be developed will also include a final decision on who will be the data controller. This could be other authorities or organisations than NPRA both for the pilot and the permanent solution.

Privacy requirements

System and pilot requirements following the principle of purpose limitation are:

Privacy req. [3]: The Norwegian Public Roads Administration shall as the provider of the ITS services in the pilots ensure that the data collected and processed are limited to the purpose of the pilots and nothing more.

Privacy req. [4]: The Norwegian Public Roads Administration shall as the data collector for the ITS services in the pilots enter into agreements with the data processors, i.e. Volvo and Q-Free, ensuring that the purpose limitation principle is adhered to by the data processors.

5.3.4 Adequate, relevant and limited (data minimisation)

The NPRA, being the data controller for the ITS services, will ensure that the personal data collected and processed will minimised. Only adequate and relevant data will be collected and processed, and the data will clearly be limited to those really needed for the ITS services and scientific research. The data controller will look for technical and administrative solutions that favours the requirements related to adequacy, relevance and limitation.

Privacy requirements

System and pilot requirements following the principle of data minimisation are:

Privacy req. [5]: The Norwegian Public Roads Administration shall as the provider of the ITS services in the pilots ensure that the data collected and processed are clearly limited to those really needed for the ITS services and scientific research.

Privacy req. [6]: The Norwegian Public Roads Administration shall, as the data collector for the ITS services in the pilots, enter into agreements with the data processors, i.e. Volvo and Q-Free, ensuring that the data minimisation principle is adhered to by the data processors.

5.3.5 Accurate and kept up to date (accuracy)

The accuracy of the personal data collected, first of all the geolocation data, is important to ensure a fair handling of the ITS service users. Inaccuracy may lead to that an ITS service user is not informed about the low speed limit or that he is incorrectly charged for driving in a low emission zone being outside the zone. The project will provide measures and controls confirming that the ITS applications supporting the ITS services are functioning properly and that the geolocation data and other relevant personal data are accurate and available when requested by the ITS application.

Privacy requirements

System and pilot requirements following the principle of accuracy are:

Privacy req. [7]: The ITS applications supporting the ITS services shall ensure by quality assurance and monitoring that the application itself and the data used are accurate avoiding that the ITS service users are not:
- unintentionally violating the traffic regulations being the legal background for the ITS services
- charged for a higher fee in the Low emission zones than due

5.3.6 Storage limitation

The requirements for the ITS applications supporting the ITS services will be designed to delete all personal data as soon as they have been processed for the purpose of the ITS service, and as soon as the scientific research in the project has either finished the immediate processing or the data has been anonymised for later processing.

Privacy requirements

System and pilot requirements following the principle of storage limitation are:

Privacy req. [8]: The ITS applications allocated to the different ITS equipment and/or external data storage(s) shall delete all personal data as soon as the data have served their purpose, e.g. calculated the Low emission zone fee or has been anonymised for scientific research.

5.3.7 Security (integrity and confidentiality)

The data controller will specify security measures and mechanisms to protect the personal data against unauthorised access (confidentiality). This goes for both the different objects and ITS stations collecting, storing and processing data and the cable and air interfaces between the objects and ITS stations. The data controller will also specify security measures and mechanisms safeguarding the integrity of the data transferred between the ITS equipment/other ICT objects.

Privacy requirements

System and pilot requirements following the principle of security are:

Privacy req. [9]: The Norwegian Public Roads Administration shall, as the data collector for the ITS services in the pilots, specify security measures and mechanisms ensuring unauthorised access to personal data.

Privacy req. [10]: The Norwegian Public Roads Administration shall, as the data collector for the ITS services in the pilots, specify security measure and mechanisms ensuring the integrity of messages between ITS equipment/other ICT objects.

Privacy req. [11]: All project partners responsible for or operating any part of the ICT systems and services supporting the ITS services in the pilots, shall comply with the security measures and mechanisms specified in Privacy req. [9]: and Privacy req. [10]:.

5.4 Objects and ITS stations in the GeoSUM project

Personal data will be collected, stored and processed in the objects and ITS stations supporting the ITS services, ref. Figure . Personal data will also be communicated between these objects and ITS stations. An overview of the objects, ITS stations and interfaces are shown in Figure . The figure covers both types of implementation, i.e. vehicles with built-in C-ITS from factory and vehicle with a refitted ITS station. The design and the specification of the pilots will elaborate the physical architecture shown in Figure down to a more detailed level.

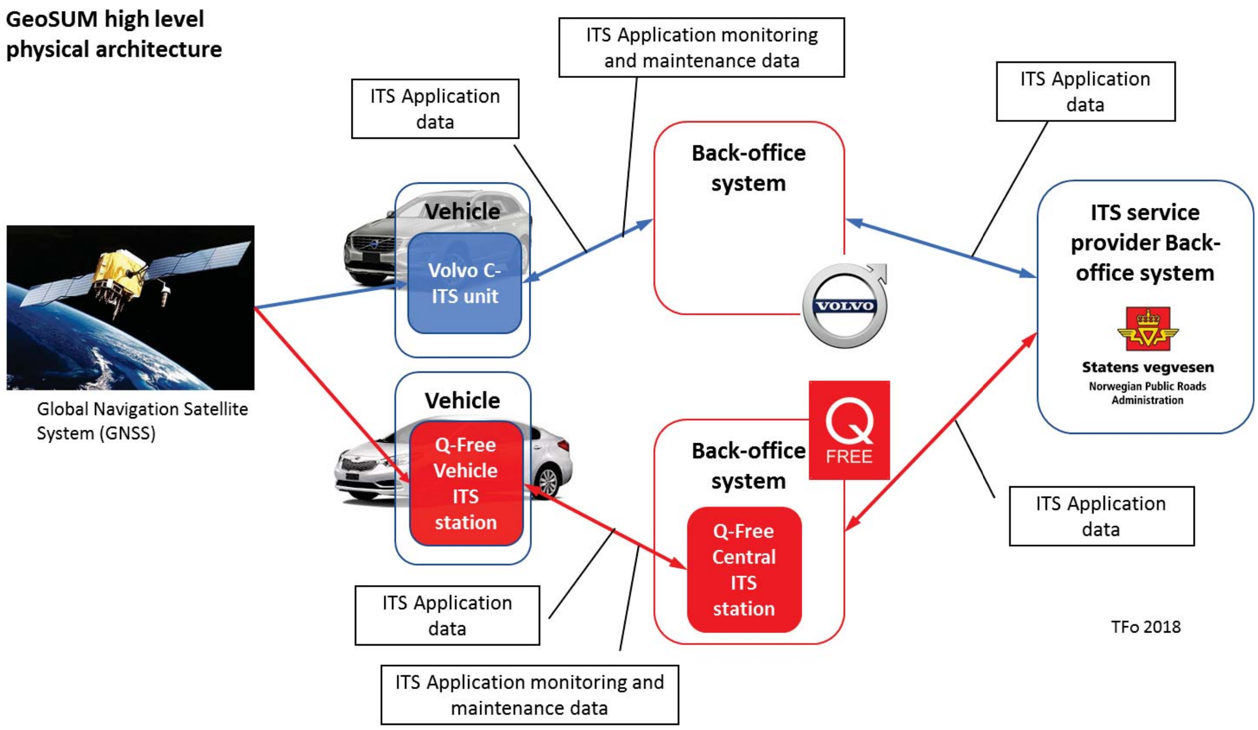

Figure 19: Objects, ITS stations and major information flows

Figure shows two different solutions for supporting the ITS services. The Volvo solution is based on the Volvo integrated C-ITS unit and the Q-Free solution is based on a retrofit Vehicle ITS-station. The Volvo unit will communicate with Volvo back-office system and the Q-Free Vehicle ITS-station will communicate with the Q-Free Central ITS-station. Both back-office systems will communicate with the back-office system of Norwegian Public Roads Administration that is assumed to be the ITS service provider. The NPRA back-office system includes amongst others the National Road Data Storage (NVDB).
There will be two major sets of information flows (messages):

- *ITS application data* will include the relevant ITS application data, e.g. maps and/or geofence zones, sent from the ITS service provider to the ITS service provider agent. Volvo and Q-Free will be ITS service provider agents as they are acting on behalf of the ITS service provider in providing the ITS service to the ITS service user, which in this case is the vehicle owner and/or driver depending on the service. In the opposite direction there will be ITS service usage data that will include personal data, e.g. vehicle registration number, speed and geolocation data.
- *ITS application monitoring and maintenance data* which will be data needed for the continuous monitoring and maintenance of the two ITS applications. The data flows will not include any personal data.

5.5 Differentiated road usage fee in low emissions zones

The differentiated road usage fee shall reflect the vehicle emission characteristics. Electric vehicles will for instance not pay for entering the low emission zone while a diesel vehicle will pay a fee that may be linked to the pollution level in the low emission zone or at least the emission characteristics as defined in EU emission standards.
There are two main principles for calculating the fee:

- *Central processing*. All the ITS application data are collected from the vehicle, and possibly from roadside equipment like air quality monitoring stations and sent to the back-office system of the ITS service provider for calculating the fee. The application data will include personal data. This principle is called the Thin client approach in [4].

- *Local processing*. The calculation of the low emission zone fee is calculated by the in-vehicle equipment, in this case the Volvo C-ITS unit and the Q-Free ITS station. Only the calculated fee is sent to the ITS service provider for settlement with the ITS service user. The data used for the calculation has to be stored in the vehicle equipment for later use in case of later controls, e.g. in case of repudiation of ITS service usage. The application data sent from the vehicle equipment will not include personal data, only a unique identifier, e.g. a reference to a customer register, and the fee to be paid. Anyone able to access the message from the vehicle to ITS service provider, will only see the value of the fee and the identifier. However, more personal data has to be stored and protected in the vehicle equipment compared to the central processing where some of the personal data, e.g. geolocation data, could be deleted shortly after confirmed and verified transfer to the central system. The principle is called Smart client approach in [4].

The diverse ways of calculating the fee has also different impacts on the processing of personal data. Central processing is assumed to cause more privacy challenges than the local processing [4]. The principles applied for the two pilots will be decided upon in the design and specification of the pilots.

The Norwegian Data Inspectorate (Datatilsynet) has given a clear recommendation that the Local processing is the preferred method for fee calculation avoiding the transfer of personal data to the central systems for processing and storage. Local processing has been a clear prerequisite from several major stakeholders.

The recommendation from the Data Inspectorate implies that local processing should be implemented as early as possible in the development and introduction of Low Emission Zone fee charging and should be the final solution when the ITS service is introduced in real-life systems.

5.6 Privacy challenges

5.6.1 Introduction

The Article 29 Data protection working party has given their opinion to the work done by the C-ITS platform on privacy [2]. Also, the International Working group on Data protection in Telecommunications (IWGDPT) has published an article on Connected vehicles [3]. A third reference is the IWGDPT report on and guidance on Road Pricing [4]. All three references have addressed the risks that are related to privacy and connected vehicles. Many of the risks identified are also relevant for the GeoSUM applications and they should be handled in an appropriate way in the solutions developed and implemented by the project partners. Privacy by design is maybe the most important and effective measure to handle privacy risks. Hence, the privacy issues are raised at the very beginning of the project enabling the industry partners (ITS service provider agents) and the road administration (ITS service provider) to take privacy into account in the further development of the ITS service pilots.

5.6.2 Lack of transparency

Information about the personal data collected and processed will in most cases be given to the vehicle owner. Other users of the vehicle may not receive the same information as there is no guarantee that the owner will inform other users, e.g. users of rental cars or vehicles in car-sharing pools. This type of ITS service users will benefit from the service without knowing which personal data that are collected and processed. Even the owner of the vehicle may not be aware of the complete chain of information flows of personal data unless the ITS service provider has informed the ITS service user about any external entities or third parties involved in the processing. A person using a car within a low emission zone may know that the registration number and the geolocation number are collected and processed by the ITS service provider, but he may not know that the personal data are processed by the car producer or retailer or the vehicle equipment supplier before the data are forwarded to the ITS service provider.

5.6.3 Unlawful processing

The ITS service provider will in the GeoSUM project have a legal basis for the processing of personal data as described in 6.3.2. However, personal data will also pass through other involved actors in the project and some of the data could be very useful for these actors, e.g. the development of other ITS services or the development of typical driver profiles. The actors in this project are to be trusted, but if the solutions developed in this project should be generic and transferable to other projects steps should be taken to ensure that unlawful processing is avoided.

5.6.4 Unauthorised secondary use

The personal data processed by the involved actors in the ITS service value network might be used and/or sold to other parties that are willing to pay for this type of information. For instance, the speeds collected and linked to a vehicle in a zone with reduced speed limits could for instance be a value for insurance companies or employers wanting to monitor the drivers in a vehicle fleet. This type of information could also be collected by external parties, e.g. by using equipment installed in the reduced speed zone eavesdropping the wireless communication between the vehicle equipment and the back-office system and at the same time collecting the vehicle registration number.

5.6.5 Excessive collection of personal data

It is a rather strong principle that data minimalization should always be the basis for all personal data processing. This implies that only data really needed for the purpose that the ITS service user has given his/her consent to, should be collected and processed. For the low emission zone, it could be very interesting for a traffic manager to track a vehicle inside the zone but tracking inside the zone is not needed for the ITS service. Continuously processing geolocation data would be outside the scope for the ITS service and unlawful. The vehicle will of course keep its own track by the vehicle geolocation sensor to monitor whether it is inside or outside the geofencing. However, there is no need for the vehicle to transmit this information to others outside the car. It should only transmit its geolocation data when entering or leaving the zone unless there could be a need from scientific research point of view to collect the tracking data .

Another similar example is collecting personal data from vehicles inside the zone with reduced speed limit. The ITS service shall give the driver a message that the speed limit is reduced and/or even take control over the vehicle and reduce the speed down to the permitted speed limit. In the first case when the driver only gets a message, it could be very interesting from an enforcement viewpoint to collect the actual speeds related to the individual drivers. However, this would be outside the scope of the ITS service and unlawful. From a scientific research point of view, it seems very relevant to collect the speeds registered by the vehicles to evaluate the impact of the ITS service, but the speed data should be clearly separated from the other personal data collected disabling any relationship between the driver (or vehicle) data and the speeds.

5.6.6 Lack of control

A vehicle may have several owners and several drivers. It should not be possible for an owner or a driver to access the data collected by previous owners and drivers. This is also very relevant for leased or rented vehicles. An owner or user should be able to delete his/her personal data when the vehicle has been used but it is currently not possible, or very difficult to erase or back up the data [3]. This challenge is also relevant in the GeoSUM project, e.g. for users driving in one of the two zones controlled by geofencing. This could be occasionally drivers like people renting a car or taking part in car-sharing pools. The operator of the renting or car-sharing may have access to the personal data collected and processed while the drivers are unable to control and possibly delete the personal data collected. The drivers may even not be aware of the processing of the personal data nor being able to object to the processing of the data.

5.6.7 Inaccurate security

There are several examples on how hackers have connected to vehicles and taken over the control of the vehicle. The channels used by the hackers are often through the same channels as used by remote controllers and mobile phone apps providing the user of the vehicle with a user-friendly interface. The hackers could use the same channels for collecting personal data, e.g. geolocation data, and later use the data for unlawful activities, e.g. extortion attempts. The hacker could also use access to the personal data for tampering with the data, e.g. change the information (lack of integrity) or delete the information (lack of availability). For the ITS service related to payment for the low emission zone the tampering could for instance imply that the user paid a fee that was not in line what he/her should pay or even pay nothing and being enforced for that. For the ITS service on reduced speed limit the tampering of the geolocation data could for instance imply that the user was not warned about the reduced speed or that the vehicle was not controlled to keep to the permitted speed limit. This could cause that the driver was subject to pay a fee for overspeeding or even being disqualified for driving for a certain period. The manipulation of the geolocation data could also in worst case lead to accidents with fatal consequences.
The general principles of confidentiality, integrity and availability should carefully be considered in the GeoSUM project even if it is a limited number of vehicles and drivers involved. The challenges should be addressed and possibly solved now, while the impacts are under control due to small and very controlled pilots, and not later in a full-scale implementation.

5.6.8 Lack of accountability

Personal data will be subject to processing by several data processors in a value chain. The awareness of the different data processors processing the personal data may differ depending on where in the value chain they are. Data processors close to the ITS service users may have a higher level of awareness than the data processors that are upstream in the value chain. It may also be unclear who in the value chain that owns the personal data, who is the data controller, and who is a data processor. The lack of accountability may cause that personal data are handled unlawfully, not necessarily in a deliberate way, but just because of the unclear distribution of roles and responsibilities.

5.7 Personal data in GeoSUM

Before the ITS services have been designed and specified in detail it is not clear which personal data that will be necessary to use in the ITS services to be piloted in the GeoSUM project. So far, the following personal data are candidates:

- *Vehicle Identification number (VIN)* enabling the identification of the vehicle and its owner
- *Licence Plate Number (LPN)* enabling the identification of the vehicle and its owner
- *Any other unique ID* identifying either the vehicle, the owner or the driver, e.g. by identifying a mobile phone and its owner or identifying the user of a mobile phone app required for the ITS service
- *Geolocation data* enabling the determination of the vehicle position at any time. The geolocation data will as a minimum include the timestamp of the GPS signal[8] and the geographical position (longitude and latitude values). The geolocation data may also include some more vehicle related data like:
    - *Vehicle speed* describing the behaviour of the driver
    - *Vehicle acceleration/deacceleration* describing the behaviour of the driver

Two other crucial data types that are needed for the ITS services, but not necessarily being a privacy risk, are the vehicle type and type of energy used by the vehicle. Even the Euro class, e.g. Euro V, could be of interest for the fee calculation in Low Emission zones.

[8] And possibly the vehicle equipment time when the geolocation data is transmitted to the central system

5.8 References

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

[2] *Opinion 03/2017 on Processing personal data in the context of Cooperative Intelligent Transport System (C-ITS),* Article 29 Data Protection working party, October 4, 2017

[3] *Connected vehicles*, International Working Group on Data Protection in Telecommunications (IWGDPT), 63rd meeting April 2018, Budapest, Hungary

[4] *Report and Guidance on Road Pricing – "Sofia Memorandum",* 45th meeting March 2009, Sofia, Bulagria

6 The use of international ITS standards in GeoSUM

Trond Foss

One of the objectives in the GeoSUM project is to use international ITS standards wherever and whenever applicable. One of the most relevant ITS standards is the European standard Intelligent Transport Systems – Urban ITS – 'Controlled Zone' management using C-ITS. The term Controlled Zone is defined in the standard as a physical area for which access conditions are applicable. Typical examples on access conditions are restrictions on axle weight, vehicle size and type of energy, e.g. diesel, petrol and electricity. The standard defines information and specifications enabling management of road traffic in controlled zones (CZ) applying geofencing. The term geofencing is defined in the standard as creation of a virtual geographic boundary by applying information and communication technologies such as specified for ITS.

The project has cooperated with the CEN TC278 WG17 Urban ITS who is responsible for the preparation of the CZ standard. The GeoSUM project was presented in a WG17 meeting in October 2018. There has also been a direct communication between the GeoSUM project and the authors of the CZ standard concerning comments to the WG draft and the application of the standard in the GeoSUM project.

The GeoSUM has also prepared a memo on the content of the CZ standard and how it could be applied in the GeoSUM project. The memo is meant to be the start of the design of a common platform for the pilots that will be part of the project. The use of the CZ standard will ensure that the project is based on the standardised traffic control measures and policies being deployed in urban area in the future as well as providing useful feedback to the CEN TC278 WG17 on the application of the standard. The GeoSUM project and its application of the standard is a potential Informative annex in future versions of the standard. Finally, the GeoSUM project has arranged a workshop in November 2018 on ITS standardisation for the project partners. The main objective of the workshop was to inform the project partners about the relevant standardisation organisations, their work areas and ITS standards that were crucial for the design of the pilots.

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