

SLRV

NEXT GENERATION CAR
Safe Light Regional Vehicle



SLRV

The Safe Light Regional Vehicle is designed as a light commuter vehicle with low energy consumption. Despite its extremely lightweight construction and cost-efficient materials and production, the vehicle is designed to achieve state-of-the-art crash safety. Further development goals are a range of 400 km, an unladen weight of only 450 kg, and autonomous driving characteristics up to SAE Level 3.

The aim is to further develop technologies and components to meet the requirements in one vehicle and to present the individual technological innovations in one vehicle demonstrator. At the same time, the project aims to identify and develop synergy effects between individual departments.

INTRODUCTION

NEXT GENERATION CAR

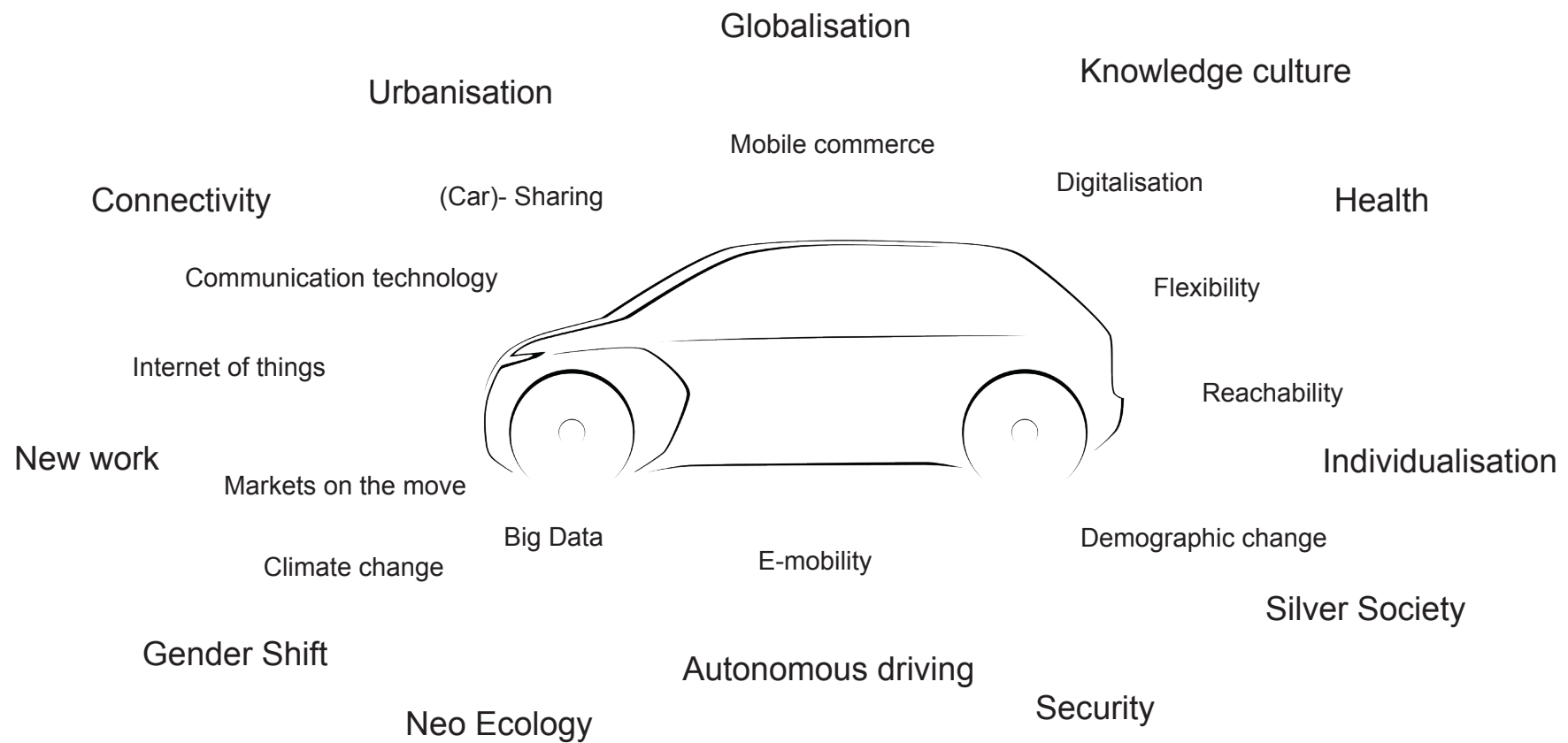
CONCEPT

SAFE LIGHT REGIONAL VEHICLE

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Future trends



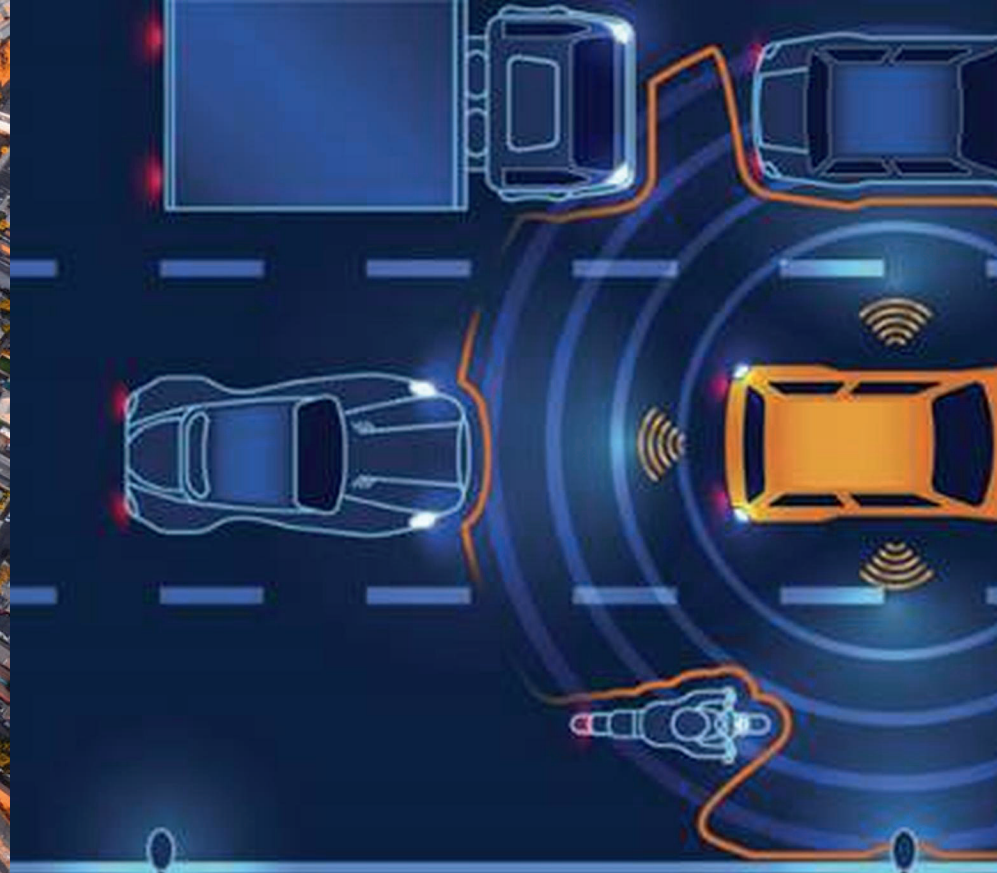
Vehicle technology & drive

Transport systems are experiencing dramatic change worldwide. The entire mobility sector is about to undergo a transformation driven by the dynamics of electrification, digitalisation and automation. The possible effects on future mobility and how terrestrial vehicle concepts will meet customer needs and offer user-oriented and individualised transport solutions are broad and diverse. The challenges to the development of environmentally sound solutions that are economically and technically feasible on the way to the mobility of the future require intensive efforts both in basic and application-oriented research.

Various future trends influence these systems, such as autonomous driving, the origins of which date back to 1925. Almost all major automobile manufacturers are currently working on technology for autonomous driving. There are already smaller start-ups with the first fully autonomous vehicles on the market today, and by 2035 up to 17 % of private vehicles in Germany could be fully autonomously driven (Trommer et al., IFMO, 2016). Autonomous driving is intended to increase safety and system reliability, optimize traffic flow and improve flexibility and comfort.

Parallel to autonomous driving, recent years have seen the promotion of research into the use of renewable energies in vehicles as a result of climate change and the decline in the use of fossil fuels. To reduce CO₂ emissions the aim is to cover more than one quarter of the global energy needs by renewable energies (International Energy Agency, IEA). To some extent future electric drive technologies for vehicles such as fuel cells (FCEV), batteries (BEV) or hybrid drives (HEV) all face the problem of short range or poorly developed infrastructure for charging or refuelling. Different types of drives offer different advantages depending on the vehicle type and location. Battery electric vehicles are suitable for short city journeys, whereas the fuel cell is more suitable for longer distances as it is capable of longer ranges.







Information and communication technology

Information and communication technology will continuously provide the driver with the necessary information concerning the vehicle and its surroundings. It will also provide entertainment and convenience. In the future safe, autonomous driving will use artificial intelligence that will enable the early detection of dangers or compensate for driver errors. Car manufacturers like Tesla are already using computer programs that can learn from the driver, memorize frequently used routes or imitate driving styles.

Vehicle networking, which is summarized under the term Connected Car, the car can alert the driver to the need for a workshop service, download software updates, make an emergency call in the event of an accident, communicate with other vehicles or road users, open the garage door or warn of traffic situations that are not yet visible, such as drivers going the wrong way down a carriageway or traffic jams. European automobile manufacturers have agreed on a common communication system called WAVE.

Infrastructure development and use

By 2030 the world's population will grow to approximately 8.3 billion people (National Intelligence Council, 2012) and the average age will rise to 34 years as life expectancy continues to increase. The increase in population and the growing regional disparities will place a heavy burden on the infrastructure, particularly in urban areas. This will call for flexible transport choices, especially in densely populated areas; the best means of transport will be selected for each route depending on price, travel time, comfort and lifestyle (ifmo, 2010). Mobility options will become increasingly diverse. Besides the various types of public transport, car sharing, bike sharing and carpooling will be on offer. Mobility apps help to show what is available and the best travel connection. This means that a person's private vehicle will spend more time parked, though seldom completely eliminated (ifmo, 2015)

NGC Metaproject

As part of the Next Generation Car (NGC) project, DLR scientists are researching vehicle concepts, technologies and mobility solutions for the road vehicles of the future.

The key challengers are:



- Reduction of the absolute energy requirement of vehicles
- Avoidance of harmful emissions, especially CO₂ and noise
- Resource conservation through the use of fuels from renewable energy sources
- Increased safety of vehicle occupants and road users
- New technological possibilities such as the networking of vehicles with the urban and interurban transport and energy infrastructure.

In the Next Generation Car, research will focus on developing holistic vehicle concepts for the road vehicle market in 2030. Cars should then be lighter, quieter, more networked, more comfortable and safer than they are today and, if necessary, also drive autonomously. They should have a lower energy requirement, use energy carriers from regenerative energy sources and generate fewer emissions.

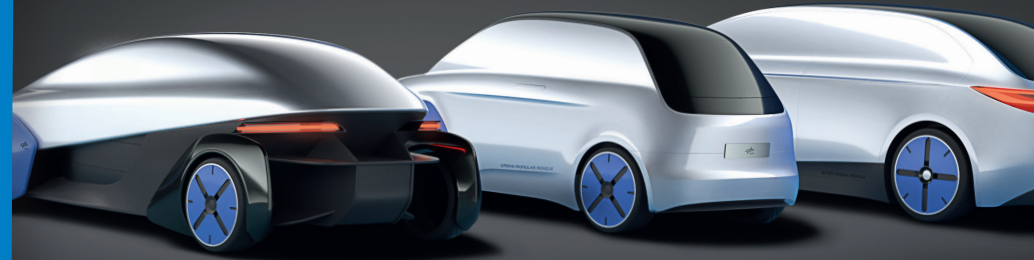
The Next Generation Car project involves 16 DLR institutes working together. The extensive competences of all institutes in different disciplines

are being used on the one hand to research the higher-level requirements of mobility needs, user behaviour, environmental protection and traffic systems and on the other hand on the technological level to develop new solutions for materials, components and systems for future vehicles.

Development of innovative vehicle concepts for the mobility of the future

Demonstration of DLR key technologies

Platform for industry cooperations

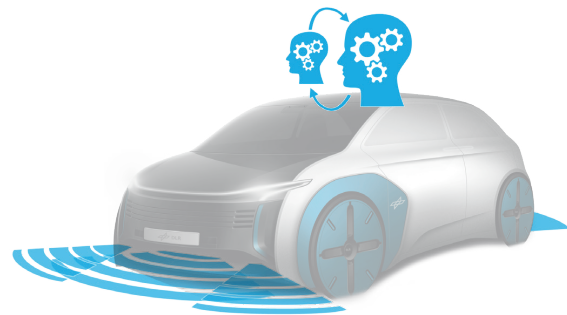


The NGC working groups

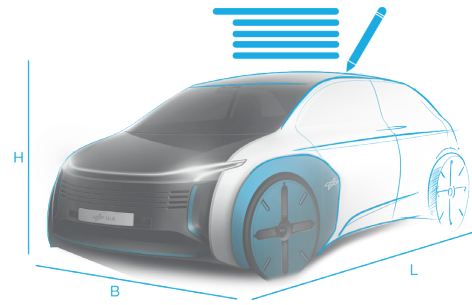
In the six research fields of vehicle concepts, vehicle structures, powertrain, energy management, vehicle intelligence and mechatronic chassis, DLR is developing technologies and solutions that will be suitable to meet future mobility requirements in the urban, long-haul and goods transport sectors.

Our vision for road vehicles is to fully integrate them into an overall mobility system, including energy and communication infrastructures. In the future we expect road vehicles to have significantly lower energy requirements, to be electrified and/or use alternative fuels, thereby reducing emissions. They will be lighter and quieter than today's vehicles, smarter and more networked, and will be able to actively balance driving errors and drive autonomously when required. For users, they will be more individual, more variable and more convenient.

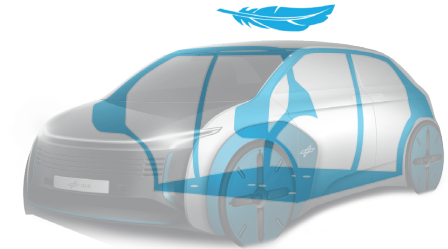
Against this background and taking into account the DLR programme Traffic Management and Transport System, e.g. socio-economic dynamics and possible future mobility use, we have systematically derived our approach to the Next Generation Car (NGC) to develop vehicle concepts with solid requirements and solutions. This has enabled us to develop next generation virtual target vehicles. The project comprises a total of three individual vehicle concepts: NGC Urban Vehicle (UMV), NGC Interurban Vehicle (IUV) and NGC Safe Light Regional Vehicle (SLRV).



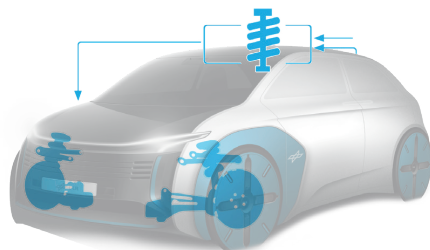
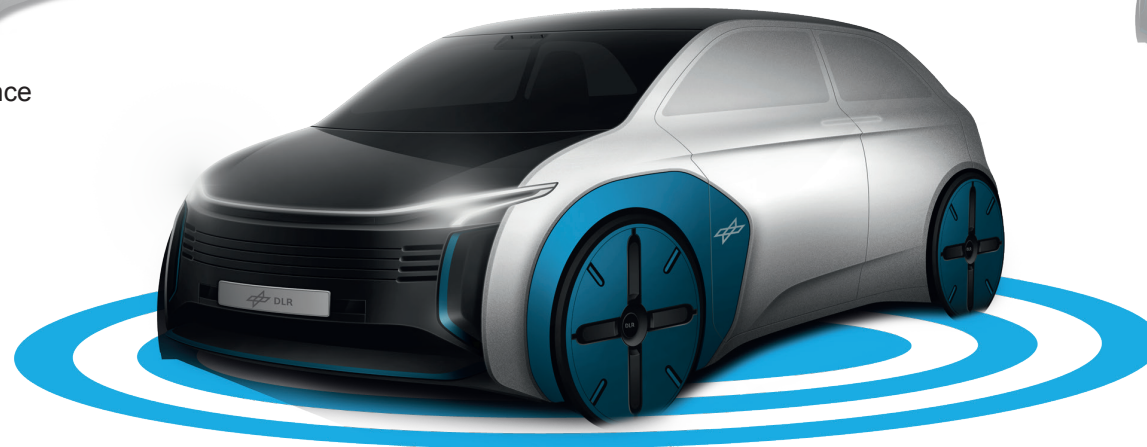
Vehicle intelligence



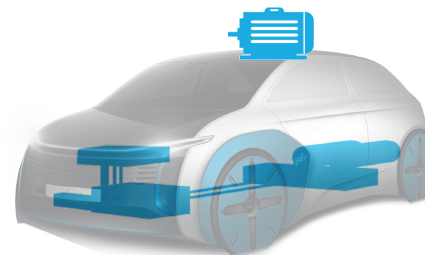
Vehicle concept



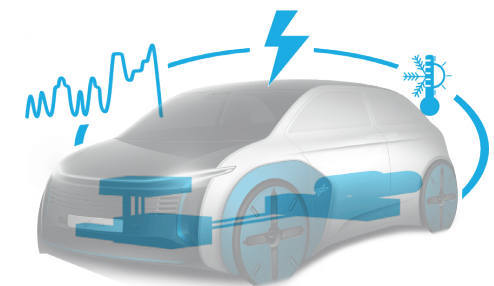
Vehicle structure



Chassis



Drive train

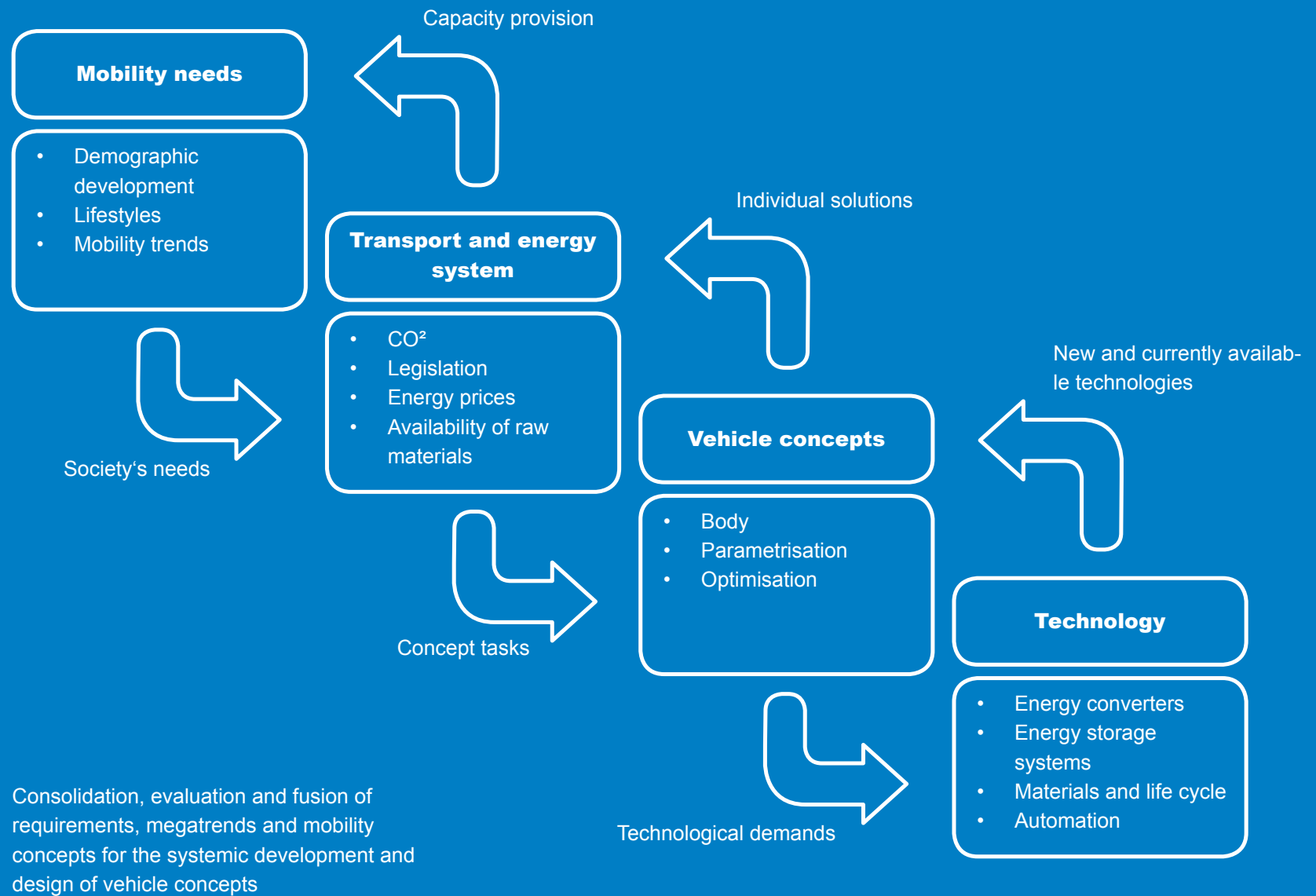


Energy management

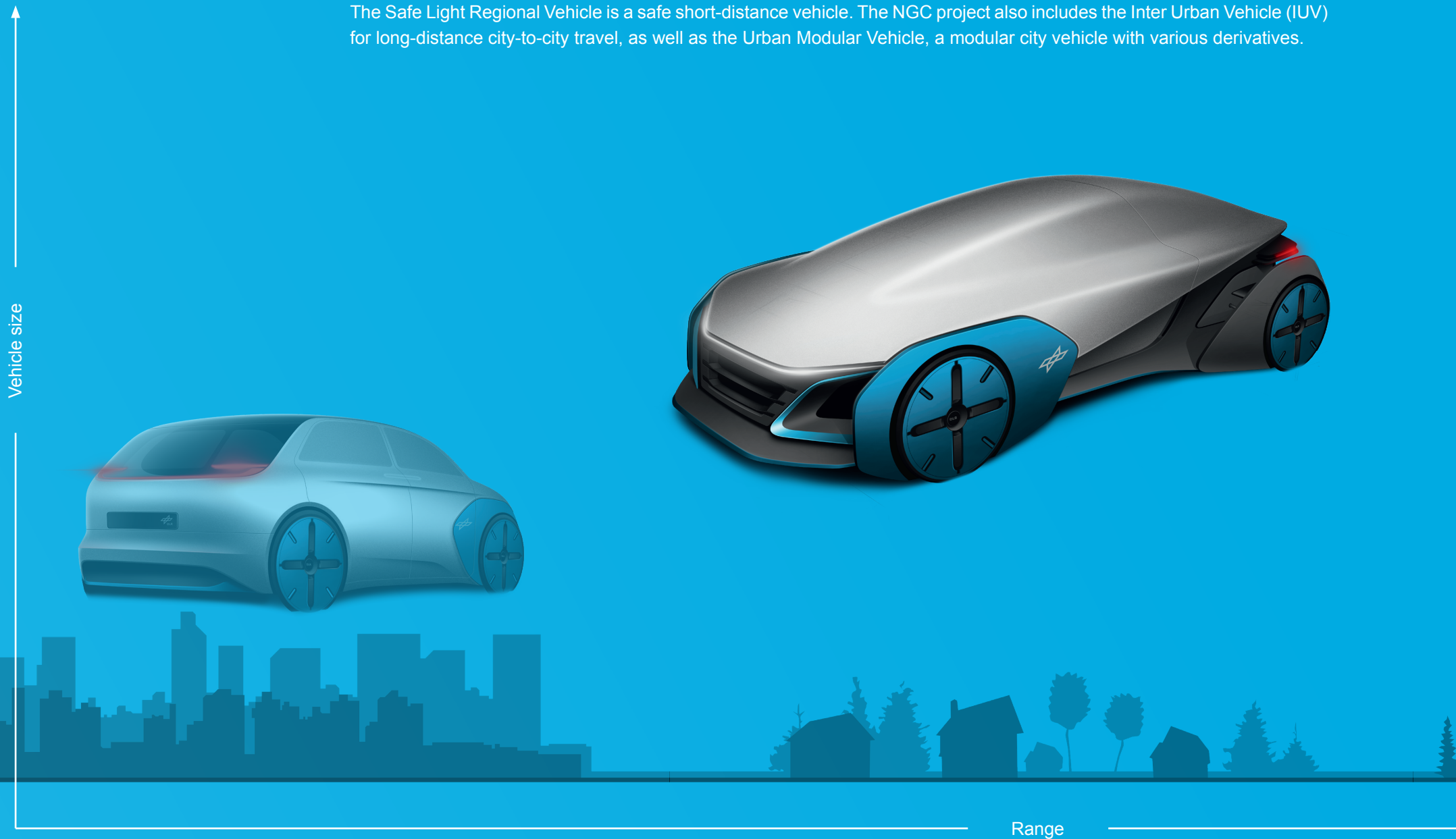
All research activities and technology developments have been reflected and aligned in accordance with the requirements and objectives defined by NGC. Systemic relationships have been presented and existing contexts analysed. The research results served to improve databases and develop new, advanced solution concepts and development methods. The foundation for the implementation of this comprehensive approach was the close networking of our research competencies over many years:

- Design, calculation, technical design and simulation of vehicle energy architectures and drives, chassis and body structures
- Development and integration of new material concepts as well as material and joining technologies
- Understanding of systems engineering for fuel cells and vehicle batteries, hydrogen storage and alternative fuel
- Synthetic capabilities for active and passive safety technologies
- Development of new solutions in aerodynamics and driver assistance
- Economic and ecological evaluation of vehicle technologies through the development of technology scenarios

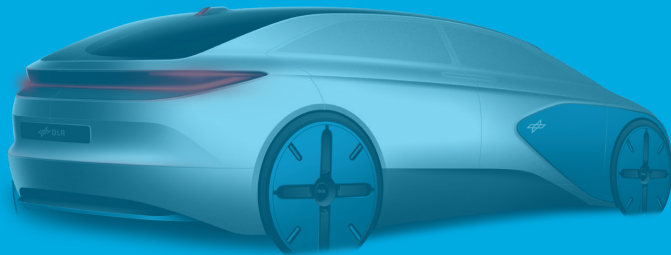
There are specific DLR requirements for the work being carried out in the NGC vehicle project. These include, for example, the use of hydrogen as an energy carrier, comprehensive approaches from aviation and automotive via uniform evaluation methods, simulation and validation tools or holistic development approaches with interdisciplinary simulation methods at system and component level.



The Safe Light Regional Vehicle is a safe short-distance vehicle. The NGC project also includes the Inter Urban Vehicle (IUV) for long-distance city-to-city travel, as well as the Urban Modular Vehicle, a modular city vehicle with various derivatives.



Safe Light Regional Vehicle



The SLRV (Safe Light Regional Vehicle) is the smallest and lightest member of the NGC vehicle family.

It addresses the issues related to the safety of today's light vehicles with a new metal sandwich construction method. The demanding safety and weight targets (450 kg) are achieved using an innovative entry-level concept, a highly efficient hydrogen fuel cell drive and an innovative chassis.

The exterior design makes it interesting for both new drivers and commuters who want a sporty and high-quality vehicle

SLRV Vision

The development of the Safe Light Regional Vehicle focused on one of the most important goals for electrified vehicles: To offer an adequate range and at the same time achieve an appropriate price for the application.

The SLRV concept has been specially developed for commuters who have regular point-to-point journeys, such as a feeder vehicle to the public transport connections or as a car-sharing vehicle in an out-of-town context. It can therefore supplement public transport in a suburban or rural environment, be used as a second car and is well suited for sharing due to its fast H2 refuelling capability.

COMMUTER ROUTE

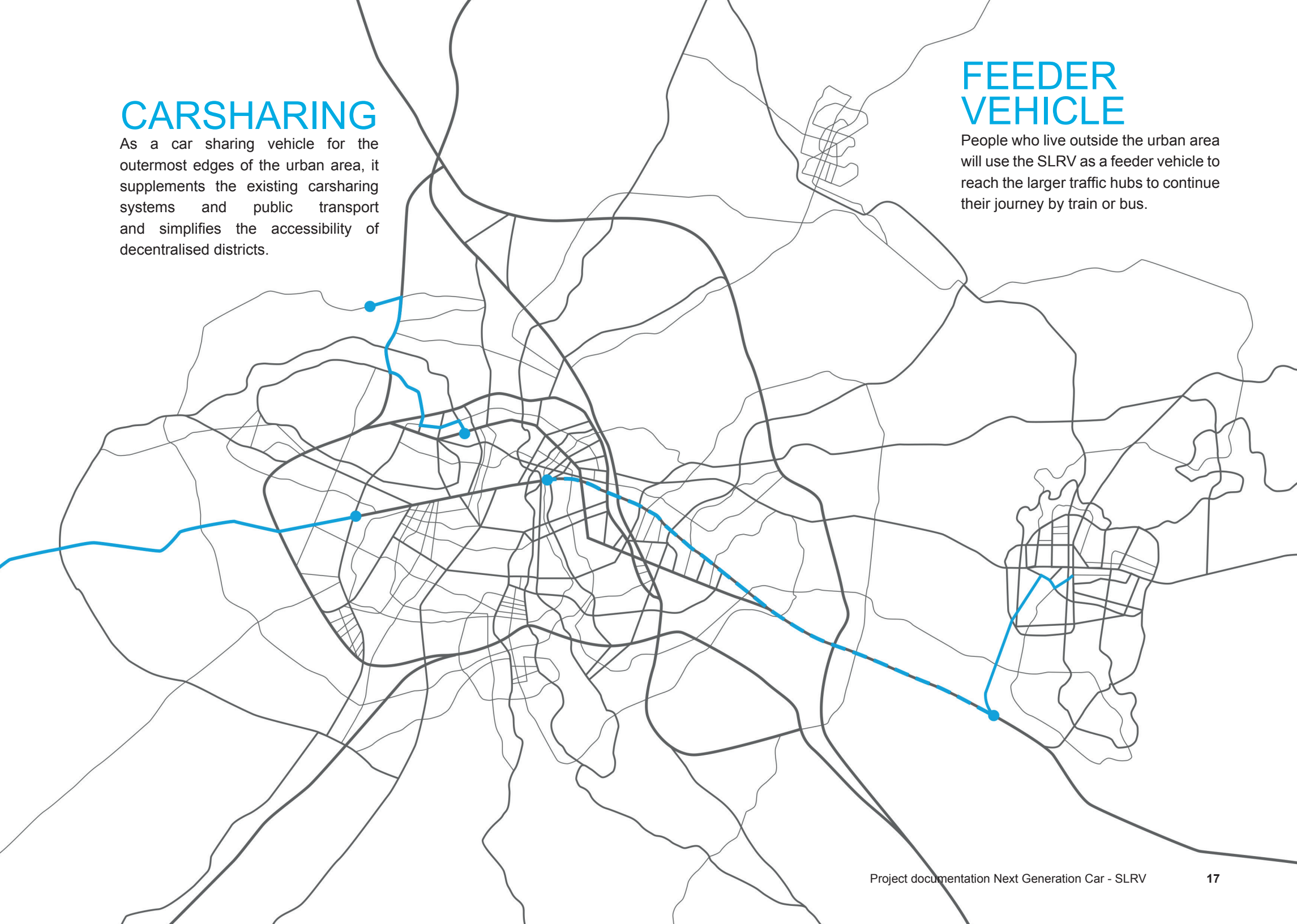
As the fuel cell drive achieves a range of 400 km, the SLRV is perfectly suited as a second vehicle for travelling from the outskirts of the city into urban areas.

CARSHARING

As a car sharing vehicle for the outermost edges of the urban area, it supplements the existing carsharing systems and public transport and simplifies the accessibility of decentralised districts.

FEEDER VEHICLE

People who live outside the urban area will use the SLRV as a feeder vehicle to reach the larger traffic hubs to continue their journey by train or bus.

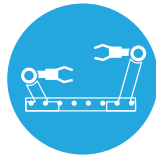


When choosing which vehicle to buy the vehicle's safety performance and the cost factor are two of the most important points. The SLRV is intended to favourably combine these two points and therefore promote electric mobility.



Cost reduction

An innovative metal sandwich construction enables the manufacturer to keep costs down for low to medium production volumes. The low vehicle weight also allows the use of a small and therefore cost-effective drive unit.



Zero emission

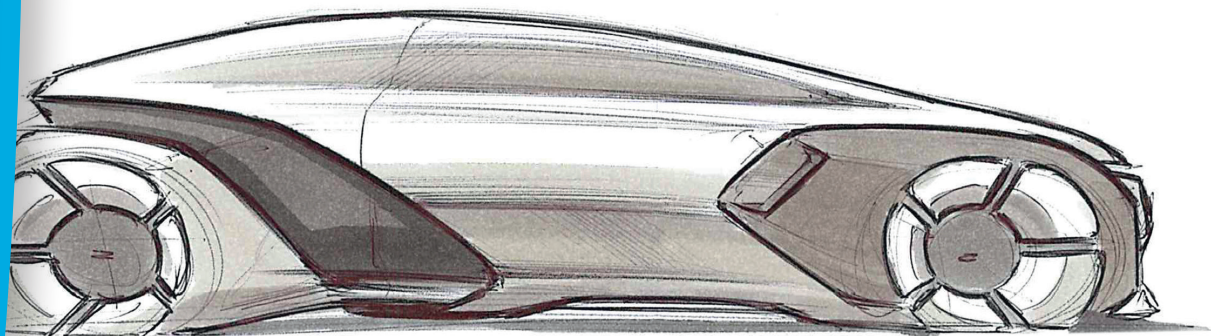
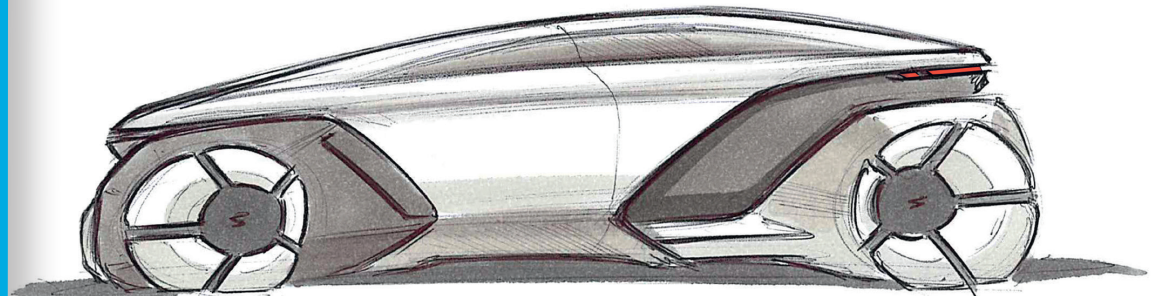
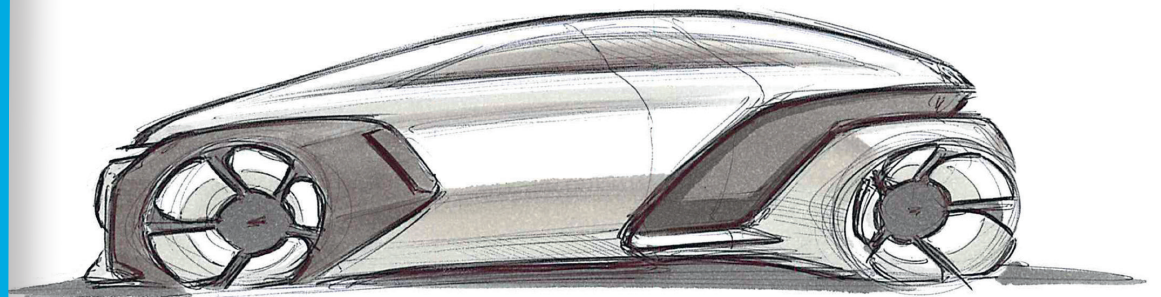
The use of a fuel cell hybrid powertrain is intended to achieve a comparatively long range of up to 400 km. The future could see hydrogen from power-to-gas systems being used.

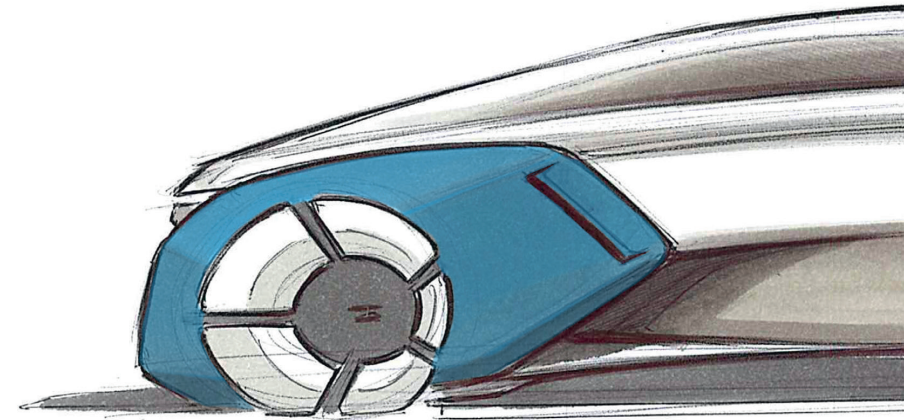
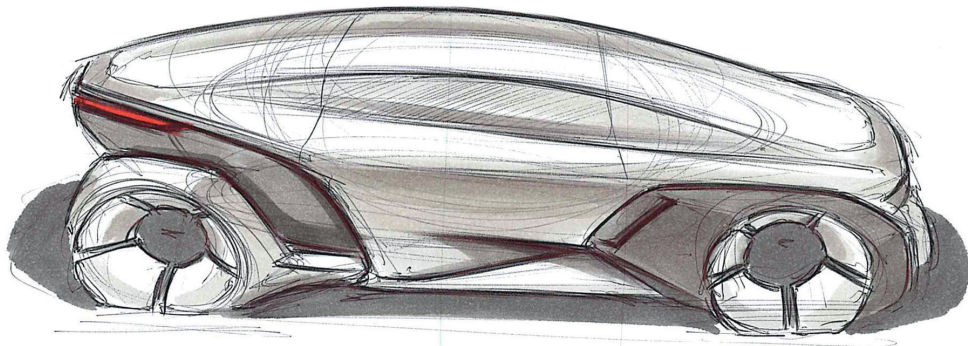
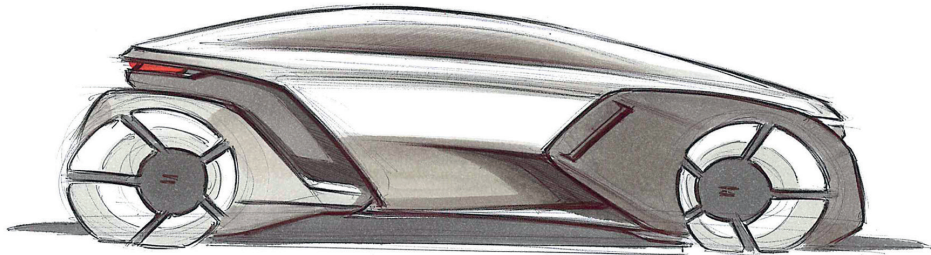
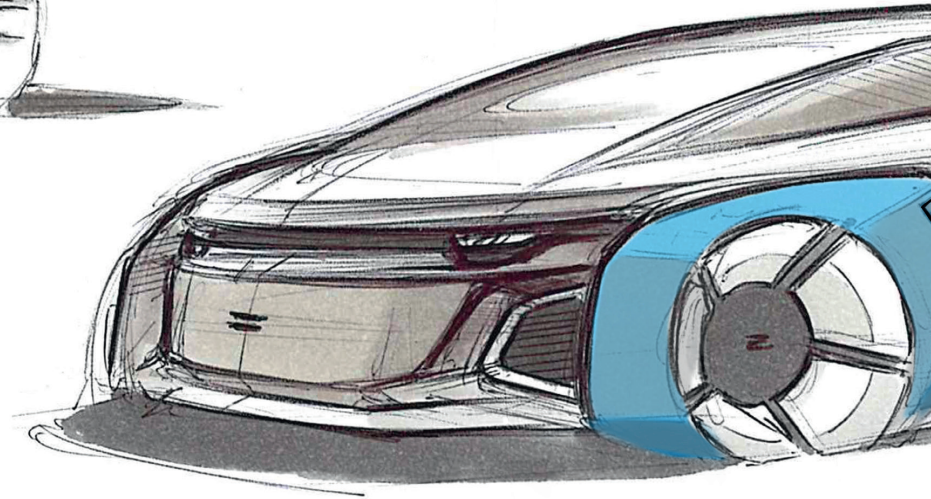
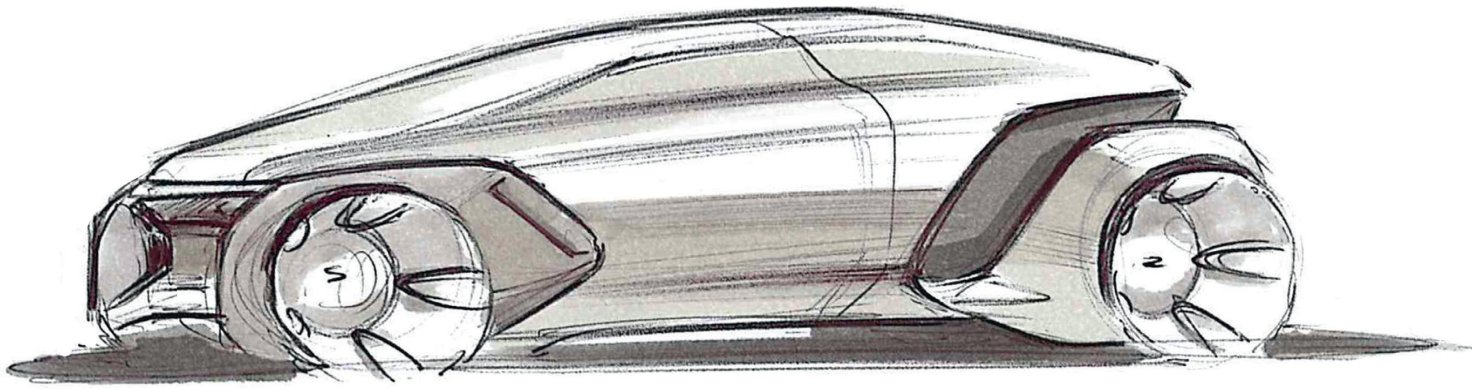


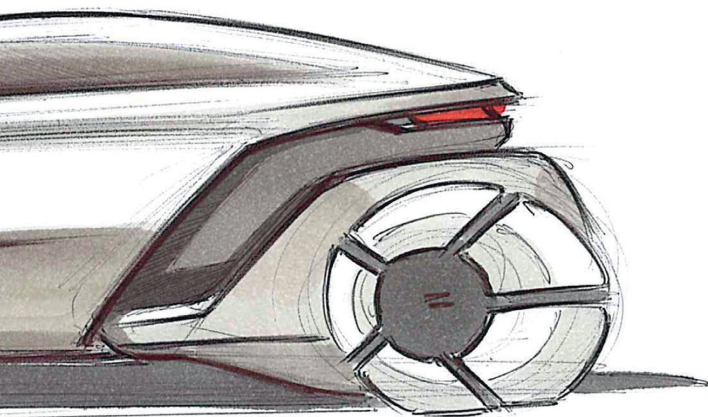
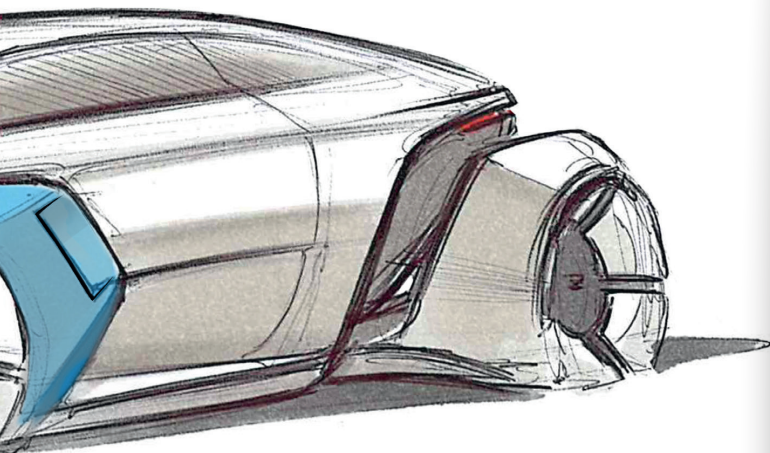


Light and safe

The innovative metal sandwich body is designed to achieve low weight at moderate cost. Outstanding passive safety can be achieved because of the excellent crash performance of the sandwich materials.





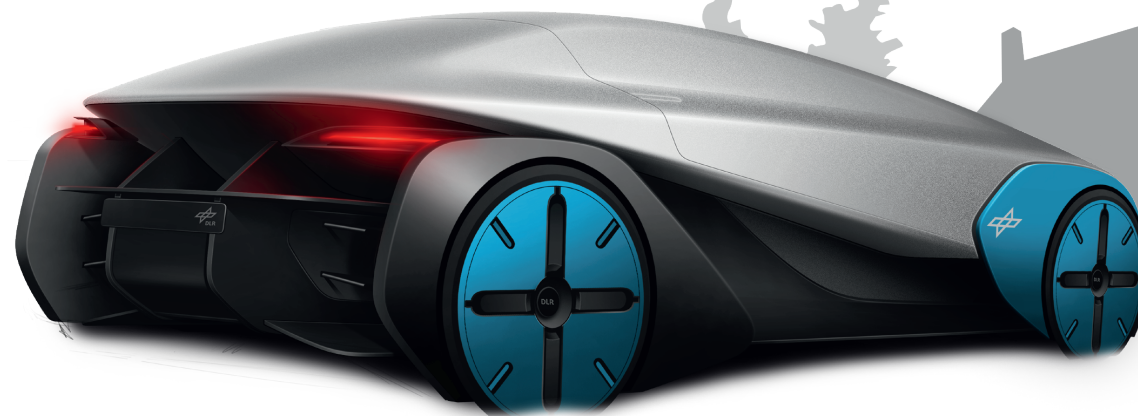


Customer benefits
automated driving
emissions
safety
seats
length [mm]
range [km]

Commuter vehicle
to SAE level 3
local zero, FCEV
Safe System Approach
2
3800
400

COST REDUCTION

LIGHT



ZERO EMISSION

Cost reduction

The continuous reduction of driving resistances, which is achieved in particular through an extremely light vehicle, will ensure that the SLRV has low fuel consumption and enable relatively small, cost-effective drive components.

The fuel cell hybrid design also enables braking energy to be recuperated. This results in hydrogen consumption in the NEDC driving cycle of only about half that of a conventional car with fuel cell drive.

Besides the very low body weight the metal sandwich structure enables the use of low-cost materials such as aluminium, steel and plastic foam. The stiffness of sandwich components also makes it possible to manufacture the body from relatively few, simply shaped individual parts. This reduces investment costs for forming tools for example.

The cost of purchasing a SLRV is currently forecast at around 15,000 Euro.

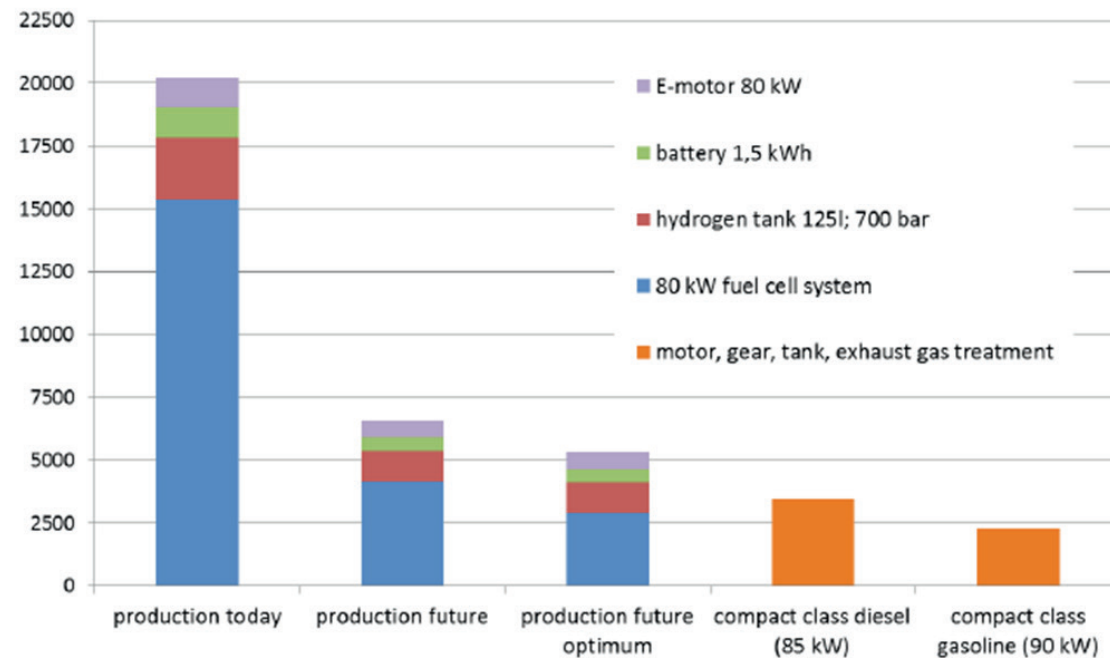
Based on a mileage of 300,000 km and a service life of 10 years, the SLRV is estimated at 0.1 €/ km for depreciation and energy costs (hydrogen), compared with 0.073 €/ km for a Renault twizy (including battery rental for 10 years). However, the SLRV concept offers significant advantages in terms of usability:

- Range of 400 km instead of 100 km
- A closed, air-conditioned cabin
- Maximum speed of 120 km/h instead of 80 km/h

Initial forecasts indicate that the production costs for a body in volume production will be approximately 600 Euro. In future production the fuel cell will remain the most expensive part to produce. The cost will depend on performance, but in the years to come the cost may fall by 3/4 of the initial cost due to production optimization and distribution if demand is sufficiently high.

The diagram below (P.23, Fig.1) shows a forecast for the cost development of an 80 kW fuel cell system. However, the SLRV only requires a fuel cell producing 8.5 kW, which will potentially result in much lower costs than the 5000-6000 € forecast for an 80 kW system that is considered here.

Fig.1
Cost development forecast fuel
cells - system



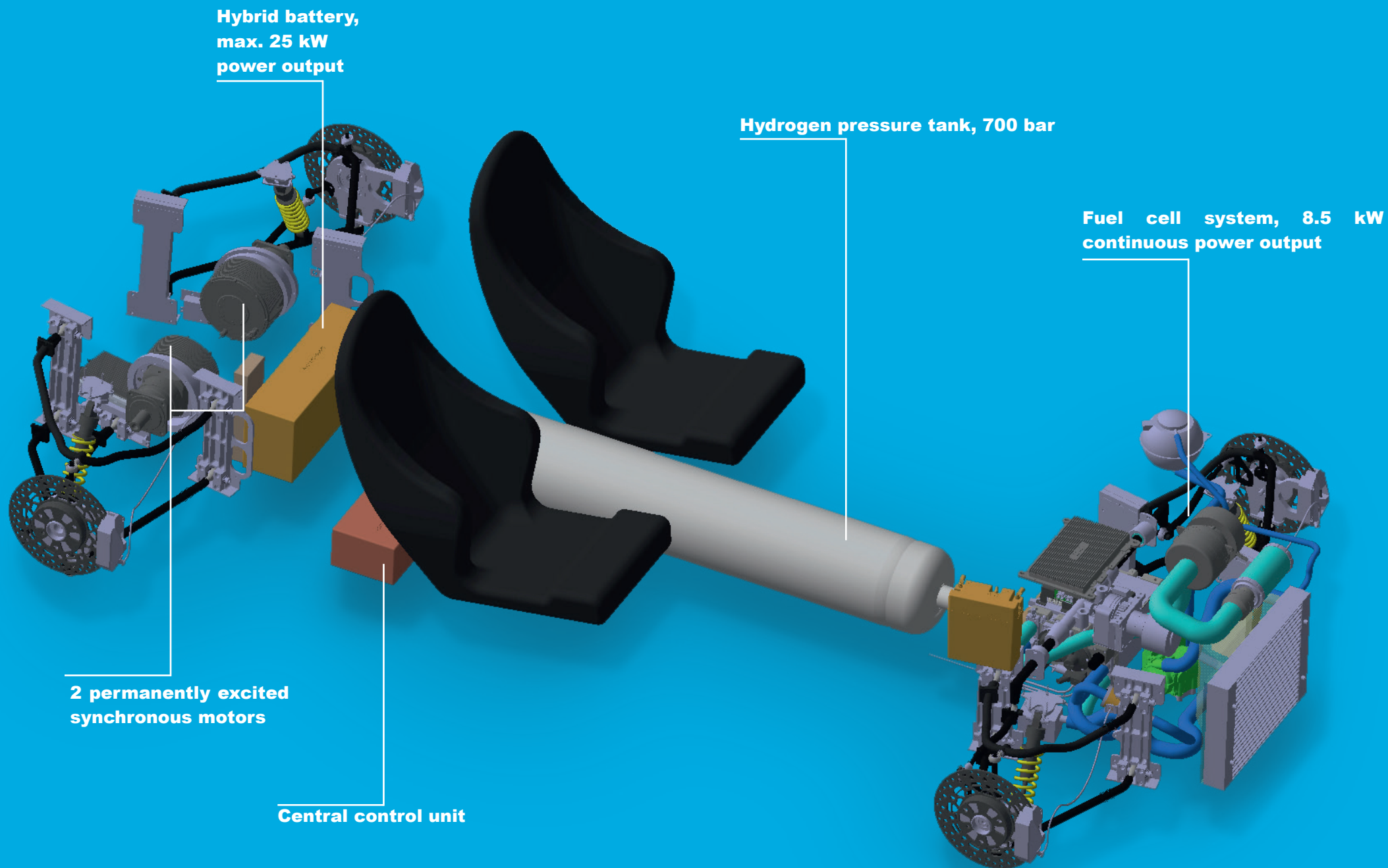
Zero emission

The NGC-SLRV is designed as a fuel cell battery hybrid. This powertrain enables a range of up to 400 km and the system weight is lower than conventional battery systems. A relatively small fuel cell with 8.5 kW continuous output is used. An additional 25 kW of power is available for acceleration from the hybrid battery.

The architecture of the SLRV body makes it possible to accommodate a 39 L hydrogen pressure tank in the vehicle's tunnel, which can store 1.6 kg of hydrogen at 700 bar. With a calculated consumption of 0.34 kg hydrogen for 100 km, this results in a maximum range of 470 km. Two near-wheel motors, each producing a continuous output of 7.5 kW, make it possible to dispense with a differential and provides excellent traction and torque vectoring.

Heating and cooling the driver's cab is a challenge for highly efficient electric vehicles. However, the SLRV uses waste heat from the fuel cell for heating, so unlike a pure BEV, no additional energy is required. The good thermal insulation provided by the sandwich body structure assists the thermal management of the vehicle.

The hydrogen for the fuel cell drive could in future be produced in a power-to-gas process. Power-to-gas systems enable large amounts of energy to be stored over long periods of time. This could make them important in the future for balancing the seasonal fluctuations in regenerative energy generation. There is a potential synergy effect as these systems can also be used to supply fuel cell vehicles with hydrogen.



Light & safe

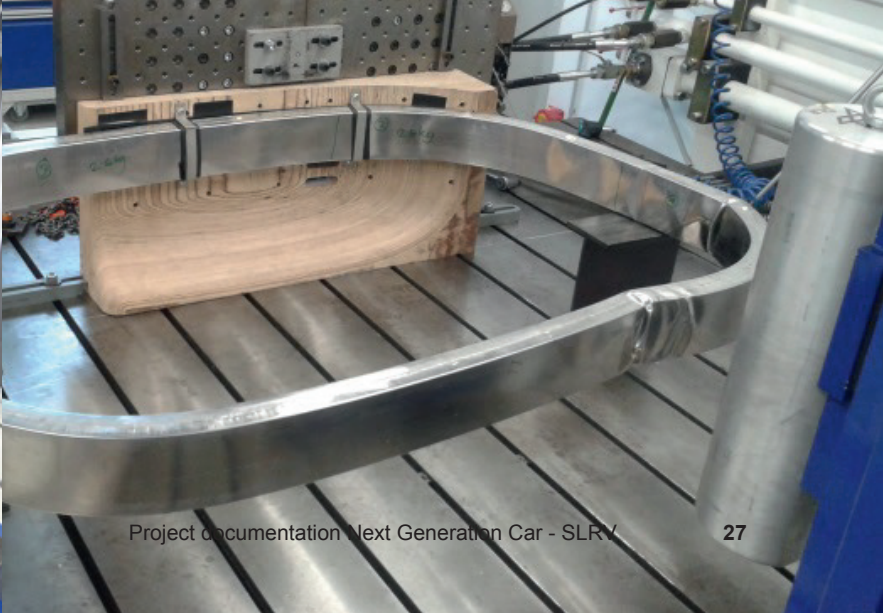
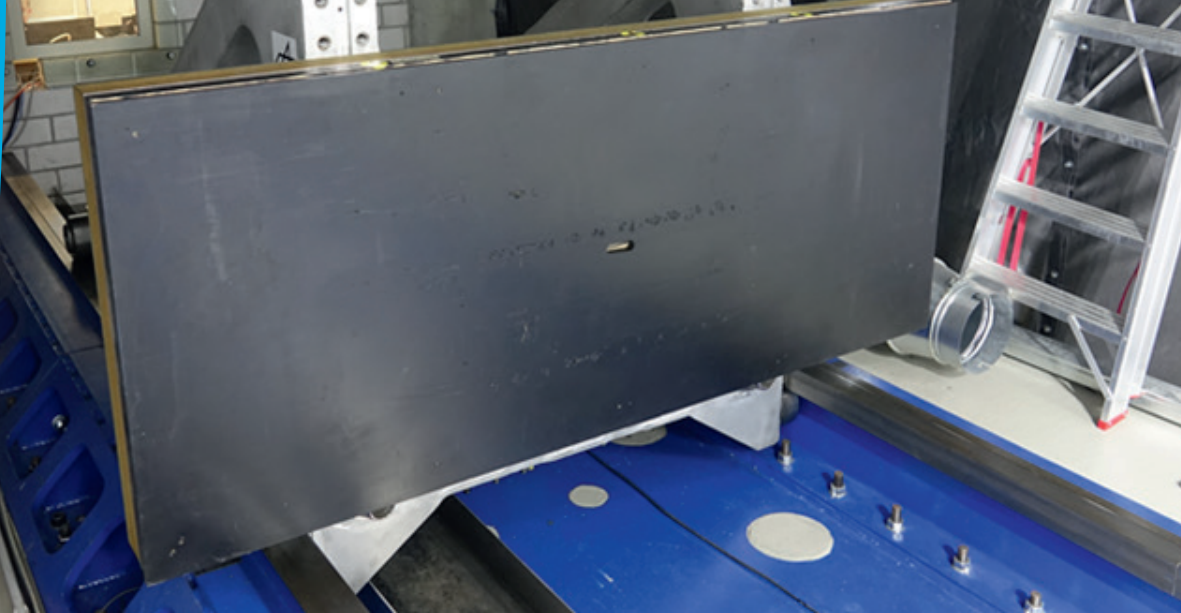
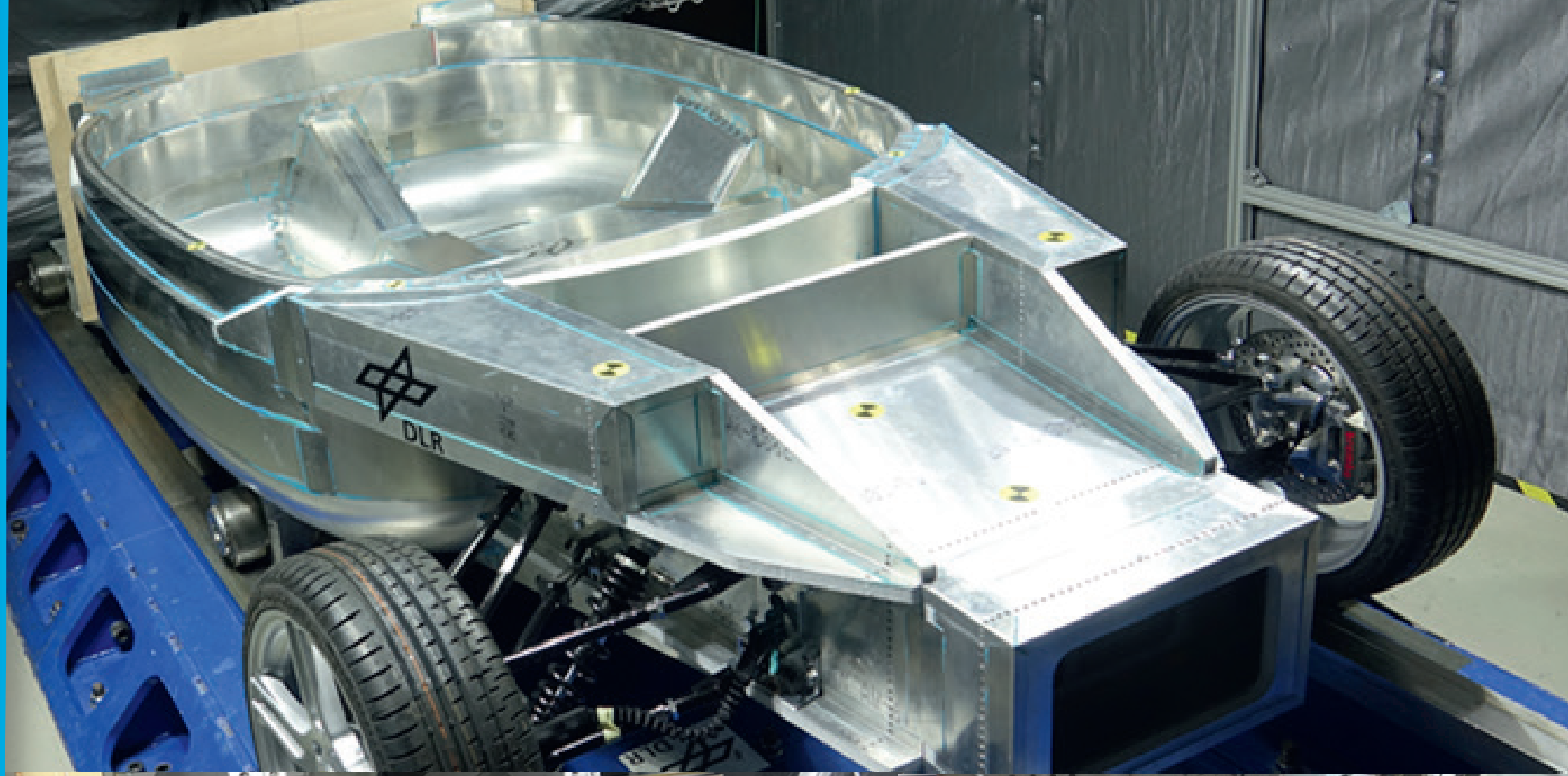
Future trends such as automation, digitization and electromobility have a significant influence on vehicle architecture and structural design. The increasing variety of models also means that production must become more flexible and modular. Intelligent multi-material design (MMD) and lightweight construction are used to meet specific requirements such as emissions, energy consumption, range, driving dynamics, safety, costs, modularity, etc. This is achieved by improving design, materials and manufacturing processes.

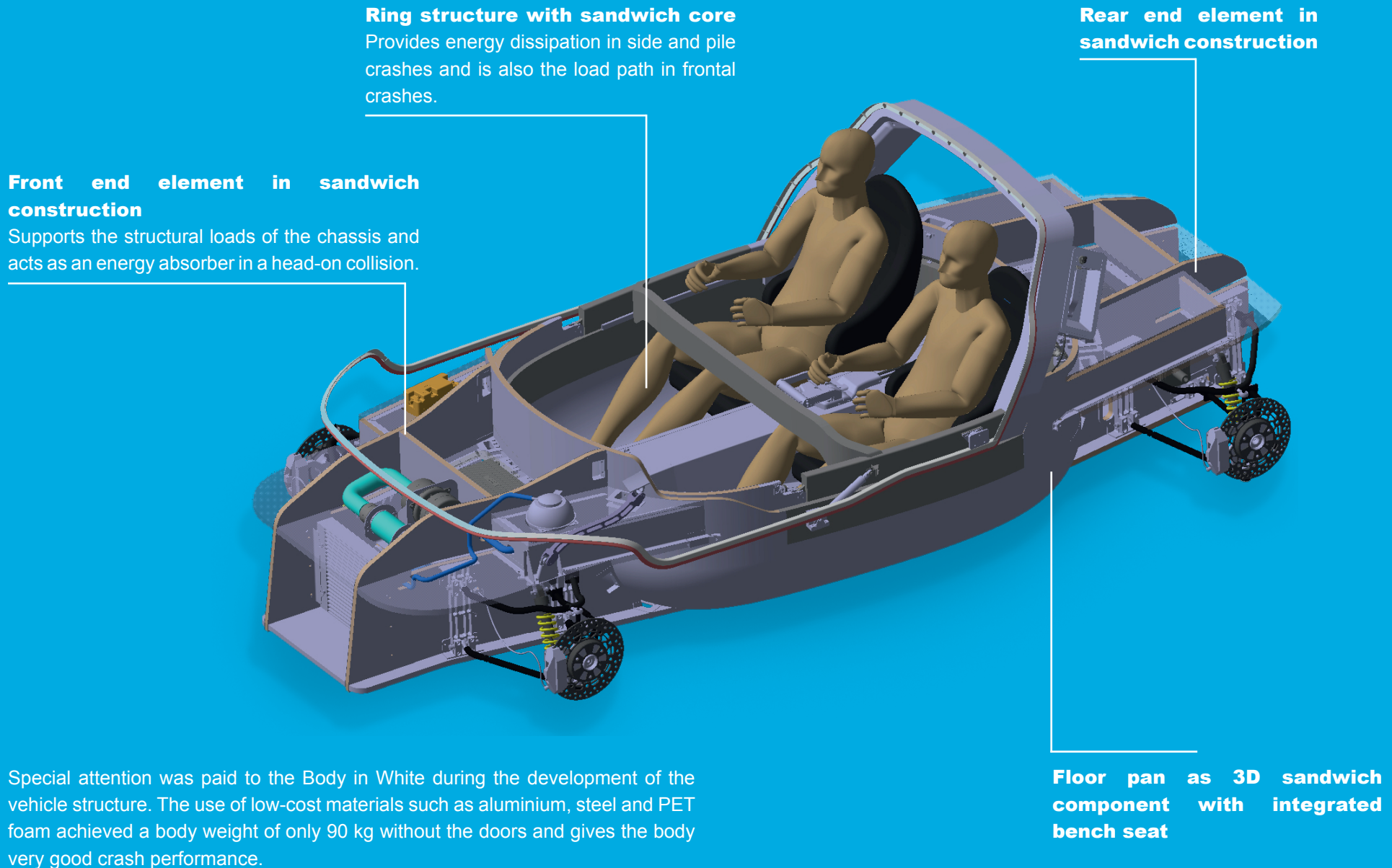
The focus of vehicle structure development was on reducing the absolute energy consumption of road vehicles (passenger cars and commercial vehicles), avoiding pollutant emissions, particularly CO₂, NO_x, soot and noise, improving safety, reliability and comfort, and developing and improving (development) methods, tools and processes. Besides the focus on increasing the integral and passive safety the reduction of the vehicle

weight was given top priority. The use of intelligent concepts, manufacturing methods and lightweight materials enabled the spiralling increase in weight to be stopped and even reversed.

An important factor in achieving these aims was the use of multi-material structures and the efficient use of light metals and fibre composites. However, the inherent potential must be exploited to an even greater extent. A significant

mass reduction was achieved through the use of Purpose Design in an innovative way. For the body of the SLRV the focus is on a metallic sandwich construction, which has been investigated both by simulations and various tests.





A major innovation in the Safe Light Regional Vehicle is the body, which is extremely lightweight at less than 90 kg and makes a significant contribution to the low overall vehicle weight of 450 kg. An innovative metal sandwich construction, consisting of metallic cover layers and polymer foam cores, is used. The passenger cell is made of a few three-dimensional sandwich components similar to the monocoque construction used in sports cars and a sheet construction is used for the front and rear of the car. This makes it possible to use relatively few, simply shaped components, which are nevertheless remarkable due to their high weight-specific stiffness and very good crash behaviour.

The mechanical properties of this innovative sandwich construction method and the joining techniques developed specifically for it were examined in the projects „NGC Vehicle Structure“ and in the TM project „Validation of a lightweight body“. The entire SLRV body underwent crash testing and other tests confirming the high potential promised by the construction method. Future investigations are aimed at verifying feasibility in volume production.

Lightweight construction also carries over to the interior of the SLRV and is influenced by the choice of materials and structure. At the same time the weight reduction measures create the largest possible open interior space.

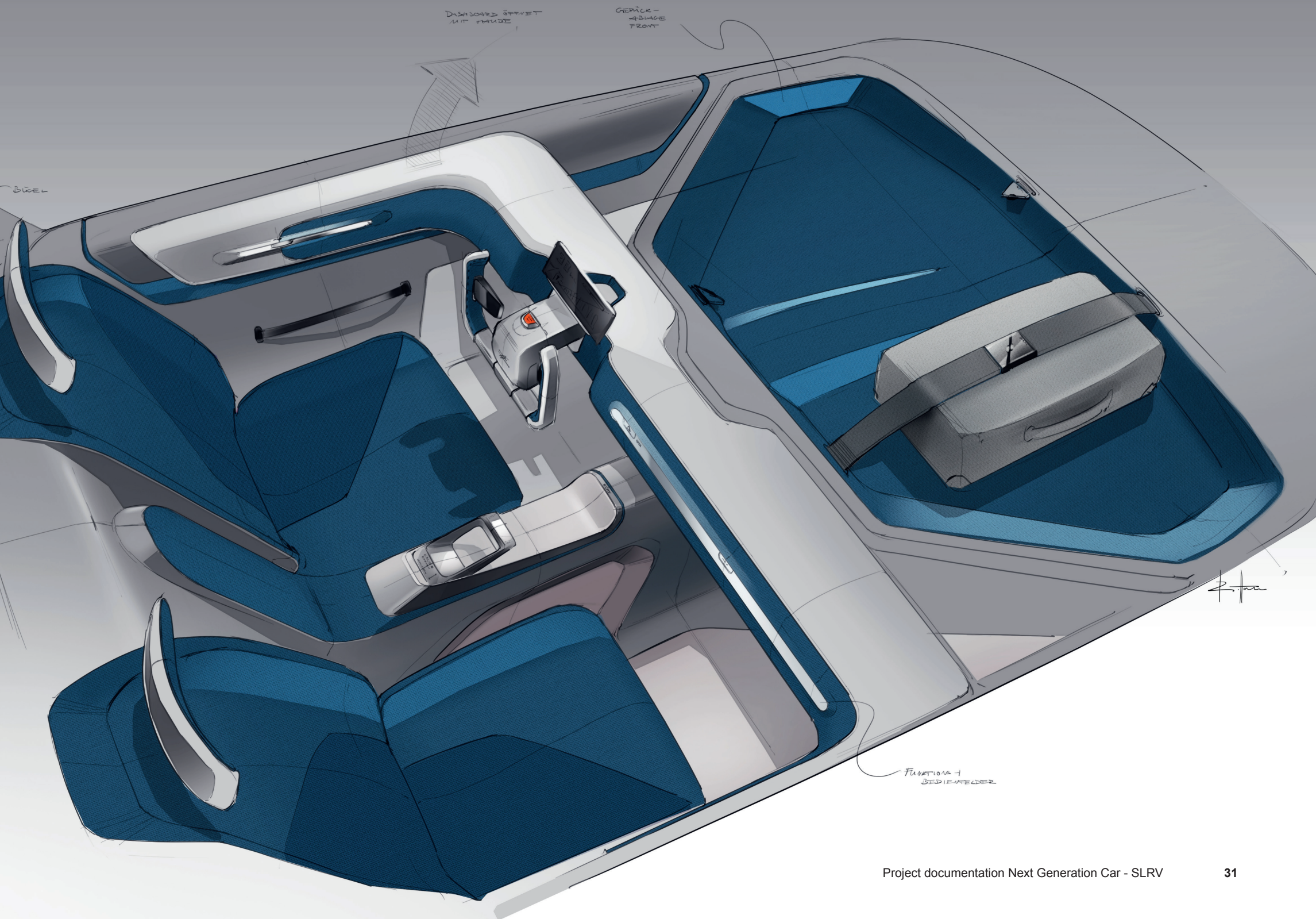
The use of a drive-by-wire steering system that has no mechanical connection to the wheels provides a large amount of free space in front of the instrument panel carrier that can

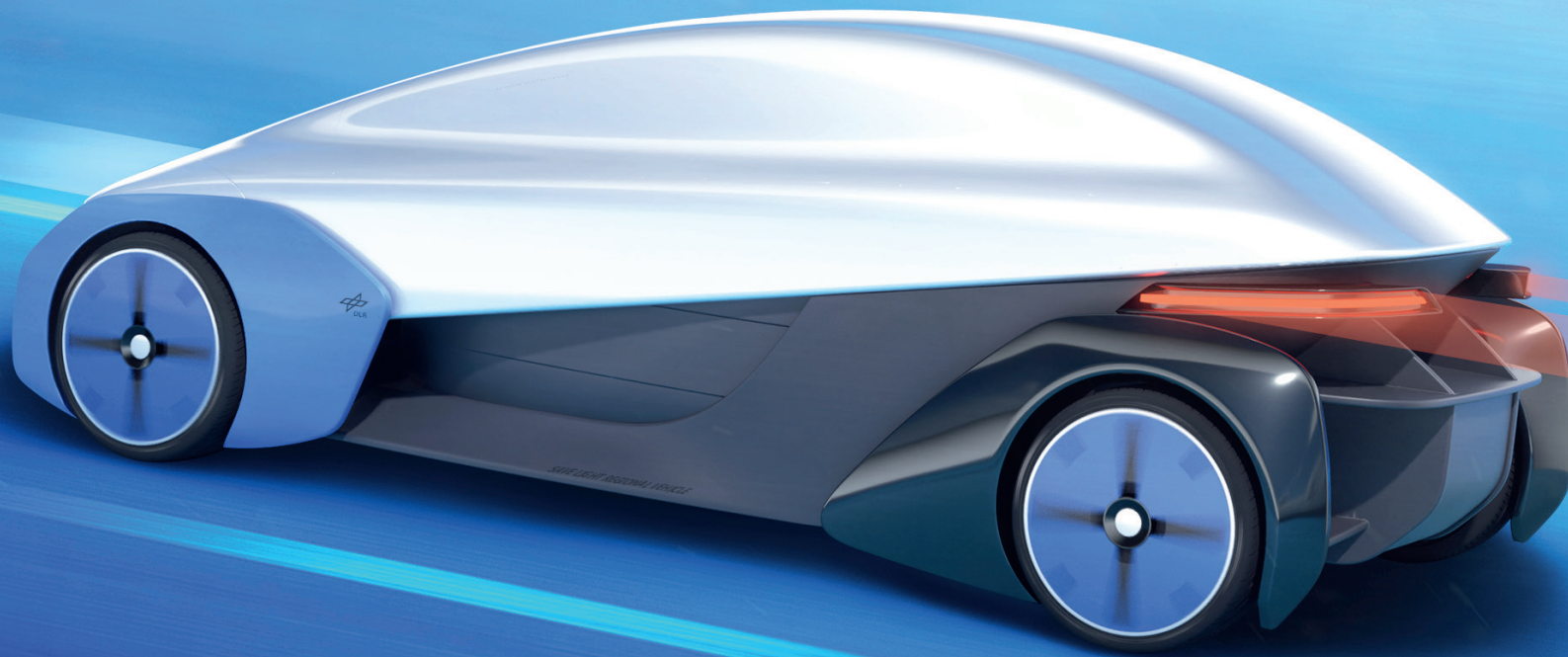
be used for other purposes, such as luggage storage.

This also enables the complete instrument panel carrier and steering wheel to be folded upwards making entering and exiting the vehicle easy.

This upright access enables the use of a comparatively high side wall in the area of the passenger compartment which has a beneficial effect on the stiffness and weight of this assembly.







Contact

SLRV concept

Dipl.-Ing. Michael Kriescher

Tel.: +49 (0) 711-6862-409

Michael.Kriescher@dlr.de

German Aerospace Center

Institute of Vehicle Concepts

Pfaffenwaldring 38-40

70569 Stuttgart

www.DLR.de/fk

verkehrsforchung.dlr.de/de/projekte/ngc-slr

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