Enabling and Accelerating eMobility Adoption

Commercial Overview

SPARK
EV TECHNOLOGY

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About Spark EV Technology

COMPANY OVERVIEW

- Founded: 2017 | HQ: Cambridge, UK
- **Personalised energy prediction software for zero emission vehicles (EV, hydrogen, hybrids)**
- Over 5 years of real-world trials across Asia, Europe and North America.
- **Patented prediction technology utilising advanced physics models and machine learning algorithms covering China, Europe, UK and US**
- **Live projects with OEMs and Tier 1 suppliers on upcoming vehicle programmes**
- Solutions that deliver improvements for the driver and fleet management experiences

Example Customers & Partnerships

ADVANCED PROPULSION CENTRE UK · AVL · NICHE Vehicle Network · STARTUPAUTOBAHN powered by PLUG AND PLAY · UKRI Innovate UK

"Our mission to enable and accelerate eMobility adoption."

Justin Ott,
CEO Spark EV Technology

Inaccurate range is slowing the transition from fossil fuels

PROBLEM STATEMENT

A significant **overestimation** of range could leave the driver **stranded!**

A significant **underestimation** of range could cause unnecessary **anxiety!**

Zero emission vehicles today use a fixed portion of time (say the last 30 minutes or miles) and assume that an extrapolation of the average energy usage over this period is sufficient to estimate remaining range

The problem with this is that it does not take into account where the vehicle is going, who is driving it, and a multitude of other environmental factors that can influence battery life.

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Range & charge anxiety is a major problem

PROBLEM STATEMENT

Commercial Vehicle Market Challenge:

- Castrol's 2020 report highlights inaccurate range and poor management as the number one obstacles for commercial EV adoption.

Addressing Industry Pain Points:

- Spark mitigates anxieties related to EV adoption and utilisation by addressing issues such as:
  - unreliable charging infrastructure
  - complex energy predictions
  - risk of stranded vehicles, drivers and goods
  - strict SLAs and operational constraints

*Accelerating the EVolution: The tipping points to mainstream electric vehicle adoption – Castrol, 2020

*"…the EV market could grow to $367 billion per year if consumer expectations for price, charge time and range are met."**

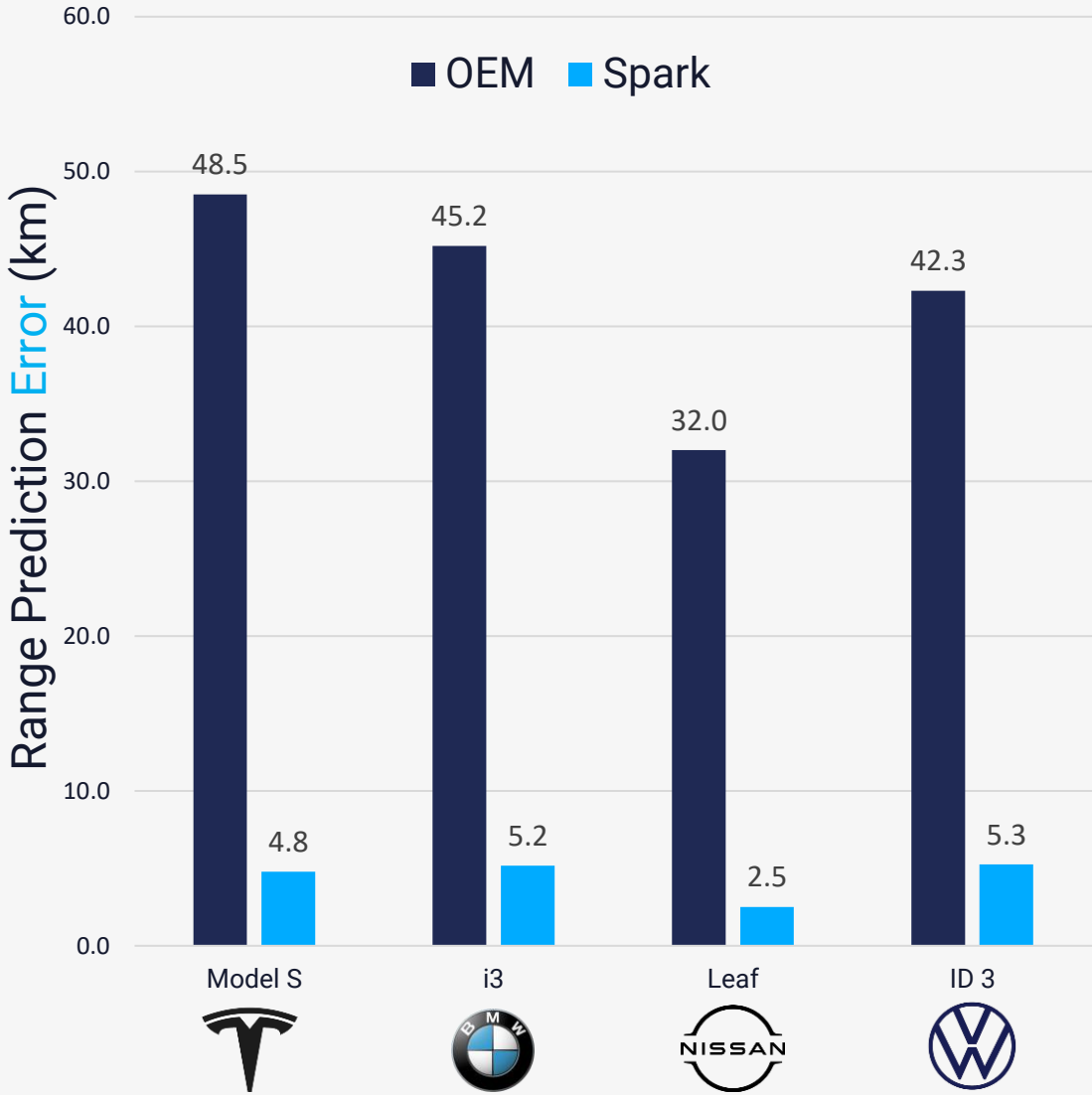
*"Eight in 10 consumers in our survey claim that the distance you can travel per full charge is an important or very important consideration when looking to purchase an EV."**

Range prediction today is sub-optimal

PROBLEM STATEMENT

In real-world EV testing, OEM prediction of range remaining can be out **by over 48km (over 100% error).***

In comparison, **Spark's prediction of energy usage for a journey is typically accurate to 2.5km***.



- *Spark EV Technology real-world testing of existing Electric Vehicles. Spark makes predictions in energy terms, and this is converted back into km using the overall efficiency of this vehicle across all journeys in testing.
- *Range Prediction Error = Actual Distance Driven – Change in Range Remaining as Displayed in Car*

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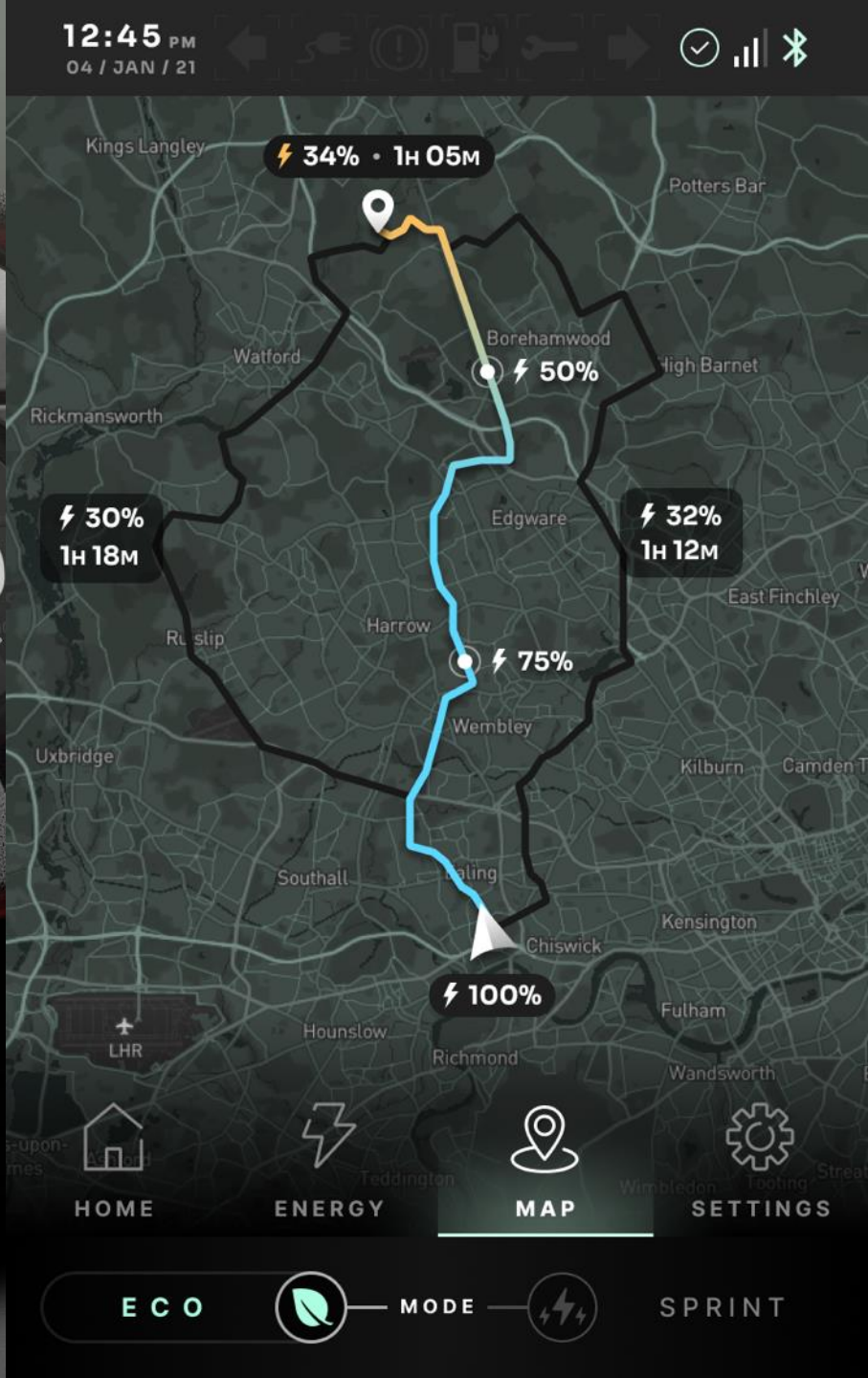
Spark ASSURE



Highly accurate, personalised journey predictions for a given route - if the destination is known, and the route planned (leveraging any major mapping solution), then ASSURE produces a highly accurate, personalised journey prediction for that route. This prediction shows the driver how battery capacity will reduce during the journey, and an accurate prediction of the remaining capacity at the destination. It can also show how that result might vary if different route options are selected.

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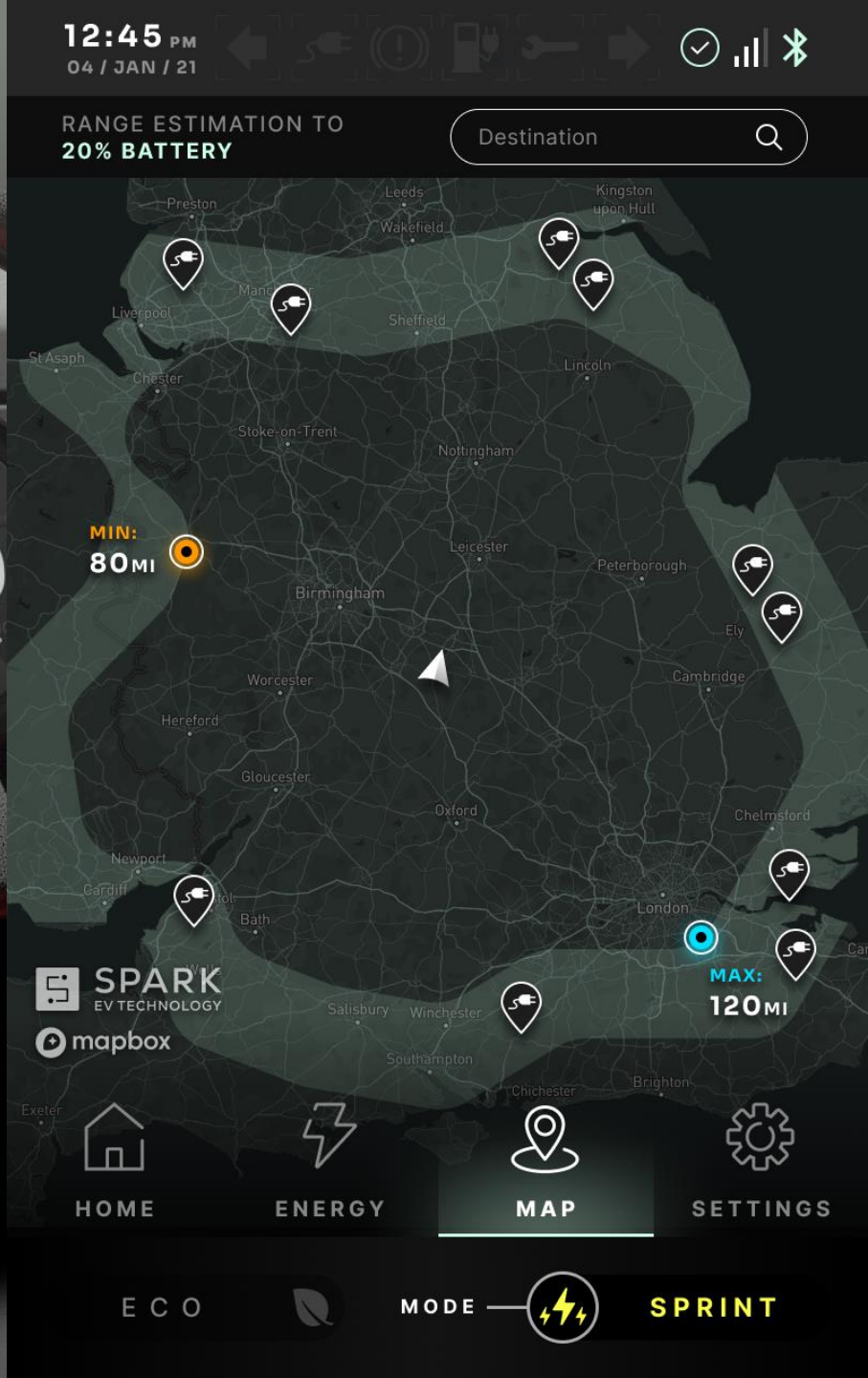
Spark FLOW



If the destination isn't fixed, and the driver wants to understand where the available energy can take them in ANY direction, we can produce a personalised range boundary estimate and show this graphically on any major mapping solution. The boundary can be set by the driver based on their preferences, for instance wanting to see the boundary when 20% battery capacity remains. We also show available charge-points between this boundary and another threshold (such as 5% remaining).

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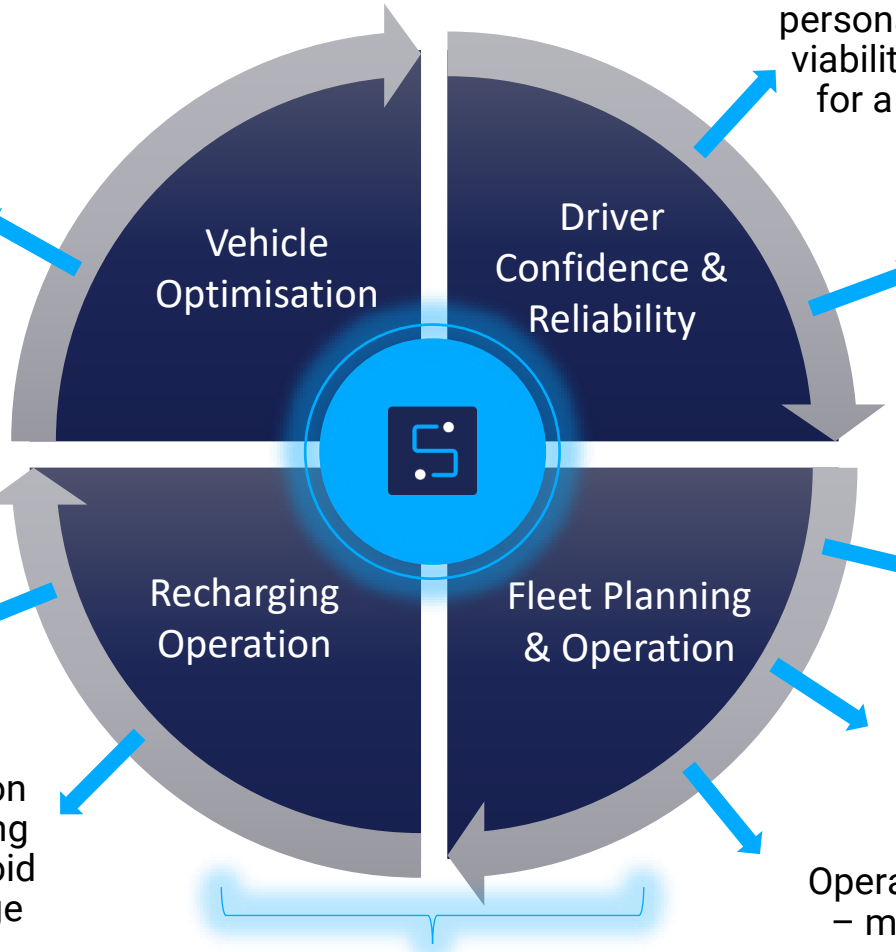
Enabling An Ecosystem of Zero Emission Vehicle Optimisation

ENERGY PREDICTION AT THE CORE; CRITICAL INSIGHTS, CREATING VALUE FOR OEMs, DRIVERS AND FLEET CUSTOMERS

Active reduction of energy consumers (such as HVAC) to conserve energy

Active management of mixed energy sources

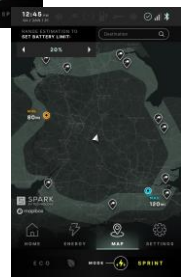
Pro-active management of vehicle energy consumption



Highly accurate, personalised journey viability predictions for a given route

ASSURE

Personalised range boundary estimates without entering the route



FLOW

Supporting fleet procurement by specifying the right vehicle for the required use-case

Planning the transition to a zero emission fleet

Operational planning – multi-stop route optimisation & charging strategy

EV FLEET CONVERT

Preferential arrangement with Charge Point / Refuelling Stations

Informing CP infrastructure deployment strategy

Minimise charging time – operational efficiency improvement

Reduce the strain on the fuelling/charging infrastructure – avoid unnecessary charge point occupation

Consistent predictions supporting the entire customer lifecycle

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Patented Intellectual Property

Patents covering Spark prediction engine across four regions which utilises advanced physics models and machine learning algorithms with broad protection across:

- **China** (published) (2019113411438)
- **Europe** (published) (EP18215804.8)
- **UK** (granted) (1721535.1 and 2539422)
- **US** (granted) (11,420,641 and 11060883).

Patents scope and primary claims:

- A prediction system using live on and off vehicle data (e.g., vehicle parameters, routing, weather, battery)
- Machine learning algorithm adapts and enhances prediction accuracy-based driver and vehicle combination.
- Applicable to any vehicle segment (automotive, aerospace, marine)
- Applicable to any energy source (electric, hydrogen, hybrids).
- Applicable to be used on any electronic device (including integrated as HMI or standalone mobile app for fleets).
- Applicable to human driven and autonomously driven vehicle systems.
- Patent valid until December 2037.

Trademarks:

- SPARK™, SPARK ASSURE™, and SPARK FLOW™

Additional IP:

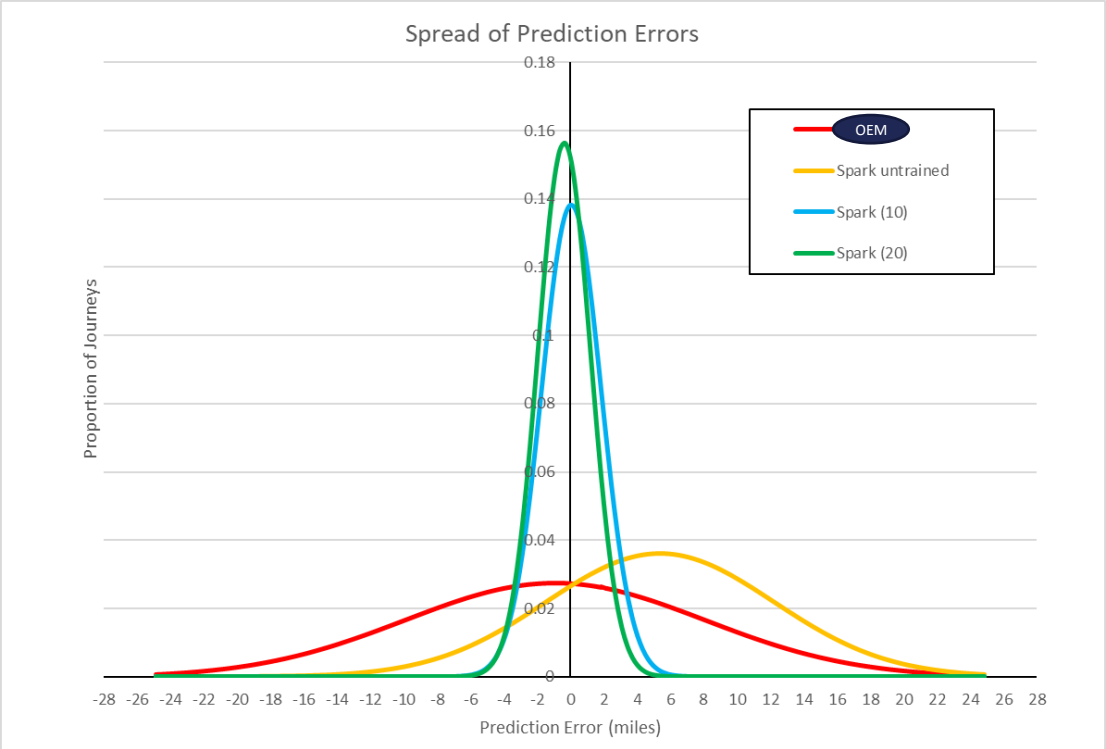
- Trade secrets gathered and documented through 6 years R&D
- Customer lists, ongoing projects and senior relationships

Case Study 1: 16T Commercial Vehicle

REAL WORLD TESTING

Effects of training (ML)

- Multiple journeys completed across two test phases logged for analysis including:
    - Varying distance and climatic conditions
    - Combined driver analysis
    - Laden and Unladen payloads
- As the number of training journeys increases, the spread of errors in the Spark ASSURE predictions decreases
- After just 10 training journeys, almost all **Spark ASSURE** journey predictions are expected to be **within ± 5 miles**
- The spread of errors from the **onboard system** mean errors can be expected to be **within ±25 miles**



Case Study 2: VW ID3

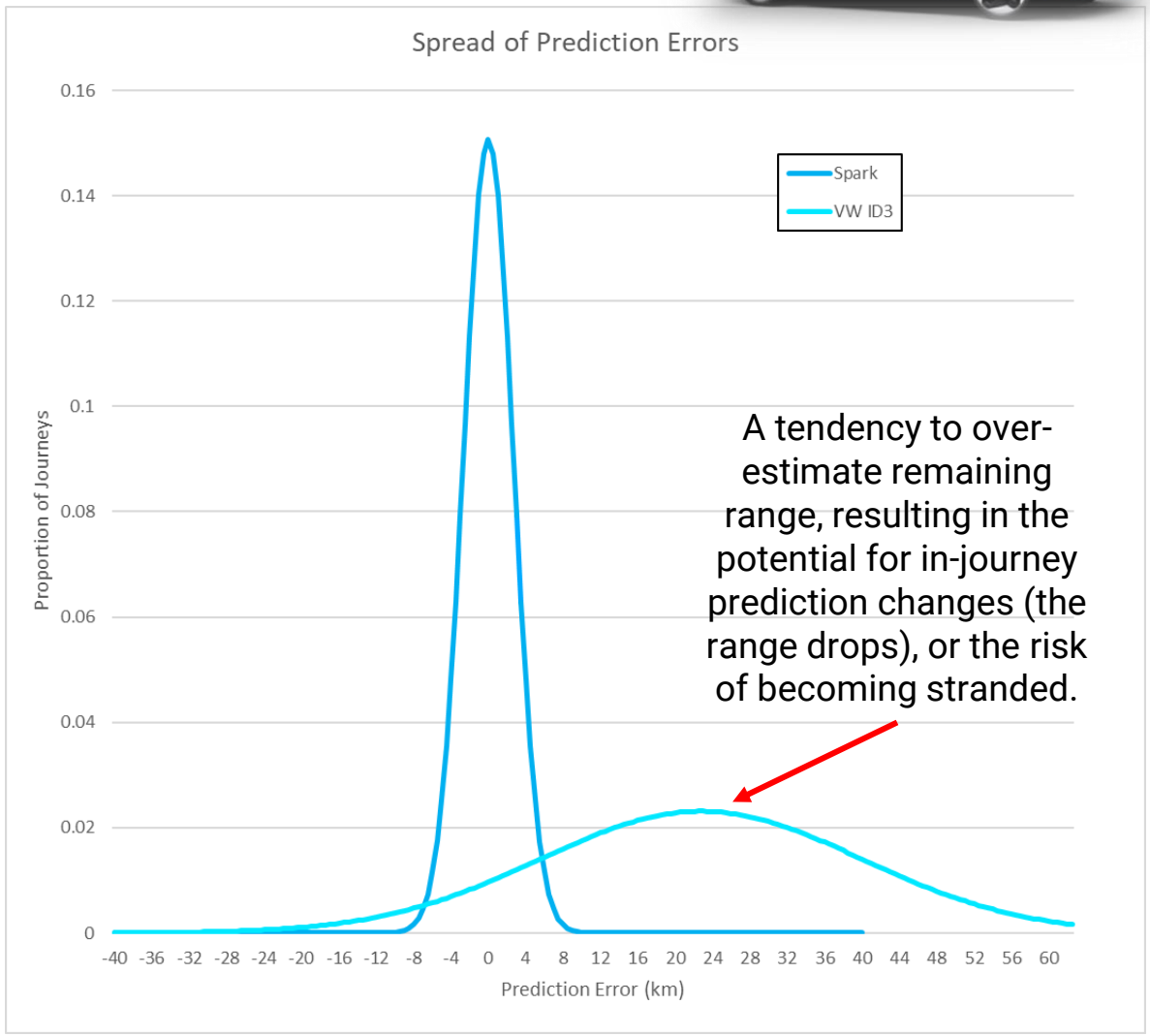
REAL WORLD TESTING

This benchmark data has been captured at Spark's expense, without collaboration with the OEM. The data is therefore Spark property and to be considered **confidential**. It does not represent official data provided by the OEM, and is not intended to imply concurrence by the OEM involved.

Spread of Prediction Errors

- Spark's spread of prediction errors is symmetrical about zero, whereas **the VW ID3 significantly over-estimates the range**.
- **To complete 99.9% (3 standard deviations, one sided) of journeys:**
  - **Spark system only needs 8km reserve range.**
  - **VW ID3 system requires 52km reserve range.**

With the Spark solution, the driver can continue to confidently use the vehicle until only 8km of range is predicted to be remaining at the end of the journey, whereas the VW solution would require a precautionary recharge with a predicted 52km at the end of the journey to avoid the potential of being stranded due to high range prediction errors.



Two Significant Automotive Market Opportunities for Spark

ADDRESSING THE BARRIERS TO BEV AND FCEV ADOPTION

1

Leveraging Spark's Existing IP to improve Electric Vehicle (BEV or FCEV) energy and range prediction outcomes

2

Combining Spark IP with best-in-class Fuel Cell management to improve the operational efficiency of FCEVs (save fuel)

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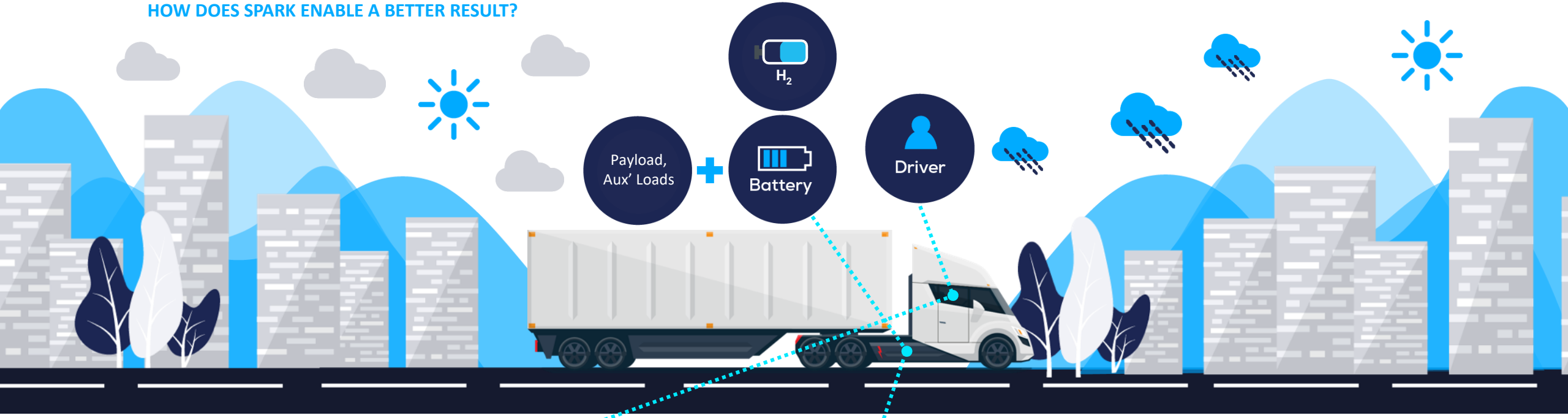
SOLUTION 1: Intelligent, Personalised & Contextual Energy Predictions

HOW DOES SPARK ENABLE A BETTER RESULT?



We take into account the history of every journey taken by this vehicle AND combine this with the influence of driver behaviour to create a vehicle and driver combination "***personal energy consumption model***"

Bring all of this together with the live vehicle status (including onboard energy & health data) **utilising Spark's machine learning algorithms to provide accurate predictions**

We model the exact route to be taken, OR create a map of the all the possible major routes in any direction, taking into account the terrain and environmental conditions, and **calculate the energy required to make that journey(s)**

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Why Would Fleet Customers be Interested?

EV COMMERCIAL FLEET EXAMPLE

- DPD in the UK has a fleet of 1600 HGVs (1,440 at 90% utilisation)
- Assuming they were to adopt the Volvo FM Electric (Rigid) Truck[1]
- The impact of **one unplanned recharging event per day** could result in the loss of 1 productive hour, per day, per vehicle, or **a loss of 11% vehicle utility**[2].
    - The fleet would need to grow in size by 11%, or the equivalent of **158 additional vehicles to avoid lost capacity** (opportunity cost).
    - Each vehicle costs approximately **€350,000 each**, resulting in a potential **CAPEX impact of €55.3m** (without finance costs).
    - With a typical lifetime of **8 years**, the **annual CAPEX impact to the DPD fleet could be ~€7.7m PA (€4,818 per vehicle[3])**
- The average driver salary is ~ €47k PA. **Lost driver productivity would equate to €5,170 per driver, or €7.44m per fleet PA** to increase the driver pool in line with the growth in fleet size.
- Additionally, fleets incur a **penalty for missed or late deliveries** (which vary depending on the logistics contract/customer).
- A customer would need to **spend just 1%[4] of the above to avoid the cost** of unplanned stops.

Significant Operational Efficiency Gains

- Annual CAPEX saving of €4,818 per vehicle (€7.7m PA)
- Annual productivity gain of €5,170 per driver (€7.44m PA)
- Avoiding costly late delivery penalties

Box body not shown

1 – Volvo FM Electric Truck
https://www.volvotrucks.co.uk/en-gb/trucks/models/volvo-fm.html.
2 – EU rules dictate maximum driver hours/day to be 9 hours (possibly slightly higher if max 56 hrs/wk leveraged). This utility calculation assumes a single driver per vehicle.
3 – Spreading the cost across the whole fleet.
4 – %age of the 'cost' of unplanned recharging (€4818 + €5170 PA) versus the software subscription (assuming €100 PA) that could avoid it.

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Why Would OEM Customers be Interested?

VOLVO

EV COMMERCIAL VEHICLE OEM EXAMPLE

- Volvo Trucks registered approximately 2500 electric trucks (16 tons+) in 2023 (worth €850m – €1.25bn)[1]
- With fleet operators achieving single digit margins (~4%), an operational efficiency impact of €10,000 per vehicle PA (plus the increased vehicle financing costs) will not be sustainable – **operators will look for vehicles that can be relied upon**.
- Any vehicle that is susceptible to unplanned stoppages will soon be identified by the trade – **reputational damage** could be devastating.
- By the same account, any OEM that can offer **the most effective vehicle can reasonably expect to secure additional market share** as a result.
    - If Volvo Trucks, with a vehicle that is potentially 11% more efficient than the competition were able to secure ~11% more market share, this could equate to incremental sales of ~€125m PA (~250 additional vehicles).
    - If Volvo Trucks provided Spark's technology at their cost on all new vehicle sales (2500 PA), this would equate to a cost of just €25000 PA (€200,000 lifetime) to secure that €125m annual sales upside.

Industry Leadership

- Reputation – trust and reliability is critical for customer retention
- Increased market share – the best product will dominate
- A 'stop-start'(ICE) tipping point for EVs

Box body not shown

1 – Electric on the rise – Volvo Trucks keeps its leading position https://www.volvotrucks.com/en-en/news-stories/press-releases/2023/may/electric-on-the-rise-volvo-trucks-keeps-its-leading-position.html.

SOLUTION 2: Proactive Management of Fuel Cell Operation

A JOINT AVL / SPARK EV SOLUTION: PROACTIVE, OPTIMISED ENERGY MANAGEMENT FOR FUEL CELL EV OEM & THEIR FLEET OPERATORS

Uphill Approach
Anticipate steep hills, inclines
Pre-charge battery

Climb
Maintain support of fuel cell during uphill
Prevent full depletion of battery

Hill Top
Deplete battery before downhill to enable full recuperation

Descent
Ensure full utilization of recuperation potential
Prevent overcharging of battery

Flat Road
Use planning of battery SOC over trip to optimize performance and H_2 efficiency

OBJECTIVE

Prediction of **journey energy requirements** can be used **to proactively manage the operation of the fuel cell**.

The resulting, optimized energy management is designed to enable fuel (H_2) savings and unlock other value-added benefits for OEMs and their fleet customers.

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Why Would Fleet Customers be Interested?

FCEV COMMERCIAL FLEET EXAMPLE

- DPD in the UK has a fleet of 1600 HGVs
- Assuming they were to adopt the Hyundai XCIENT Fuel Cell Truck[1], and that each truck benefitted from the AVL/Spark Power Split optimization
- With an annual use of approximately 53,000 km per vehicle per year,
- Taking a 5% H_2 fuel saving on average:
    - DPD could **save €4.25m per year**, or
    - With a typical lifetime of **8 years**, the DPD **fleet could save ~€34m**
    - **With additional battery SOC management this saving could be double** (e.g. depletion at depot).

Significant Operational Efficiency Gains

- Annual fleet Hydrogen fuel saving of €4.25m PA
- Lifetime (fleet replacement cycle) savings of €34m
- Rebalancing the TCO model in favour of Fuel Cell Electric Commercial Vehicle adoption

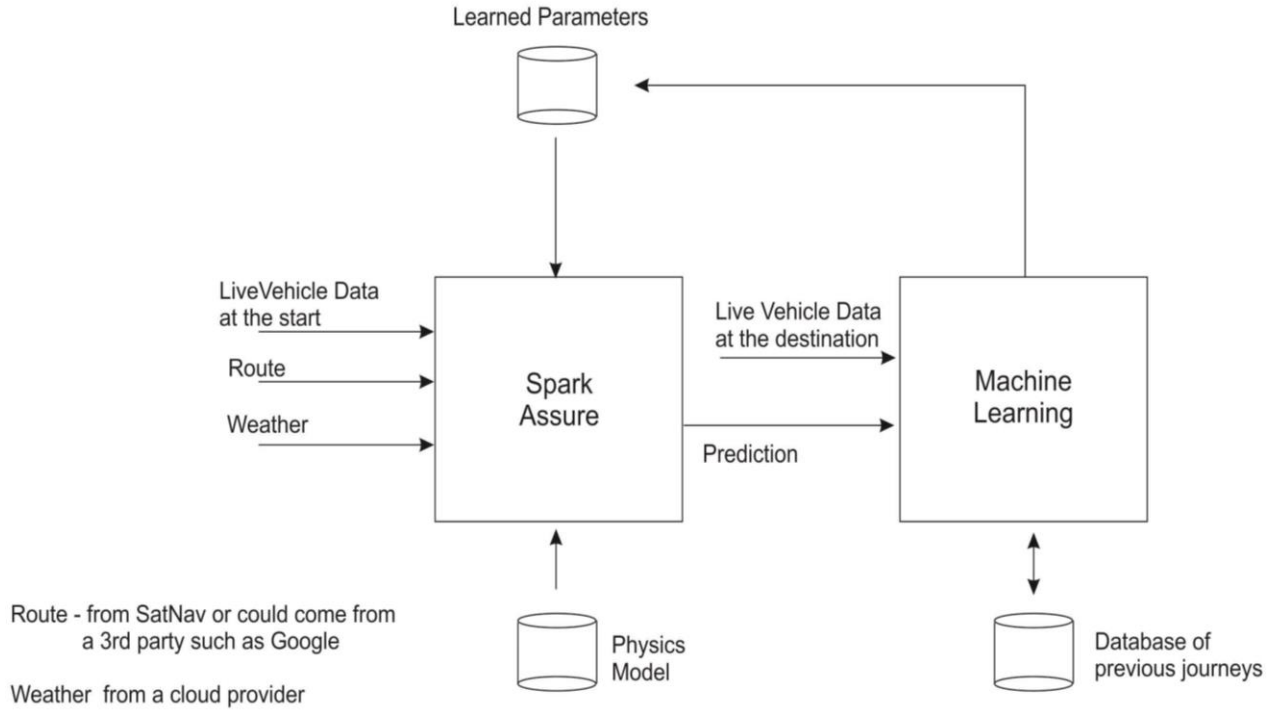
Savings per vehicle	
H_2 fuel saving per year	€3,092.04
Cost/saving[2]	3.76%

A saving that could be added to the operational efficiency benefits presented by Spark's core range prediction technologies (see DPD BEV example)

1 - Hyundai XCIENT Fuel Cell Truck https://www.prnewswire.com/news-releases/xcient-fuel-cell-fleet-racks-up-5-million-km-reinforcing-hyundais-hydrogen-leadership-301661945.html#:~:text=%22XCIENT%20Fuel%20Cell%20is%20the,Innovation%20at%20Hyundai%20Motor%20Company.
2 - '%age of fuel saving 'spent' on the software subscription that enables the saving

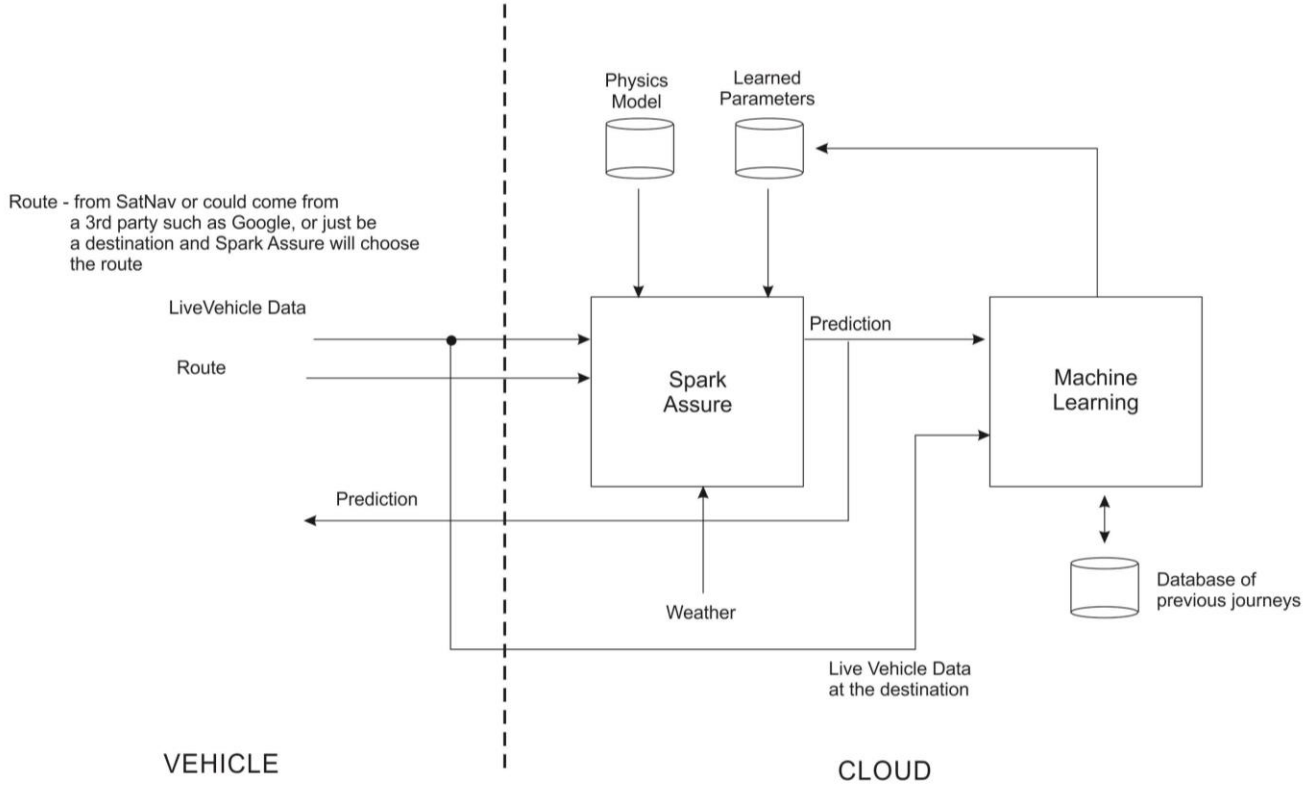
ASSURE / FLOW Embedded SDK

- For automotive operating systems (e.g. QNX, AAOS)
- Comprehensive set of APIs:
  - Driver registration
  - Journey predictions
  - Driver metrics
- Individual driver profiles
- Low resource requirements
- Native C++ for optimal execution
- Core prediction engine and machine learning (black box model)
- Example integrations as source code



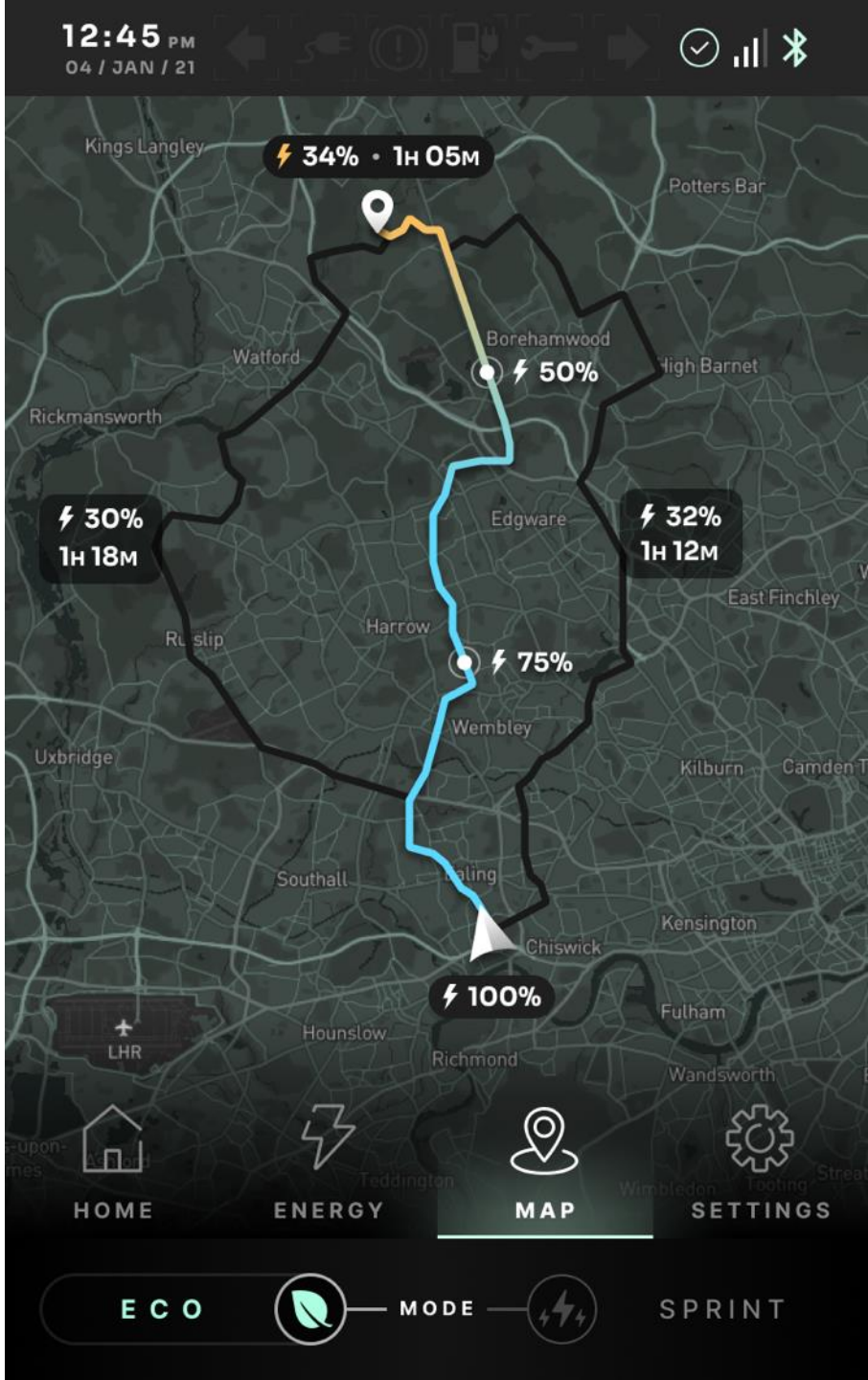
ASSURE / FLOW Cloud SDK

- C#/.NET implementation
- Example Azure implementation and visualisations
- Scalable solution
- Encrypted data storage and transmission
- Comprehensive set of APIs:
  - Driver and vehicle registration
  - Journey predictions
  - Driver metrics
- Individual driver profiles
- Core prediction engine and machine learning (black box model)
- Example integrations as C# source code



Data Storage and Compute

- **Journey requests are typically ~20kB each**
- Predictions can be made on vehicle and data is requested at the beginning and end of the journey only
- **Can be adapted to many 3rd party routing and weather data sources (e.g. HERE, Google, OpenWeather)**
- Machine learning can be processed onboard or in the OEM cloud and can be batched and run during quiet periods
- **Our prediction system has been tested on very modest hardware and can make predictions within 100ms with further optimisation available**
- The largest data storage requirement is the database of historic journeys for machine learning (1000's of journeys @ 1kB/record)
- Spark requires the OEM to provide unique IDs for drivers and in a multi-driver fleet scenario (multiple drivers/vehicle), a scheme could be used creating ~100 user IDs, once this is used up, the oldest unused profile is reassigned
- For Spark FLOW we keep a coastline database that is used along with the mapping/routing provider to determine the range in all directions, that database is typically 100s of MB.



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