

# IUV

NEXT GENERATION CAR  
Inter Urban Vehicle



# IUV

The Inter Urban Vehicle is designed as a travel vehicle for long distance city to city travel and offers a range of up to 1000 km. The aim is to bring passengers to their destination in the greatest possible comfort with zero local emissions. Vehicle automation up to SEA Level 4 is also planned.

The required long range represents a challenge for battery drives, which is why in the IUV drive technologies for locally emission-free range extension are being investigated. The research and development is focused on the fuel cell.

# INTRODUCTION

## NEXT GENERATION CAR

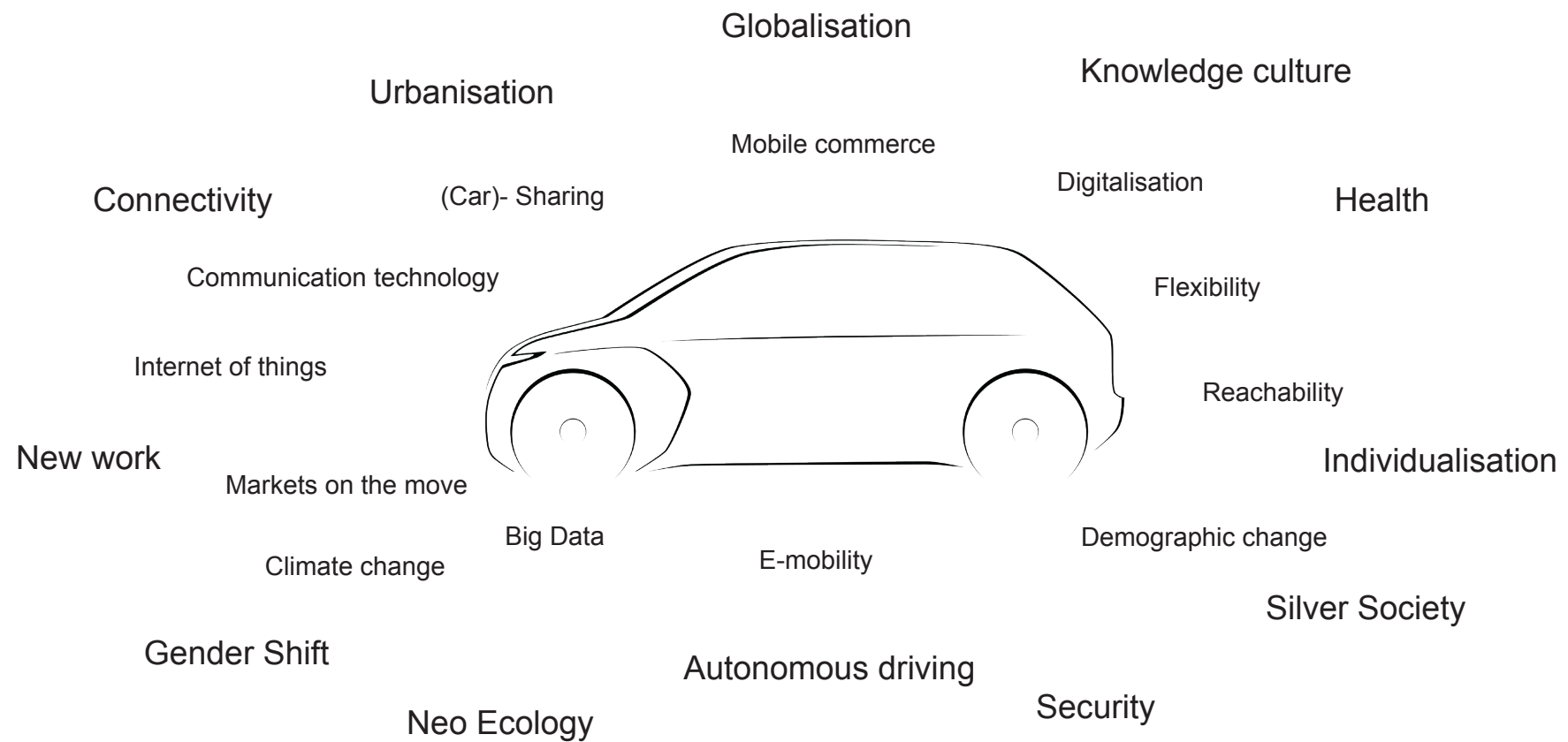
# CONCEPT

## INTER URBAN 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.

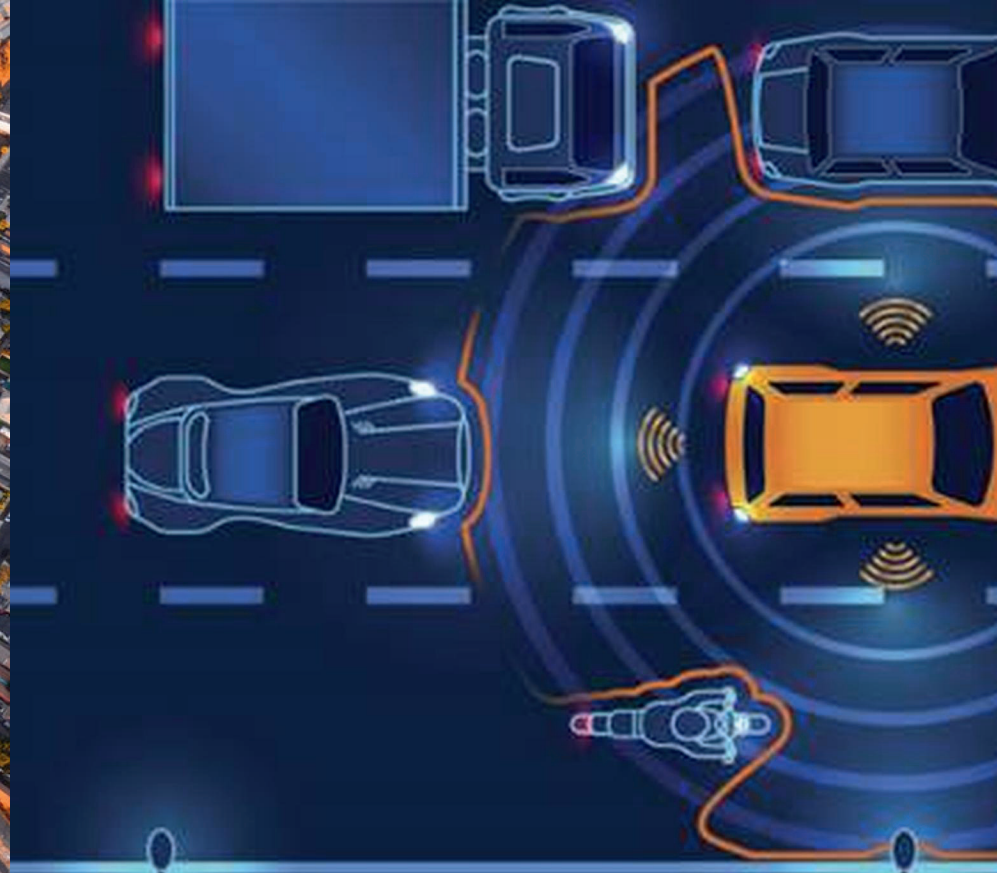
Various future trends influence these systems, such as autonomous driving, the origins of which date back to 1925. Almost all major automobile manufacturers are currently working on technology for autonomous driving. There are already smaller start-ups with the first fully autonomous vehicles on the 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 CO<sub>2</sub> 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.





INTRODUCTION





### **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 CO<sub>2</sub> 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.

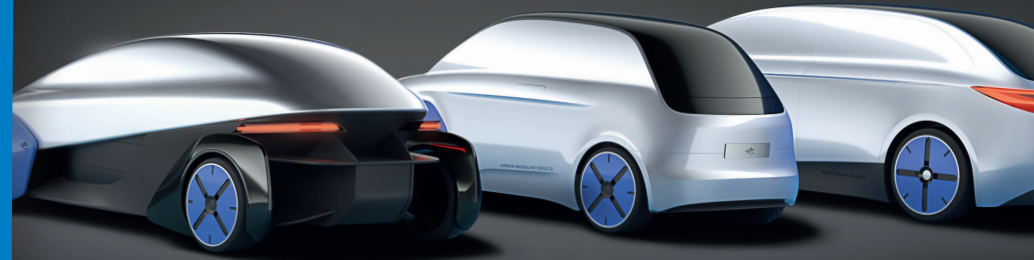
The Next Generation Car project involves 16 DLR institutes working together. The extensive competences of all institutes in different disciplines

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



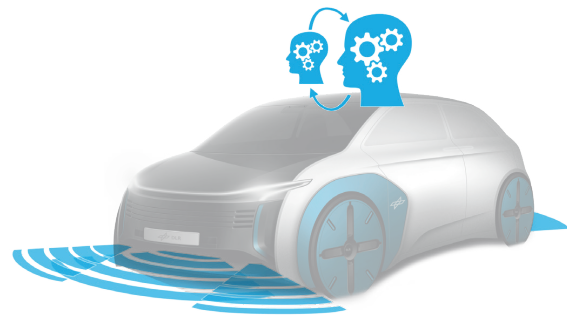
Next Generation Car - IUUV

# The NGC working groups

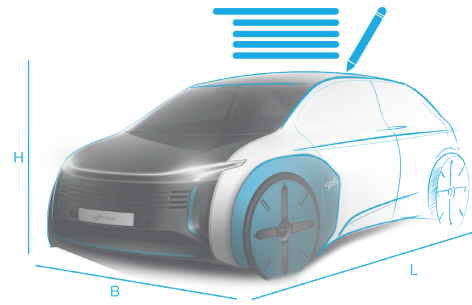
In the six research fields of vehicle concepts, vehicle structures, powertrain, energy management, vehicle intelligence and mechatronic chassis, DLR is developing technologies and solutions that will be suitable to meet future mobility requirements in the urban, long-haul and goods transport sectors.

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.

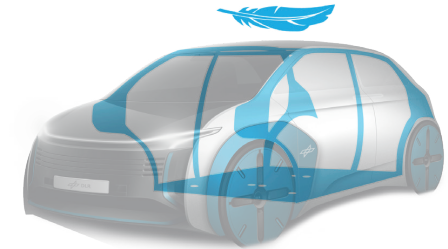
Against this background and taking into account the DLR programme Traffic Management and Transport System, e.g. socio-economic dynamics and possible future mobility use, we have systematically derived our approach to the Next Generation Car (NGC) to develop vehicle concepts with solid requirements and 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).



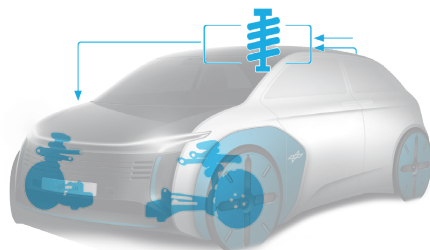
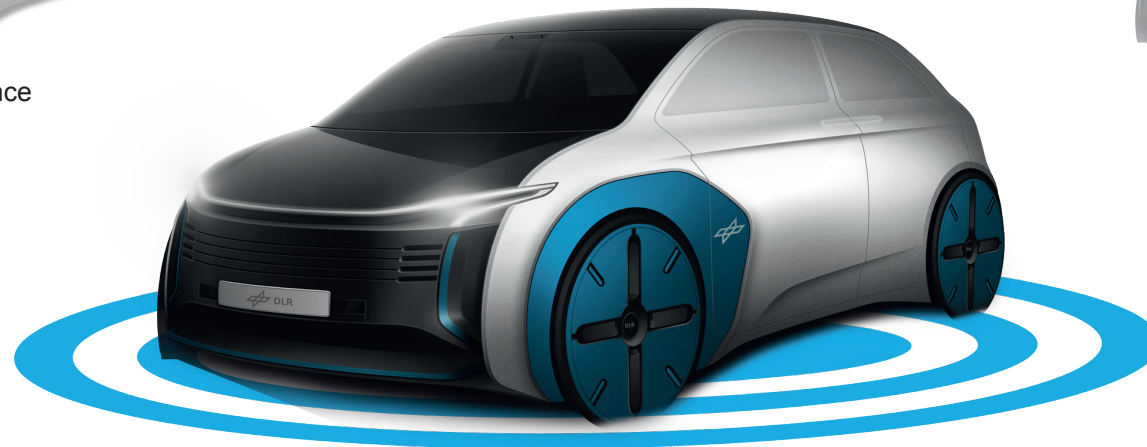
Vehicle intelligence



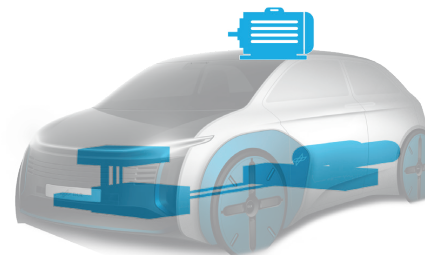
Vehicle concept



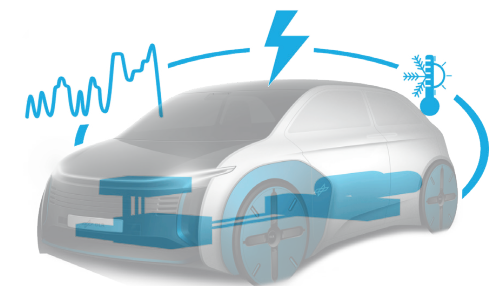
Vehicle structure



Chassis



Drive train

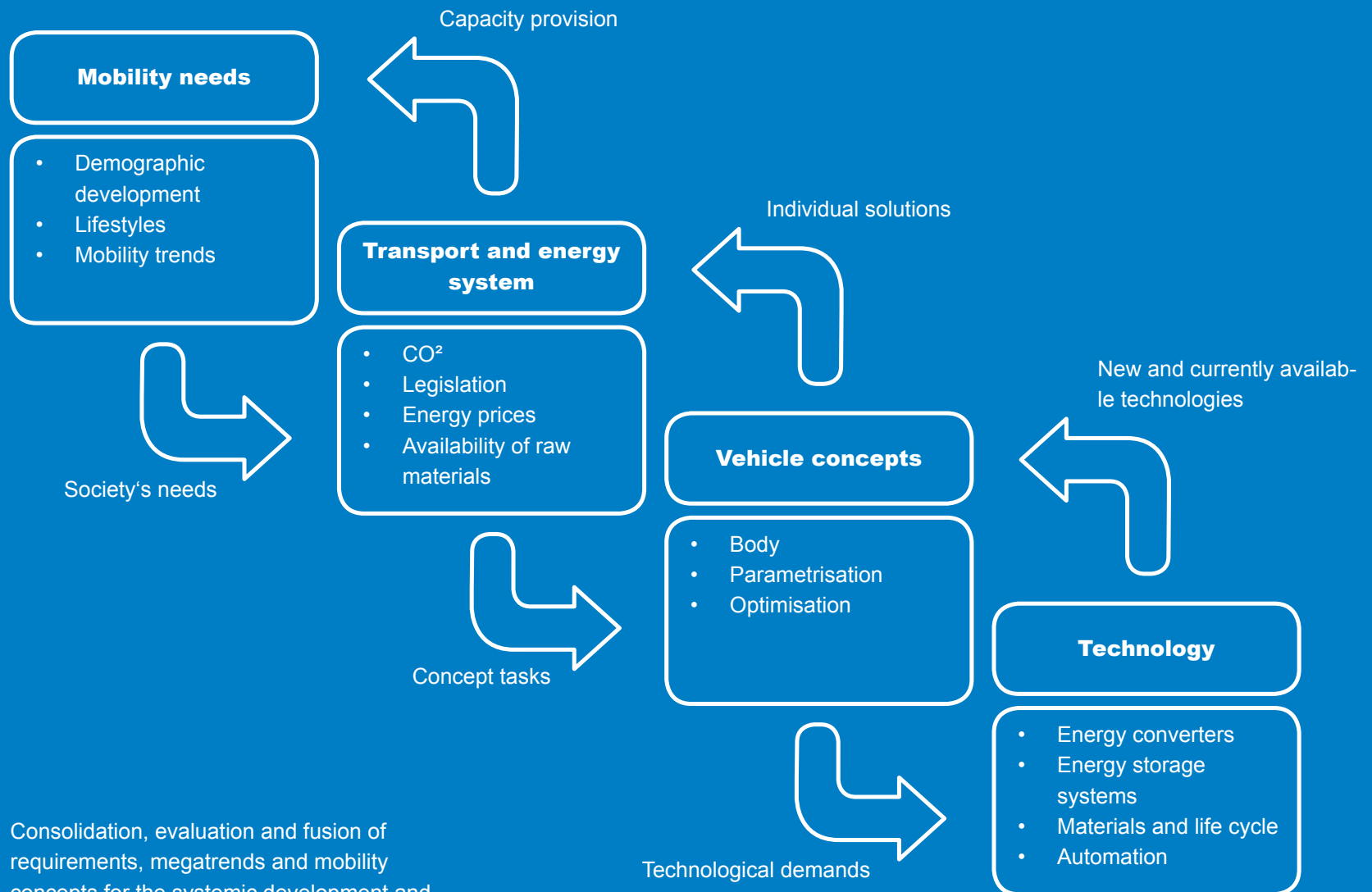


Energy management

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

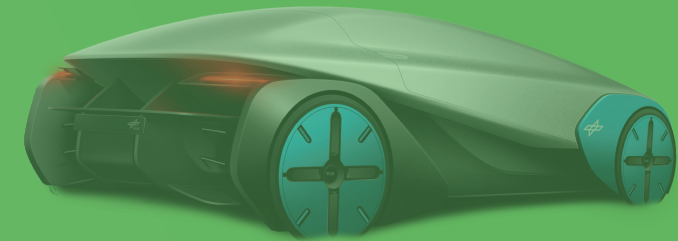
There are specific DLR requirements for the work being carried out in the NGC vehicle project. These include, for example, the use of hydrogen as an energy carrier, comprehensive approaches from aviation and automotive via uniform evaluation methods, simulation and validation tools or holistic development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



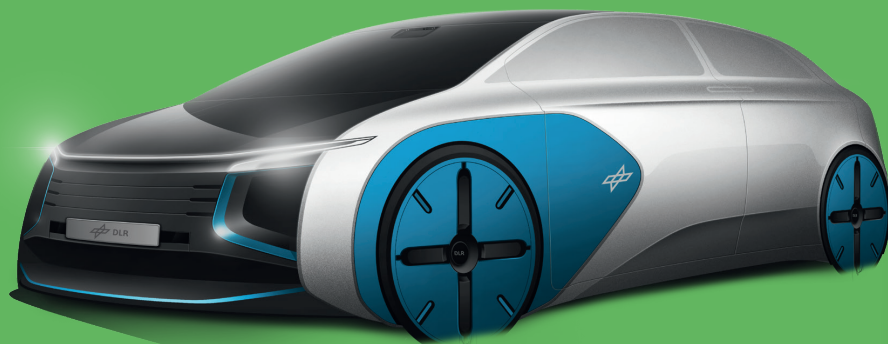
## INTER URBAN VEHICLE

The Inter Urban Vehicle (IUV) is designed for long distance city to city travel. Besides the IUV, the NGC project is also developing the Safe Light Regional Vehicle (SLRV) for short distances and the Urban Modular Vehicle (UMV) as a people mover for urban traffic.

Vehicle size



Range



# Inter Urban Vehicle

The Inter Urban Vehicle (IUV) is a long-distance vehicle designed for comfortable and emission-free travel between urban areas. The fuel cell hybrid drive enables distances of up to 1000 km to be covered without stopping for refuelling. The IUV offers a completely new type of individual mobility using automated driving functions up to SAE Level 4.

# IUV Vision

The NGC IUV is designed as a comfortable luxury vehicle for the interurban area and also for inter-regional and long distances. As a five-seat, approximately 5000 mm long vehicle of the middle and upper class, it is ideal as a „travel vehicle“ for the entire family.



## Comfort on long journeys

The IUV achieves a range of up to 1000 km using a fuel cell drive and is therefore particularly suitable for long-distance journeys. The interior is adapted to this use. Particular attention is paid to the aspect of comfort with an optimised ventilation system, an ergonomic entry concept and a flexibly designed interior.



## Zero emission

The IUV is designed as a fuel cell plug in. Emphasis is placed on the use of hydrogen as a typical DLR energy source, in particular for conversion to fuel cells.

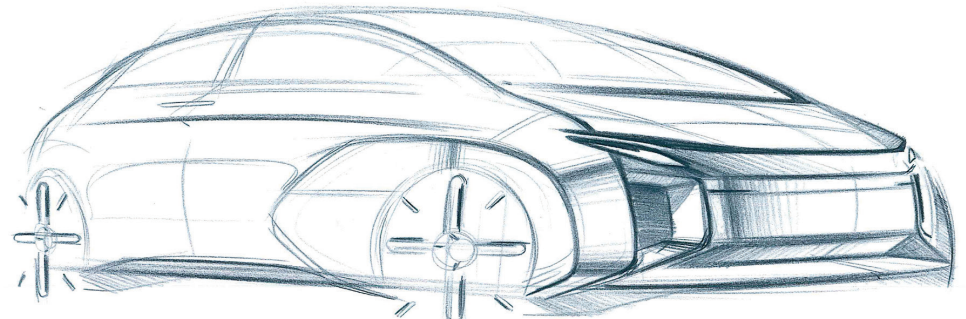
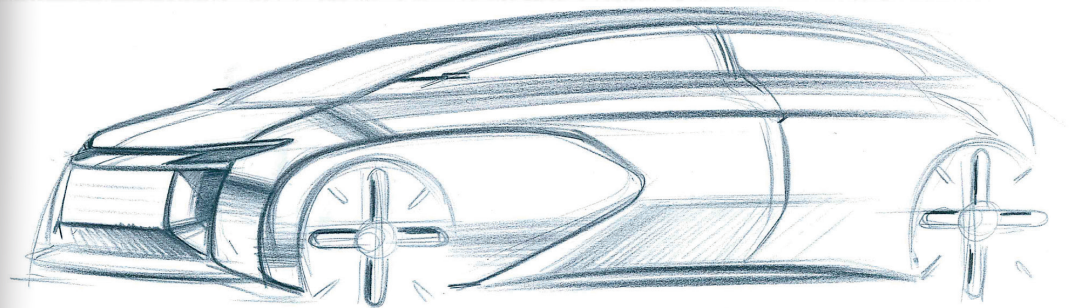
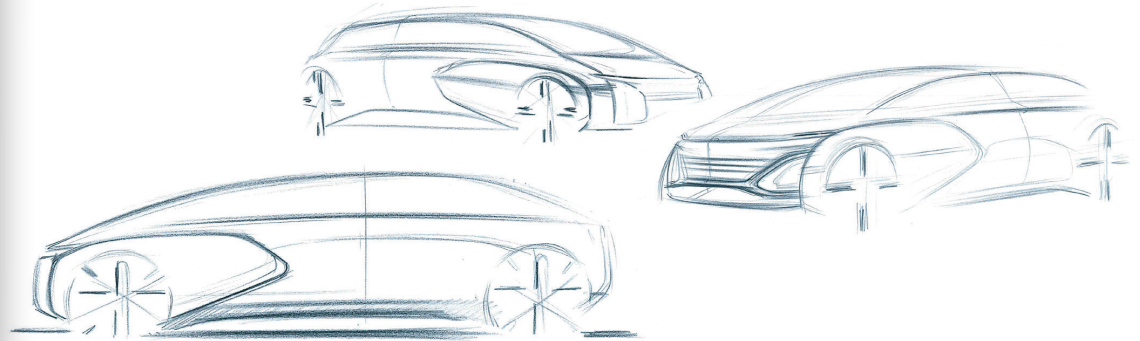
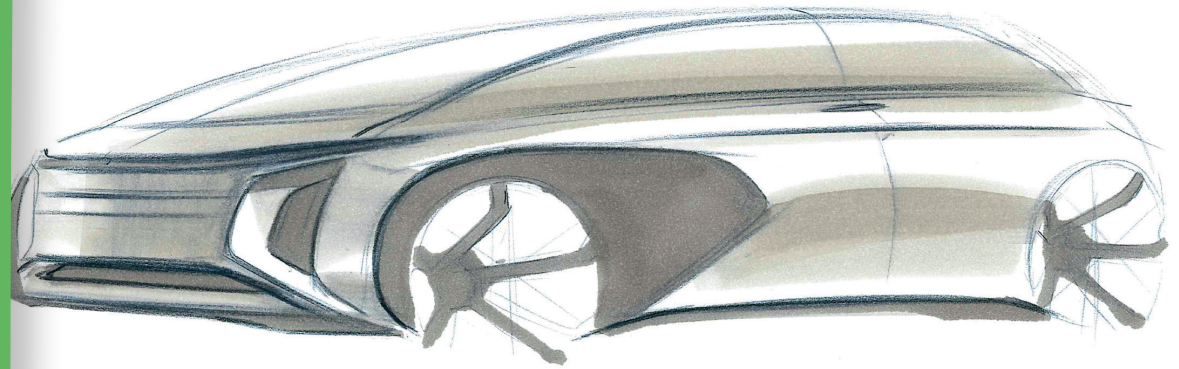
The fuel cell drive means that the IUV is locally emission-free. The development of a new, energy-efficient thermal management system also falls under the field of zero-emissions.

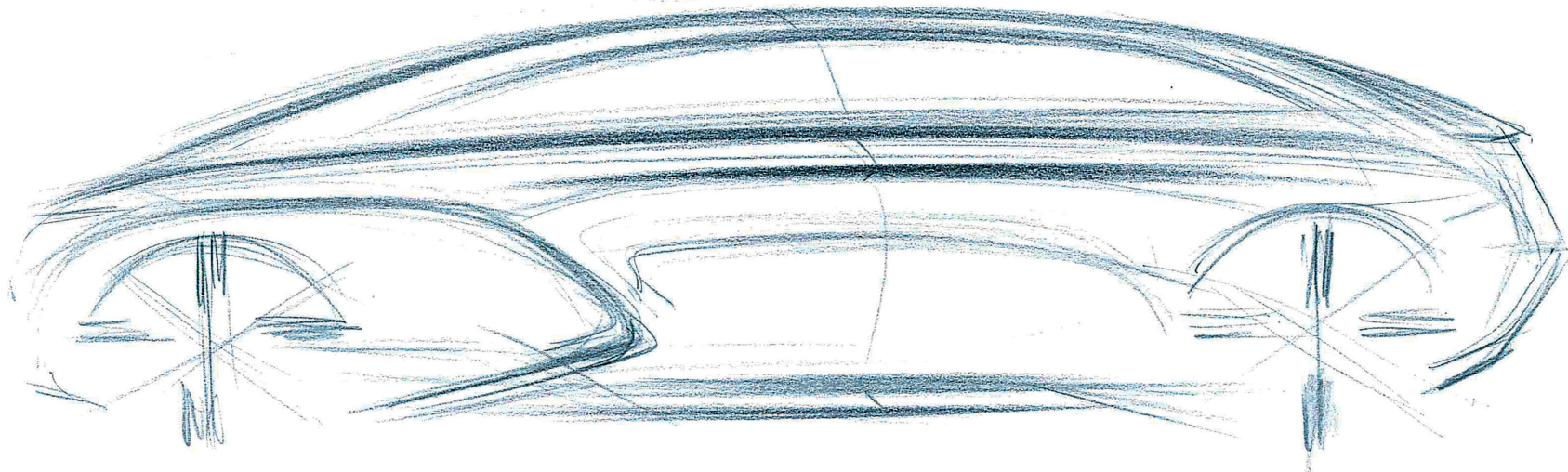
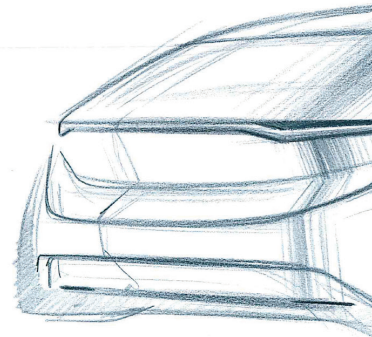
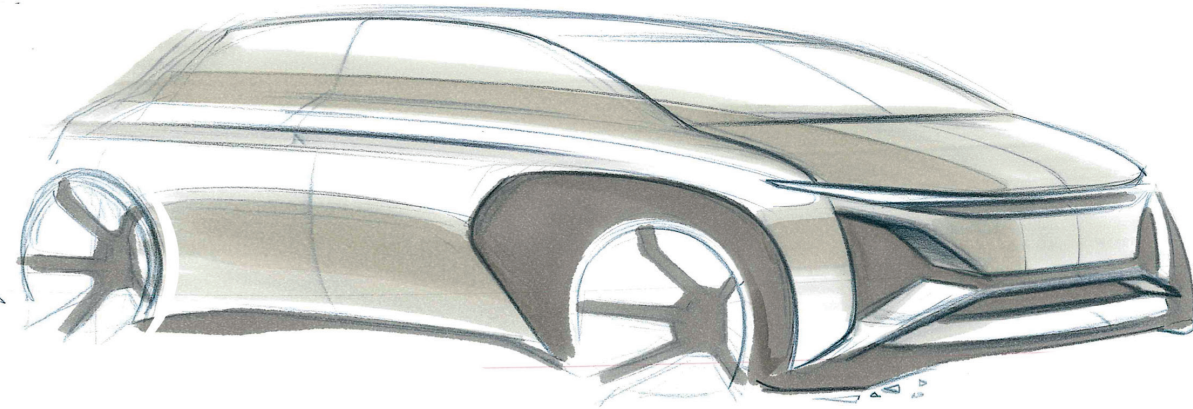
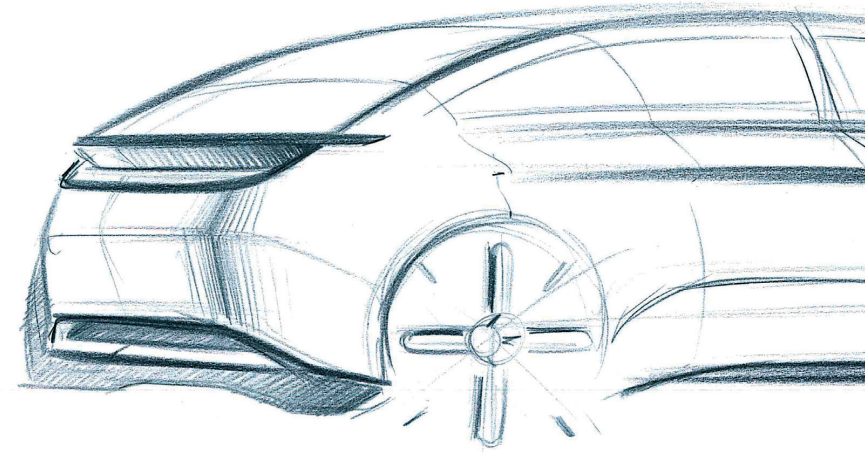
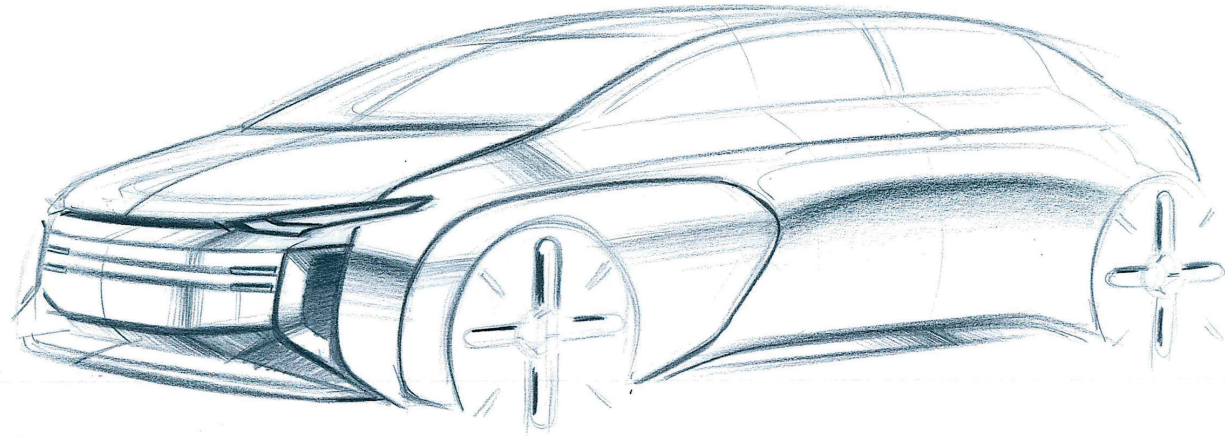


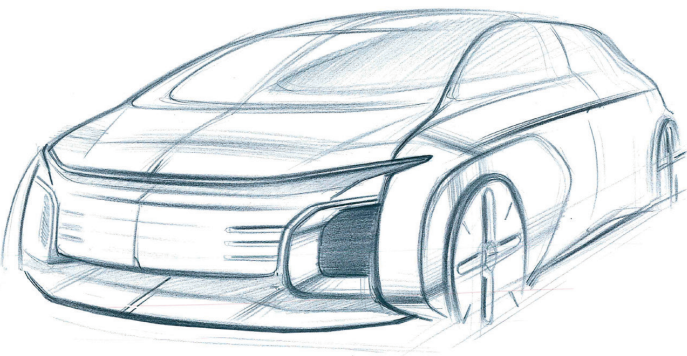
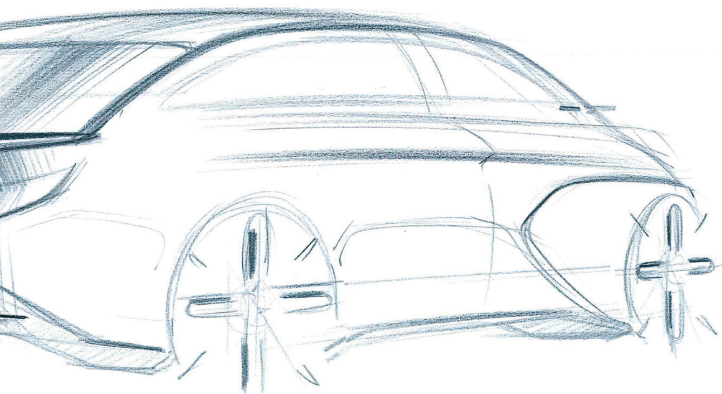
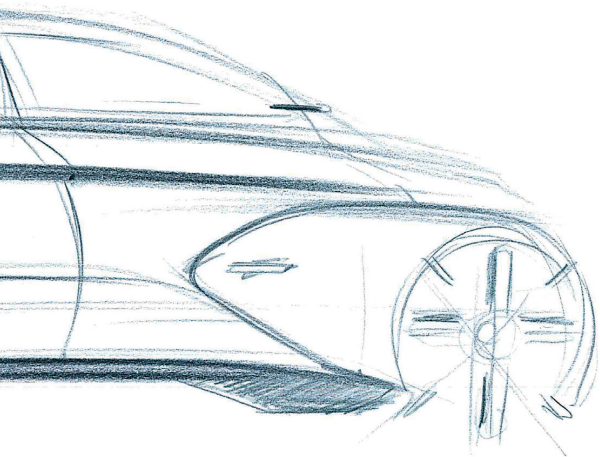


### Light and safe

Active and passive safety concepts were combined in the IUV to increase crash safety and permit a safe system approach. The function-integrated lightweight structures reduce the weight of the vehicle and contribute to efficiency.







#### Customer benefits

automated driving

emissions

safety

seats

length [mm]

range [km]

Long-distance vehicle with a

high degree of comfort

to SAE level 4

local zero, Fuel Cell

Safe System Approach

5

5000

1000

## FUEL CELL



## INTERURBAN

## LIGHT CONSTRUCTION

# Comfort on long journeys

The focus of the IUV concept is on automated travel with the aim of achieving a range of over 1000 km for long distance journeys. Automating the vehicle up to SAE Level 4 frees the driver from the task of driving during long-distance travel and he can sleep, work or engage in other activities during the journey. The aspect of interior comfort is therefore an essential element of the development. The ergonomic entry concept together with a flexible interior also played a major role. The vehicle will also be equipped with a convenient driver's cab ventilation system that can adapt to the interior setting and always create a pleasant environment for the occupants, as well as being fast and economical.



## **Entry concept**

To make entry and exit particularly easy and convenient, the IUV will be equipped with sliding doors that open against each other. Together with the absence of B-pillars this creates the largest possible door opening.

## **Air conditioning**

The air conditioning is no longer located in the dashboard as with conventional vehicles, but is integrated into the IUV's headliner enabling uniform yet individually adjustable interior ventilation.

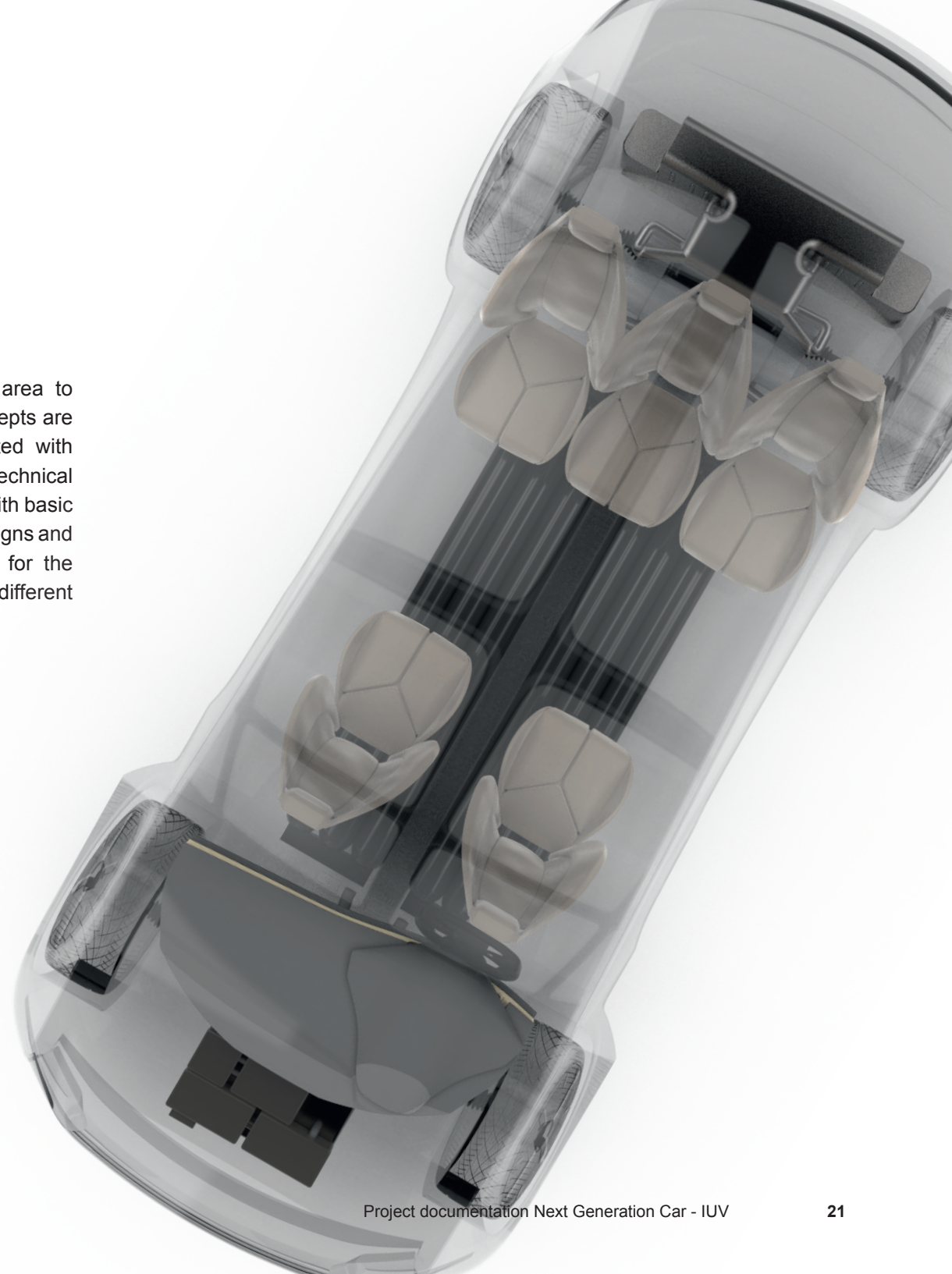
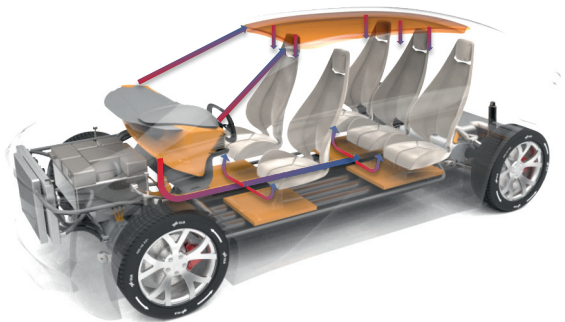
As in an aeroplane, each traveller has their own settings for their seat.

### Flexible interior

The interior of the IUV will be open and flexible to offer passengers as much space as possible and enhance comfort. To achieve this conceptual designs have been developed and evaluated with regard to their functional and technical feasibility.

The front seats can be rotated and arranged against the direction of travel. This eliminates the effect of separation that comes with rows of seats and creates a common communication space. The integration of the vehicle automation in the flexible interior and in the structural parts of the vehicle body

is the second IUV research area to increase comfort. Interior concepts are being developed and evaluated with regard to their functional and technical feasibility. This field is linked with basic research on body structure designs and research on suitable designs for the human-machine interface at different vehicle automation levels.



# Zero emission

## Drive train

The design of the locally emission-free powertrain plays a central role in the conceptual design of the IUV. With extended-range vehicle concepts such as the „Interurban Vehicle“ in particular there are numerous degrees of freedom and systemic interactions that require an iterative design of the drive train in the overall vehicle context. These dependencies are investigated early in the concept phase using parametric vehicle models and a design point enhanced for the required concept sizes and requirements is identified. The IUV combines efficient battery technology to achieve battery electric driven vehicle ranges of more than 200 km with long-distance ranges of up to 1000 km as a plug-in hybrid using a fuel cell system combined with 700 bar hydrogen pressure tanks. Modular motor assemblies and innovative individual technologies are

being designed in the field of electric drive systems. There is a particular focus on external and hybrid-excited motor concepts, brushless rotor feeds and wear-free service brakes. New holistic motor concepts and assemblies are being developed as part of a modular motor system. The aim of this development push is to generate a wide range of drives adapted to the respective application for different vehicle concepts. The key aspect of work here is the modelling of the electromagnetic components, the control, the use of additional functions as well as the constructional integration into the existing installation space of the motor. Demonstrators are also being prototypically constructed and measured on test benches.

On the search for the locally emission-free driving of the future DLR is also investigating bridge technologies

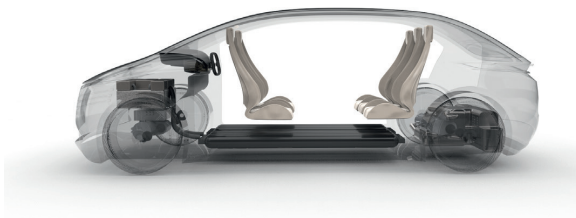
for reducing pollutant emissions in conventional or hybrid drive trains. Primary energy converters such as combustion engines can continue to be used in the hybrid drive train to facilitate long ranges. Efficiencies above 35% are rare because much of the energy contained in the fuel is dissipated in the form of waste heat. The use of thermoelectric generators (TEG) makes it possible to convert this thermal energy loss into electrical energy. Using advanced technologies in the manufacture of thermoelectric conversion materials, the construction of the individual components and the operation of the generator, future TEGs will be able to offer maximum economy and consequently maximum efficiency. The close cooperation of several institutes enables the competences to be bundled specifically toward the vision of the highly efficient thermoelectric generator.

### **Thermal management**

The increasing number of electric vehicles has changed the requirements for efficient heat and energy management. The aim is to reduce the load caused by auxiliary consumers and achieve zero emissions. The fuel cell offers new possibilities for thermal management. The focus is on creating a driver's cab without ICE waste heat recovery or conventional refrigerant circuits with climate-damaging refrigerants.

The challenge is to guarantee unrestricted comfort. Thermal management also plays an important role, as the capacity of electrochemical energy storage devices depends largely on the ambient temperatures in which they are used. A significant reduction in the vehicle's range at very warm or very cold ambient temperatures is one of the greatest weaknesses of electric vehicles (EV).

Activities in this area for the NGC concept are based on the analysis and description of the vehicle-specific energy demand. This includes improving the modelling principles of the core components and the methodical processes for identifying, designing and integrating new concepts for vehicle thermal management. The reduction of energy requirements for heating, air-conditioning and cooling by using existing heat and material flows is also part of the research. The result is the development of a new holistic principle for heating and air-conditioning the vehicle cab and for the safe and efficient cooling of the drive components.



# Light & safe

A key aspect in limiting energy consumption and extending the range of electric vehicles is reducing the weight of vehicle structures.

The research field Vehicle Architecture and Lightweight Concepts develop new vehicle structures and construction methods using fibre composites with the help of suitable development and simulation methods. The exciting challenges here are the design of

load path compatible constructions optimised for various crash scenarios. This will enable the construction of safe vehicles with minimum weight in the future. Conclusions drawn from calculation and simulation are validated through the prototypical realization and testing of selected structural components. This enables sustainable recommendations to be made for such construction methods.

A multi-material body structure with a high proportion of fibre-reinforced plastics (FRP) is being developed for the IUV. High-performance materials with high weight-specific mechanical properties are used to increase bending and torsional stiffness and, together with metallic construction methods, to ensure the safety of occupants and energy storage devices, especially in crash scenarios.

Crash concepts are created for the

various load cases with regard to intrusion zones, safety areas and energy absorption areas based on the demands placed on the entire vehicle with regard to crash requirements. For these zones, suitable principles of action for the desired failure behaviour, such as CFRP crushing for high specific energy absorption, are investigated for the particular structural behaviour required.

To achieve an unladen vehicle mass of less than 1600 kg including energy storage, the target mass of the body-in-white for the IUV is 250 kg, more than 25% lower than the state of the art in the automotive segment.



This weight saving will be achieved through the use of various lightweight construction strategies. Besides the lightweight construction strategies applied to the materials, the focus will also be on the integration of functions. Fibre composite construction opens up numerous possibilities for the integration of additional functions in load-bearing structural components, whereby non-load-bearing masses can be shifted to load-bearing masses and secondary lightweight construction potentials can be achieved.

One example of this is the integration of electrical functions into the body structure. Here, the metallic conductor runs can contribute to the load transfer in the vehicle structure and at the same time provide an electrical contact for the power consumers. The integration of further functions (sensory, thermal, mechanical), creates intelligent structural modules

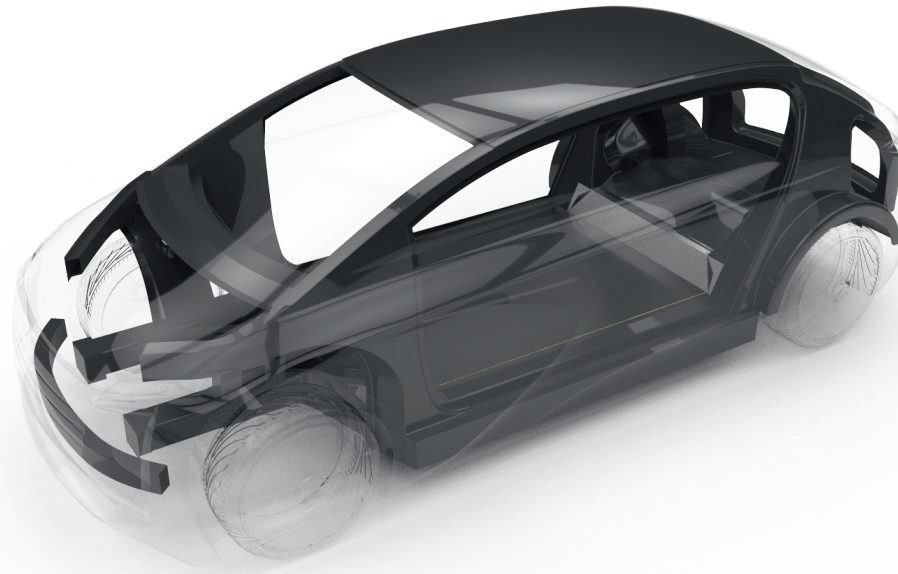
that can be functional at an early stage of assembly.

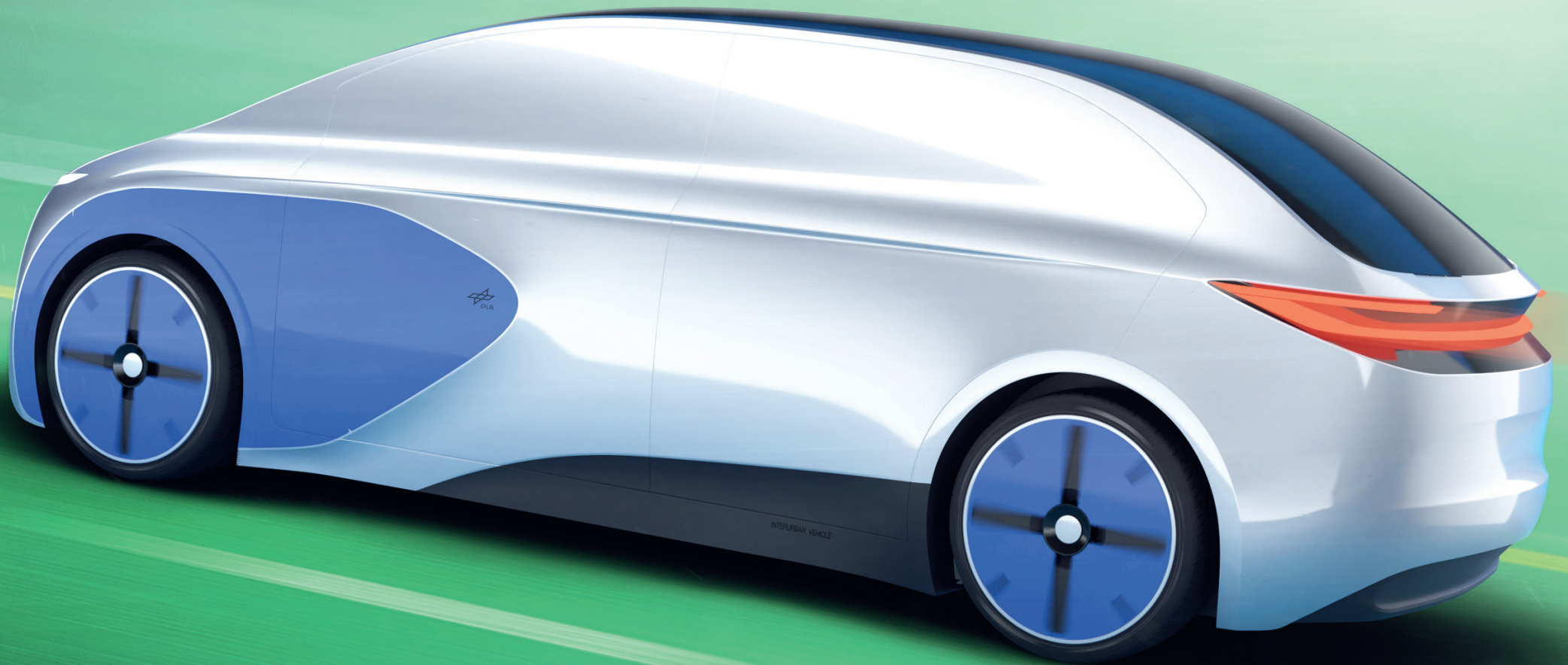
Joining technology is also a key research topic, especially in modern multi-material design, as suitable solutions are required for joining different components made of different materials. With a focus on mechanical joining technologies, adhesive hybrid joining technologies and individually tailored methods the complexity of joining components made of different materials is considered in the concept

phase. New joining technologies and inserts are also developed. The resulting concepts will be validated by subjecting multi-material design joints to crash simulations and the technologies will be implemented in the three NGC vehicle concepts.

### **Highly automated driving**

In the research field of automation and networking of road vehicles for urban traffic situations, the focus is on sensor technology and sensor data fusion, with a focus on vehicle-based sensor technology. There are also research projects in the field of Car-to-X communication for infrastructure-based recording and for testing automated and networked vehicle systems.





# Contact

IUV concept

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[verkehrsforschung.dlr.de/de/projekte/ngc-iuv](http://verkehrsforschung.dlr.de/de/projekte/ngc-iuv)

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P.5, Fig.1: Charging plug i3 [Photo 2017, Robert Hahn]; P.6, Fig.1: Infrastructure [<https://unsplash.com/photos/k5w21D7PgMk?searchKeyword=autonomous+driving>]; P.6, Fig. 2: Vehicle Sensors Environment [<https://www.transportextra.com/publications/local-transport-today/news/55406/smart-mobility-living-lab-london-will-be-operational-in-2019/>]; P.6, Fig. 3: Smartphone Hand Options [<https://unsplash.com/photos/q8U1YgBaRQk>]; P.6, Fig. 4: Connected car [<http://joebarkai.com/connected-car-challenge/>]; P.9, Fig.1: NGC vehicle family [Rendering 2018, Robert Hahn]; P.9, Fig. 2: SLRV Vehicle structures [[http://www.dlr.de/fk/desktopdefault.aspx/tabid-6194/13132\\_read-42103/](http://www.dlr.de/fk/desktopdefault.aspx/tabid-6194/13132_read-42103/)]; P.9, Fig.3: Institute building [<http://www.dlr.de/fk/desktopdefault.aspx/tabid-2827/>]; Figures not listed [DLR; Dipl. Ing. Sebastian Vohrer, Robert Hahn]