




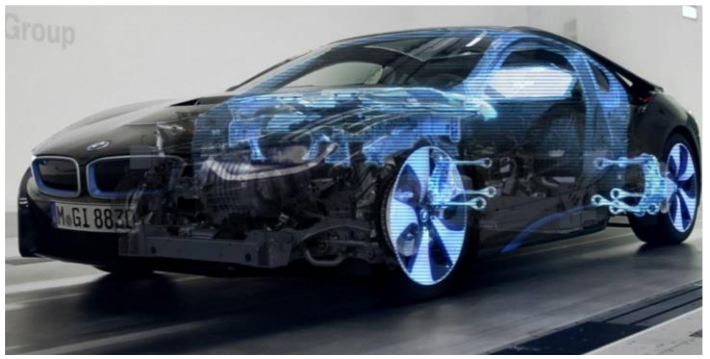


GPU Technology Conference, April 18th 2015.

THE FAST LANE FROM SILICON VALLEY TO MUNICH.

UWE HIGGEN, HEAD OF BMW GROUP TECHNOLOGY OFFICE USA.

BMW GROUP

Rolls-Royce Motor Cars Limited

THE AUTOMOTIVE INDUSTRY WILL UNDERGO MASSIVE CHANGES DURING THE NEXT 10 YEARS.

SUSTAINABILITY

CARS ARE **POWERED BY ELECTRICITY**

CO_2 SUSTAINABILITY HAS GAINED GREATER SIGNIFICANCE

DIGITALIZATION

CARS ARE DRIVING ALMOST **ACCIDENT-FREE**

UTILIZATION CONCEPTS LIKE **CAR-SHARING** ARE **WIDELY AVAILABLE**

HUMAN-MACHINE-INTERFACE BECOMES MORE **INTUITIVE**

CARS AS ELEMENTS WITHIN THE **DIGITAL ECOSYSTEM**

BMW GROUP TECHNOLOGY OFFICE USA.
MISSION.

The BMW Group Technology Office aims to **accelerate the delivery of automotive innovation to customers** through the **evaluation**, **development** and **design of new technologies**.

Located in Mountain View, California, the Technology Office is meant to:

- **Explore new technologies** and form relevant business partnerships, outside of the automotive world
- Promote external perception of the BMW brand as a **leader in innovation**
- Attract **top talents** to BMW within highly competitive Silicon Valley marketplace

The Technology Office produces work that enables BMW to **be the future**, **see the future** and **reimagine the future** of **world-class automotive engineering for individual mobility**.

BMW GROUP TECHNOLOGY OFFICE USA.

SUSTAINABILITY

FUTURE MOBILITY CONCEPTS	BATTERY TECHNOLOGY
POWERTRAIN	SMART HOME
SMART GRID	RENEWABLE ENERGY
BATTERY 2ND LIFE	SMART CHARGING

DIGITALIZATION

CONNECTED CAR	APPCENTER
SENSORS	ADVANCED DRIVER ASSISTANCE SYSTEMS
BIG DATA AND MACHINE LEARNING	HIGHLY AUTOMATED DRIVING
USER EXPERIENCE CONCEPTS	INTERNET OF THINGS

EXAMPLE.

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BMW i CHARGEFORWARD PROGRAM. THE NEXT STEP FOR ELECTROMOBILITY.

CUSTOMERS

Enjoy reduced upfront vehicle costs and total cost of ownership.

Extend their contributions to sustainability.

UTILITY

Efficiently use grid resources.

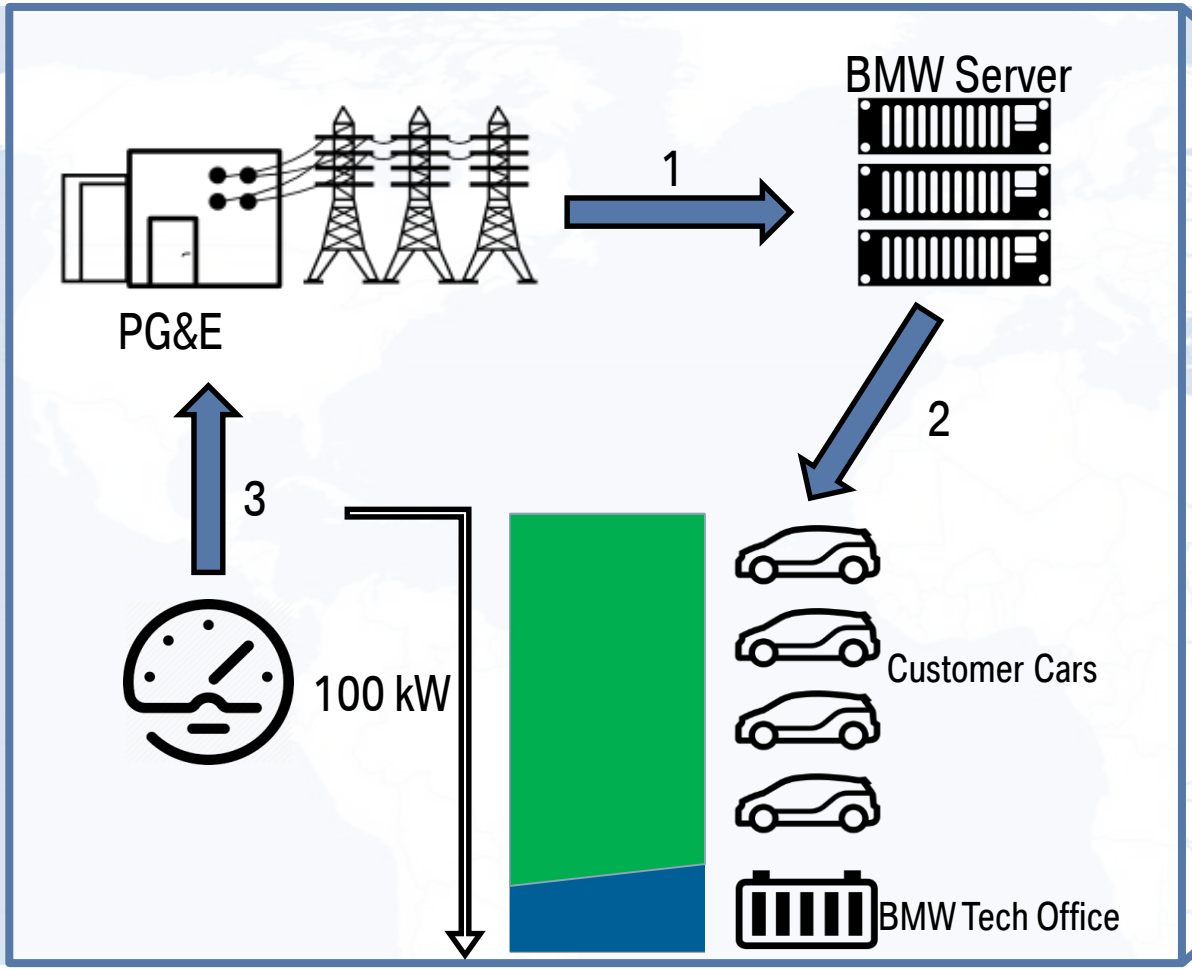
Reduce costs of operating and maintaining power grid.

BMW GROUP

Encourage adoption of electric vehicles.

Expand upon commitment to sustainable mobility.

BMW i CHARGEFORWARD PROGRAM. TECHNICAL APPROACH.



1. PG&E contacts BMW server and requests load drop (up to 100 kW).
2. BMW selects vehicles for charging delay based upon owner preferences and notifies customers, who can opt out as desired. Stationary battery provides additional power as needed.
3. Smart meters verify that total desired load drop is achieved.

EXAMPLES.

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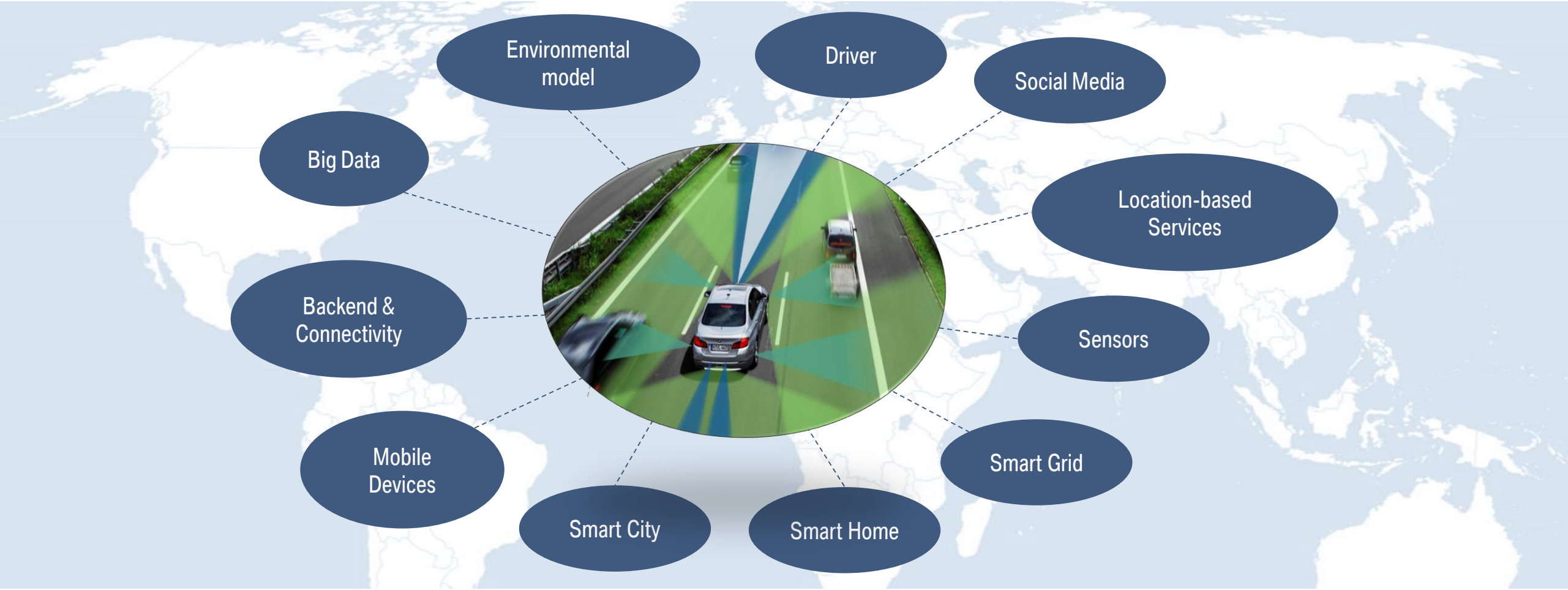
CARS AS ELEMENTS WITHIN THE **DIGITAL ECOSYSTEM**

CONNECTED MOBILITY.
BMW i - THE NEXT GENERATION OF A CONNECTED CAR.

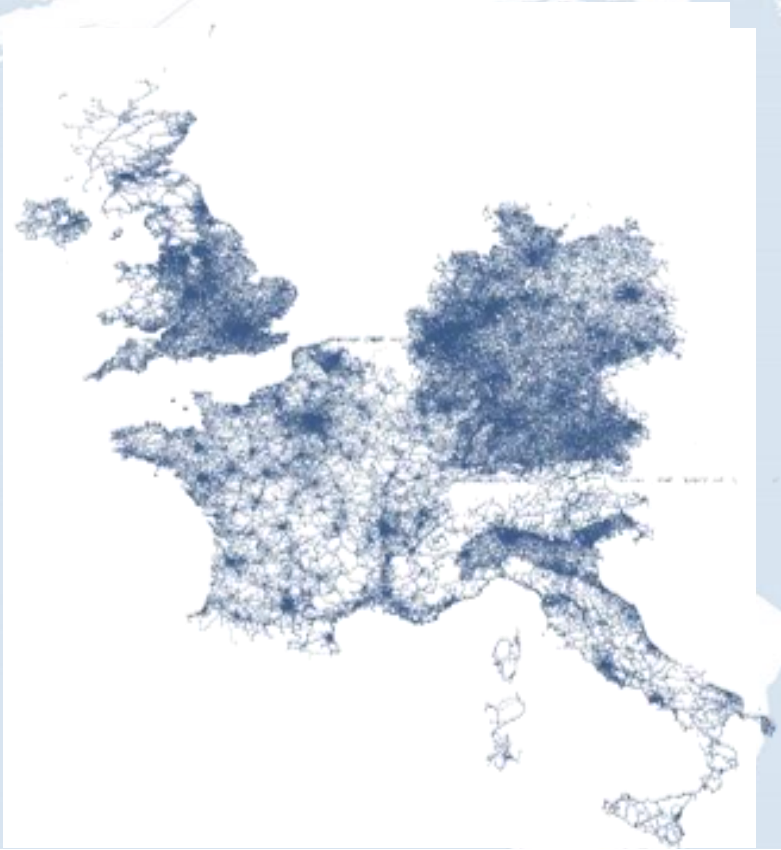
- Charging station availability, off-board range calculation.
- Intermodal routing using off-board sources, Remote Smartphone App.

CONNECTED VEHICLES ARE PART OF THE INTERNET OF THINGS. CONTEXT OF DRIVER AND VEHICLE WILL MELT TOGETHER.

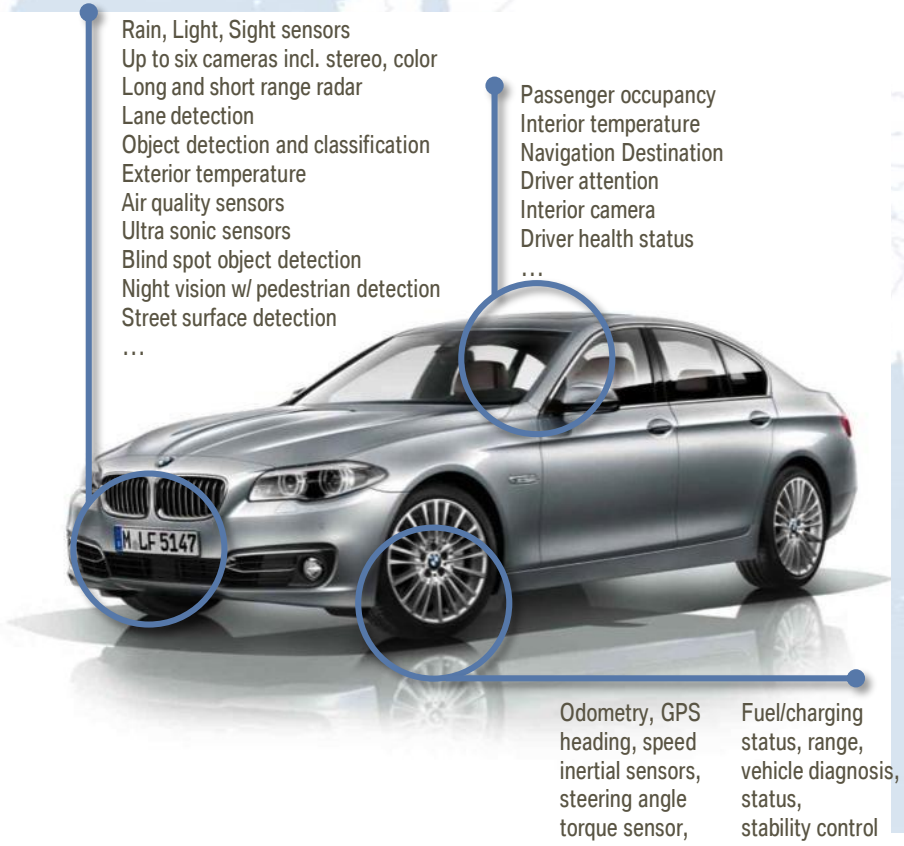


VEHICLES EQUIPPED WITH SENSORS, SENSOR FUSION AND BACKEND CONNECTIVITY PROVIDE A REAL-TIME REPRESENTATION OF THE ENVIRONMENT.

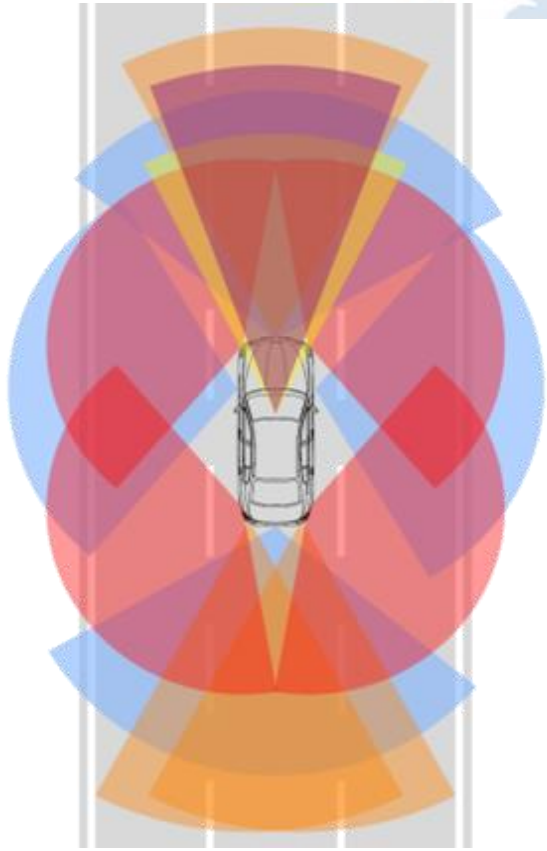
DENSE ROAD NETWORK COVERAGE



CURRENT VEHICLE SENSOR TECHNOLOGY

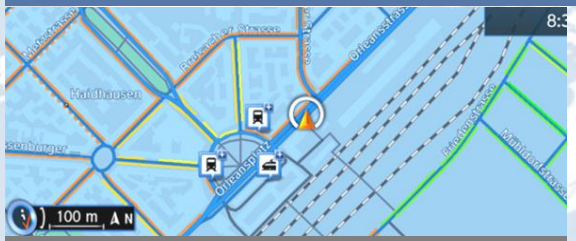


ONBOARD SENSOR FUSION



CROWD-SOURCING OF SENSOR DATA ENABLES FUTURE USE-CASES AND BENEFITS THROUGH UP-TO-DATE, HIGHLY ACCURATE MAPS.

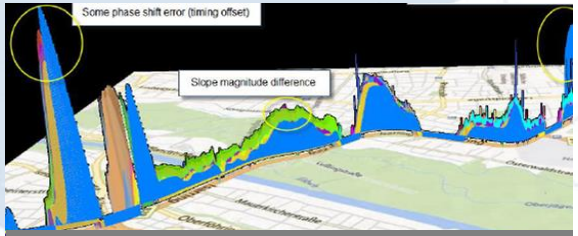
KNOWLEDGE EXTRACTION FROM SENSOR DATA



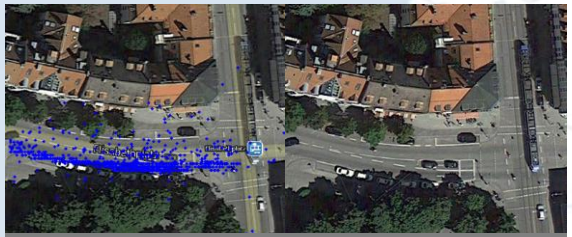
PARKING PROBABILITY

MAPPING OF INDOOR PARKINGS

ENERGY CONSUMPTION PREDICTION



CURVE SPEEDS AND CURVATURE



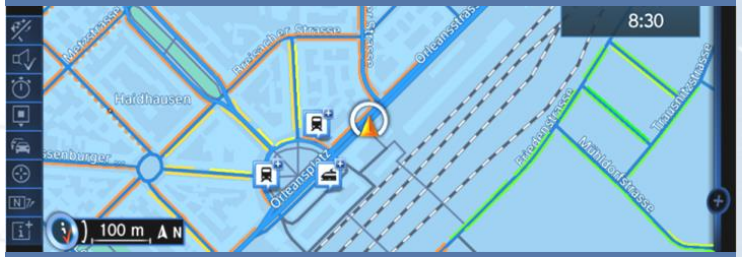
STOP LINE EXTRACTION

ROAD GEOMETRY EXTRACTION

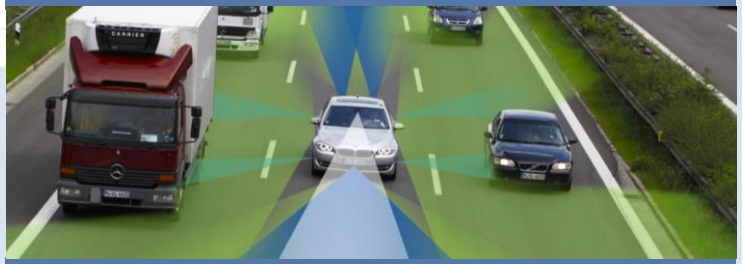
DIGITAL MAP

- Up-to-date
- Accurate
- HD Content
- Coverage

SERVICE



ADAS AND AUTOMATED DRIVING



EFFICIENT DYNAMICS

HIGHLY AUTOMATED DRIVING WILL INCREASE SAFETY, COMFORT AND EFFICIENCY FOR THE DRIVER AND SOCIETY.

IMPROVED TRAFFIC AND DRIVING SAFETY.

Vehicle can see and react to hazards that a human driver may not be able to.

INCREASED DRIVING COMFORT.

Gaining valuable time by delegation of driving tasks.

IMPROVED DRIVING EFFICIENCY.

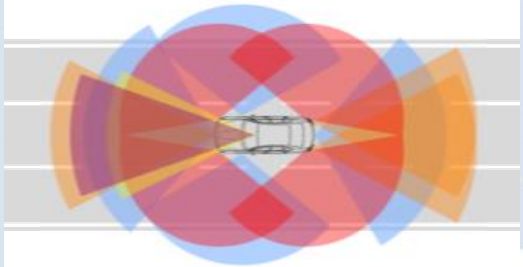
Time and fuel savings through optimized driving strategy.

HIGHLY-AUTOMATED DRIVING AND DIGITALIZATION WILL CHANGE THE USER EXPERIENCE IN THE FUTURE.

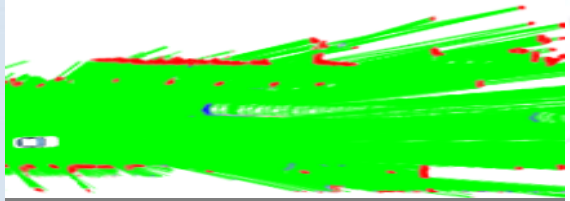
BESIDES THE USER-INTERFACE, ADDITIONAL TECHNOLOGIES NEED TO BE MASTERED ON THE WAY TOWARDS HIGHLY AUTOMATED DRIVING.

BACKEND

SENSORS



ENVIRONMENT MODEL

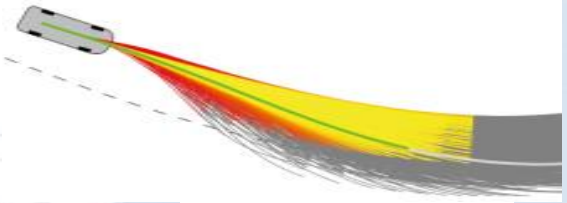


FREE SPACE

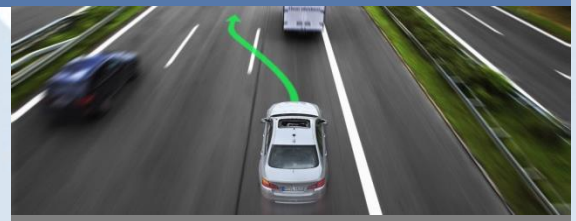
SELF-LOCALIZATION

MOTION CONTROL

HAF DRIVING FUNCTION



TRAJECTORY PLANNING

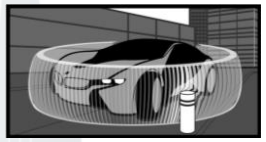


DRIVING STRATEGY

E/E ARCHITECTURE & CONTROL UNITS

360° COLLISION AVOIDANCE.
THE NEXT STEP TO ACCIDENT-FREE MOBILITY.

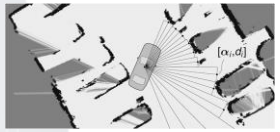
FUNCTION.

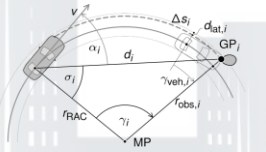


- The vehicle automatically avoids collisions with static obstacles.
- When the driver approaches an obstacle suspiciously fast, the vehicle assumes that the driver has overlooked the obstacle and starts to brake.
- At any time the driver can steer away from the obstacle and the brakes will automatically disengage.
- The brakes will also automatically disengage when the driver backs away from the obstacle.

360° COLLISION AVOIDANCE.
THE NEXT STEP TO ACCIDENT-FREE MOBILITY.

TECHNOLOGY.

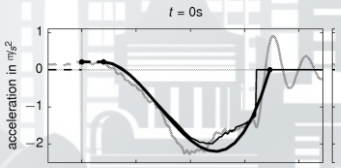




$$r_{obs,i} = \sqrt{d_i^2 + r_{RAC}^2 - 2\, d_i\, r_{RAC} \cos(\sigma_i)}$$

$$\gamma_i = \arccos\left(\frac{r_{RAC}^2 + r_{obs,i}^2 - d_i^2}{2\, r_{RAC}\, r_{obs,i}}\right)$$

$$\Delta s_i = \left(\gamma_i - \gamma_{veh,i}\right) r_{RAC}$$



- Build-in laser-scanners permanently collect data of the vehicle surrounding to build a 360° obstacle map.
- Even if the sensors can not directly see the obstacles close to the doors, the vehicle still estimates their positions relative to the vehicle by predicting the vehicle movement.
- The vehicle calculates an optimal stopping trajectory 100 times per second in order to quickly react to changes in the environment.



HOW DOES IT FEEL TO DRIVE THE ALL-ELECTRIC BMW i3?



THANK YOU FOR YOUR ATTENTION.