VOLKSWAGEN

AKTIENGESELLSCHAFT

DRIVING INNOVATION IN THE AUTOMOBILE INDUSTRY

PROF. DR. JÜRGEN LEOHOLD
EXECUTIVE DIRECTOR VOLKSWAGEN GROUP RESEARCH AND AUTOUNI

VOLKSWAGEN GROUP RESEARCH

THE BRANDS – OUR CUSTOMERS

KEY FIGURES OF THE VOLKSWAGEN GROUP – 12/2014

Production plants

118 worldwide

Employees

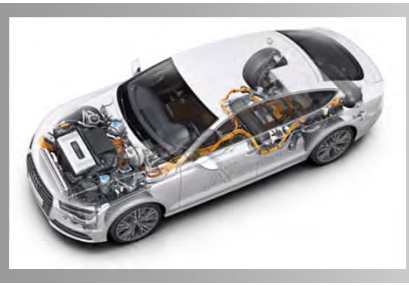
592,600[1)]

Models

approx. 335

1) 597.800 on June 30, 2015.

RESEARCH FOCUS



Powertrain

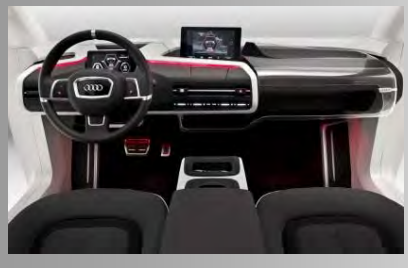
- Powertrain Concepts
- Technologies for Emission Reduction
- Efficient Combustion Engines
- Fuel Cell Systems
- Li-Ion and Post Li-Ion Batteries

Business Innovation

- Business Models & Services
- Service Design

Virtual Technologies

- Virtual Reality
- Augmented Reality



Electronic & Vehicle Engineering

- Intelligent Car & Data Analytics
- Vehicle Technology and -Concepts
- Assisted and Autonomous Driving

Materials & Production Process

- Metallic Materials
- Plastic / Fiber-reinforced Composites
- Active Materials & Funct. Surfaces
- Joining and Manufacturing Processes

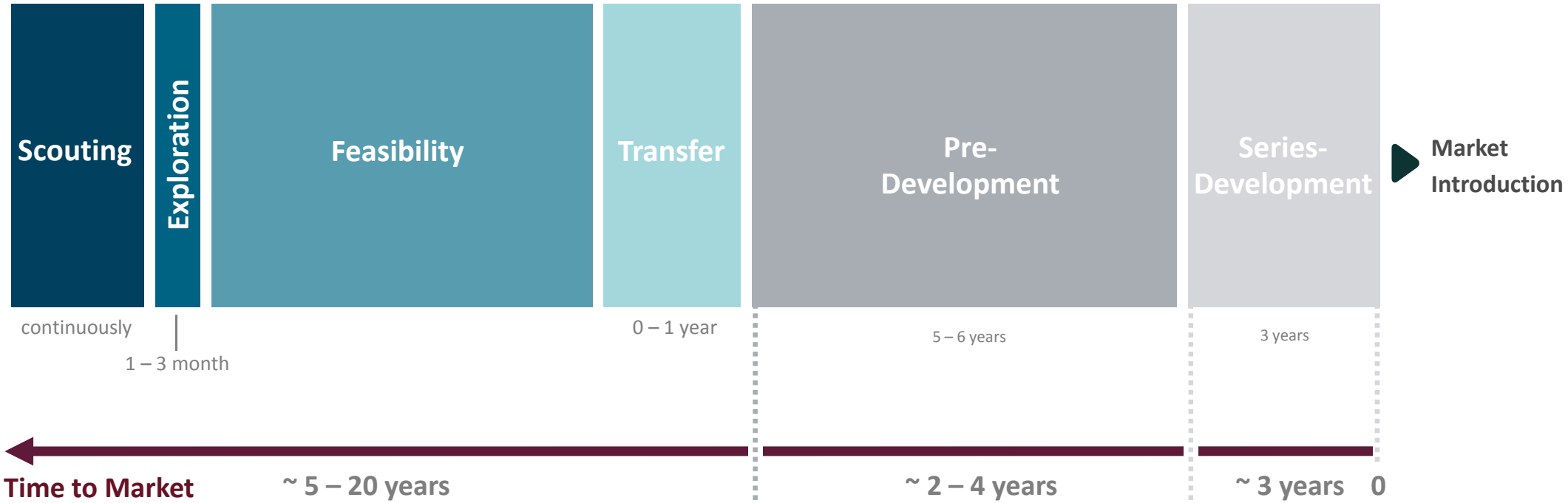
Environmental Affairs

- Group Environmental Strategy
- Life Cycle Analysis
- Environmental Aspects of Production

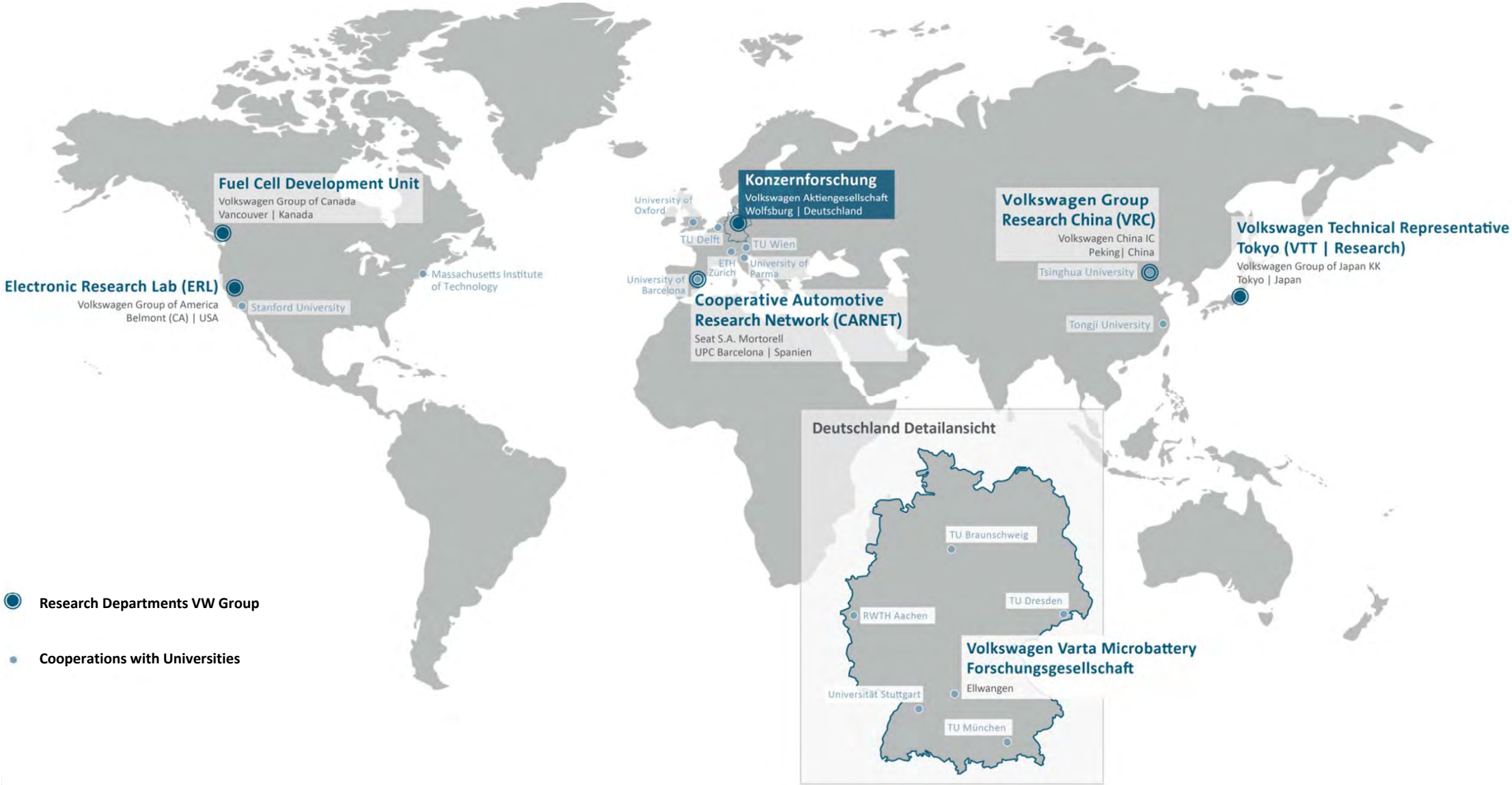
Future Research

- Future Research
- Corporate Foresight
- Technology Intelligence

OVERVIEW RESEARCH PROCESS

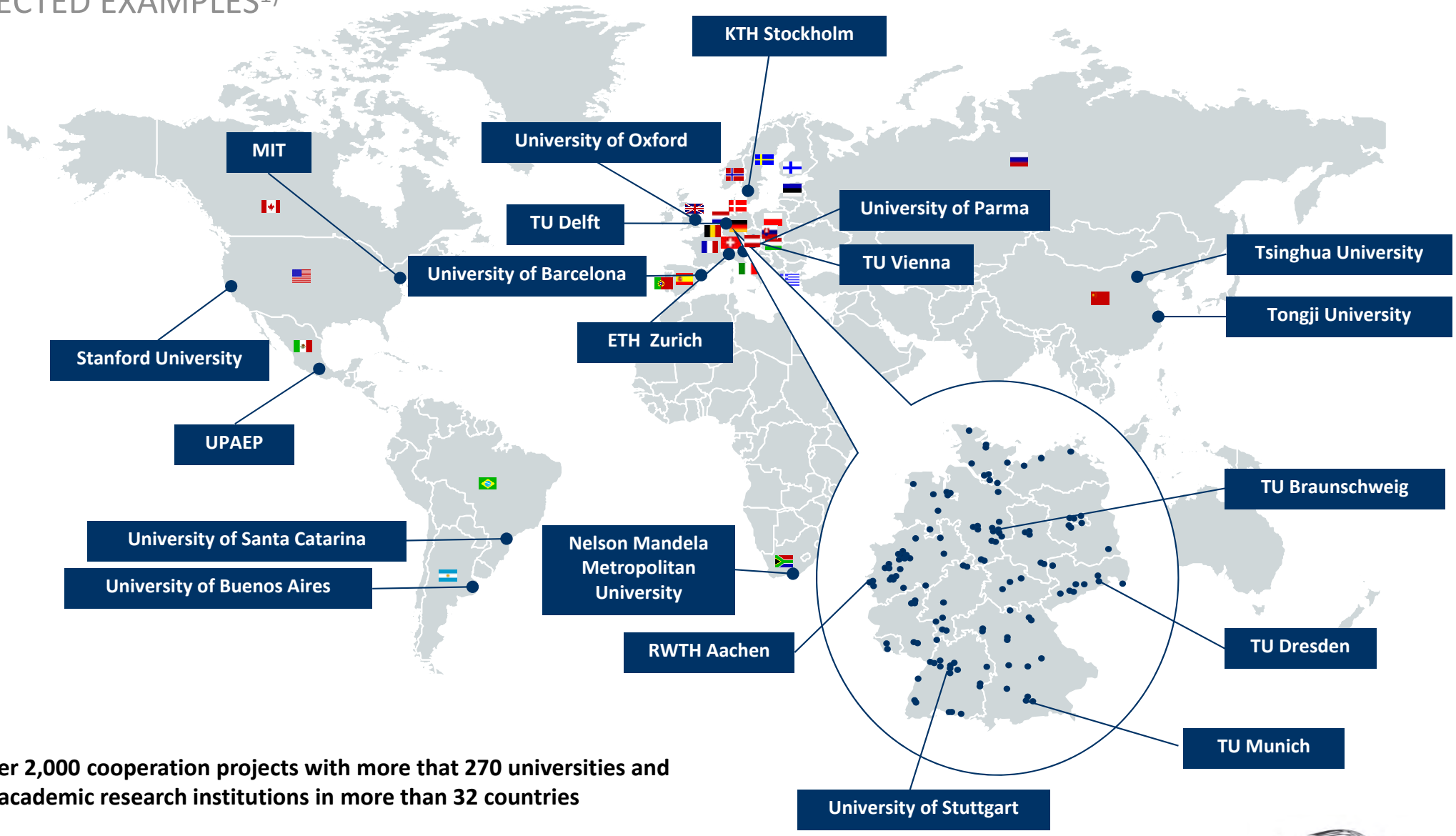


INTERNATIONAL RESEARCH-NETWORK



COOPERATION ACTIVITIES OF THE VOLKSWAGEN GROUP

SELECTED EXAMPLES[1)]



[1)] **Over 2,000 cooperation projects with more that 270 universities and non-academic research institutions in more than 32 countries**

THE AUTOMOTIVE RESEARCH CENTRE NIEDERSACHSEN

NIEDERSÄCHSISCHES FORSCHUNGSZENTRUM FAHRZEUGTECHNIK

THE NFF FOCUSES ON PROMISING TOPICS IN AUTOMOTIVE RESEARCH

Supported by Lower Saxony's state government and Volkswagen AG, the NFF was founded as an interdisciplinary research center in 2007 to establish the research region Braunschweig as the leading location for internationally renowned automotive research. It is the basis for effective cooperation between science and industry and their research, which was further enhanced by the opening of the branch in Wolfsburg.

Key Figures:

- Located at Braunschweig Airport since 02/2015
- 7 Partner Institutes
- Investment Volume: 60 Mio. €
- Office Space: 3.000 m²; Technial Centre: 2.100 m²
- Employees: 158 research associates

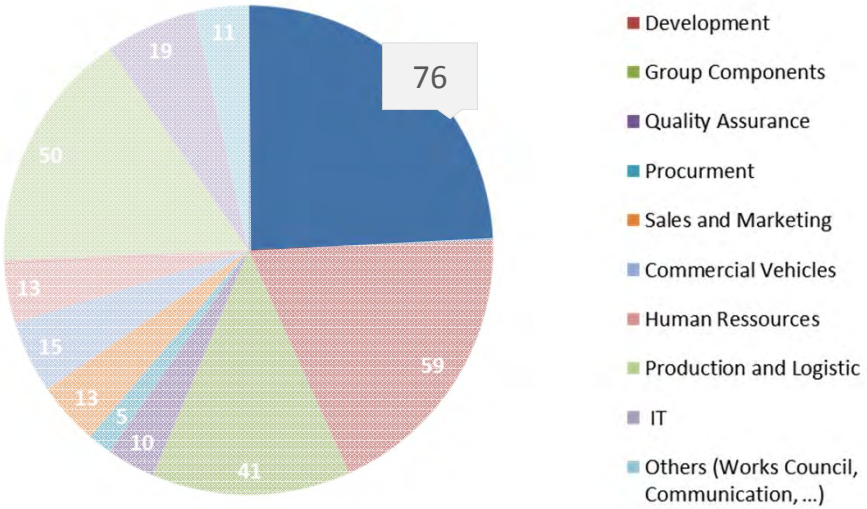
Research Program:

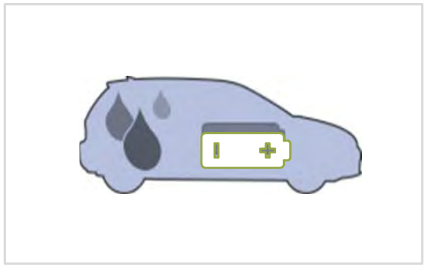
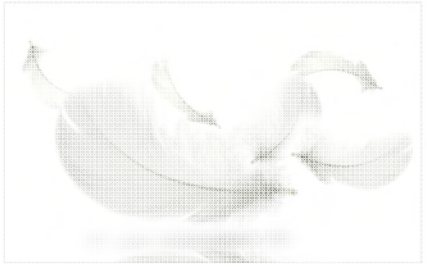
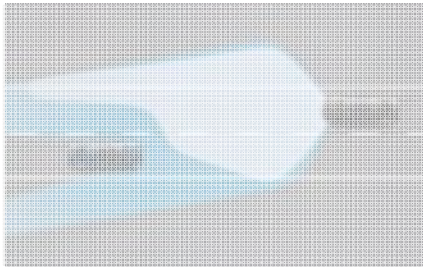
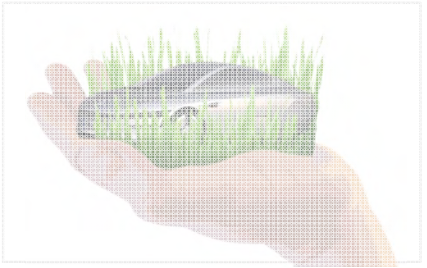
- „Intelligent Vehicles"
- „Low-Emission Vehicles"
- „Flexible Vehicle Concepts & Vehicle Production "
- „Mobility Management"

VOLKSWAGEN PHD-PROGRAM

PHD-STUDENTS AT VOLKSWAGEN GROUP

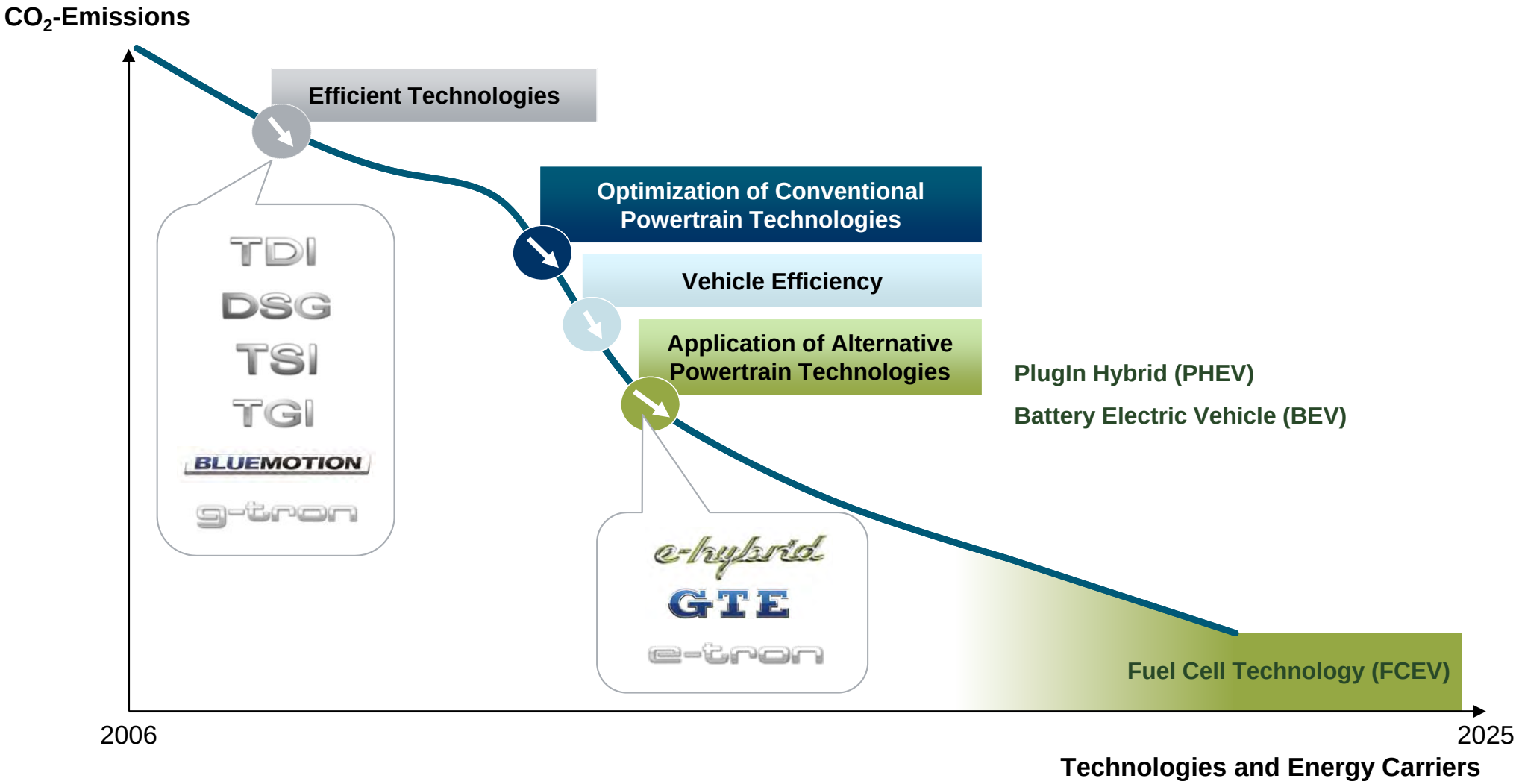
- Duration: 3 years
- PhD seminars and PhD-student network
- Annual Volkswagen PhD-day
  (> 600 visitors colleagues from all brands and professors who supervise the PhDs)
- Publication of dissertation at “AutoUni Schriftenreihe”
- 584 PhD-students within Volkswagen Group, 306 within Volkswagen brand (09/2015), 76 within Group Research



POWERTRAIN TECHNOLOGIES

PATH TO CO_2-REDUCTIONS

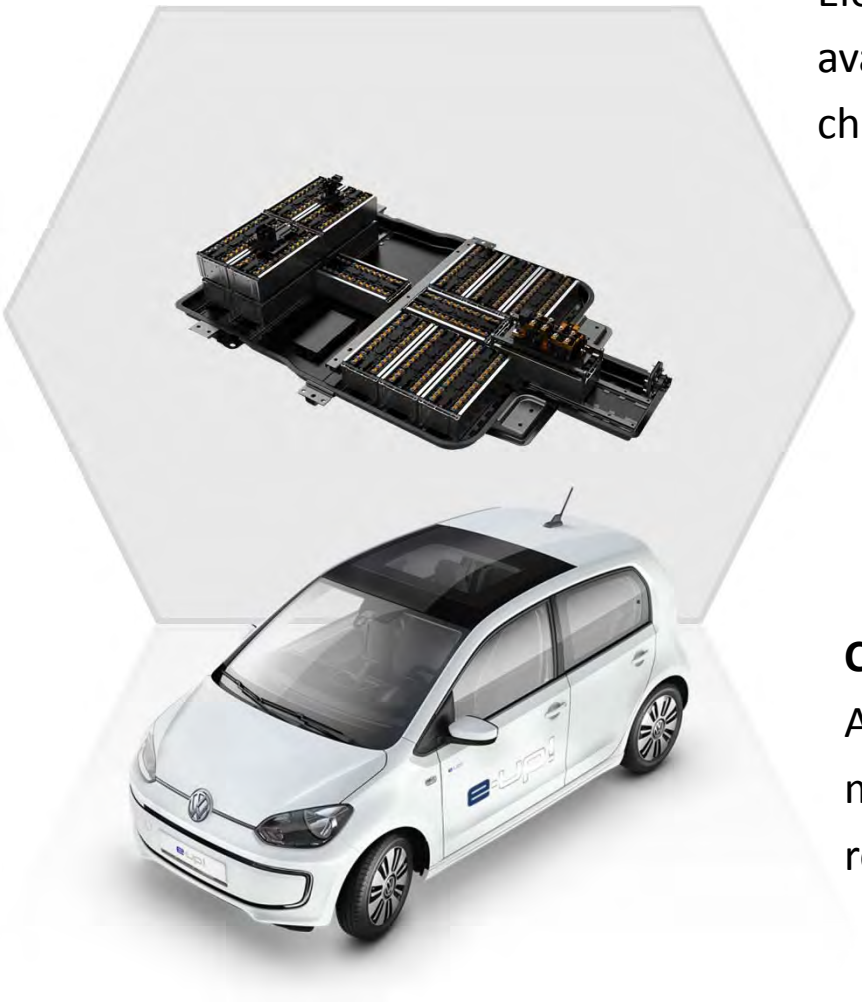


CHALLENGES FOR ENERGY STORAGE SYSTEMS

Safety
Failure, accident,
abuse, maintainance,
comfort, reliability

Energy
Electrical driving range,
availability of comfort devices,
charging time and infrastructure

Power
Driving power,
performance, dynamics



Durability
Cycles, lifetime

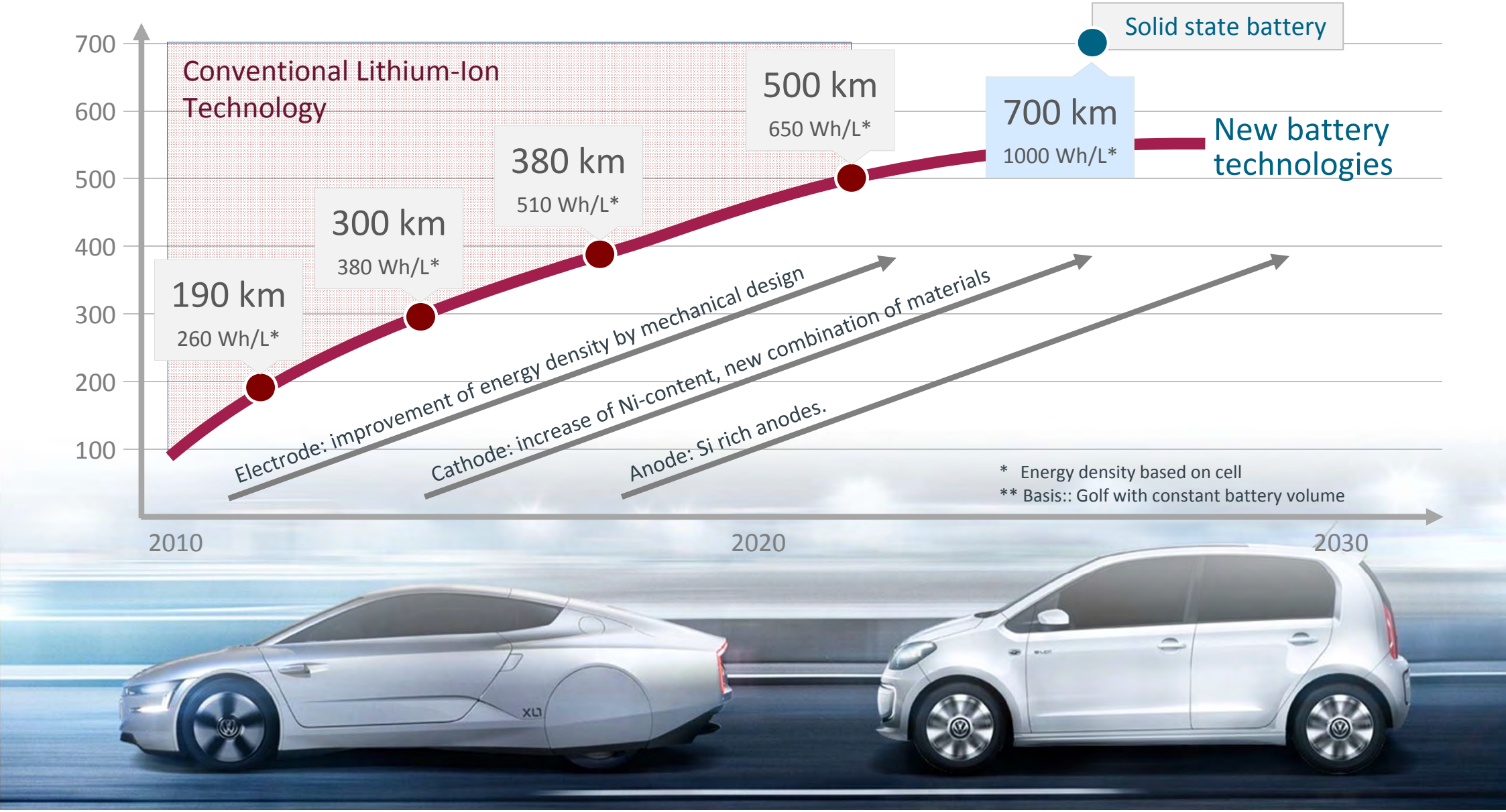
Temperature behaviour
Cold start,
heat in summer

Cost
Affordability,
market acceptance,
recycling

VOLKSWAGEN
AKTIENGESELLSCHAFT

LI-ION-BATTERIES: ROADMAP FOR HIGH ENERGY BATTERIES

ELECTRICAL RANGE IN KM **



SCOUTING INNOVATIVE BATTERY COMPANIES

*1: acquired by Bosch
*2: acquired by Dyson
*3: acquired by Apple

FUEL CELL TECHNOLOGY

LOS ANGELES AUTO SHOW 2014

CORE CHALLENGES FOR FUEL CELL TECHNOLOGY

Cost

Push: Legislation

Pull: Customer's demand

Availability of renewable energy and fuel

Fuel Cell business

Availability of vehicle

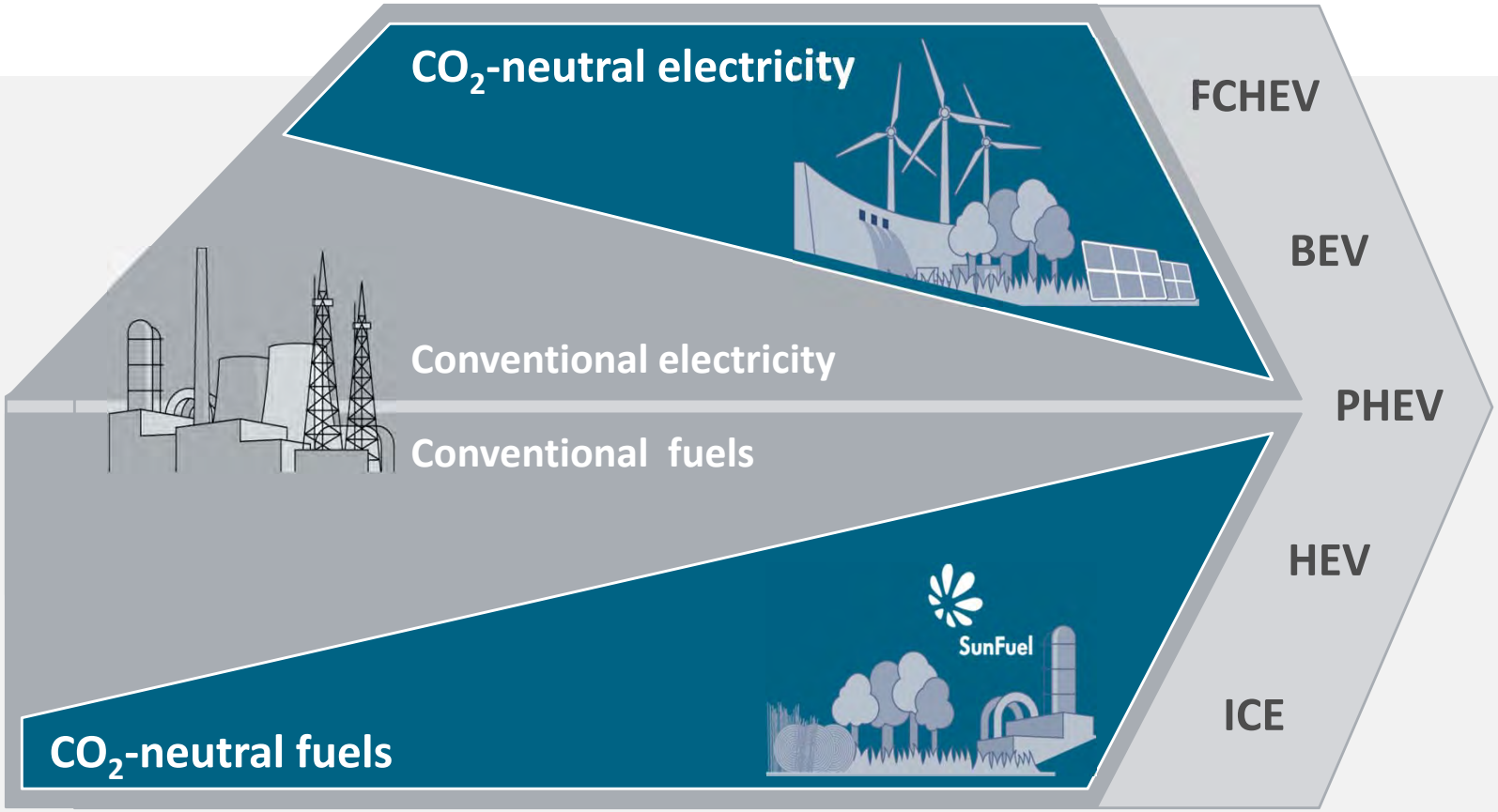
Renewable energy availability
- Peak oil
- Land use change
- Seasonal availability

H_2 availability incl. economics
- Fuel production
- Fuel delivery and infrastructure

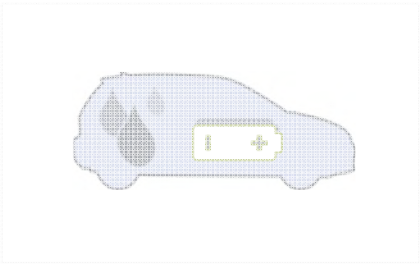
Fuel cell vehicles
- Performance
- Durability
- Cost

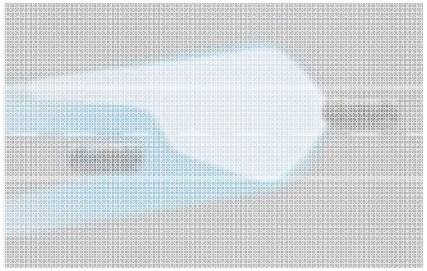
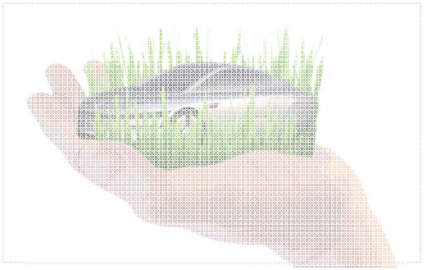
POWERTRAIN AND FUEL STRATEGY

COEXISTENCE OF POWERTRAIN TECHNOLOGIES



CO_2-neutral and sustainable mobility

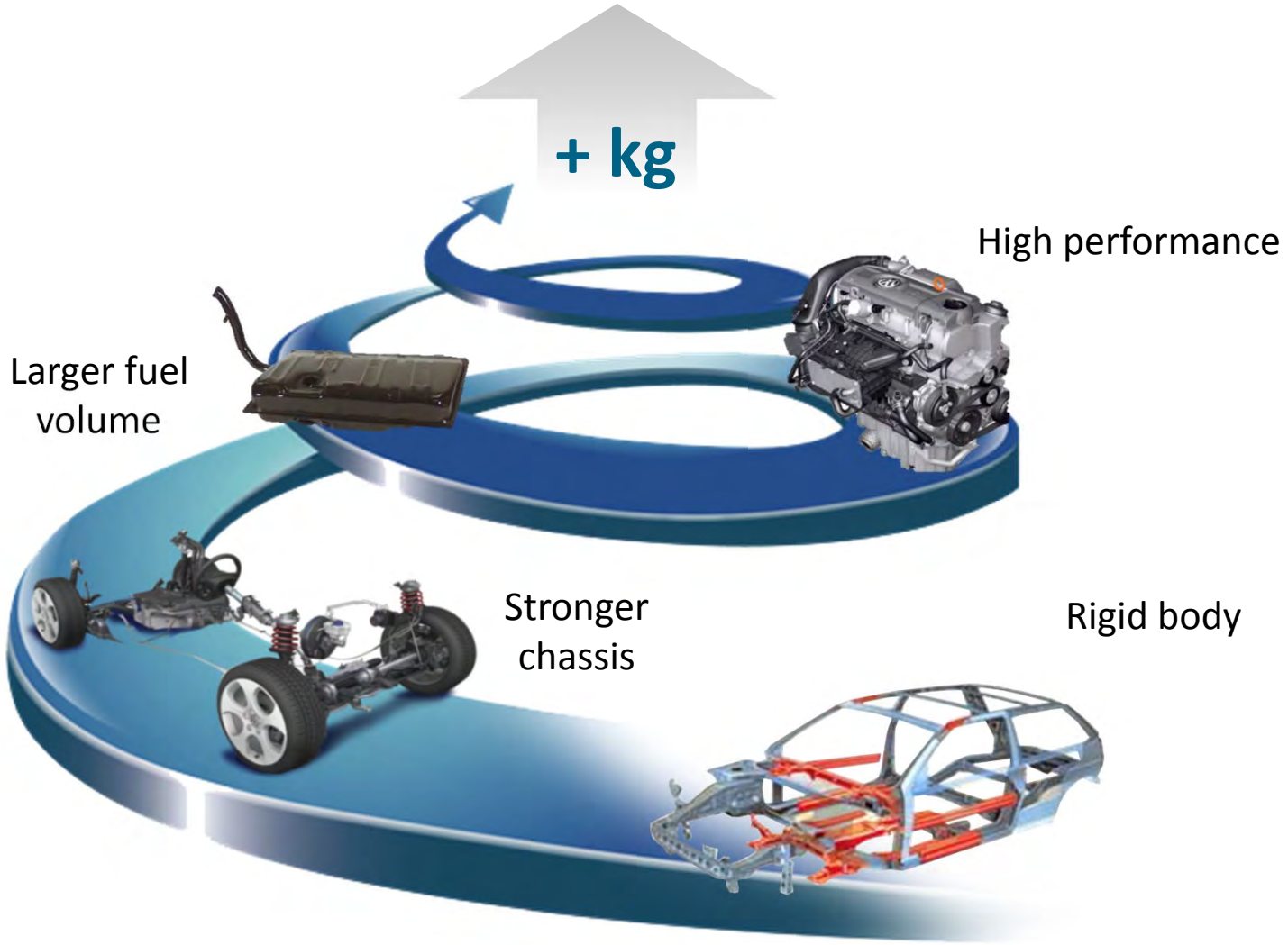


OPPORTUNITIES FOR WEIGHT REDUCTION

THE WEIGHT SPIRAL

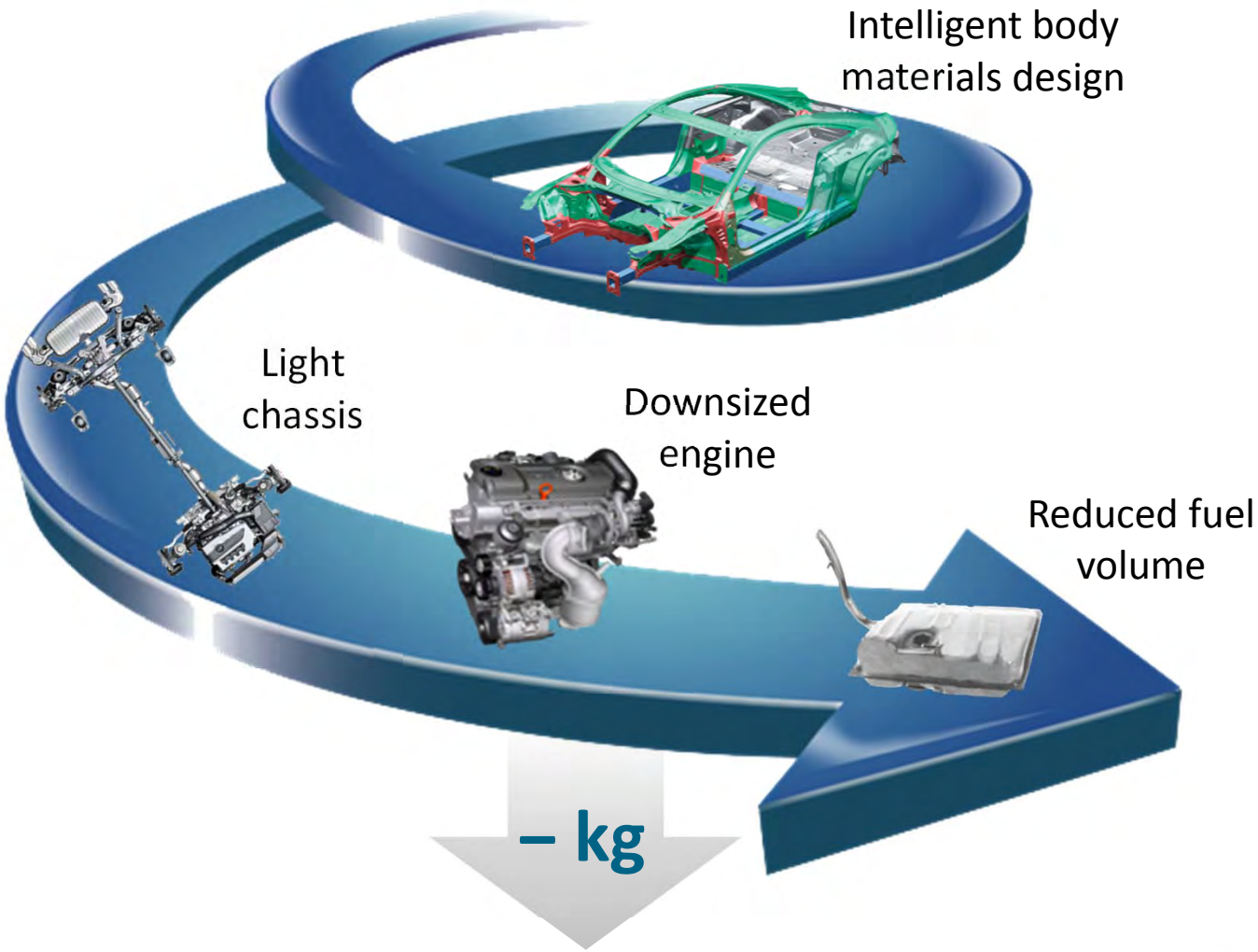
- Comfort
- Safety
- Quality
- Legislation
- Interior



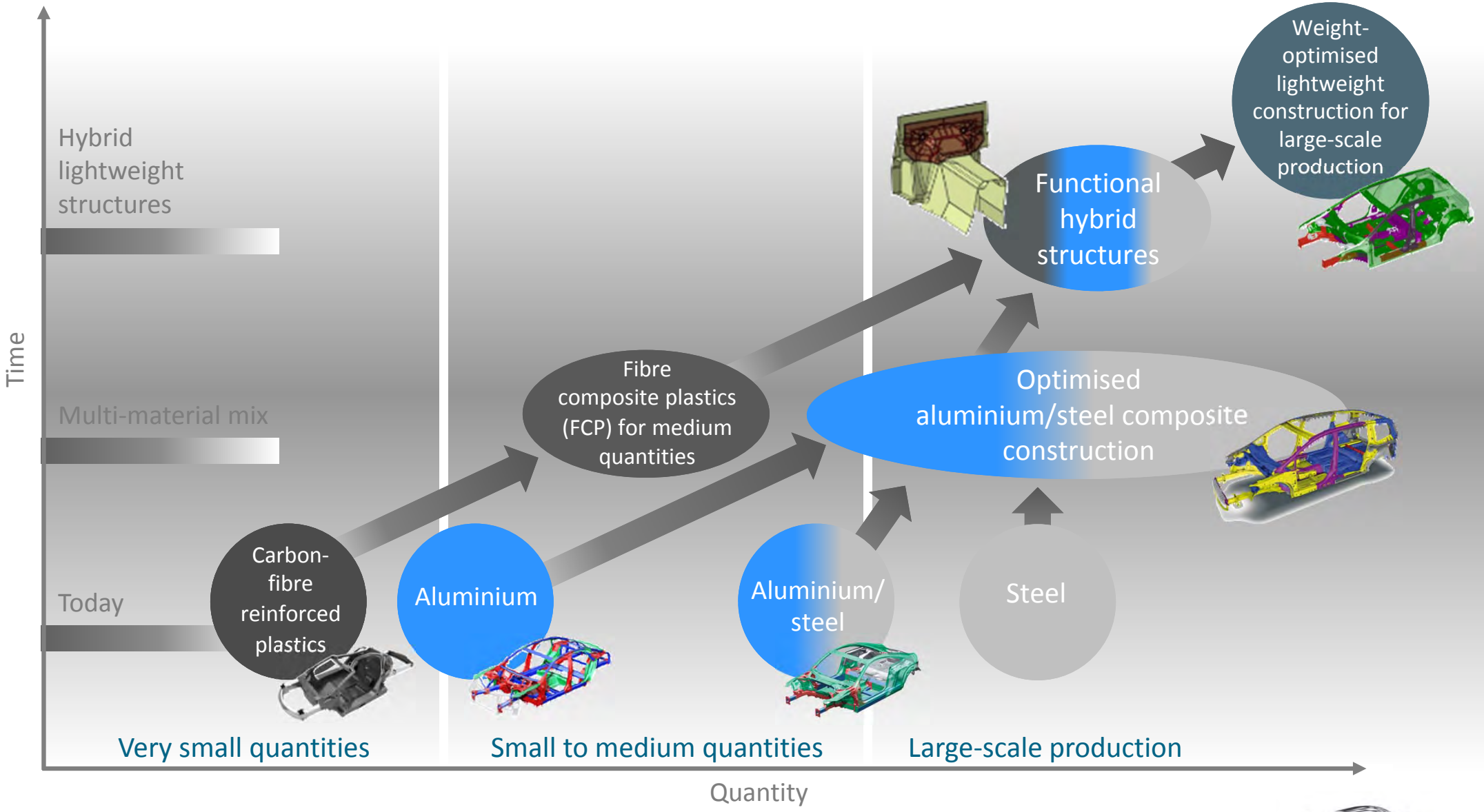
REVERSAL OF THE WEIGHT SPIRAL

- Integrated components and functions
- New materials and processes
- Cost- / weight-optimisation

Next vehicle generation



LIGHTWEIGHT DESIGN CONCEPTS FOR THE FUTURE



OPEN HYBRID LABFACTORY: INNOVATIVE RESEARCH COLLABORATION PLATFORM

OBJECTIVES AND RESEARCH FOCUS

Lightweight Construction suitable for mass production

Development of ecologically and economically sustainable manufacturing and production technologies for hybrid lightweight components suitable for mass production

Covering the entire process chain for hybrid components

Gain access to innovations within the entire process chain

Public-Private funding between science and industry

Exploration of complex fields of research with a high level of risk

Research location Wolfsburg

Realization of a research centre (LabFactory) in Wolfsburg in the framework of a public-private partnership (PPP)

Research focals

Concept/Construction/ Simulation

Component and process developement for hybrid lightweight components

Load-path-optimised textile structures

Textile manufacturing technology and sustainable fibre production

Process hybridisation

Integrated production technologies

PUBLIC-PRIVATE PARTNERSHIP OPEN HYBRID LABFACTORY E.V.

DER LEICHTBAUCAMPUS. WOLFSBURG

Manufacturing and production technologies for hybrid lightweight components

- **Starting point:** **BMBF* Funding initiative "Forschungscampus - Public-Private Partnership for Innovation”**
- **Objective:** **Shared research facility between science and industry (Public-private Partnership, PPP)**
- **Project initiator:** **Niedersächsisches Forschungszentrum Fahrzeugtechnik (NFF), TU Braunschweig and VW**

Premium Members

Technische Universität Braunschweig NFF, VOLKSWAGEN, BASF The Chemical Company, DOWAKSA, ENGEL be the first., Fraunhofer, automotive engineering iav, MAGNA, Siempelkamp, ThyssenKrupp

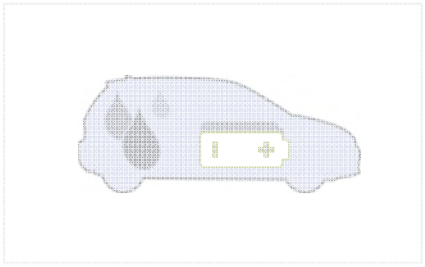
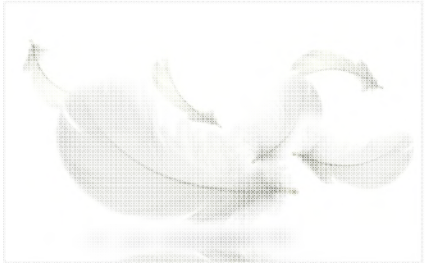
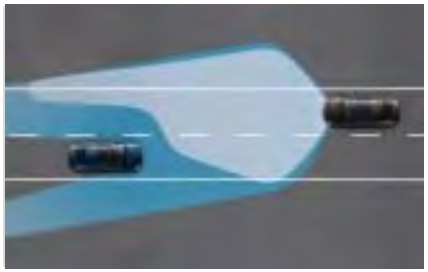
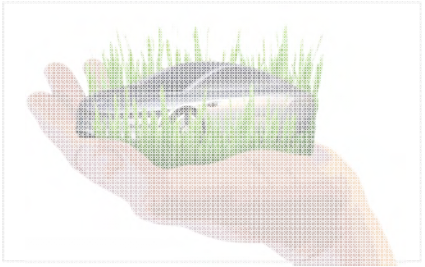
Funded by

Bundesministerium für Bildung und Forschung, FORSCHUNGS CAMPUS öffentlich-private Partnerschaft für Innovationen, Europa fördert Niedersachsen, Niedersächsisches Ministerium für Wissenschaft und Kultur, Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr, WOLFSBURG

OHLF OPEN HYBRID LABFACTORY
Der LeichtbauCampus.

Research center

*) BMBF - German Federal Ministry of Education and Research

AUTOMATED DRIVING

DRIVING TECHNOLOGY CHANGE IN THE AUTO INDUSTRY

VW PASSAT








1973

Today

- Direct fuel injection
- Climatronic
- Multi-functional display
- Remote control central locking
- ESC, EDL, ASR, Brake assist system
- Park pilot
- Rain sensor
- KESSY
- ACC
- Front Assist
- iPod Adapter, Media-In
- DVD navigation system, Touchscreen operation
- Parking assistant
- city emergency braking function
- Lane Assist
- Rear View
- Hard drive space
- Active seat ventilation
- Interior ambient lighting
- Tyre pressure monitoring system
- Easy Close Light
- Park Assistant 3.0
- Trailer Assist
- Emergency Assist
- Traffic jam assistant
- Area View
- Active Info Display
- Drive mode selection
- LED Headlights with dynamic cornering light
- Car-Net
- Proactive occupant protection system
- Side Assist 3.0
- Traffic sign recognition Gen. 2
- city emergency braking function with pedestrian detection

HISTORY OF AUTOMATIC DRIVING AT VOLKSWAGEN

Stanley

(2005)

Junior

(2007)

PAUL

(2007)

iCar

(2007)

HAVEit

(2011)

eT – Follow me!

(2011)

Race-Pilot (Bobby)

(2014)

Auto-Pilot (Jack)

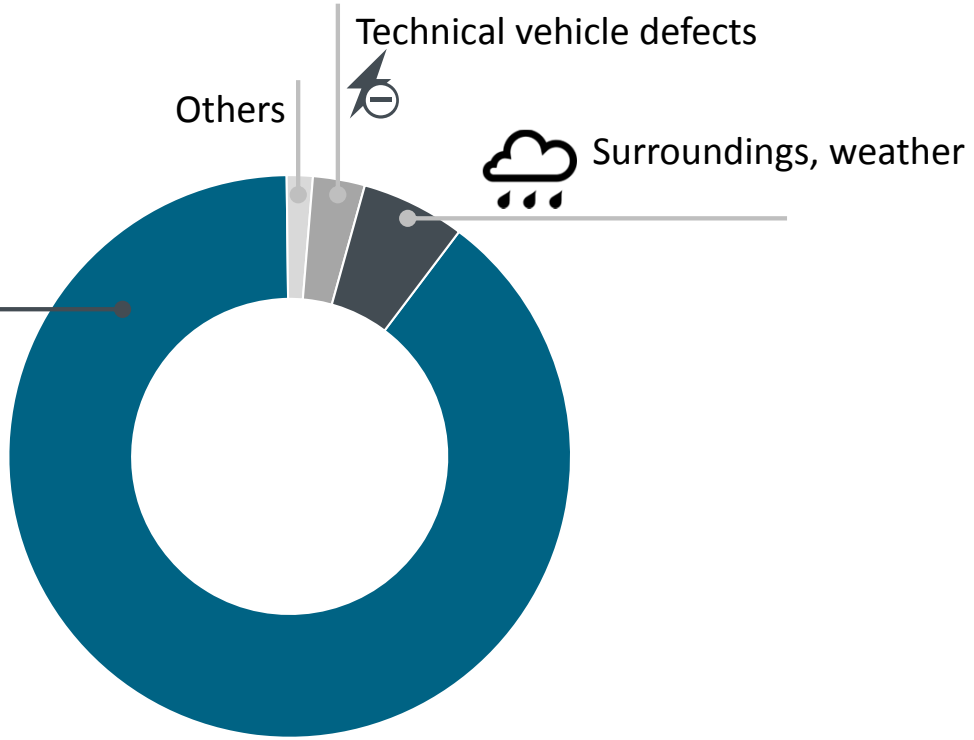
(2015)

V-Charge

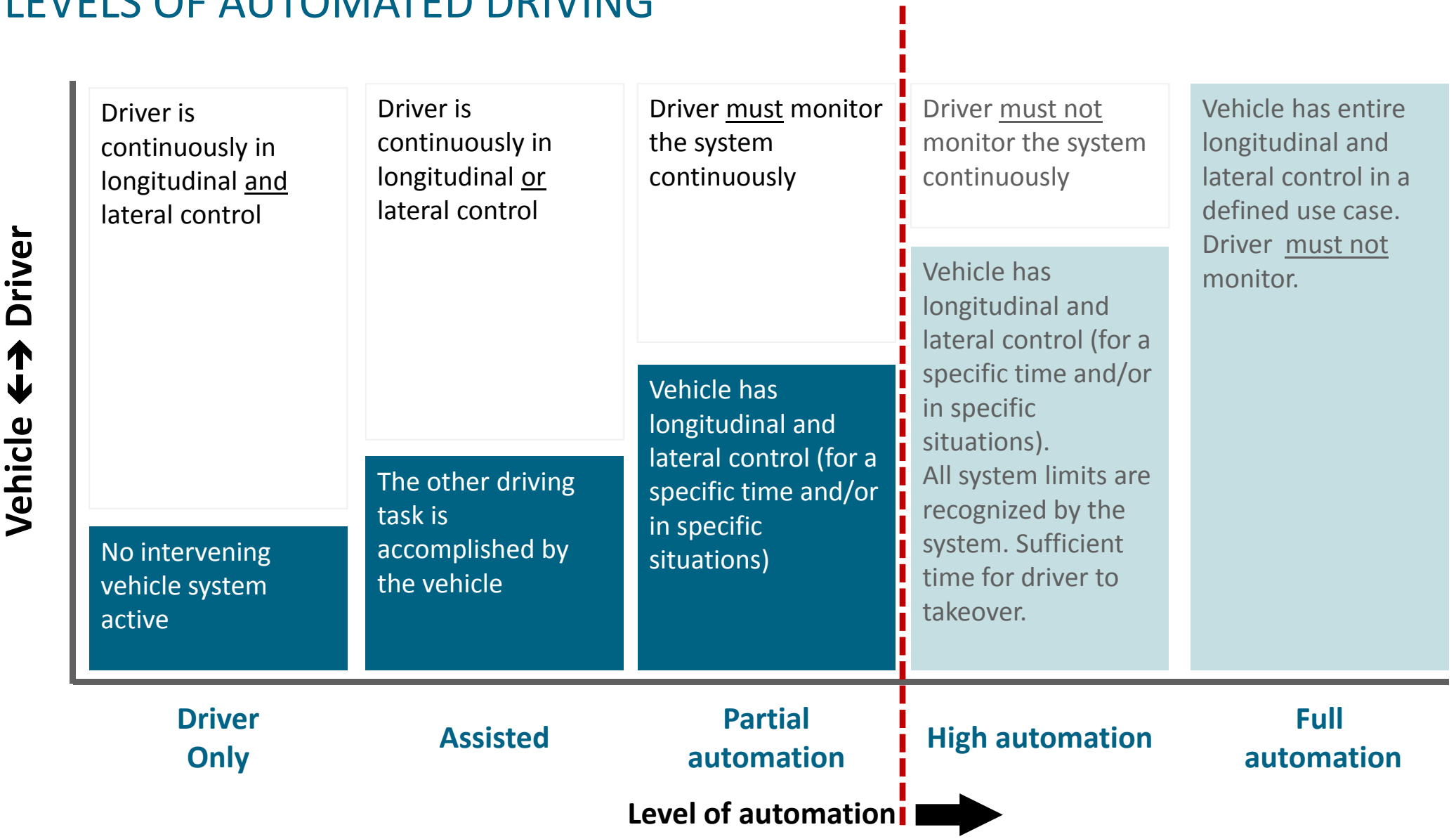
(2015)

CHALLENGES DRIVING DEMAND FOR AUTOMATED DRIVING

More than **90%** of all **Accidents** are caused by **human errors.**



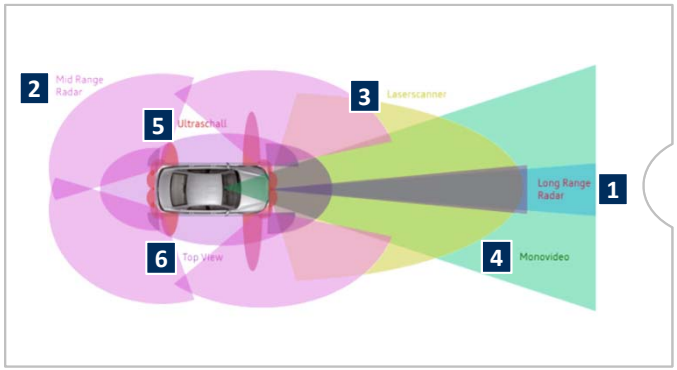
LEVELS OF AUTOMATED DRIVING



Source: VDA

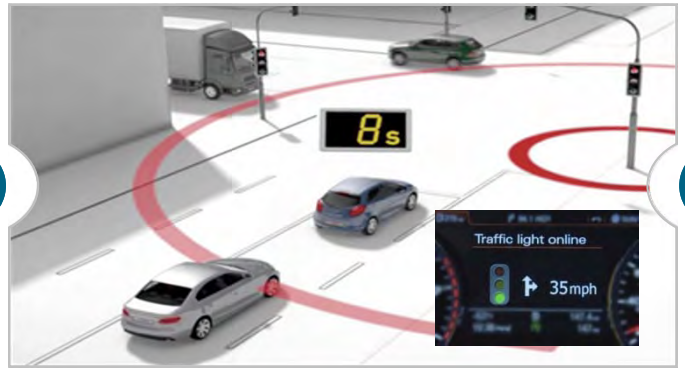
ACTION REQUIRED FOR IMPLEMENTING AUTOMATED DRIVING AND PARKING

1. Technology



- Sensors
- Safety architecture
- Redundant actors such as brakes
- High-performance computer
- User interface
- Validation methodology
- Artificial intelligence

2. Infrastructure



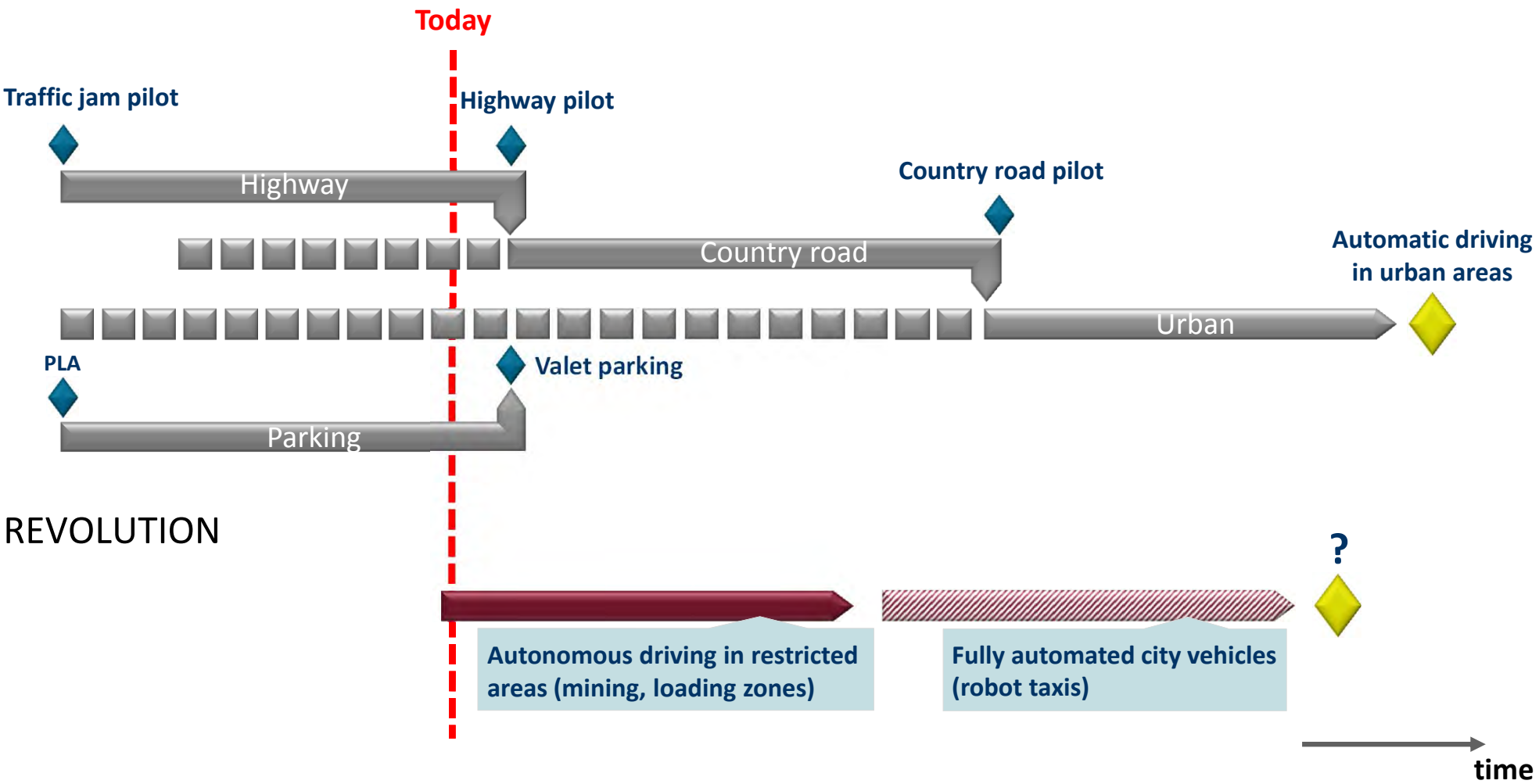
- Global Implementation of standards
- Car2Car communication
- Accurate digital maps with short-term updates
- Maintaining and expanding infrastructure

3. Regulation

- Vehicle registration regulations
- Regulatory law (Vienna Convention, highway traffic regulations)
- Liability

STRATEGIC ROADMAP TO AUTONOMOUS VEHICLES

EVOLUTION VS. REVOLUTION

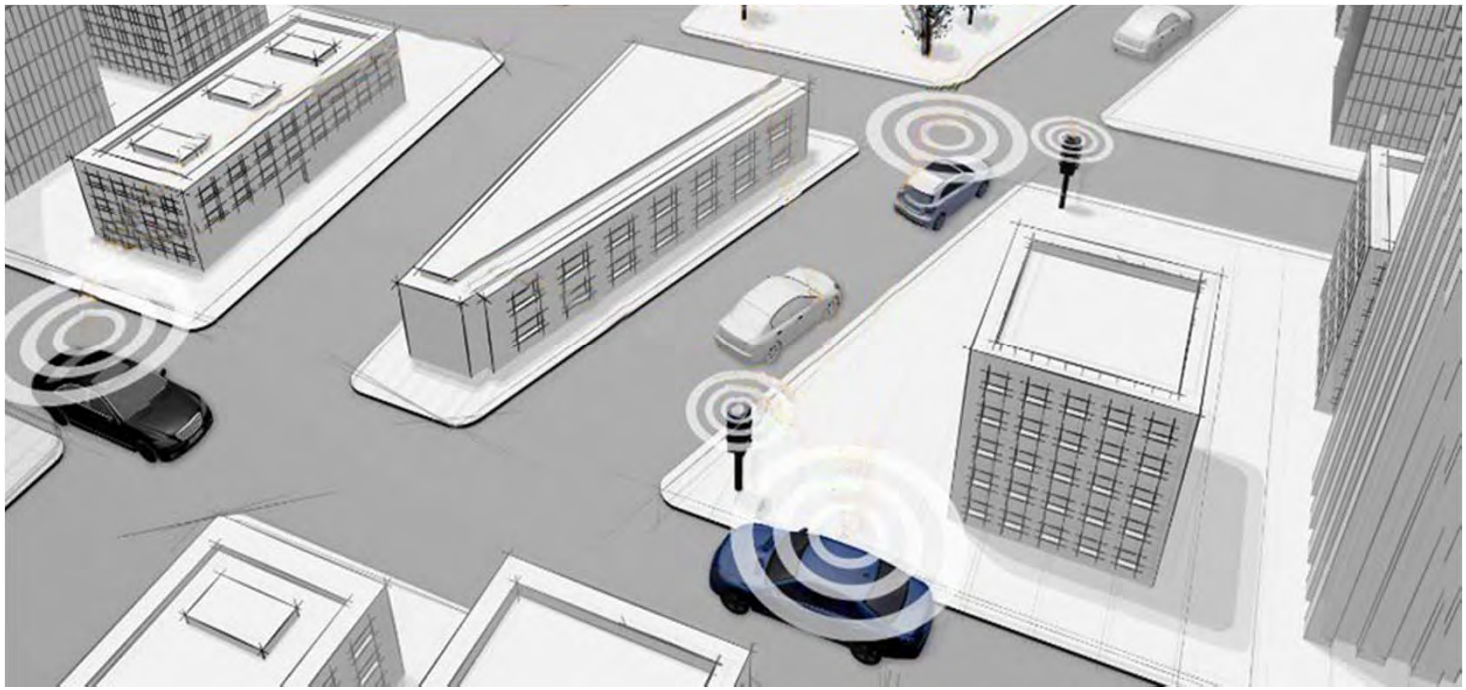


THESES FOR THE AUTOMATED DRIVING VEHICLE 2030+

- All vehicles are constantly connected
- The customer chooses product based “ecosystems” instead of individual products
- Automated Driving provides safe and comfortable mobility
- Thanks to Automated Driving, the vehicle comes directly where it is required
- The vehicle is becoming more individual – it adjusts to the customer and his/her demands automatically
- Vehicles will become more complex – but they will be easier to operate

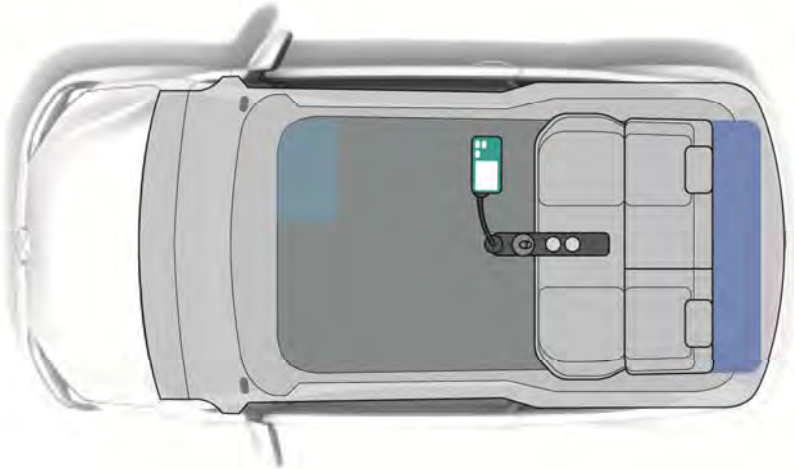
AUTOMATED DRIVING IS SAFE AND COMFORTABLE

THE VEHICLE FINDS PARKING SPOTS INDEPENDENTLY AND COMES DIRECTLY TO THE DRIVER/CUSTOMER



- Sharing concepts become more attractive, due to the elimination of picking up or parking the vehicle by yourself
- Different types of vehicles “on demand“ (i.e. for transports or weekend trips)
- Possession of vehicles in urban areas becomes attractive again, because vehicles are parked in central parking facilities
- The charging of electric vehicles (over night) doesn’t necessarily need to be made at home

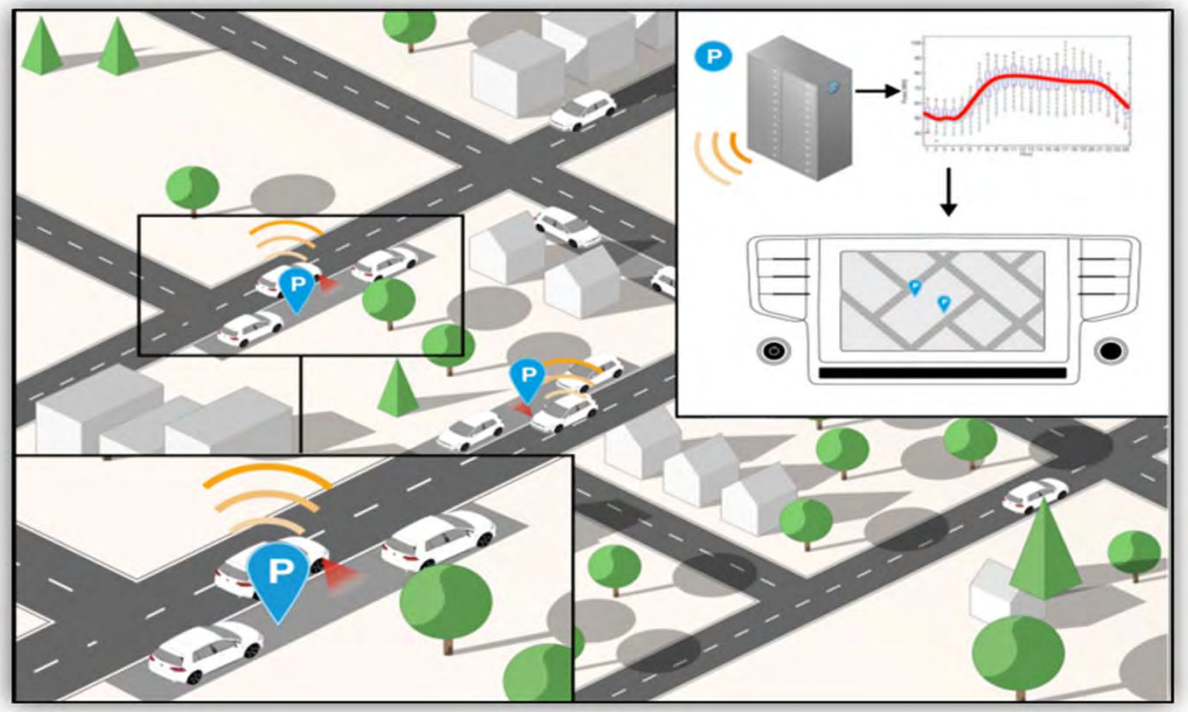
AUTOMATED DRIVING SWITCHES THE DRIVER TO THE PASSAGENGER



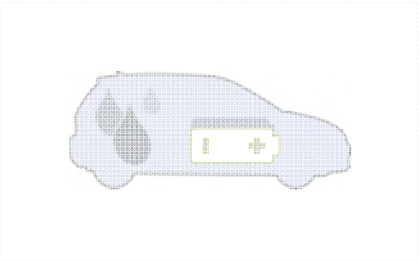
- Claims of the driver regarding driving behavior and interior are changing, the vehicle interior becomes a living and working space
- Flexible and comfortable seating concept – Sitting and sleeping is possible throughout the trip
- New concepts of mobility due to and automated deployment und returns of vehicles

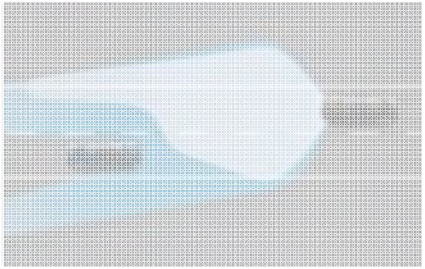
CONNECTED WITH THE SURROUNDING AREA, AMONG THEMSELVES AND THE PASSENGERS

THE VEHICLE AS A BROADBAND WIRELESS DATA NODE



- Allows the efficient flow of traffic, the formation of traffic jams will be minimized by intelligent traffic guidance
- Cooperation with user road users and the infrastructure will enhance the traffic efficiency
- The customer (incl. all passengers) expects to be always online



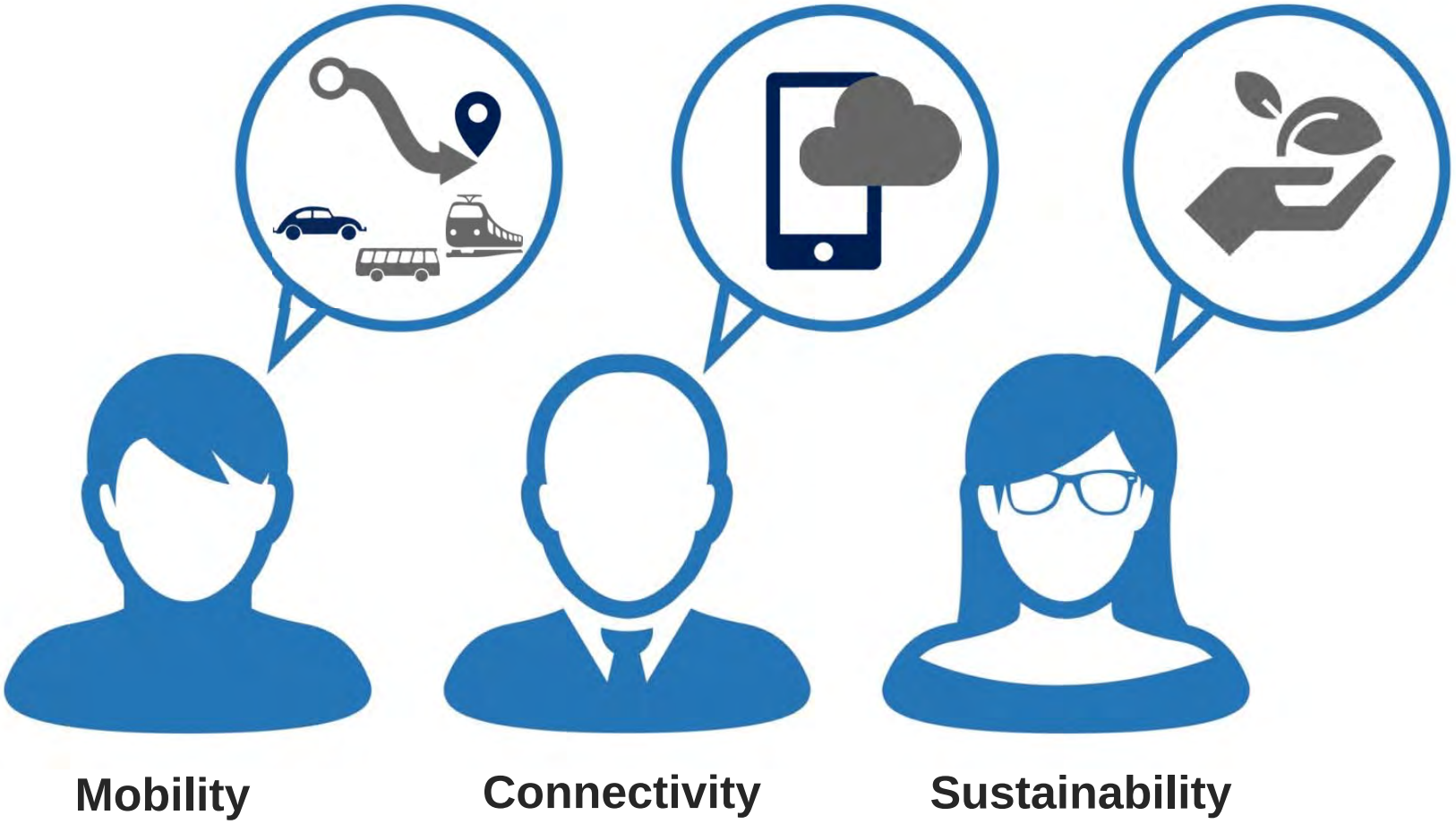



FUTURE CHALLENGES FOR MOBILITY

FUTURE CHALLENGES AND MEGA TRENDS

CHANGING CUSTOMER EXPECTATIONS

AFFECT THE NEW SPHERES OF LIFE

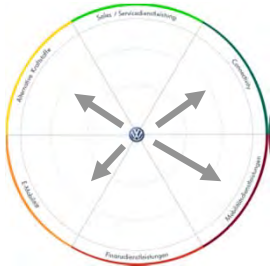


DEVELOPMENT OF NEW BUSINESS AREAS

STRATEGIES OF THE (NEW) COMPETITORS

Three visible strategies to develop new business areas

1 **OEMs expand their core business** and develop new Business Areas



2 **New Players** penetrate into the field of (auto)mobility

3 **Specialists occupy** individual Business Fields

CHALLENGES FOR CORPORATIONS

NEW BUSINESS PRINCIPLES FROM PRODUCT-FOCUS TO SERVICE-SYSTEM-APPROACH

Today	Tomorrow
Products	Solutions
Transactions	Relationships
Technology	People
Suppliers	Network-Partners
Parts	Eco-Systems

DIGITAL ECOSYSTEMS – CURRENT SITUATION

Consumer Electronics

"Lock-In-Effect"

Continuous Selling of Services

E-Commerce

Long-Term Customer Loyalty

Huge Number of Customers

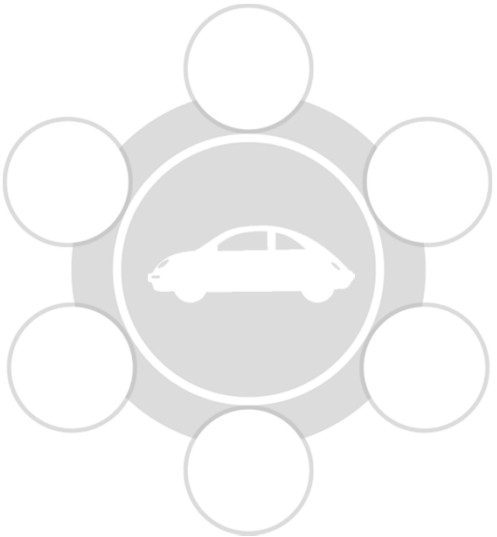
Lifestyle Products

Integrated Product-Service-System

Driven by Costumer Needs

Direct Contact to Customers

Car Industry?



WE LIVE IN ECOSYSTEMS

DIGITAL SPACE – THE „GROUP-MOBILITY-ECOSYSTEM“

Secures sales, innovations and return of investment

New business field

Generateing / marketing of vehicle-, user- and enviromental data in a fleet network

Bidirectional connection to Smart Home / Office / Institution

Secure sales

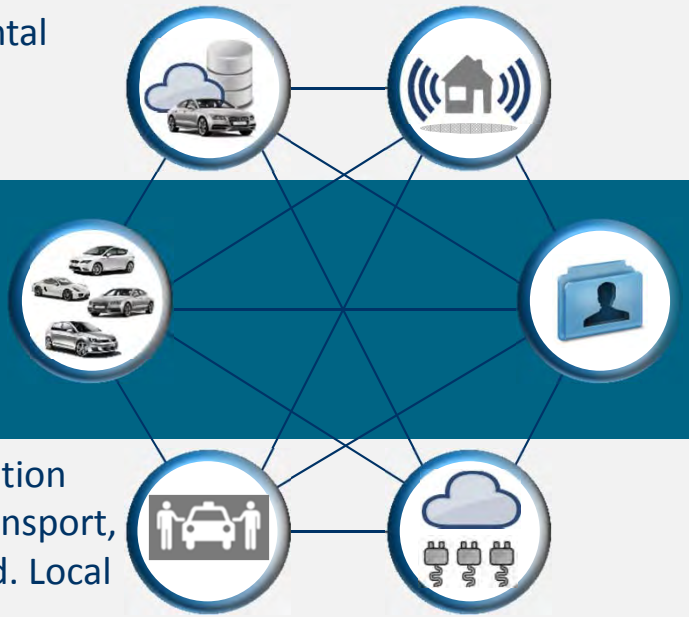
Intelligent and situational vehicle functions & services

My profile / my Data
→ High transparency and data security

New business field

Best intermodal mobility solution incorporation local public transport, Car- & Ride-Sharing → Individ. Local transport

Cross-Over-Platform for 3rd-Party Services & Devices



- The Vehicle provides easy access to the personal cloud
- The VW Group-Mobility-Ecosystem with his media services seamlessly integrates with iOS/Google & Co

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AKTIENGESELLSCHAFT

THANK YOU FOR ATTENTION!