THE DAWN OF EPOWER

How to successfully tackle the challenge of range anxiety in electric vehicles and conquer the mass market.
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“The stone age did not end because the world ran out of stones, and the oil age will not end because we run out of oil”

— Ahmed Zaki Yamani,
former oil minister of Saudi Arabia
For more than ten years, the future of electromobility seemed like a distant prospect thanks to the high prices of eCars, their low range, and the near-absence of charging infrastructure or battery research.

Today, we can confidently say that in upcoming decades this industry will change the automotive world as we know it. The question is no longer if, but when and how.

The public and governments alike are campaigning to lower carbon emissions, while individual countries are addressing their dependence on fossil fuels, and technological progress is resulting in electric vehicles that offer greater range at lower prices.

**In spite of all the efforts, the global market share of e cars is still just two percent.**

Technological progress is mostly focused on improving batteries, charging capacity and speed, or on the affordability of electric vehicles. But car makers are for the most part ignoring an equally important aspect – the anxiety that most drivers experience at the prospect of switching from internal combustion engines.

Electric vehicles and batteries behave differently in traffic jams, on highways, in cold or hot weather, cannot be instantly refuelled, have different plugs from model to model, and rely on a network of charging stations that is still developing. All these factors lead drivers to doubt the range and ease of charging of eCars, and may be inhibiting demand.

**Infotainment systems seem not to be part of the technological revolution.**

With some exceptions, most of today’s electric cars use the same or only slightly modified software as internal combustion engine cars. This includes navigation and advanced telemetry, which is a crucial part of the solution for tackling range and charging anxiety.

In this white paper we will discuss a modular, easy-to-integrate smart driving assistant developed specifically for electric vehicles. It consists of navigation based on individual car profiles and state-of-the-art eRouting, live traffic information and offline maps, charging-service providers and payments integration, and telemetry that provides guidance for eDrivers.

This solution is lightweight and flexible enough to be part of each car’s built-in systems, providing drivers with confidence about their range and charging, thereby easing their transition from internal combustion engine vehicles to electric vehicles.
The range anxiety challenge

It is 1884. One sunny afternoon, a vehicle pulls out of a garage in London. It silently crosses the street and disappears into the busy (mostly horse-drawn) traffic. More than twenty years before Ford’s Model T, engineer and inventor Thomas Parker had introduced the first practical production electric car, powered by high-capacity rechargeable batteries.

At that time, if you saw a car, it was most likely electric. Later, electric vehicles were priced out of the market by much cheaper vehicles powered by internal combustion engines.

Today, more than a century later, we are at the beginning of a similar revolution. Except that fossil fuel propulsion is the technology on the verge of extinction.

Before that happens, however, several challenges need to be addressed to encourage generations of drivers used to internal combustion engines to switch to vehicles powered by batteries.
These challenges include:

• The different behaviour of electric motors compared to internal combustion engines
• Calculating actual driving range
• Real-time integration of vehicle data
• Driver behaviour telemetry
• Factors negatively affecting driving range (e.g. weather, battery age, climate, air-conditioning usage)
• An undersized network of charging points
• Variation between charging point providers and specific conditions of use
• Cross-border travel using an international roaming solution
• Various charging modes (AC, DC) and connector types used in the charging points (Chademo, Combined Charging Standard - CCS)
• Variable charging speeds for each charging point, depending on the available electric voltage (230 V – 920 V) and maximum performance of the charging stations (from 2.5 kW up to 350 kW)
• Compatibility of the peak performance capability of the vehicle and the charging station

All of these challenges form a complex problem for electric vehicles that we call range and charging anxiety.

Range and charging anxiety – range drop

Despite the 64 percent growth in the number of electric vehicles worldwide in 2018, internal combustion engine cars still make up 97.8 per-cent of global sales. The automotive industry is struggling to take the next step, from innovators to mass acceptance.
According to the **Diffusion of Innovation Theory**, there are five adopter categories: innovators, early adopters, early majority, late majority, and laggards.

Currently, almost all European markets are stuck in the innovator phase of 2.5 percent of total car stock. The only country which has taken the next step and achieved early adopter stage, with a share exceeding seven percent, is Norway.

*Europe new battery electric and hybrid vehicle registrations 2019*
Along with the higher price, the top reason why most drivers are still sceptical is, according to a Frost & Sullivan survey commissioned by Nissan in Asia, the fear of running out of power – i.e. range anxiety.

Most of this anxiety can be resolved by providing the driver with comprehensive and transparent information regarding their available driving range, the compatibility and availability of charging points, and by tailoring each route to a specific electric vehicle while taking into account driving style, elevation and weather.

An eDriver navigation companion app can address most of these issues. It provides users with range confidence on long trips, gives them an overview of compatible charging stations, and actively helps their eDriving style by means of real-time feedback.

The problem

There are several factors that negatively influence the range of each electric vehicle.

Currently, the route is calculated assuming a fully charged battery and does not take into consideration how the driver actually drives, if they might need to temper their speed, or how fast the compatible charging points en route will be.

The solution

Navigation with predictive eRoute planning actively uses real-time information, taking into consideration several variables:

- Weather (current, forecast)
- Road topology (elevation)
- Traffic
- Driving style
- Historical data
- Charging speed (see Chapter 2, Charging Anxiety)
- Driver behaviour (see Chapter 2, Charging Anxiety)

Driving style

Internal combustion engines are most fuel-efficient at higher speeds – up to 90 kilometres per hour (55 mph). Electric motors achieve the best results at speeds lower than 70 kilometres per hour (40 mph).

From the routing perspective, this means that if a driver navigates from point A to point B with an higher average speed, they might need to make at least a one-hour stop to fully recharge.

By avoiding highways and going via a slightly longer route at an average speed of 70 kilometres per hour (40 mph) it might, conversely, be possible to skip the charging stop and arrive directly at the destination.

For internal combustion engines, the first route will be the most time-efficient. For electric vehicles, even at the cost of more kilometres driven, the most efficient will be the second.
**Traffic**

Although braking and acceleration in electric vehicles do not result in higher consumption as they do in conventional cars, thanks to recuperation, there is still a penalty. Especially when the driver is using, for example, air conditioning or heating.

The role of the eDriver navigation companion app in electric vehicles is to predict the estimated time spent in traffic and how this will influence the range. Taking into account weather conditions, it reads or estimates the battery’s status and takes into consideration the availability of the nearest charging spots.

It then uses all of this information to estimate if it is safe to refill after passing through an area of traffic congestion, while remaining on the optimal route. Alternatively, if the risk is too high, it will navigate you away from the route before serious traffic is encountered in order to reach a recharging location that is safely within range, and then return you to the original route.

**Road topology (elevation)**

Going uphill in electric cars results in higher consumption, comparable to conventional cars. On the other hand, descending and using regenerative braking results in the recharging of power cells and can increase driving range.

By taking the route topology into consideration, the eDriver navigation companion app can accurately calculate range and, at the same time, offer the driver a route with shorter ascents and longer declines in order to achieve better efficiency.

**Weather**

Changes in the weather have a relatively small effect on the driving range of conventional vehicles. By contrast, electric vehicles can in some cases experience a significant range drop.

As most current navigation aids don’t take into account the weather as a factor, there is a risk that the electric vehicle’s battery will be depleted faster than expected in cold weather, for example, which can result in an unexpected emergency stop.

A navigation app with predictive eRouting for electric vehicles integrates current weather data en route and uses these to calculate the real driving range influenced by the weather directly (e.g. cold, hot) and by other related factors (e.g. usage of heating and/or air conditioning).
“Seamless navigation is the imperative of eDriver convenience and the most crucial part of electric vehicles mass adoption.”

— Petr Fuzek, 
Vice President eMobility at Sygic
Charging anxiety

The basic purpose of a car is to get you from point A to point B with the fewest number of unplanned stops. Our dependence on internal combustion engines for more than a century has taught us that cars are affordable, can be instantly refueled, are easy-to-use, and have ample range.

But refueling in the early 1900s wasn’t so different from the present-day hunt for electric charging points. The first drive-in petrol station opened in Pittsburgh on December 1, 1912. If you were looking for fuel before that, the best option for several decades was hardware stores or pharmacies.

The adoption of electromobility is a complex and unpredictable process that includes several challenges which remain to be solved. Recharging is not instant, is sometimes slow, and in some cases is also not guaranteed due to the limited number of available charging points, or because of extended waiting times at eStations.

According to a white paper by the US International Council on Clean Transportation (ICCT), charging infrastructure is the most important factor in electric vehicle adoption, along with consumer incentives and awareness-raising.

All this plays an important role in range anxiety. As the struggle to achieve electric mobility becomes mainstream, it can be considered a separate topic on its own, with a number of challenges to be addressed, among them:

- Different charging modes
- Charging speed
- Provider registration and price

The problem

Charging modes

When you refuel an internal combustion engine vehicle, the process is straightforward. The fuel flows at the same speed from each pump, even if several drivers are refueling at the same time. If the last available pump is occupied, you can be sure that in matter of minutes another will come free.

You don’t have to care about compatible plugs, or flow rate. But on the other hand, eVehicles don’t have to visit a centralized location like a petrol station to recharge. You can recharge at home, at work, or while shopping.

If you are driving with electric vehicles, you will come across four charging modes with different charging currents and outputs.
In 2019, Europe had 170,149 public chargers. Most of them were AC chargers, with slow or average charging speeds. Fast chargers represented only a small amount of the them.

### Charging speed

If you are going 400 kilometres to visit your parents during the holidays and you need to stop to refill with petrol, the effect on your arrival time is unlikely to be significant.

Driving the same journey with electric power is different. The fastest route might be, using electric vehicle logic, the longest, depending on how the fast charging points en route are, or if they happen to be occupied when you arrive.

### Provider registration and price

In the early years, construction of charging station infrastructure in Europe wasn't regulated. Bills are currently calculated by energy use, charging time, flat rate tariffs – or a combination of all three factors. There is also no uniform payment mechanism.

Currently, you can pay in several different ways:

**MODE 1**
Slow AC charging, including household charging. Charging device integrated into the vehicle.

**MODE 2**
Slow AC charging with semi-active safety connection to the vehicle.

**MODE 3**
AC charging with active connection between charger and vehicle, allowing smart charging.

**MODE 4**
DC fast charging with active connection between charger and vehicle.
• Cash/Credit Card
• Radio-frequency identification (RFID)
• Mobile phone app or text message (SMS)
• Direct car-charger communication

So if, for example, you are going on vacation with your electric car, as you travel, you may have to deal with different charging stations, with different payment options, and with different mobile apps, all of which you will have to download and register with in order to access the service.

The European Union has addressed this issue by directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID), which allows operators to provide recharging.

**AC mode 1 – Home**
- Up to 11 kW
- 1 – 2 km

**AC mode 2 – Commercial**
- Up to 19.4 kW
- 3.2 km

**AC mode 3 – Commercial**
- 22 or 43 kW
- 21 km

**DC fast charging – Standard**
- 20 – 50 kW
- 64 km

**DC fast charging – High Power**
- 100 – 400 kW
- 90 km

services to customers on a contractual basis. It also counts on a scenario in which you can pay a new provider with no prior contract.

This means that if you are a customer of a charging operator whose services you use frequently in your home country, you can use the same registration and payment method you are used to, but with different providers.

For now, however, most EU member states have a minimum of two different billing systems and attempts to build interoperable systems mostly exist only at the local or regional levels. In the near future, we can expect industry solutions that will allow interoperability.

Without further regulation from the European Union, in particular of smart charging applications, this probably won’t be possible.

**The solution**

Most drivers use their car without knowing how it works or what its range is.

If they want to refuel, they just stop at the nearest petrol station. Electric vehicles require them to know the principles of their vehicle’s technology and plan ahead by noting charging spots, the weather, their average speed, and/or traffic congestion.

As a result, eMobility is still more the preserve of enthusiasts, rather than the majority of drivers. Navigation with predictive eRouting should ease the transition from conventional cars and give drivers confidence about their range.
To achieve a convenient charging experience, navigation has to address several challenges:

- Charging service provider integration
- Vehicle data integration
- Real-time driver coaching

**Charging service provider integration**

Today, if you are on a long trip to visit family or friends and you need to recharge, you can check for compatible charging stations en route and manually pick one which works for you.

The issue with this practice is that it is not for everyone and you have no assurance that the charging point will be free. This is not to mention unexpected situations, like getting stuck in a traffic jam in the winter with your heating on. You just have to take that risk.

Navigation with predictive eRouting takes into consideration static and dynamic data from your car, your current situation and battery level, nearby charging infrastructure and availability, and then adjusts the route automatically.

In practice, this means that if you just set a route from point A to point B, you might get several options, among them:

I. A shorter route with higher congestion via highways, with a maximum speed of 130 km/h and slow charging spots en route with the need to recharge fully.

II. A longer route with lower congestion, with a maximum speed of 90 km/h and a fast charging spot en route with no need to recharge to full battery capacity.

Navigation with predictive eRouting will automatically suggest the most efficient route and ask you if you would like to book the best charging spot at the time you will pass it, if available, or indicate how busy it is at the time of transit.

If it is busy, it will include into the route calculation the time and distance needed to get into the nearest available charging spot.

**Vehicle data integration**

Integration of the data from the electric vehicle itself is just as important as integration of data from charging points.

With these data, you can predict when to charge the car; current energy consumption when, for example, your heating is on; the capacity of the battery and how long it will take to charge it to the level needed to safely reach your destination.

These data can be static or dynamic. With the direct integration of the technology with the car, the navigation can obtain real-time data about current battery status, what systems are on, and the current maximum capacity of the batteries.

On the other hand, static data are based on available information about the car and user input. Navigation with predictive eRouting technology then tailors the routing to match the specific car profile.
Driver scoring: Detection of events and coaching

Driver behaviour has a significant impact on range and, before electric vehicles progress to early majority adoption, it is an essential part of the navigation in the car.

Coaching teaches drivers the basic principles of electric vehicle commuting on the go. For example, if you are unexpectedly stuck in traffic and your battery is nearly depleted, it can recommend that you turn off the heating in order to save power.

Another scenario might be that if you will have a choice of two routes – one with a maximum speed of 130 km/h and the other 90 km/h, it will advise you that you will achieve the best efficiency on the slower route.

The evaluation of driver behavior algorithms relies on the proper detection of driving events. These events are directly calculated by using a combination of data from GPS, accelerometer, gyroscope, CAN bus and an underlying map.

To ensure maximum accuracy, the solution employs advanced mathematical models.

The majority of events are also associated with their severity based on exceeded thresholds, which are reflected in multiplicative factors affecting the final score.
<table>
<thead>
<tr>
<th>Events</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start/end of the trip</td>
<td>Detection uses a combination of GPS map-matching trajectory and motion characteristics retrieved from sensors to filter out the walking part of the trip.</td>
</tr>
<tr>
<td>Hard acceleration</td>
<td>Hard acceleration is detected by processing accelerometer data. Based on g-force, severity is also identified.</td>
</tr>
<tr>
<td>Hard braking</td>
<td>Hard braking is detected by processing accelerometer data. Based on the g-force, severity is also identified.</td>
</tr>
<tr>
<td>Cornering</td>
<td>Cornering is detected by processing accelerometer data in search of a known pattern. Based on g-force, severity is also identified.</td>
</tr>
<tr>
<td>Speeding</td>
<td>Excessive speed is detected using map-matching techniques and checking speed limits given a road map is present. Severity is also measured as a percentage over the speed limit. Speeding is measured as a continual percentage over the trip.</td>
</tr>
<tr>
<td>Contextual</td>
<td>For a trip, the distance driven in different driving conditions is measured, such as time of day (day, night, weekday, weekend), road type (highway, urban), and traffic conditions (peak, off-peak, weather).</td>
</tr>
<tr>
<td>Smoothness</td>
<td>Smoothness is measured as micro-braking and acceleration cumulatively. This measure impacts fuel consumption.</td>
</tr>
<tr>
<td>Breaks and rest</td>
<td>Detection of breaks and rest characteristics.</td>
</tr>
</tbody>
</table>
Automotive integration

In the automotive world, the road to a new infotainment system is difficult. On average, auto-makers need up to 5 years from the first head unit upgrade input to find an original equipment manufacturer (OEM) and software contractors, go through the approval process, and finally put the system into production.

According to the Global Automotive Executive Survey 2019 by KPMG, surveying more than two million industry professionals, the #1 trend up to 2030 among car makers will be seamless connectivity and digitalization.

The report states that “connectivity is clearly the single most important prerequisite for the provision of additional services and content provided in the car and emphasizes the need for an easy-to-use and seamless human-machine interface, which will become increasingly important as a new ecosystem evolves.”

Additionally, for the first time, two out of three executives (65 percent) agreed that car manufacturers and information and communications technology (ICT) companies should cooperate, rather than compete, in order to bring innovative and attractive solutions to their cars.
To successfully support the transfer of most drivers from conventional cars to electric vehicles, giving them a tool to successfully tackle range anxiety is essential.

More than conventional navigation, they need a versatile all-in-one assistant, one which will give them confidence in their range, teach them the essentials of electric vehicle behaviour, and significantly contribute to a positive experience.

It will allow them to add a credit card and pay for charging services without the need to register separately for each provider.

The solution should be smart enough to predict daily situations en route by combining and evaluating data from several sources, including real-time traffic information, vehicle data and charging points.

Additionally, it should use precise high-quality maps from renowned providers like TomTom or Here (who know the terrain) and be capable of correcting and dynamically adjusting battery usage accordingly.

In the upcoming years, car makers, who are gradually announcing new electric vehicle models every year, will face several significant challenges requiring a flexible and innovative solution:

- Electric vehicle range calculation
- Real-time data integration (car data, live traffic, charging spots, weather)
- Real-time driver behavior and style evaluation (driver scoring)

**The challenge**

**Electric vehicle range calculation**

To successfully tackle range anxiety, it is essential for drivers to have confidence in their vehicles’ range.

The built-in navigation solutions in present-day eCars are still far from the breakthrough point at which they can process data from several sources, integrate them and use them to evaluate and predict new, unexpected and unknown situations which drivers can face en route while operating an electric vehicle.

This means that a good eDriver navigation companion app should be able to predict various specific situations that may challenge a user from the start to the end of their trip and provide assistance that ensures frustrating experiences are avoided.

*These include, for example:*

- **High congestion**, low battery, cold weather with the heating turned on, dynamically tailoring the route to the last possible available charging spot
- **Higher battery consumption**, because of load or higher speed, dynamically tailoring the route to the last possible available charging spot
- **Lower battery consumption**, because of economical driving, dynamically tailoring the route to reach a charging station with higher output, instead of a charging station with lower output, positively influencing the estimated time of arrival.
Real-time data integration
Electric vehicles and the surrounding infrastructure generate a vast amount of data. These include data from:

- The car itself
- Live traffic
- Charging stations
- Weather services

Car data
Except for the car data, this might be a challenge for automakers as third-party services require bilateral agreements.

Most currently used navigation solutions do not integrate into the routing all dynamic data from the car, so the expected range is based on the assumption that the battery is 100 percent full, the car doesn’t carry any load except the driver and that the heating or air conditioning is turned off.

Live traffic
To successfully calculate the range, live traffic data from a renowned provider as TomTom HD Traffic is crucial. Without it, the driver might get stuck in a jam with low charge and incorrect information about the range to the last charging station before the battery is completely depleted.

Charging points
Built-in navigation contains eVehicle related points of interest (POI), but the driver doesn’t know if these are busy, cannot make a reservation before reaching them, and might be required to register with a new provider in order to use them.

Weather
Some existing systems do provide current weather information and forecasts, but the algorithm in the navigation cannot work with these data and use them in the actual calculation of the optimal route.

Real-time driver behaviour and style evaluation
With electric vehicles’ market share at just slightly above 2 percent, in the upcoming years most new drivers will be switching from internal combustion engine vehicles. To change their habits, and help them with the transition, it is imperative to evaluate their behavior behind the wheel and their driving style.

By doing this, automakers can positively influence their experience, increase range, battery life and prevent frustrating events on the road.

The solution
In the upcoming years, electric vehicle makers should consider changing the slow technological response of current infotainment systems' development and join forces with experienced navigation app developers, who are bringing fresh thinking into the industry.

For their part, developers should offer flexible and easy-to-integrate solutions as a complete package, in the form of a software development kit (SDK) or as separate modules in the form of an app user interface (API).
Electric vehicle range calculation

Currently there are two ways to correctly predict the range of an electric vehicle. The basic prediction model employs static car data and high-quality map data. The dynamic prediction model uses real-time car and map data to dynamically adjust the route to reflect the current status of several key indicators.

The most important real-time data, which affect the precision of the algorithm, are:

- Actual weight
- Battery state
- Speed

Basic prediction model

Basic estimation of battery usage relies on map data and the static parameters of the vehicle.

These are the required parameters of each vehicle:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Abbr</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>M</td>
<td>Vehicle mass including the driver (kg)</td>
</tr>
<tr>
<td>Frontal area</td>
<td>Af</td>
<td>Frontal area for aerodynamic resistance in m²</td>
</tr>
<tr>
<td>Aerodynamic drag</td>
<td>cD</td>
<td></td>
</tr>
<tr>
<td>Rolling resistance</td>
<td>cR</td>
<td>For a typical tyre pressure</td>
</tr>
<tr>
<td>Battery efficiency</td>
<td>n1</td>
<td>Efficiency from battery to power train</td>
</tr>
<tr>
<td>Battery efficiency rec.</td>
<td>n12</td>
<td>Efficiency for recuperation from power train to battery</td>
</tr>
</tbody>
</table>
**Advanced prediction model**

The advanced model extends the basic model by relying on a periodic check of actual battery usage by the vehicle based on real-time data obtained from on-board diagnostics (OBD). These are compared against the calculated prediction, resulting in new predictions adaptively calculated with greater precision.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Abbr</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight actual</td>
<td>Ma</td>
<td>Actual vehicle weight measured by suspension</td>
</tr>
<tr>
<td>Battery state</td>
<td>P</td>
<td>Percentage of battery</td>
</tr>
<tr>
<td>Speed</td>
<td>V</td>
<td>Vehicle speed</td>
</tr>
<tr>
<td>DC current to the engine</td>
<td>le</td>
<td>Actual current (or power) averaged over a unit of time, e.g. 1s, 10s.</td>
</tr>
<tr>
<td>DC current to aux</td>
<td>la</td>
<td>Actual current (or power) averaged over a unit of time to auxiliary systems (audio, A/C, heating, lights)</td>
</tr>
<tr>
<td>DC current recuperated</td>
<td>lr</td>
<td>Actual recuperation current (or power) averaged over a unit of time</td>
</tr>
<tr>
<td>Battery temperature</td>
<td>Tb</td>
<td></td>
</tr>
<tr>
<td>Outside temperature</td>
<td>Ta</td>
<td></td>
</tr>
<tr>
<td>Engine torque</td>
<td>Tau</td>
<td></td>
</tr>
<tr>
<td>Engine rpm</td>
<td>Rpm</td>
<td></td>
</tr>
</tbody>
</table>

**Real-time data integration**

The eDriver companion app evaluates data from several sources (e.g. ADAS), integrates them into the routing information and becomes a vital part of the electric vehicle experience. It provides users with range confidence, facilitates and accelerates the learning process, and at the same time minimizes negative experiences en route.

**Car data**

By correct injection of the dynamic data into the route calculation, the eDriver companion app is able not only to adjust the route according to the static vehicle data but also to correctly predict various factors that might influence its range. These include higher weight and current to the engine, lower energy recuperation, or preheat the battery when a charging station is added to the navigation for better charging experience. According to these data, the route is dynamically adjusted to achieve the best efficiency and comfort for the driver.

**Live traffic**

Although the power consumption of electric vehicles in traffic is better than in internal combustion engine cars, congestion can dramatically change in a short time during the trip. Having a quality live traffic provider like TomTom, which processes data from more than 500 million users is essential to correctly predict vehicle range and calculate the most efficient route.
**Charging points**

Charging anxiety is an inseparable and important part of range anxiety. The current experience, especially for new and potential drivers, is discouraging. Therefore the eDriver companion app shows electric vehicle-related points of interest (POI), but also integrates data from eMobility providers (EMP) like Plugsurfing in Europe, which covers over 130,000 charging points. Using these inputs it can guarantee the quality of the service, check the availability of each location, and offer reservation in advance and payment afterwards. All this without leaving the app or the car.

**Weather**

By integrating the current and forecast weather into the routing algorithm and combining these data with others mentioned above, the eDriver companion app is able to better evaluate, estimate and calculate the route and maximum range. It takes into account the different behavior of the battery in cold or hot weather, usage of air conditioning or heating, and also changes in the rolling resistance of the wheels when driving on snow.

**Real-time driver behaviour and style evaluation (driver scoring)**

To minimize the risk that a new electric vehicle user will carry over bad practices learned from driving vehicles with internal combustion engines, the eDriver companion app can also serve as a real-time coach by monitoring key indicators that influence range – such as speed, acceleration, braking and cornering. Based on these variables it can recommend to the driver, for example, to lower the speed to 70 kilometers per hour, in order to reach the next fast-charging point, or to adjust their acceleration and deceleration habits.
As we stand at the dawn of the electric vehicle age, the quality and user experience of the software installed in our cars is turning out to be just as – perhaps even more – important, especially for younger customers, than more traditional buying factors like engine performance or exterior styling.

Today, it normally takes up to five years for new infotainment systems and software to enter production. After that, most car makers guarantee updates for just a limited time, often with the need to visit an official service point.

The new companies in the electric vehicle market, like Tesla, show that it can be done better. They do this not only via maintenance updates, but also by adding new features that have a direct impact on the overall user experience.

The driving assistant which we have described in this white paper comes as a sustainable, always up-to-date, all-in-one solution for the user-driver industry, capable of delivering new features over time and integrating data from car to smartphone, and vice versa.

It also provides drivers with range confidence for long-distance trips, real-time traffic information and a hassle-free charging experience, by integrating payments and data from charging stations that drivers use in their daily commutes.

At the same time, car makers can benefit from a modular solution which comes as a software development kit (SDK), based on their specific requirements. It is easy to integrate and maintain, and will provide a unique selling point for customers embarking on their journeys as electric vehicle users.