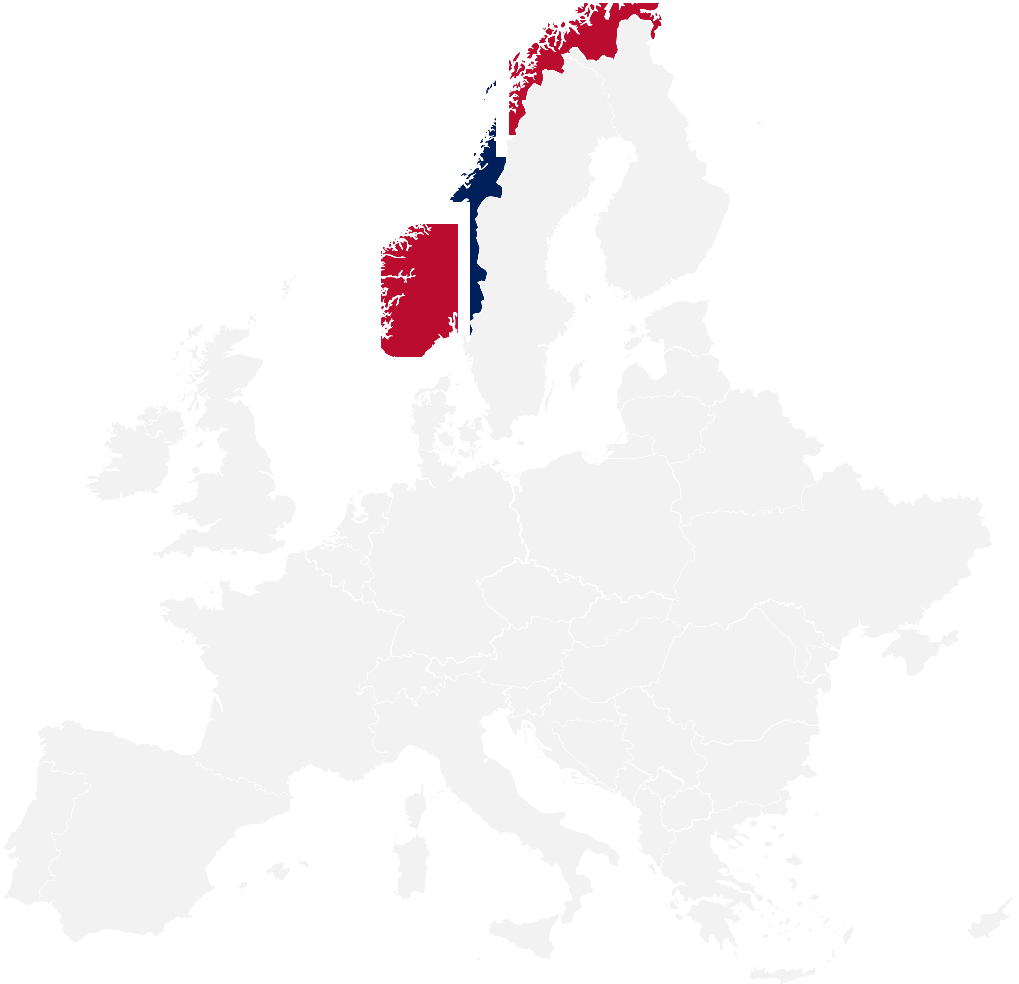


JuztDrive

Road user charging proof of concept (RUC PoC)

Aventi

kapsch

Table of contents

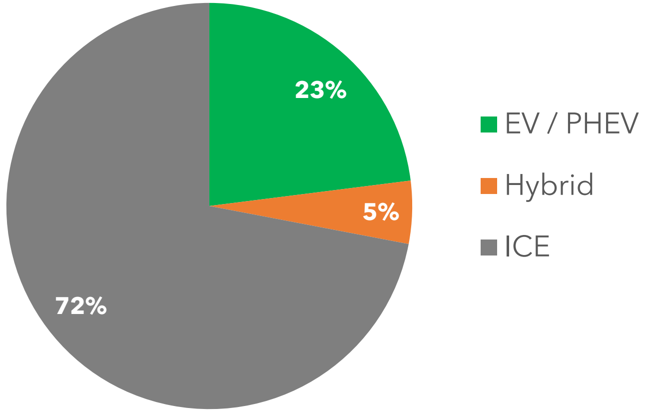
1 Project background & market context

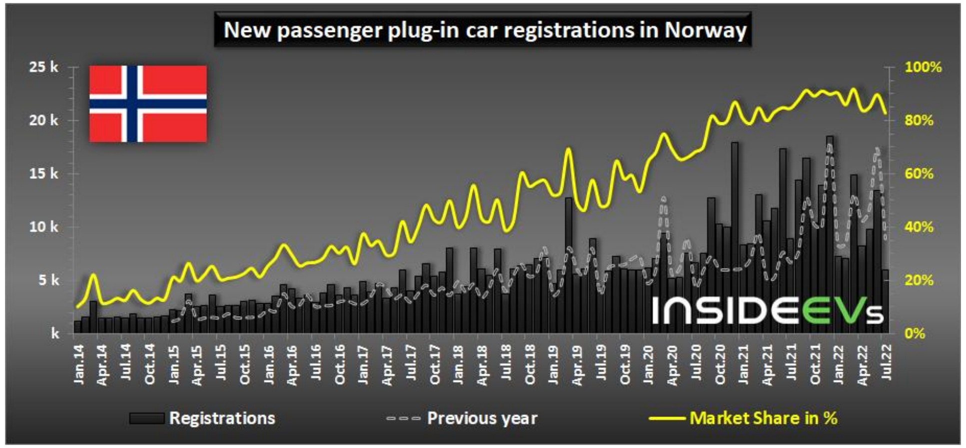
Norway has a unique set of circumstances which have resulted in an acute need for change in vehicle taxation

- Norway has c.900km of tolled roads* using DSRC technology and video-based enforcement (mandatory sign up plus device for HGVs)
- Electric vehicles pay maximum 50% of the toll cost, but in some cities, it is closer to 25% (0% prior to June 2019) and 50% of ferry costs. Source 1, Source 2
- EV sales are VAT (sales tax) exempt, but from 2023 there will be VAT for the purchasing amount exceeding 500,000 NOK.
- Many OEMs target Norway first when launching new models (e.g. Ford Mustang Mach-E)
- The success of government policies to encourage the adoption of EVs has had an adverse effect on fuel tax, VAT, toll and ferry receipts
- A more sustainable solution is therefore required if Norway is to retain the contribution from vehicle sales and fuel related taxes
- However, existing fuel taxes cost <1% to collect, therefore **any replacement solution must be cost effective and require as little investment as possible**
- The existing DSRC based tolling system is heavily concentrated in the south of the country and relies upon fixed infrastructure for both charging and enforcement purposes
- Road networks are constantly changing and evolving, therefore the chosen solution must be able to constantly adapt to this change

Map of existing toll stations

Light vehicle parc (Apr, 2022)



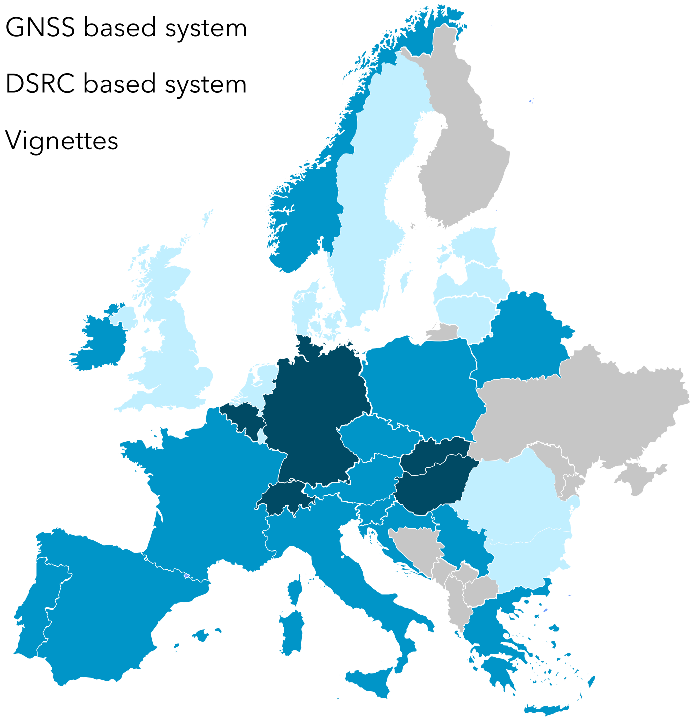


Source: InsideEVs

More and more countries across Europe are adopting (GNSS) distance-based pricing for heavy vehicles

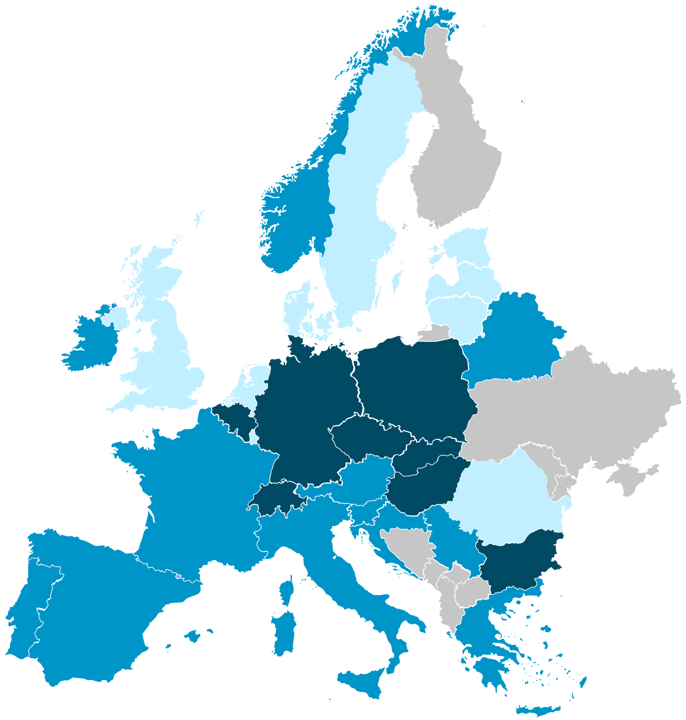
- GNSS based system
- DSRC based system
- Vignettes

2018



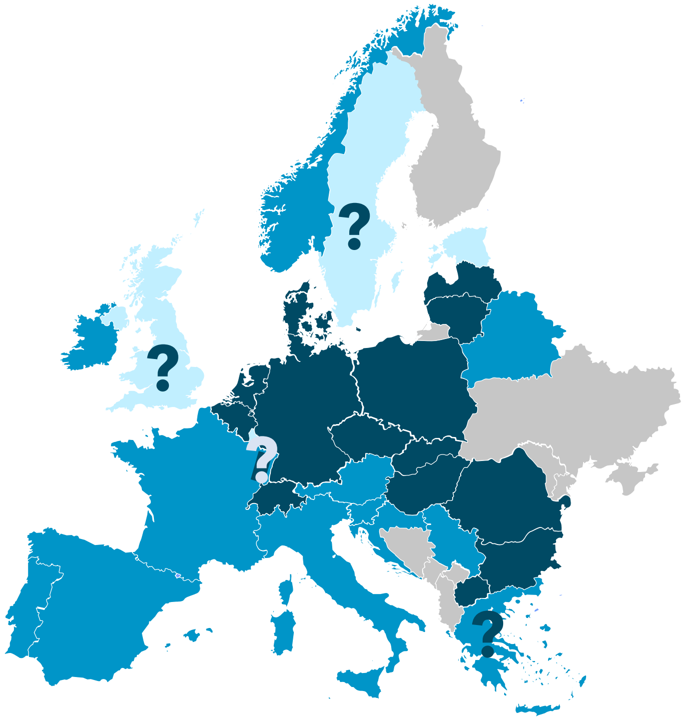
- In 2018, Germany, Belgium, Switzerland, Slovakia and Hungary were operating GNSS tolling schemes for heavy good vehicles (HGVs)
- At this point, Belgium and Hungary were fully open to EETS providers using a mixture of a centralised (Hungary) and de-centralised (Belgium) model for trip building and rating

2022



- Today, the Czech Republic, Bulgaria and Poland have launched GNSS schemes for trucks largely based on centralised trip building and rating models
- **Approximately 110,000km of roads and almost 5 million vehicles are now subject to GNSS tolling** for HGVs
- Almost all countries now enable EETS providers to provide the device and service to end users

2026



- Within the next four years we expect to see Denmark, Romania, Lithuania, The Netherlands and the Alsace region in France launch brand new GNSS tolling schemes for HGVs
- Latvia, Macedonia, Sweden, Greece and the UK are known to be actively exploring and/or considering such a scheme – **all are expected to use a thin client + centralised trip building and rating approach**

Most countries either have or are moving towards a centralised (thin client) trip rating model

> Countries with **a centralised model do not require any map matching or rating by the toll service provider** and offer lower rates of remuneration as a result

> Almost **all new GNSS domains are expected to implement a centralised model** (Denmark, Lithuania, the Netherlands etc.)

> Germany – the most important GNSS domain – is in the process of moving away from an outsourced model and towards a centralised model

> Czech republic is operating a centralised model and Slovakia has opened recently tender for a centralised model, too

> Belgium (Viapass) will continue to outsource matching and rating until 2028 at least

Key points:

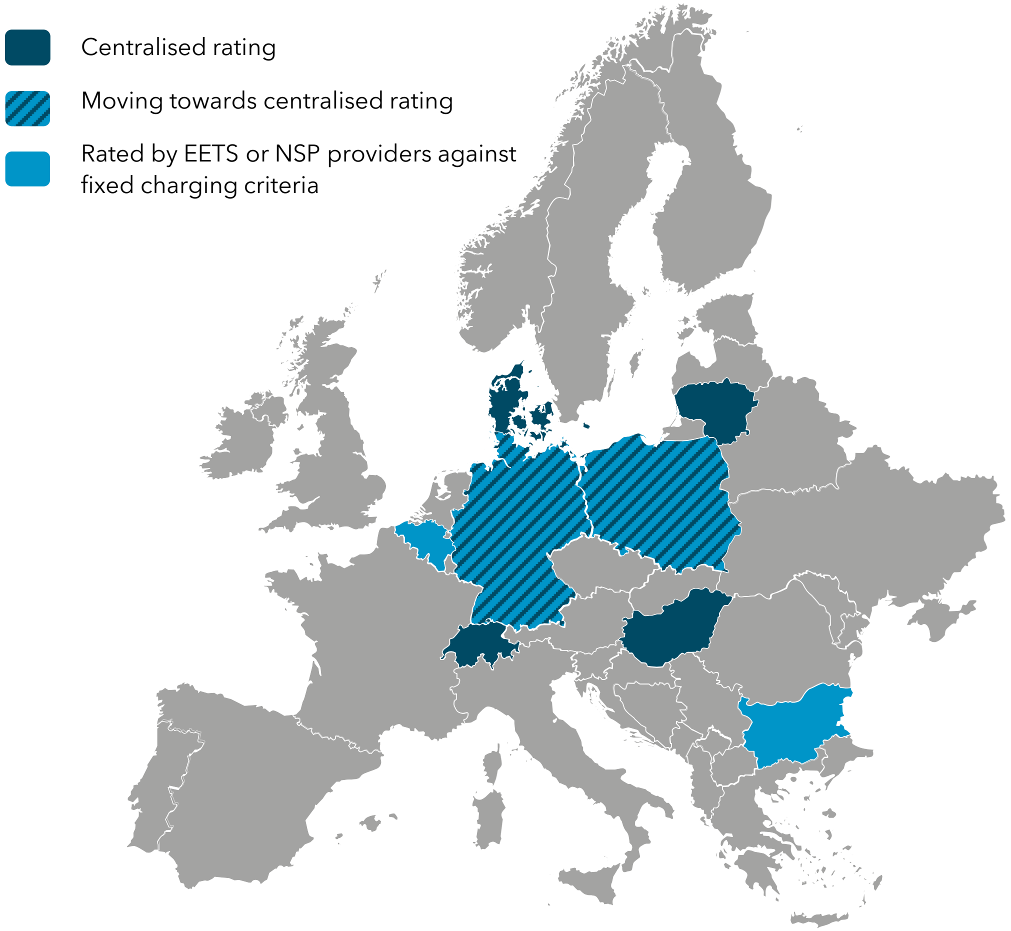
> In the HGV road charging space, countries across Europe are fast moving to a standardised architecture based on GNSS in a thin client model with a centralised rating engine

> Germany's legacy thick client model is being phased out and replaced with a centralised, thin client approach

> Once the German LKW MAUT scheme has fully transitioned, there will be no other examples of a thick client approach in use

> GNSS HGV tolling schemes typically offer the ability to acquire 'toll tickets' up front for infrequent users without a device

Centralised vs outsourced map matching / rating



Brussels is planning to introduce road user charging in an urban environment using a very similar approach to JuztDrive

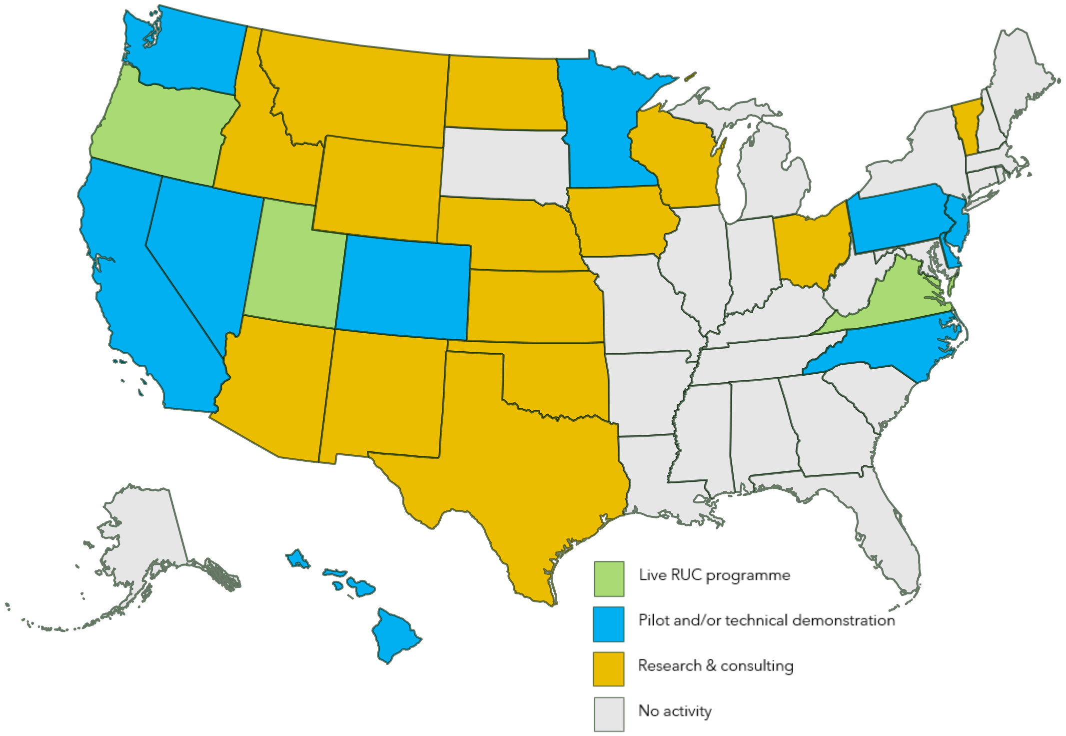
- Brussels is currently trialling a multi functional mobility and kilometre based pricing smartphone application known as SmartMove
- SmartMove is a tax project which aims to improve mobility and introduce a new way to price individual car trips within the city
- SmartMove is designed to introduce a new system of taxation for vehicle use, with a per trip price calculated according to:
  - Day of the week
  - Distance travelled
  - Type of vehicle
- Individual users must have a SmartMove account, including a method of payment
- SmartMove represents a new form of kilometre based pricing within cities which could serve as a model for other cities, such as London and Paris, which are searching for new means of pricing vehicle based travel according to the same measures (time of day, vehicle type etc.)
- In addition to kilometre based pricing, SmartMove enables users to view and pay for public transport and other forms of mobility such as car sharing and micro scooters etc.

Key points:

- Multiple use cases and services can be integrated within the JuztDrive RUC approach
- Our PoC has demonstrated that road usage charges can be accurately calculated according to data received from a separate smartphone app and rated trips displayed alongside other use cases such as road safety / C-ITS
- Smart Phone based app with central map matching, thin client approach, and according to SmartMove GDPR compliant

SmartMove .brussels

Outside of Europe, multiple states in the US are actively exploring, piloting or launching road user charging



Key point:

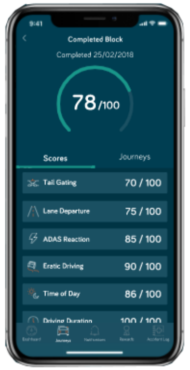
> Many states have conducted RUC PoCs and pilots over the years and largely concluded that a thin client approach, combined with additional value added services represents the best way forward

- As in Norway, RUC activities in the US are focused on delivering a replacement for existing fuel taxes
- States including Oregon, California, Washington and Utah have been exploring various distance or mileage based charging options and are now focussing almost exclusively on an approach similar to JuztDrive
- In addition to the use of existing aftermarket devices, such as OBD dongles and smartphones, most pilots and PoCs have focussed on the integration of additional value added services as a means to enhance the user experience and improve user satisfaction with the scheme
- Behind this approach is a conviction that integrating RUC with other services can improve overall acceptance of the scheme and overcome public resistance to the collection and use of vehicle location and odometer data
- There is also a recognition among states that adopting the same approach as neighbouring states and municipalities can help to build consensus and acceptance among the general public
- Furthermore, use of vehicle location data can identify where trips have taken place, down to the city, state or individual road level, ensuring that each authority receives its correct allocation of collected funds

The movement towards existing and non-traditional tolling devices for GNSS has begun

Dedicated tolling device

Smartphone



In-vehicle telematics

Telematics OBD dongle

Smart digital tachograph

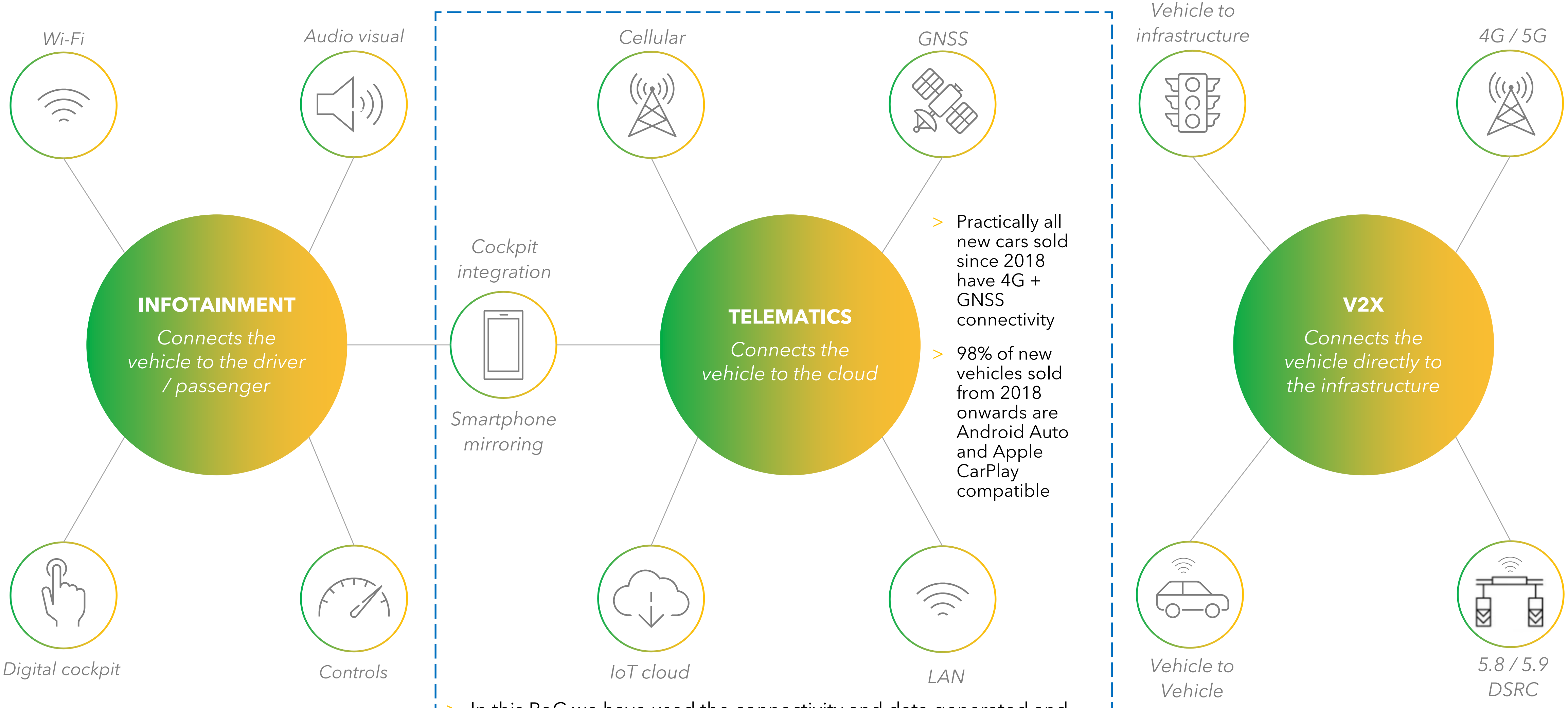
Telematics black box

- In addition to EETS devices, Poland, Hungary and Bulgaria now enable the use of existing telematics devices to record and send GNSS trip data
- Data from these devices is typically processed by a centralised processing engine, similar to the architecture employed within the JuztDrive RUC PoC
- In future, we expect a combination of smart digital tachographs (mandatory for all HGVs), smartphones and in-vehicle telematics to become the primary data generators for GNSS road charging schemes

Key points:

- Enabling the use of existing devices can reduce CAPEX spend and eliminate related logistics / distribution challenges for the charging authority
- Users often prefer to use their existing devices, which offer far greater convenience and lower costs

Vehicle connectivity can be defined in multiple ways – however it is the telematics connectivity which can deliver RUC in future



- Practically all new cars sold since 2018 have 4G + GNSS connectivity
- 98% of new vehicles sold from 2018 onwards are Android Auto and Apple CarPlay compatible

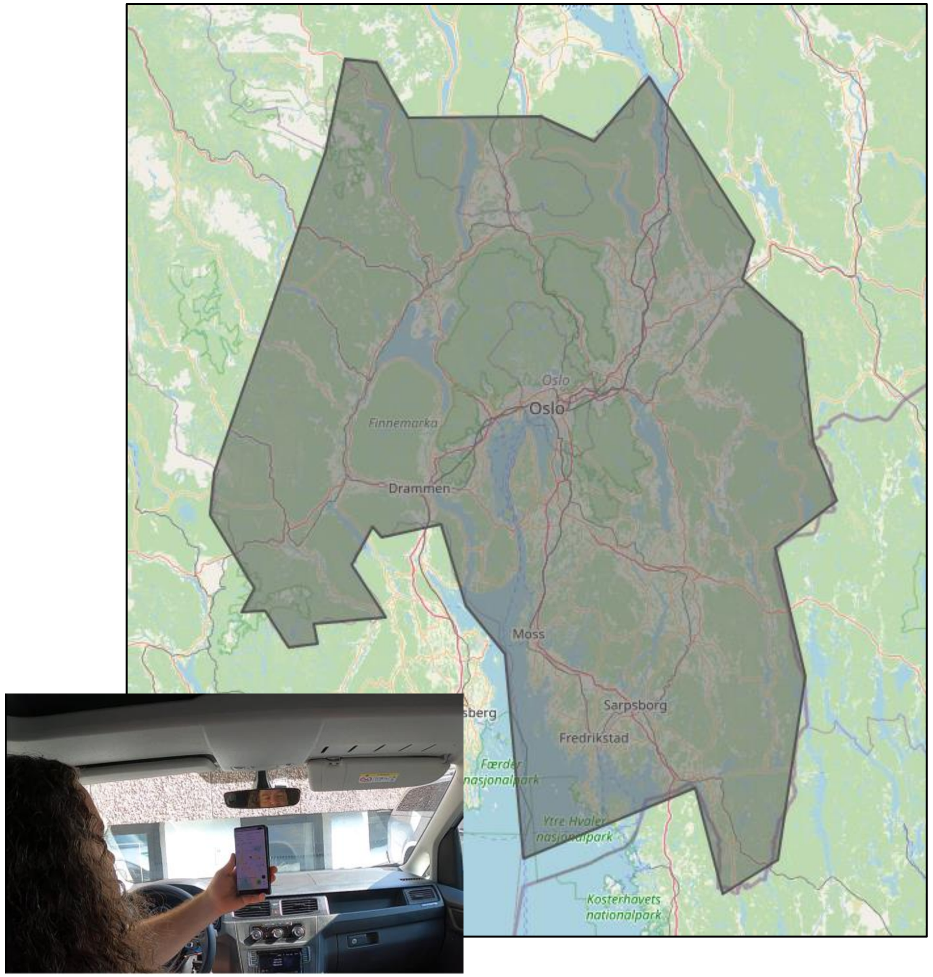
- In this PoC we have used the connectivity and data generated and sent by the smartphone, but the vehicle represents a more robust and secure long term solution

2 Description of PoC

The JuztDrive PoC began in June 2022 and has focused on vehicles in and around Oslo

- JuztDrive was launched in order to demonstrate a device / hardware agnostic, infrastructure light, thin client proof of concept for road usage charging in Norway
- More specifically, JuztDrive has demonstrated that smartphones (as the data recording device) and smartphone apps (as the user interface) can be used to measure and collect road usage charges in place of dedicated in-vehicle hardware
- While the app could be used on any smartphone operating system, for the purposes of this PoC only phones with an Android operating system were used
- The PoC consisted of approximately 20 vehicles driven over the operational period, in addition to approximately 25,000 distinct simulated vehicles
- Drivers using the app were able to register vehicle details, start and stop trips, enable pairing with the vehicle and see completed trips in various formats
- Trips were recorded in and around the Oslo area during all times of day (i.e. peak and off peak periods) and all traffic conditions
- In August 2022, the primary testing phase of the PoC, more than 80 million positions have been processed against the Norwegian road network using Kapsch' geo processing services (both real-world and simulated data provided by Aventi)
- Over 25 million road segments were detected, using Kapsch' map matching, over 2 million kilometres matched (August 2022)
- Per kilometre pricing was applied on a variable basis according to road type, road location (urban or non-urban) and vehicle type

JuztDrive



Various organizations and companies collaborated towards this PoC

Statens vegvesen
(Norwegian Public Roads Administration)

Observed the design and deployment of the PoC and participated in regular update calls, discussions and workshops

Aventi

Joint PoC lead with responsibility for user interface (mobile application), data proxy, central ITS server and in-field testing

kapsch

Joint PoC lead with responsibility for geo services incl. mapping, road segmentation and trip cost calculation

DRIVKRAFT NORGE

tøi Institute of Transport Economics
Norwegian Centre for Transport Research

Provided input into pricing table and vehicle classification etc.

The end-to-end process consisted of six steps

1. *App automatically starts when entering a paired vehicle*
2. *App records vehicle positions*
3. *Packages of positions sent to the GLP*
4. *Position reports mapped to individual road segments and rated*
5. *Rated reports sent back to app as completed trips*
6. *Completed trips stored and displayed in the app with attached price*

User and vehicle details → 1

Tariff table provided by charging authority → 4

> The app recorded a vehicle position every second, including:
  - Create time
  - Latitude
  - Longitude
  - Heading
  - Speed

> Packages of these positions (data) were aggregated and sent from the app via Aventi's central ITS server to the Kapsch Geo Location Platform (GLP) every minute

> Upon receipt of the data, the GLP map matched the coordinates against the road network and calculated the corresponding rate

> Rated trips were then passed back to the app (again via the Central ITS server) and displayed to the driver within a dedicated page

The rating table was calculated by TØI to reflect existing fuel tax rates and environmental costs

> TØI calculated reasonable kilometre charges based on estimated external vehicle costs, such as CO2, local pollution, noise, accidents, congestion and road wear

> These prices were calculated for four vehicle classes separately (zero-emission, hybrid, gasoline + Diesel)

> Geographic criteria were urban vs. non-urban, and several road classes such as motorway or tertiary road (adapted from TØI's recommendations)

> Time criteria were weekends vs. weekdays and rush-hour times (only in urban areas)

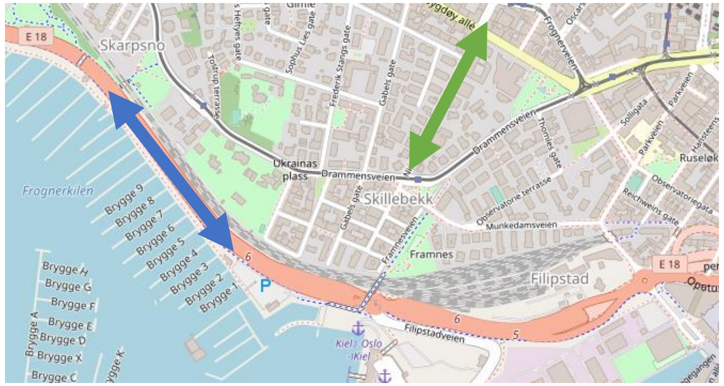
> In addition, special policies were applied to the E18 on general price and direction-based (city-in vs. outbound), to demonstrate system capabilities

			Urban		
				Weekday	
		Non-Urban	Non-weekday	Non-rush-hour	Rush-hour
Motorway	Zero-emission	0.33	0.79	1.25	3.57
	Plug-in hybrid	0.35	0.83	1.31	3.75
	Gasoline	0.36	0.86	1.35	3.85
	Diesel	0.40	0.95	1.49	4.27
Trunk	Zero-emission	0.33	0.79	1.25	3.57
	Plug-in hybrid	0.35	0.83	1.31	3.75
	Gasoline	0.36	0.86	1.35	3.85
	Diesel	0.40	0.95	1.49	4.27
Primary	Zero-emission	0.30	0.71	1.12	3.21
	Plug-in hybrid	0.32	0.75	1.18	3.37
	Gasoline	0.32	0.77	1.21	3.47
	Diesel	0.36	0.85	1.34	3.84
Secondary	Zero-emission	0.27	0.63	1.00	2.86
	Plug-in hybrid	0.28	0.67	1.05	3.00
	Gasoline	0.29	0.68	1.08	3.08
	Diesel	0.32	0.76	1.20	3.42
Tertiary and Unclassified	Zero-emission	0.20	0.48	0.75	2.14
	Plug-in hybrid	0.21	0.50	0.79	2.25
	Gasoline	0.22	0.51	0.81	2.31
	Diesel	0.24	0.57	0.90	2.56
Residential	Zero-emission	0.17	0.40	0.62	1.79
	Plug-in hybrid	0.18	0.42	0.66	1.87
	Gasoline	0.18	0.43	0.67	1.93
	Diesel	0.20	0.47	0.75	2.13
Track	Zero-emission	0.00	0.00	0.00	0.00
	Plug-in hybrid	0.00	0.00	0.00	0.00
	Gasoline	0.00	0.00	0.00	0.00
	Diesel	0.00	0.00	0.00	0.00

Prices in NOK per km

Key point:

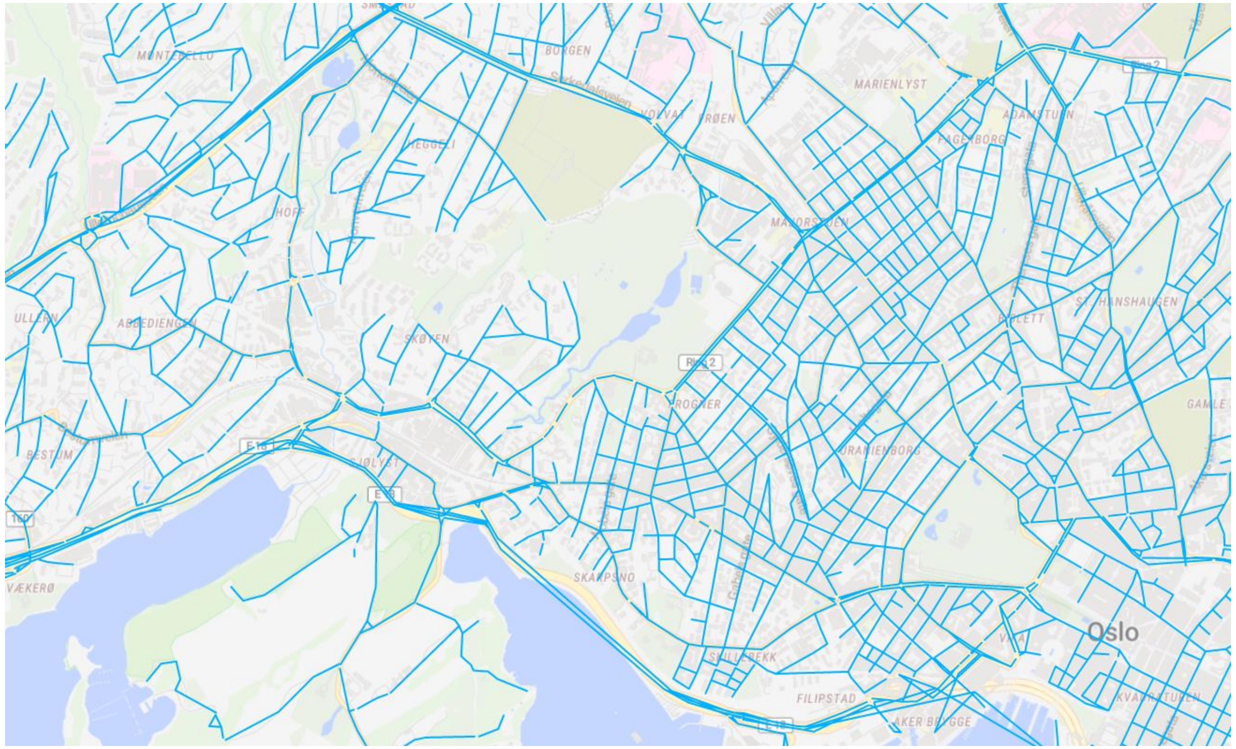
> Roads within specific urban areas (Oslo, Bergen, Trondheim etc.) can be priced differently to interurban, rural and access roads or according to the time of day should the charging authority wish to pursue additional objectives such as congestion reduction and demand management in cities



Example 'Trunk' *Example 'Residential'*

In order to accurately price each trip according to these variable tariffs we created granular charge segments within the GLP

- ISO12855:2022 (Information exchange between service provision and toll charging) offers different means of charging schemes such as section-based or distance-based within an area
- Most European countries today apply section-based charging for HGV tolling, to be able to provide the explicit definition of the respective charging scheme
- Also, this approach offers granular pricing policy options down to single road links
- Tariffs and contexts can (and have been throughout the PoC) updated quickly with such a centralised thin-client approach, while having QA processes and checks in place to ensure correct charging at all times
- For the RUC PoC, Kapsch automatically created charging segments based on the underlying road network of greater Oslo using Open Street Map data, and applied the tariffs to the resulting network as defined with TØI beforehand

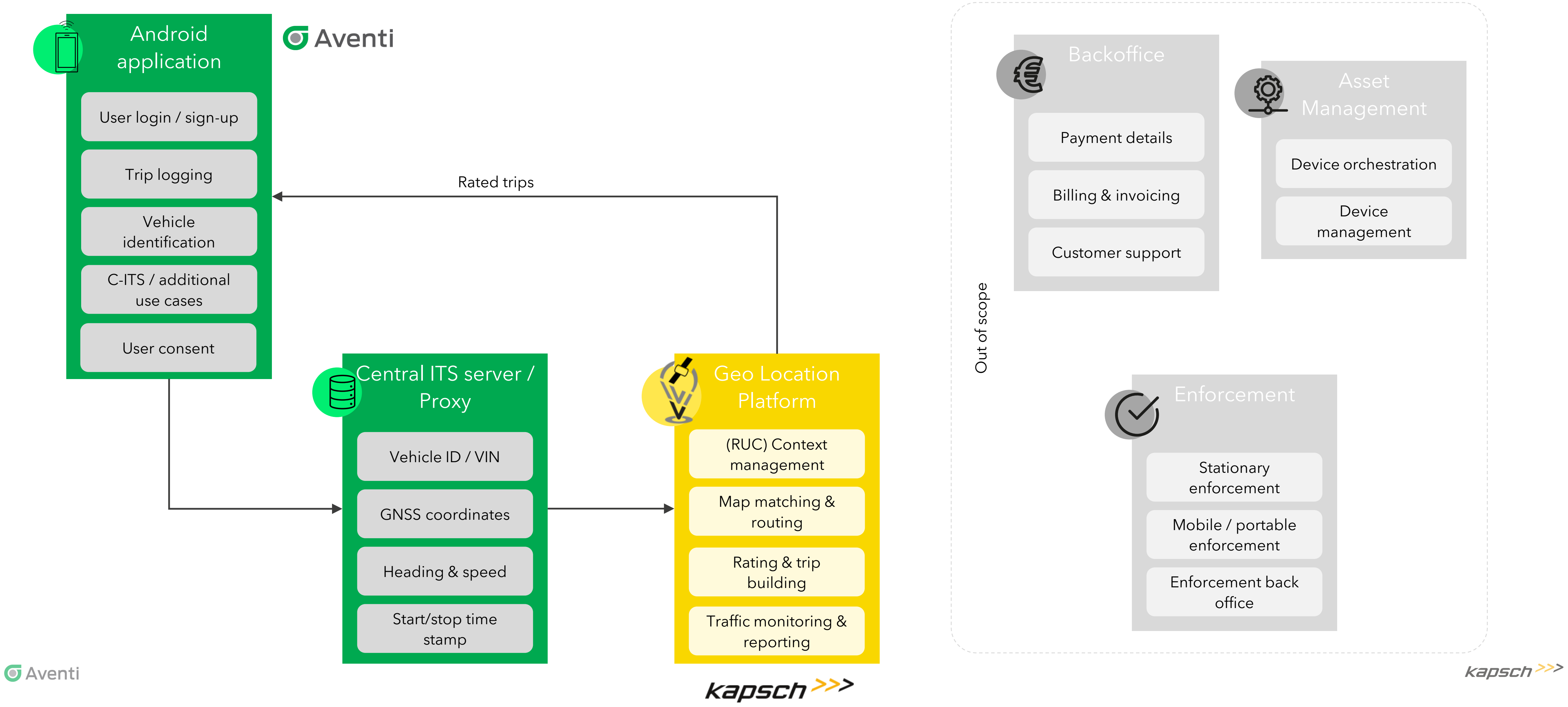


Example segments used for the charges in the PoC visible in blue. Average segment length was 120m, with minimum segment length defined as 20m

Key points:

- Regulations in the EETS context to enable GNSS charging and tolling are available, which offer a policy toolbox to enable e.g. section-, distance-, time-, area-based charging. Respective processing technologies have already proven viable for heavy goods vehicle GNSS tolling in nationwide schemes.

Kapsch and Aventi had a clear work split, with both delivering key competencies



Kapsch and Aventi had a clear work split, with both delivering key competencies

- The smartphone app developed and provided by Aventi is the main user interface, as well as the primary means of data generation
- For the purposes of the PoC, the app was made available directly to participants, but could in future be listed on the Google (Android) Play and Apple App Stores
- In a real world deployment, user consent would be detailed and confirmed via this application
- Although not deployed as part of this PoC, the app is capable of delivering multiple, including C-ITS, use cases, e.g. for road safety

Aventi

Android application
- User login / sign-up
- Trip logging
- Vehicle identification
- C-ITS / additional use cases
- User consent

- Once processed by the Kapsch GLP, completed and rated trips were sent back to the Aventi smartphone app (via the C-ITS server)

Rated trips

Key point:

> Although smartphones were chosen as the data generators and user interfaces for this PoC, **the vehicle itself could / should provide the required data in future**

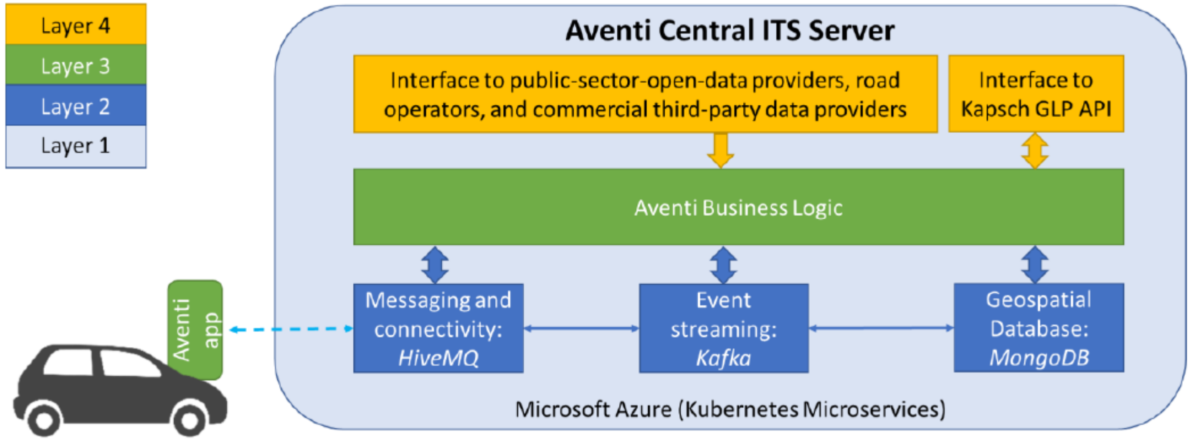
Central ITS server / Proxy
- Vehicle ID / VIN
- GNSS coordinates
- Heading & speed
- Start/stop time stamp

Geo Location Platform
- (RUC) Context management
- Map matching & routing
- Rating & trip building
- Traffic monitoring & reporting

- The Kapsch Geo Location Platform (GLP) is the data processing engine and contains the respective mapping and charging logic
- Similarly to the Aventi app, although not deployed as part of this PoC, the GLP is able to deliver additional functionalities such as anonymised real-time traffic monitoring and status reporting

- Aventi provided the Central ITS Server, taking the required data generated by the smartphone and delivering it to the Kapsch GLP for further processing

Aventi Central ITS server

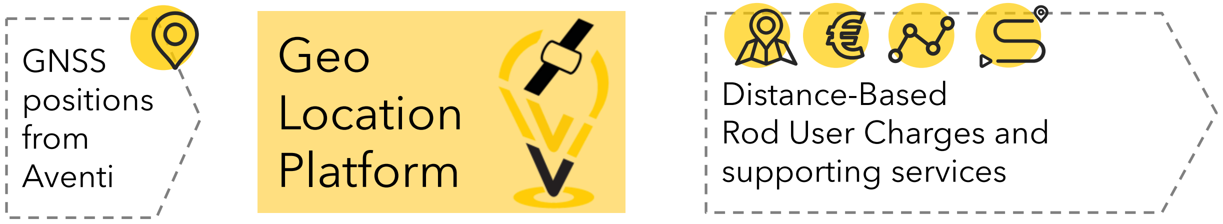


Key points:

> The Central ITS Server was designed to support all road traffic related information services.

- The Aventi Central ITS Server was developed as part of these NPRA and RCN (Research Council of Norway) projects:
  - NPRA: E8 Borealis (Nordic Way), 2018 - 2021
  - NPRA: E6 Patterød (Nordic Way), 2019 - present
  - RCN: Pilot-T ASAM, 2019 - present
- It is built according to the European standards and specifications for Cooperative Intelligent Transport Systems, also called C-ITS.
  - It supports both short-range ITS-G5 communication and long-range 2G/4G/5G cellular communication.
  - It supports EU CCMS (European C-ITS Credential Management System) for permissions, authentication, and verification.
- It runs in the cloud using a modern IT architecture similar to LinkedIn, Netflix, Uber, and several car manufactures. It is horizontally scalable and can support millions of smartphones and vehicles.
- In this proof-of-concept project, its functionality was expanded to support GNSS-based road use charges according to the requirements for Kapsch GLP.
- In the future it will be expanded to support vehicles with automated driving functionality in line with European CCAM initiatives (Cooperative, Connected and Automated Mobility).

Kapsch's Geo Location Platform (GLP) receives vehicle location data and creates rated, distance-based trips (near) real time



Key points:

> The GLP was designed to process GNSS data from any source, matching received location data with a very high degree of accuracy, e.g. typically offering road segment detection rates above 99.50%

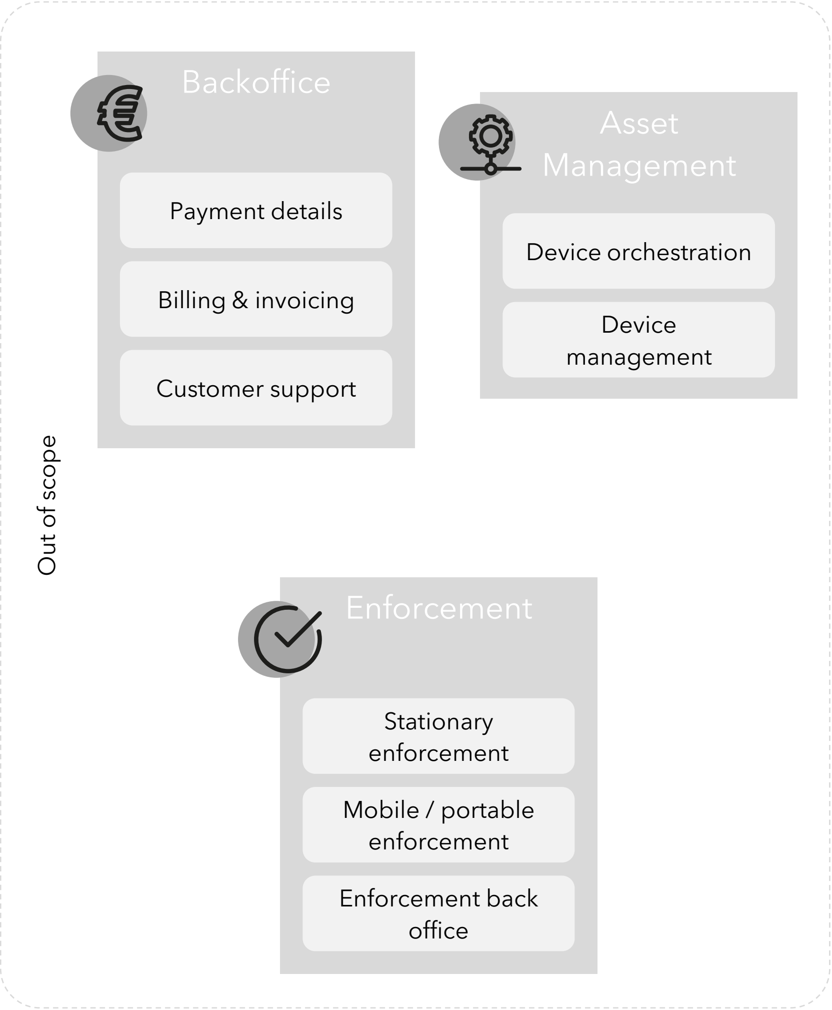
> The GLP is designed to operate in an ever changing environment and according to a variable road and charging context, including:
- Variations in the size and scope of the chargeable road network
- A changing number of users utilizing different devices and different methods of data generation
- Strict regulation and privacy by design surrounding data collection, processing and storage
- Changes in vehicle connectivity and (road charging) technology, e.g. from on-board units to mobile applications
- Fast update cycles are integral part of GLP design, e.g. to account for ever-changing road networks

> To ensure the GLP remains fit for purpose over the long term we have developed a solution that is fully cloud-native and technically flexible

> The GLP was designed specifically to deliver nationwide road charging schemes – as such the technology stack supporting the GLP is fully scalable to enable support for many millions of vehicles

Components such as a commercial back office, asset management tool (if required) and enforcement were not part of this PoC

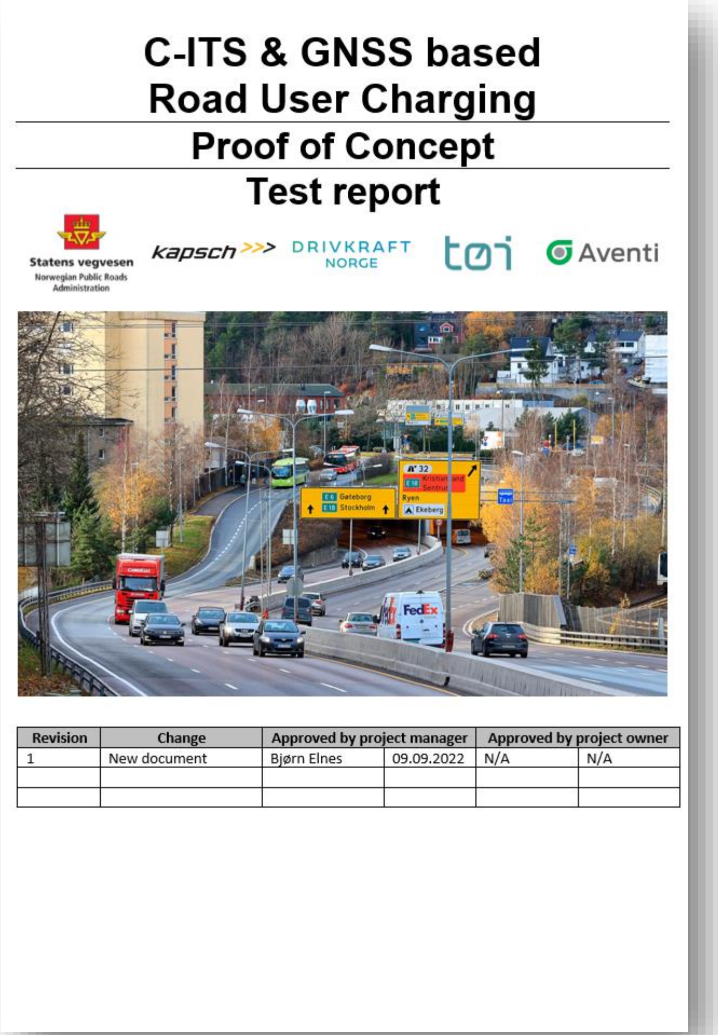
- In a real world deployment it would be necessary to introduce additional components to complete the overall solution
- A commercial back office would be required in order to handle individual user accounts, which could be provided by a single central / national service provider (as is used in some national HGV GNSS tolling schemes) and/or multiple service providers each responsible for their own users (as is the case with the EETS market)
- An asset management tool would be required if dedicated devices were issued by either a national or open market service provider, although we do not recommend to use dedicated devices for reasons of cost, complexity, usability and public acceptance
- Enforcement is an unresolved issue which requires additional investigation and examination regardless of the charging solution and was not addressed as part of this PoC
- In the short term, it would be possible to enforce vehicles by using a mixture of existing and additional mobile / portable enforcement cameras
- Over the longer term, additional enforcement possibilities could be explored linked to the vehicle's unique identification etc.



3 JuztDrive functionality & user experience

During the live phase we stress tested the solution against several scenarios

- Trips with no or intermittent cellular coverage
  - The app will typically upload its driving log every minute, but if the cellular connection is lost, the app will continue logging GNSS coordinates on the phone and wait for the connection to be re-established before it resumes uploads.
- Trips with no or intermittent GNSS signal
  - The phones lose GNSS reception in tunnels. The missing parts of the driving logs are filled in by the Kapsch GLP by detecting the entry and exit of the tunnels.
- Users forgetting to launch the app
  - The app can be configured to recognize the Bluetooth MAC ID of the vehicle's infotainment system and lay dormant. When the user enters the vehicle and the Bluetooth connection is established, the app is activated and starts logging GNSS coordinates.
- Verification of GNSS coordinates against cellular tower IDs to detect GNSS spoofing and misbehaviour.
  - While logging the vehicle GNSS coordinates, the app will also log detected cell phone tower IDs. The Central ITS Server compares the vehicle GNSS coordinates to the known GNSS coordinates of the cell phone towers and uses this to detect GNSS spoofing and positioning misbehaviour.


C-ITS & GNSS based Road User Charging

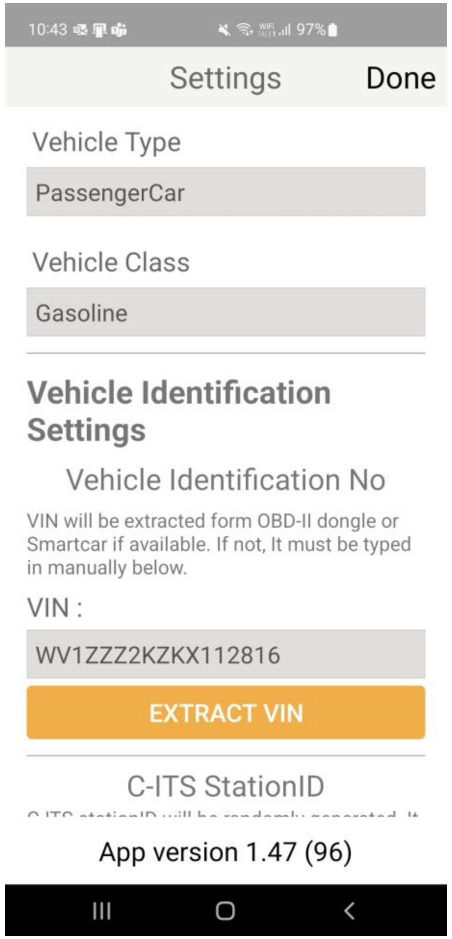
Proof of Concept

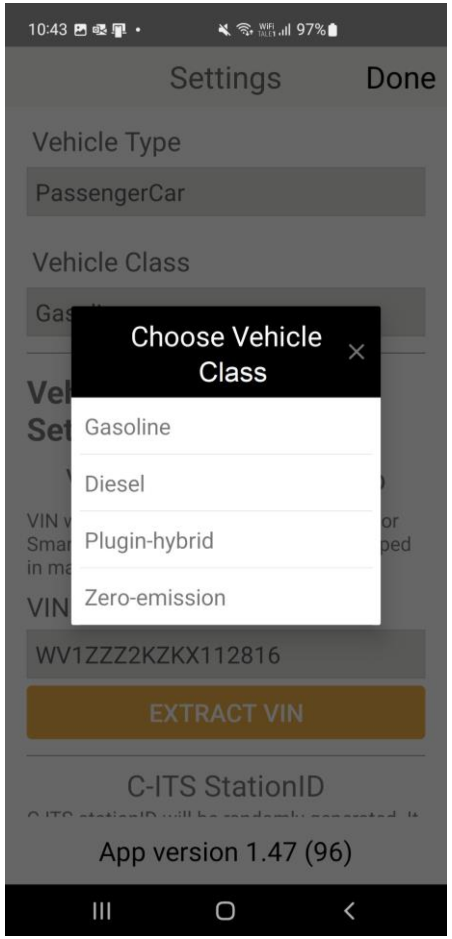
Test report

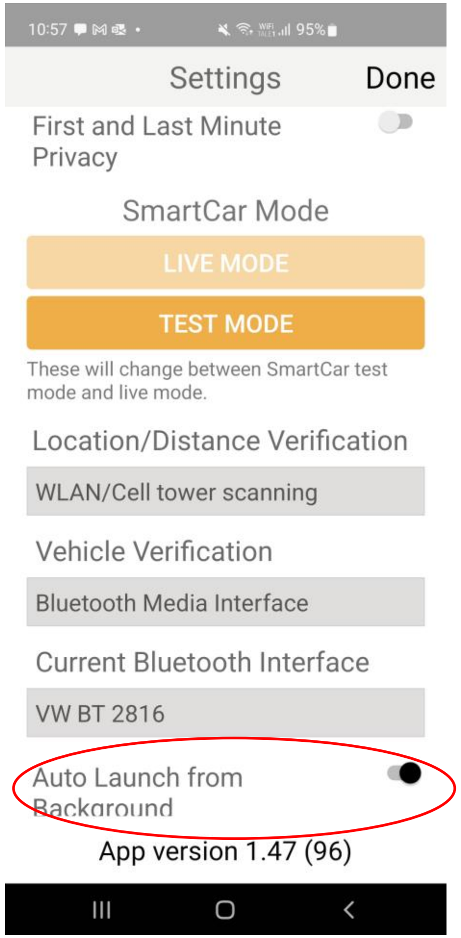
Revision	Change	Approved by project manager		Approved by project owner	
1	New document	Bjørn Elnes	09.09.2022	N/A	N/A

The mobile application delivered a simple user interface

Sign up process

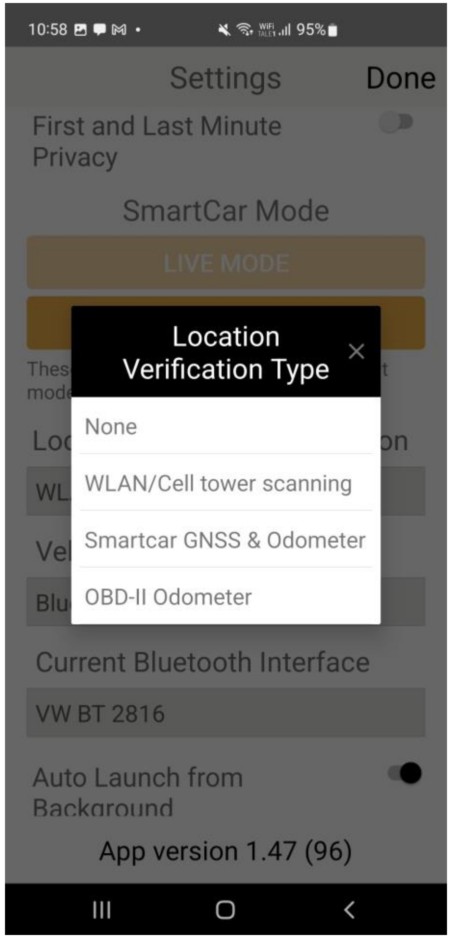


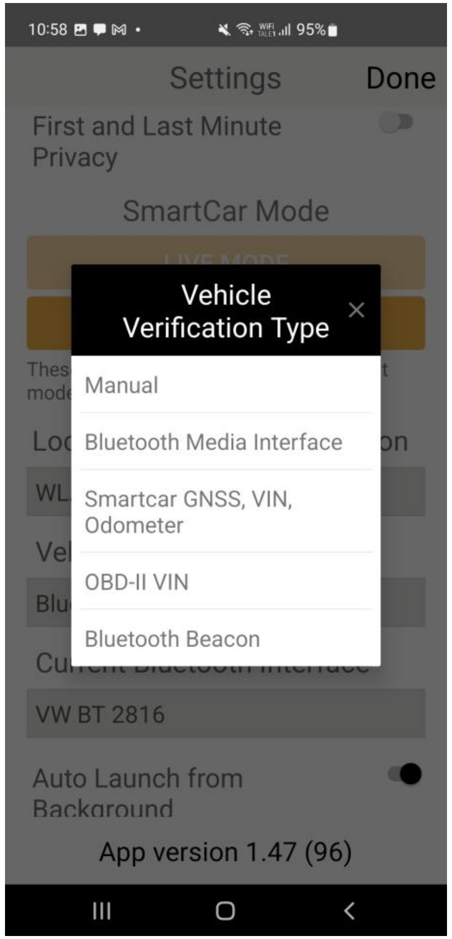




We added an auto launch function linked to the vehicle's Bluetooth/infotainment system

Verification

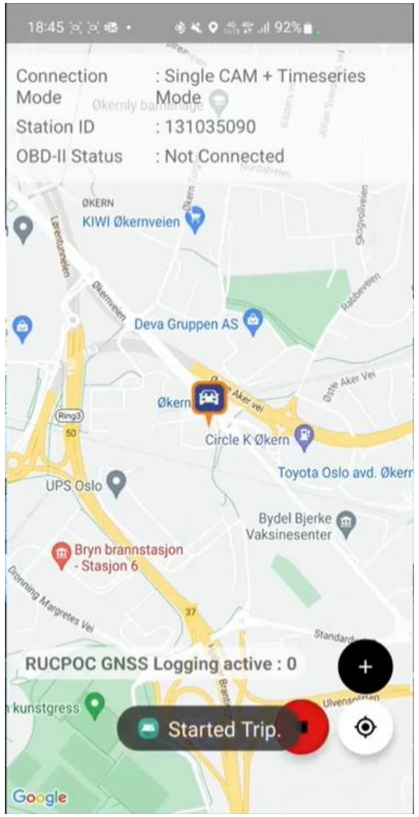


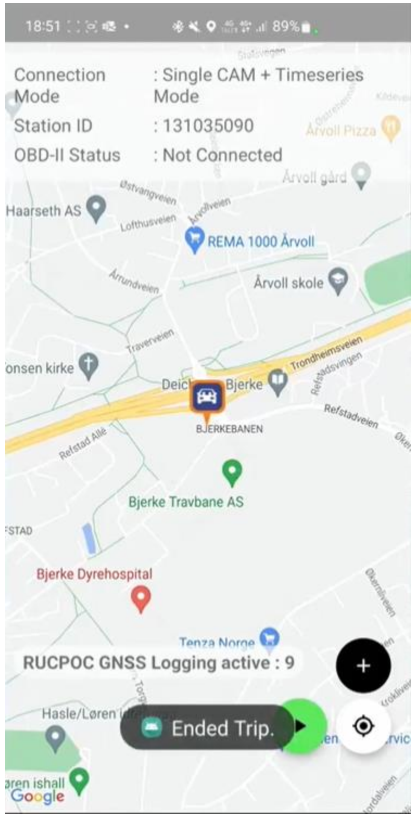


We've been testing several different verification methods

Trips were clearly logged and displayed within the app

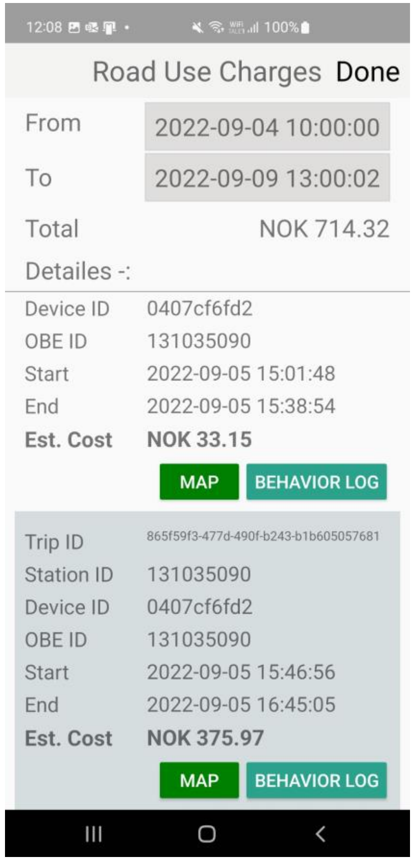
Driver view during trip

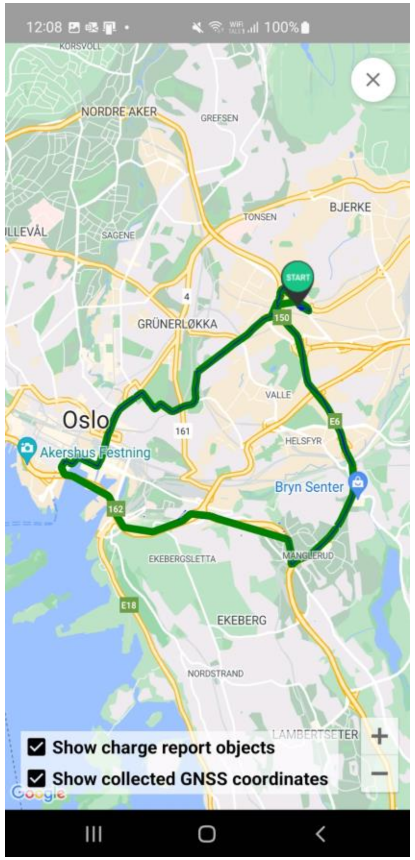




We experimented with a start / stop button as a means to isolate trip data and add additional user interaction

Trip log and completed trip view(s)



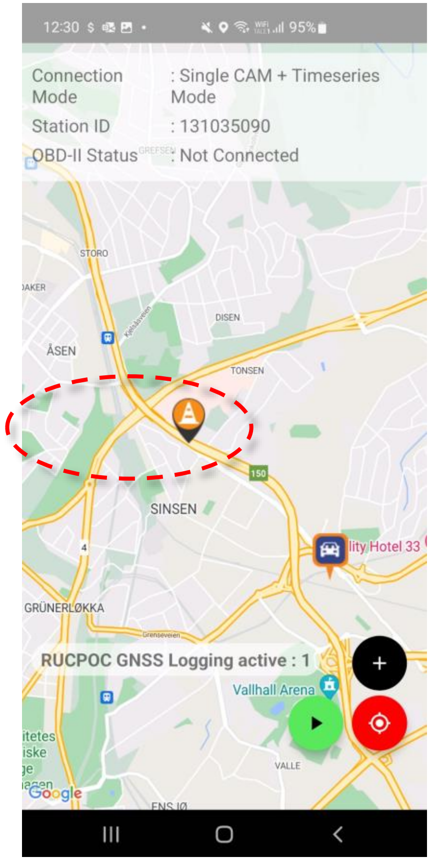


Completed / rated road usage charges are displayed within the app, with the option to also see the completed trip on the map

Potential for the app / user interface to include multiple use cases and services

- C-ITS services
  - Realtime traffic information (RTTI)
    - Real-time information about traffic congestions
    - Long-term roadworks with information about expected traffic delays and planned closings
    - Snow plowing, sanding, and salting status and plans for winter roads
    - Tire chain and winter tire requirements
    - Winter convoy information
    - Winter closed roads
    - Detour suggestions
  - Safety-related traffic information (SRTI)
    - Weather forecast and nowcast for planned travel route
    - Location of short-term roadworks and mobile roadworks
    - Animals, people, obstacles or things on the road
    - Accidents along the road

- Other services
  - Collecting toll road fees for private roads like ski resort areas.
  - Automatic payment for roadside parking in cities
  - Automatic booking of charging station for electric vehicles
  - Automatic booking of rest area for trucks
  - Electronic driving log for accounting, tax purposes, insurance, and CO_2 footprint



The app also supports C-ITS services - here a roadworks warning from the NPRA

The approach is completely scalable and able to handle (very) large quantities of data

Data processing and scalability:

> The system uses Microsoft Azure as the cloud platform provider and is built to scale according to load and demand in a horizontal fashion

> Load is determined by the amount of positions sent (via the existing cellular network) and processed

> The amount of data sent and processed depends on the frequency/sample rate of positions and the number of live devices

> For the PoC, sample rate was one position per second, usually, 1 position every 10 seconds is sufficient for excellent results

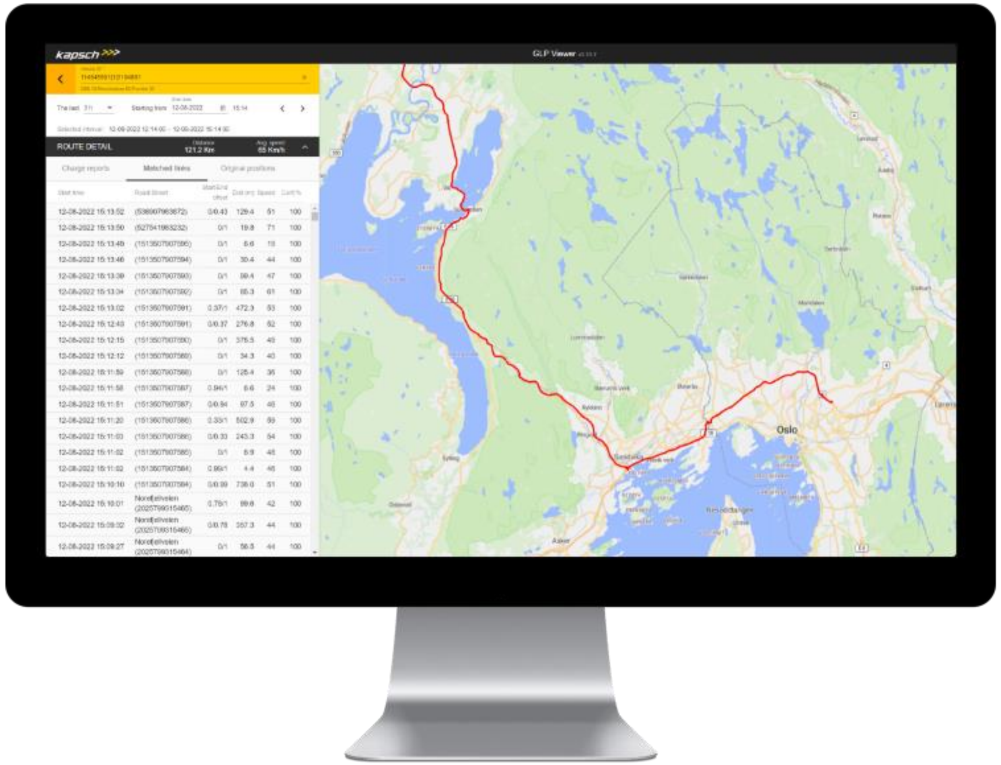
> Positions are arranged within packages and a package is sent every minute, which can be configured differently

> Each position is roughly 30 – 50 bytes in size

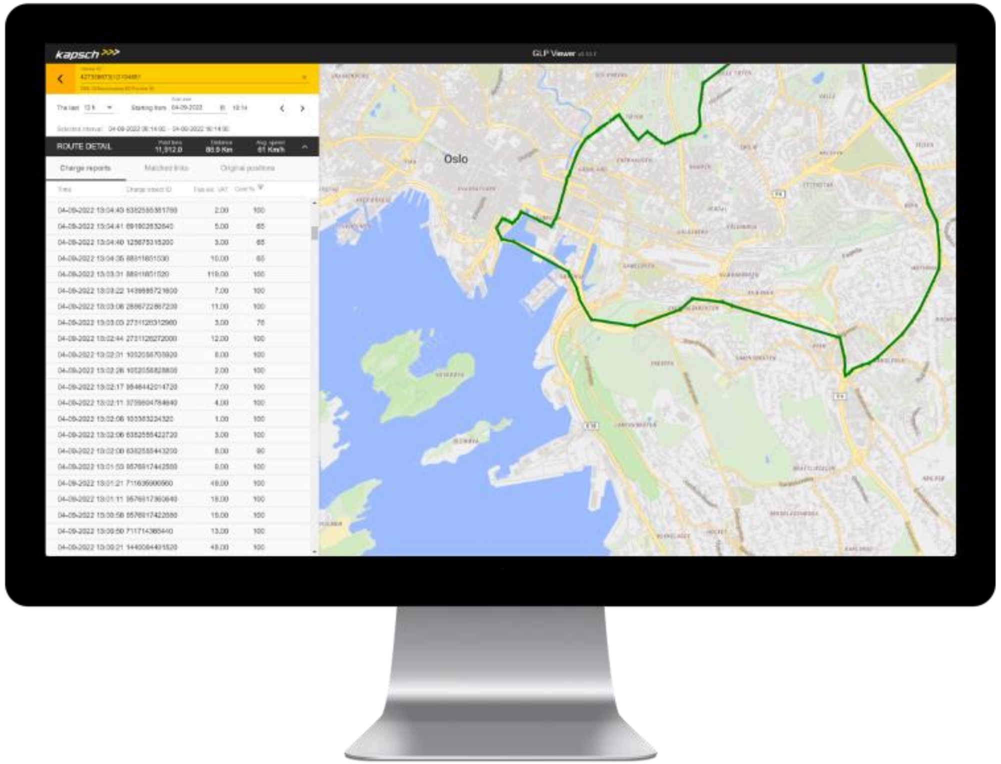
> If a car is driving for two hours and collecting a position every five seconds it will send up to 72 kilobytes of data or 0.072 megabytes. An average photo taken on a smartphone is 2 megabytes

4 Back end processes

Completed trips are immediately rated and visible within the Kapsch Geo Location Platform to enable auditing

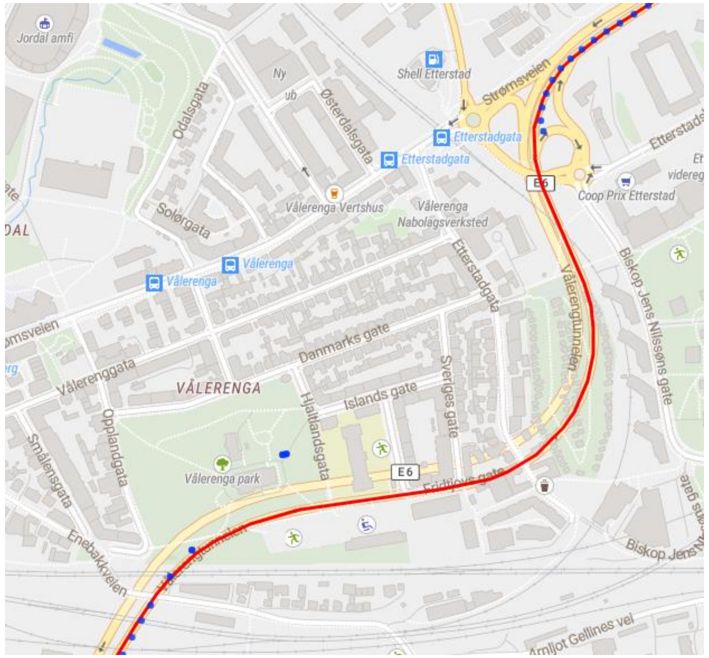


Completed trips appear within the GLP viewer near real time, with individual sections / road classes rated according to their specified tariff (map matched track/road segments in red)

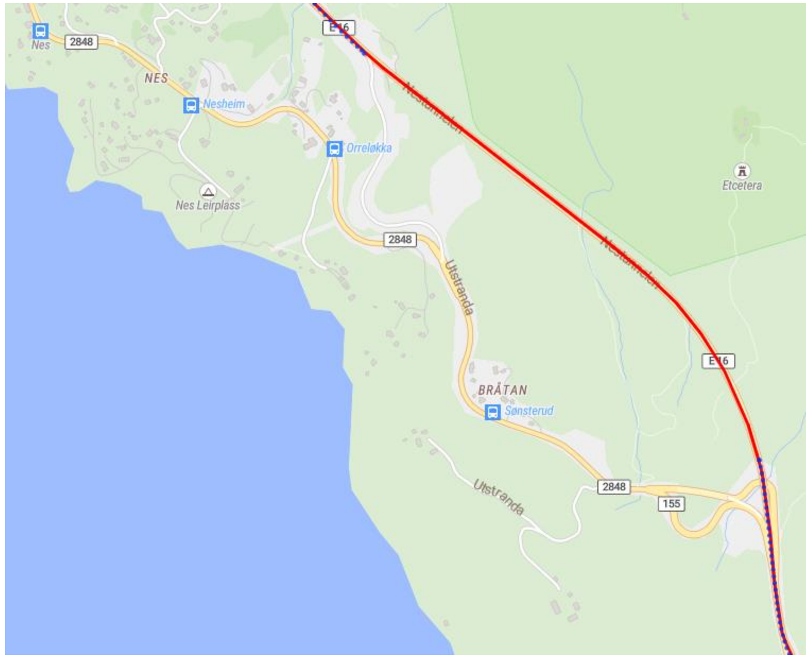


Gaps due to loss of GPS signal, e.g. in tunnels, can be closed with a high degree of confidence with Kapsch's proprietary gap closing logic (rated charge segments in green)

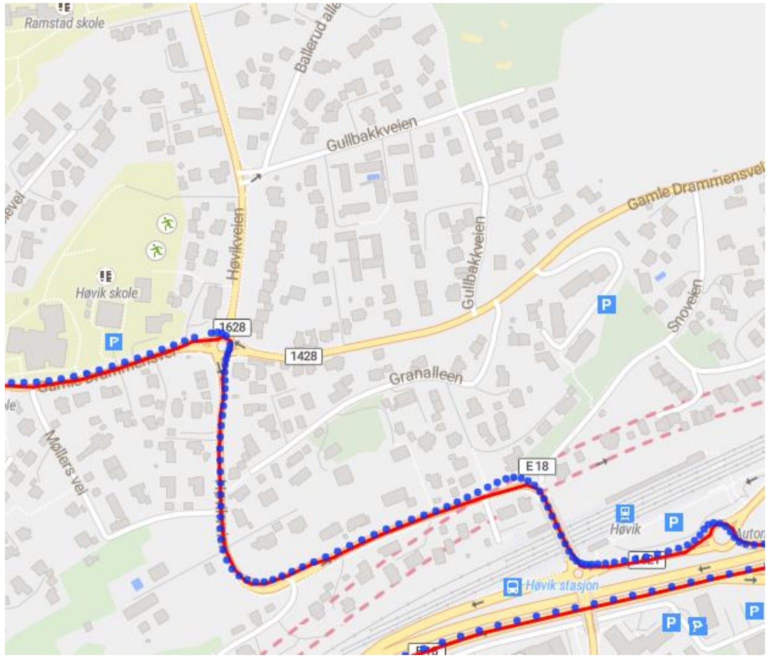
Kapsch's Geo Location Platform handles challenging environments and ambiguous data input



Example of tunnel entry and exit. GLP is capable of matching the correct route (red) while input GNSS points (blue) might be partly highly inaccurate due to connection loss



Another tunnel example in a non-urban environment. GLP is again handling these cases successfully (red track matched), even with significant GNSS gaps (blue dots)



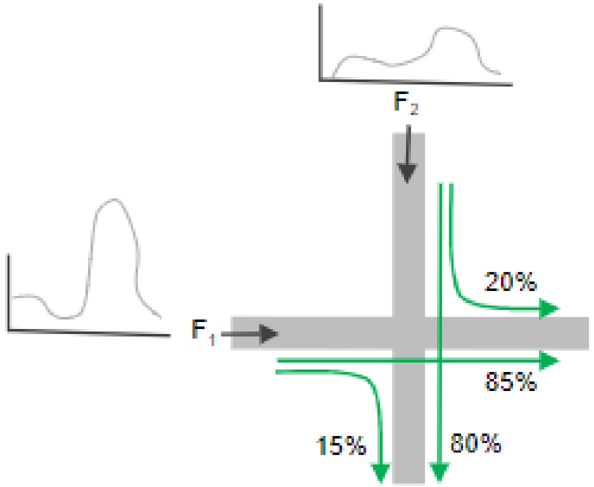
Multiple roundabouts in urban environments are handled successfully by GLP for a sample track

Key point:

> Even in challenging environments, such as tunnels in dense urban areas, GLP has proven to be able to handle GNSS locations from multiple Android devices

GLP also can provide services to derive traffic analysis data and high-fidelity, granular insights for traffic management

- While not in scope of the RUC PoC, GLP's capabilities for so-called floating car data (FCD) processing and routing can be leveraged to provide granular real-time traffic information and services to be utilized in subsequent traffic and/or demand management applications
- FCD can be used to provide information such-as Origin-Destination matrices or road-link-based volume, speed and travel time data, as typically used for traffic management use cases and traffic analyses
- Potentially enriched further with additional context information such as signal or weather data, high-fidelity actionable insights can be achieved without additional roadside infrastructure and also serve Demand Management
- Data is naturally anonymized for such use cases, for which personal information is not required, to ensure privacy by design

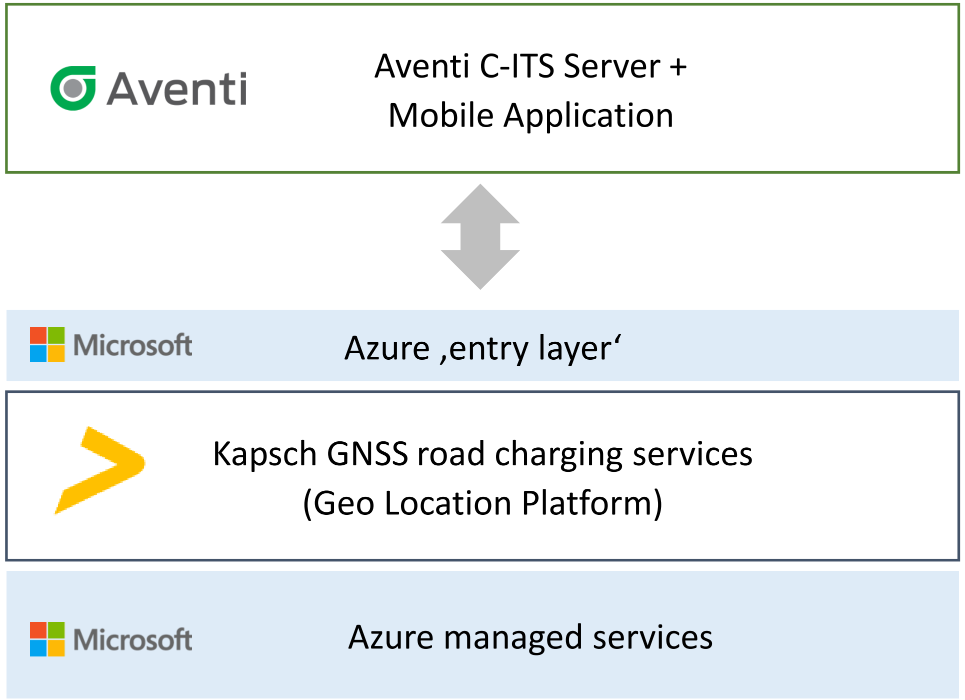


Key point:

> Modern road charging systems are able to leverage the GNSS data they process, to provide high-fidelity traffic management information without additional roadside infrastructure, while not compromising on privacy matters

For the RUC PoC, a dedicated Geo Location Platform cloud instance (tenant) was deployed in Northern Europe

- GLP is built in a cloud-native fashion, meaning infrastructure and platform services are fully utilized by so-called hyper-scalers such as Microsoft Azure
- During the load tests conducted for the PoC, GLP has proven to scale seamlessly in a horizontal fashion
- These hyper-scalers typically adhere to industry-leading information security principles and certifications such as (not limited to) ISO/IEC 27001:2013 (information security), ISO/IEC 27017:2015 (cloud information security) and ISO/IEC 27018:2019 (privacy) for MS Azure
- Different regions are supported, to e.g. ensure data is not leaving the European Economic Area (EEA)
- Kapsch itself is also following industry best practices for the development of all its products and is certified to ISO-27001 and ISO-20000-1 IT Service Management. Kapsch has very high security standards and are used to acting in GDPR-compliant manner. Kapsch also has the option to act as the Data Processor within EU/EEA.
- Regular external and internal audits such as penetration tests are executed to harden the system



Key point:

> Modern cloud deployments are able to scale horizontally and as such support charging schemes in entire countries or regions, while applying state-of-the-art security and privacy measures

5 GDPR compliance & analysis on use of data

The JuztDrive solution is based on user consent and adheres to all applicable legislation

- Our detailed legal analysis has identified several distinct roles as defined by the GDPR legislation, which are also applicable to this PoC, namely that of:
  - The **Data Subject** (the person whose data is being processed e.g. the driver) **in this case the driver**
  - The **Data Controller** (the person or entity who determines the purposes and means of data processing e.g. the service provider) **in this case Aventi** as the owner of the driver
  - The **Data Processor** (the person or entity processing the data, often on behalf of the data controller) **in this case Kapsch**
- The Data subject has been requested to collect route information to establish the (simulated) distance-based tax based on the tariff table provided in collaboration with TØI
- The Data Subject is provided with detailed information regarding the collection and processing of their data via the app provided by the Data Controller
- Processing and storage of data in line with GDPR regulations on a consent driven basis by the user
- If the user does not consent, then no data is gathered or processed
- Collecting data within the car and not transmitting it outside still needs to comply with GDPR
- In a future system there probably must be an alternative to on-board data collection for drivers without connected cars/smart phones or any other on-board unit, such as a flat rate solution alternative, odometer-based reporting – this has been outside PoC scope

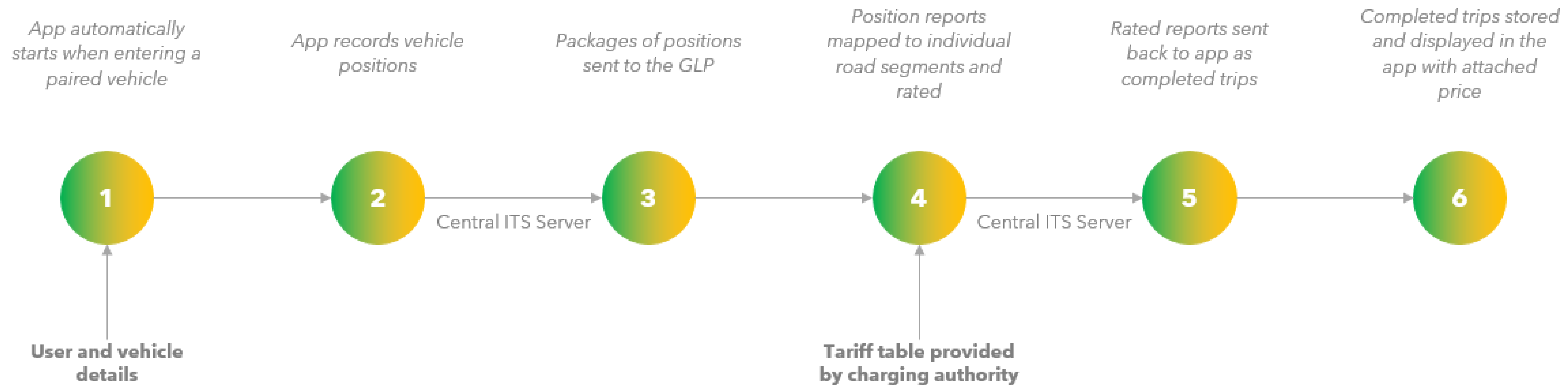
Importance of integrity

- Legitimate purpose and a lawful basis (GDPR and EDPB Guidelines)
- Prevent surveillance and misuse of date
- Minimization of data, e.g. only collect data necessary for the purpose of the processing
- Only collect data when the vehicle's location needs to be known
- Clearly inform the user that geolocation is taking place
- Option to deactivate geolocation
- Limited storage period

Examples of ways to comply with this

- Machine to machine interfaces and automated decisions to reduce human involvement of data
- Not collecting excess data for other purposes
- Avoid to store exact start and end positions of a route
- Only store data until the tax is collected or the appeal period is passed
- For statistical purposes (as traffic management analyses) the data can be fully anonymized when the tax have been collected (Optional)
- Security measures according to EDPB recommendations in place
- Valid consent under GDPR and possibly special legislation needed

The responsibilities of the data controller and the data processor are clearly defined and communicated



Data Subject	Data Controller	Data Processor	Data Controller

Data touchpoints for each defined party

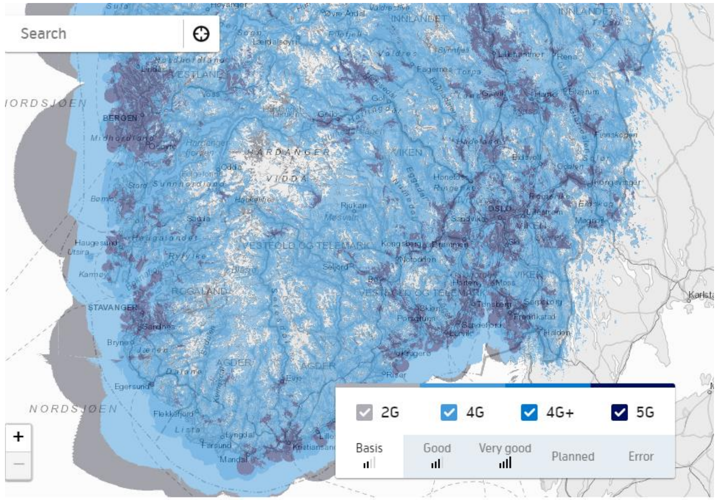
6 Conclusions & outcomes

The Norwegian road network presented a unique set of challenges, each of which we were able to overcome

- Each road network has its own characteristics and idiosyncrasies, which can often present challenges to a road charging solution
- In this case, we anticipated that Oslo's dense network of tunnels could result in occasional incorrect or inaccurate GNSS positions, particularly in cases where the tunnel featured openings at certain points (i.e. Operatunnelen) and/or a poor quality device was being used
- To resolve this problem, **we were able to make modifications to the trip building algorithm** in order to compensate for poorer quality or inaccurate data being received from the device
- Creating accurate trip reports in cases of inaccurate or missing positions presented a challenge, however such cases were successfully enhanced by adapting the quality thresholds for sending accurate GNSS data on the mobile application
- The Central ITS Server and GLP were configured to allow larger packages to be sent in cases of cellular coverage gaps – this solution was repeatedly tested and found to be able to produce accurately rated trips without any problems in cases of missing cellular coverage

Large number of tunnels – many with sporadic openings and crossing road sections

Areas with poor or no cellular reception

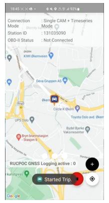


Conclusions: The JuztDrive approach fits very well with broader developments in the tolling and road charging market

1. The JuztDrive solution represents a viable approach to the challenge of implementing road user charging in Norway

2. Our approach is in line with current and expected future changes and compliments broader developments in the EETS, tolling and road user charging markets

3. The use of existing devices can significantly reduce costs by removing the need to procure dedicated hardware



JuztDrive

4. Use of existing devices can also improve the end user experience and public acceptance of the scheme by providing both choice and convenience

5. The solution is completely scalable and can cope with a very large number of total and concurrent vehicles causing high data throughput

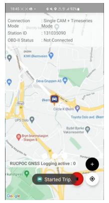
6. Delivering the solution with separate 'front end' and 'back end' providers ensures a balanced split of responsibilities and avoids over-reliance on a single supplier

Conclusions: The JuztDrive approach fits very well with broader developments in the tolling and road charging market

7 Over time, the app could be increasingly migrated to the vehicle using a combination of the in-vehicle telematics and smartphone mirroring platforms such as Android Auto

8 Multiple use cases can co-exist within a road user charging application, whether in-vehicle or on the smartphone, further increasing user acceptance and convenience

9 The JuztDrive model can be made fully GDPR compliant through respective user consent and by following GDPR and security principles (minimised data footprint)



JuztDrive

10 Personal metadata for invoicing can be separated from GNSS data sent for processing, with customer specific details held locally within the app and with the commercial service provider

11 While GNSS schemes are probabilistic by nature, excellent KPIs can be achieved by using commodity hardware even in challenging urban environments

12 Clear charging transparency on the mobile frontend can help towards public acceptance by making charges fair, transparent and intelligible

7 Glossary

Glossary of terms used

GNSS	Global Navigation Satellite Systems
NSP	National service provider
EETS	European Electronic Tolling Service
HGV	Heavy goods vehicle
GLP	Geo Location Platform
ICE	Internal Combustion Engine
EV	Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
EEA	European Economic Area
GDPR	General Data Protection Regulation
ITS	Intelligent Transportation System
PoC	Proof Of Concept
EDPB	European Data Protection Board
C-ITS	Cooperative Intelligent Transportation System

JuztDrive

Thank you

Key contact persons:

Terje Hundere
Daglig leder / General Manager

+ 47 90 59 99 60
terje.hundere@aventi.no

Aventi Group
Østre Aker vei 19
0581 Oslo

www.aventi.no

Mikael Hejel
Area Sales Manager

+46 76 879 55 45
mikael.hejel@kapsch.net

Kapsch TrafficCom AB
Bataljonsgatan 12, Box 1063
551 10 Jönköping

www.kapsch.net

Aventi

kapsch