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UNICAR*agil* news

1. Issue | September 2019

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Disruptive Modular Architecture for Agile Autonomous Vehicle Concepts

Automated driving polarises! Let yourself be inspired by current topics around the project UNICARagil.
The first newsletter introduces the project UNICARagil **|page 2|** and gives a review of our past consortial meeting **|page 3|**. We also report on the upcoming mid-term event **|page 4|**.

In our „modularity" section, you will learn more about our overall concept **|page 5|**, the geometric structure **|page 7|**, the dynamic modules **|page 8|** and the sensor modules **|page 9|**. Here, we also present our four different vehicle manifestations **|page 10|**.

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1. Issue
09/2019

Newsletter

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Dear readers,

Automated driving will be an essential component of the future mobility in many ways. Therefore, this topic is of utmost interest for research as well as for the industry and our society. Automated driving is one of four megatrends which include connected driving, shared mobility in the form of diverse driving services and powertrain electrification. The UNICARagil project, a cooperation between seven universities and innovative companies, addresses many open research questions in this area. In the UNICARagil project funded by the German Federal Ministry of Education and Research, we are defining a modular architecture to create multiple agile driverless vehicles, which we would like to expand on in this newsletter.

We hope you enjoy this edition of our newsletter.

Yours sincerely,

Lutz Eckstein

UNICARagil

From 1978 to 1982, the Federal Ministry of Research and Technology (BMFT) supported the project „uni car - Demonstration of automotive research results in integrated overall concepts of passenger car test models“, in which a consortium of four German universities developed four ready-to-run prototypes. Many of the innovations presented can be found in production vehicles nowadays. 40 years later, the scientific association Uni-DAS e. V. initiated the UNICARagil project. In this BMBF-funded project, leading German universities in the field of automated driving have joined forces with other university departments and selected partners from industry, to redefine automated vehicles and their architecture.

The project consortium with over 100 scientific employees will develop disruptive, modular architectures from hardware and software components for automated and driverless vehicle concepts within the framework of the four-year project. These form the basis for the implementation and prototyping of four different applications, from private automated family vehicles to fully automated delivery vehicles.

After a successful project launch in February 2018, the concept phase has now been completed. In numerous workshops and consortial meetings, concepts were interdisciplinary developed to analyse complex issues from different perspectives and thus identify new approaches to solutions. The combination of competences from various project partners in their respective fields of expertise significantly contributed to creative solutions. After the concept phase, the realization of hardware and software modules and thus the prototyping of

Thomas Rachel, Parliamentary State Secretary of the BMBF, announced the official start of the project on March 8, 2018:
„The demand for electric vehicles suitable for everyday use is high, whether as taxis or delivery vehicles. With our research, we want to ensure that efficient, reliable and emission-free vehicles are developed. With UNICAR*agil*, we are launching a flagship project that is unique in Germany.“

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the resulting concepts begins. Over the course of 2019, the first vehicle modules will be set up and completed. A first ready-to-run platform prototype is expected in the first half of 2020.

This first project newsletter focusses on the topic modularity. It presents UNICARagil's overall concept and some selected modules. You get exciting insights into the project work of various partners.

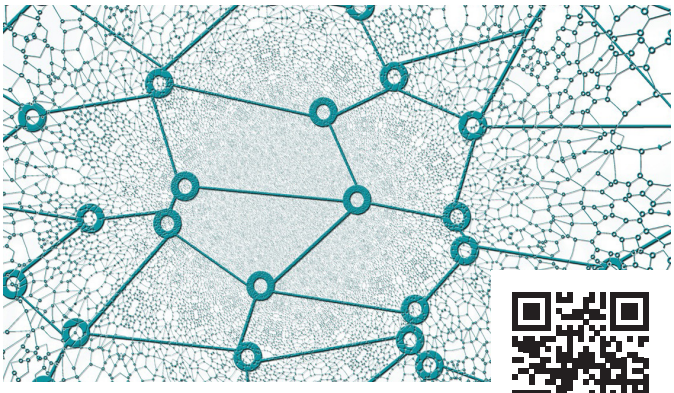
Make sure to follow us on Twitter, Facebook, LinkedIn, Xing, Research Gate, Instagram and YouTube to receive project updates and the possibility to connect with us. At www.unicaragil.de we provide project updates, freely accessible publications and current topics on automated driving.

Consortial Meeting at Castle Reisensburg

At the last consortial meeting, the project consortium met for three days at the science centre „Schloss Reisensburg" of the University of Ulm and discussed current project challenges.

Different workshops focused on topics from different areas of the project. Those workshops manly focussed on necessary decisions regarding „Geometry", i. e. the physical structure of the vehicle. Thus, the consortial meeting has successfully set the course for the further progression of the project.

New Internet Presence



The project UNICARagil got a new corporate design. The logo as well as the social media pages and our website have been redesigned. In addition to short presentations of the project partners and a lot of project information, publications were posted as well as news. We look forward to your likes and follows on our social media channels as well as a visit to our new website, which will be online in September 2019. Just scan the QR-Code!

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Half Time Event

Monday March 23, and Tuesday March 24, 2020

The UNICARagil project, funded by the Federal Ministry of Education and Research, will reach half of its planned duration in spring 2020. Eight German universities are working together with six industrial partners to develop a disruptive and modular architecture for agile automated vehicle concepts to re-think the future of our mobility. The unique characteristics of UNICARagil make it a German flagship project on automated driving. After the successful launch in February 2018, more than 100 researchers finished an intensive and exciting concept phase. In numerous workshops and consortial meetings, concepts and solutions were interdisciplinary developed to solve the complex questions from different perspectives.

By reaching the 24th of 48 project months of our unique cooperation project UNICARagil we are thrilled to present some of the project's, initial results and corresponding concepts.

We cordially invite you to our halftime event, which will take place at

the Technical University of Munich
from Monday March 23, to Tuesday March 24, 2020.

On Monday, March 23, 2020, you have the opportunity to take part in a workshop in which interested journalists can inform themselves about current developments and trends in the field of automated driving. On the following Tuesday, March 24, 2020, interested visitors, press, politics, business and universities can be part of this event. Feel free to join us!

We will inform about current project developments and present the first implemented components of the planned prototypes. Participants will also have the opportunity to get to know scientists from leading German universities and innovative companies in the field of automated driving to discuss current developments with them.

Best regards

We look forward to your participation. If you are interested, please contact our project office at *pr@unicaragil.de*

Prof. Dr. Lutz Eckstein
Overall Coordinator

Timo Woopen, M.Sc.
Project Manager

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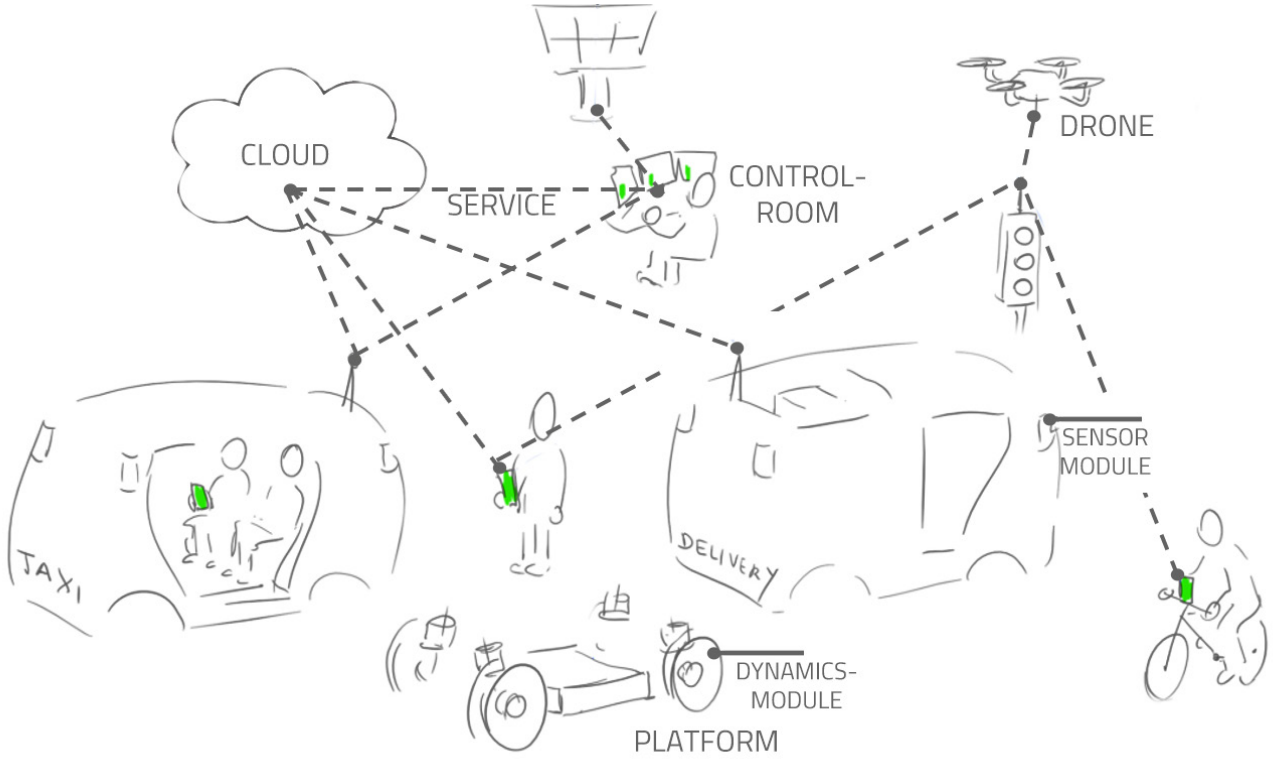
Overall Concept



Overall Concept Sketch

Automated driving will shape the future of mobility. It offers an enormous potential, but also comes with new challenges. Therefore, many projects deal with a wide variety of topics, from the development of specialized control units to individual software functions. UNICARagil focuses on the overall concept of automated vehicles. One of the goals is to develop a modular architecture that can be used as a basis for a variety of automated vehicle concepts.

UNICARagil presents a disruptive modular approach for architectures of automated and driverless vehicles. This approach offers the potential to significantly shape the future of automated vehicle development. However, not only parts of an automated vehicle, such as environmental perception, are considered. UNICARagil focusses at the entire system of automated driving. In addition to automation, the focus is on the development of innovative **hardware concepts**, **modularization**, **software architecture**, **mechatronic architecture**, and topics such as **functional safety**, **IT security**, and **safety assurance** of automated driving.

The overall concept sketch shows a schematic project overview. Core element of the realized vehicles is a scalable platform, which is presented in detail later. Together with the dynamics modules it forms the so-called „rolling chassis", which is introduced in this newsletter, too. The dynamics modules enable steering angles up to 90° on all four wheels and form physically and functionally independent modules, which are also controlled independently. With the 48 V wheel hub drive on all wheels, the vehicle can safely be maintained and is nevertheless powerful enough for its intended use in an urban environment. In the project, two platforms with a short wheelbase and two platforms with a longer wheelbase will be set up. Together with the associated add-on modules, these can be equipped for a wide variety of applications. A total of four fully automated and driverless vehicles in two different sizes and four different versions will be assembled. The vehicles interior design is deliberately designed with driverless operation in mind and does not make any compromises regarding to a driver's workplace.

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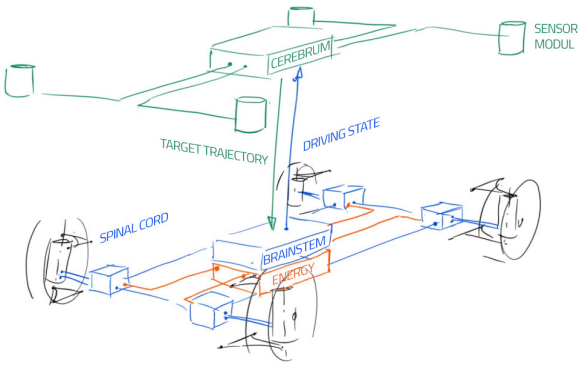
Automated operation requires a highly accurate perception of the environment, which is achieved by a large number of different sensors and processing units. Since modularisation has high priority, UNICARagil develops four sensor modules, which will be presented later in detail.

All four vehicles will be able to drive autonomously without the need of external systems. Nevertheless, networking and cloud solutions are important for future applications and are therefore considered in the UNICARagil project, as well. Data is exchanged between vehicles and the cloud in order to provide additional information. An environment representation is created by cloud solutions and can be further enriched with intelligent infrastructure sensors. This is realized by automated drones, which represent flying sensor clusters that provide additional information.

Another element of the overall concept is the control room. In addition to a service centre to which passengers can communicate in emergencies, the control room also includes fleet monitoring. It can be used to influence the vehicle in exceptional circumstances, after it come to a safe stop. This can even include tele-operaton of the vehicle by a human operator in the control room.



E/E-architecture sketch

To implement the described functions, new functional and electrical/electronic architectures are required. The predominant architectures in the automotive industry make it possible to upgrade or update software components only with considerable additional effort and with renewed validation and verification of the entire system. For future automated vehicles, it is necessary to be able to update the latest components without this full revalidation and -verification. Therefore, UNICARagil presents a new E/E architecture whose terminology is based on the human nervous system. The figure on the left illustrates it in a sketched form.

In the uppermost layer, the „sensory organs", the vehicles sensor modules, perceive the environmental data. The environmental representation takes place in the cerebrum, which calculates trajectories and forwards them to the underlying layer. In the brainstem, the entire vehicle-specific control tasks and safety-critical functions such as „safe stopping", which transfers the vehicle into a minimum-risk state at all times, are performed. The spinal cord finally controls the actuators of the dynamic modules. In addition, the spinal cord can react reflexively to failures of the higher layers.

Based on the mechatronic architecture, abstract functions are required to perform the automated driving task which are represented in the functional architecture. We will present this architecture in detail in one of our future newsletters.

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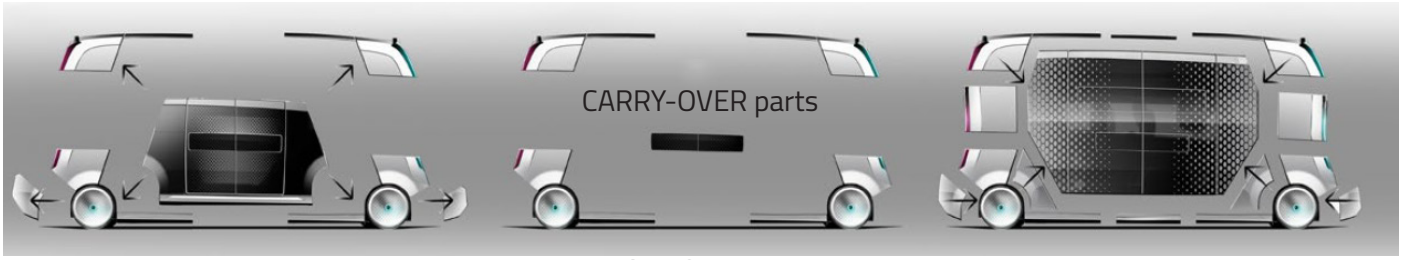
Modularity in Platform and Structure



Carry-Over Parts

The UNICARagil concept is characterized by its cross-project modularity. This also impacts the concepts of the mechanical architecture of the vehicles. In summary, these consist of the so-called modular platform and the add-on modules. The division of the overall vehicle structure into these components makes it possible to implement a wide variety of vehicle concepts based on a small number of elements constructed with identical parts. The four concepts introduced in this newsletter only represent a small part of the number of possible application scenarios.

The platform itself is the basis of the vehicles and is complemented by dynamic modules, which ensure the vehicles movement. It also houses the majority of the necessary components starting from the IT-infrastructure, such as the various computers and control units, but also the components of the thermal wiring system and, of course, the batteries. The platform is scalable in length. This way UNICARagil is able to develop vehicle concepts with different wheelbases. Together with add-on modules, the platform forms the actual vehicle. The add-on modules characterize the vehicle's design. Thereby, it is possible to design longer and at the same time higher vehicles that can carry more loads or people.

The aim of the development in this area is to be able to use as many carry-over parts as possible. This means that the parts used in the smaller variant of the add-on modules are also used in the larger variant and supplemented by additional parts. This approach, which is usual in today's series production processes, can minimize duplication of work.

In total, two larger and two smaller derivatives of the UNICARagil family are built up in this way. Due to the modular approach and the use of carry over parts, a family affiliation is clearly recognizable. In the future, this approach facilitated to realize other vehicles for many different use cases. It is conceivable to increase the number of dynamic modules in order to further expand the maximum payload and thus the number of passengers. Simpler vehicle concepts with standardized axles in the rear and two dynamic modules at the front are also conceivable.

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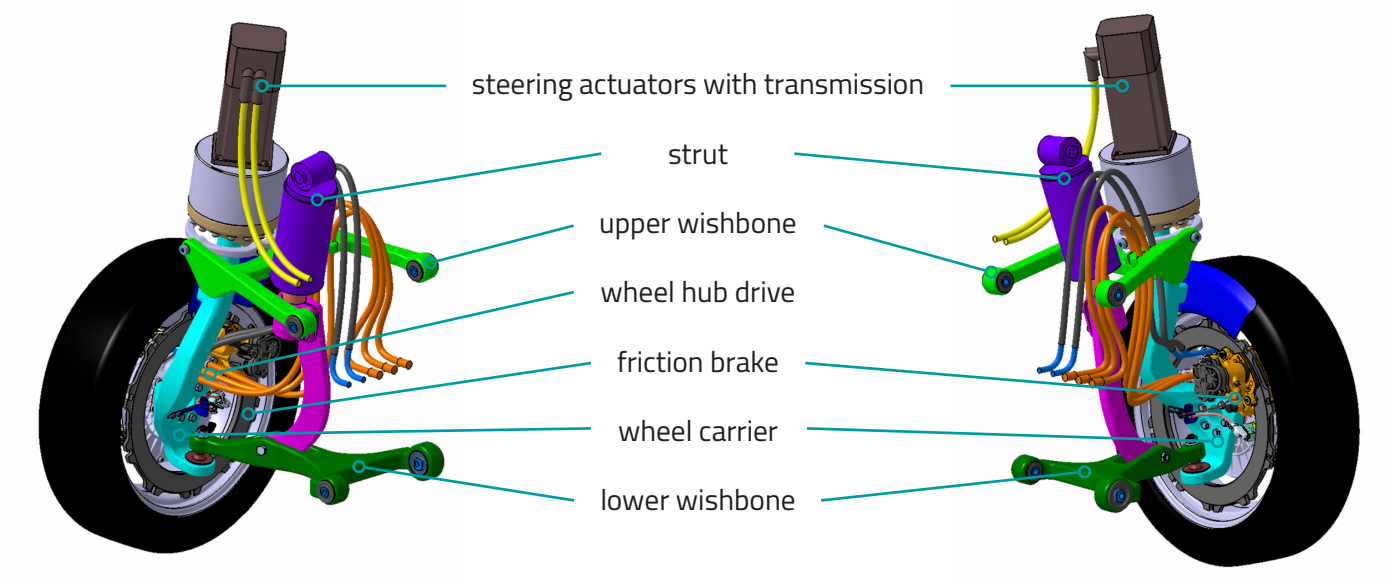
Dynamic modules



Dynamics Modules

The dynamics modules form the most important component for the actual movement of the vehicles. Four almost identical dynamic modules are mounted on each platform of an UNICARagil vehicle. These modules realize the trajectories given by the different computing units. They provide the direct contact to the road surface and are responsible for the tasks of steering, accelerating and braking. Each dynamic module is individually controllable and can set steering angles up to 90°. This enables completely new forms of movement in road traffic.

One dynamic module consists of actuators for the vehicles movement and the associated control units. Wheels and suspension, an integrated wheel hub motor, friction brakes and a steering controller together form the mechanical part of the module. Both electric motors have their own power electronics, each of which is mounted on the vehicle platform. In addition, each dynamic module has its own control unit, which is connected with the control units of other dynamic modules to form the „spinal cord". All associated control algorithms run on this control unit. These spinal cord control units are completely new and thus meet all requirements for automated driving. Automotive technologies such as BroadR-Reach-Ethernet are used to ensure fast and secure data transmission.

The spinal cord represents the lowest layer in the mechatronic architecture. During normal operation, it receives its inputs from the brain stem, checks whether they are within the range of current capabilities, and controls the various actuators. In addition, the spinal cord constantly provides information about its own capabilities for other vehicle services. In the event of a brain stem failure, the spinal cord is able to receive the signals directly from the cerebrum and control the vehicle through its own motion strategy to follow a trajectory request. During the commissioning process, a human driver who operates a sidestick may control the vehicle. The driver's input interfaces are directly connected to the spinal cord so that the vehicle can also be operated without the brain stem and cerebrum.

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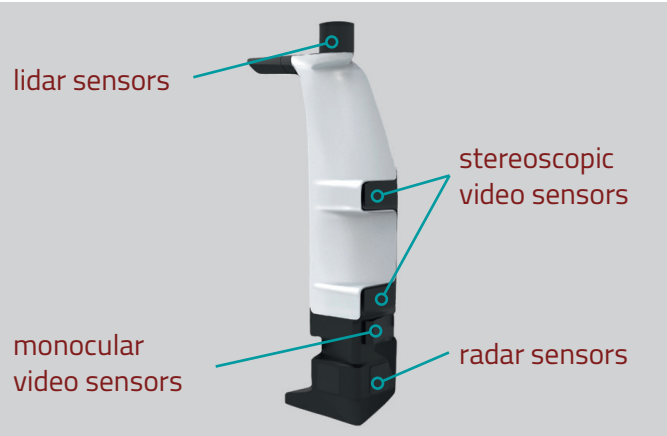
Newsletter
www.unicaragil.de
1. Issue
09/2019

Sensor Modules

UNICARagil aims at a service-oriented, strictly modular architectural concept in hardware and software for the realization of fully automated, driverless vehicles for urban environments. All vehicle versions have four identically equipped sensor modules, which are installed at the corners of the vehicles. These represent an independent module both mechatronically and functionally.

Each of the sensor modules comprises radar sensor technology, lidar sensor technology, monocular and stereoscopic video sensor technology as well as an associated computing unit for sensor data processing. The sensor system is designed in a way that each module covers the horizontal field of view of 270° around the respective vehicle corner with each of the different sensor principles. The computing unit processes the data of all sensors belonging to the module and calculates a module-specific environment model. This model consists of a list of all dynamic objects located in the vehicle's environment with information on the object type, the geometric extent and position as well as the object's current dynamic state of motion. In addition, there is information about the open space that can be navigated as well as a complementary representation of the environment as a grid. The latter divides the vehicle environment into square cells, for each of which the probability is determined whether the cell is occupied by an object or not. Due to the redundancy in the visible areas, the



Sensor modules

sensor module-specific environment model calculation can be carried out reliably even in the event of failure or weather-related degradation of one of the three sensor principles. With the help of the cameras, a video-based self-localization of the vehicle relative to a highly accurate map is also carried out.

The environment models of the four sensor modules are then communicated to the cerebrum, which then fuses the models into a consistent overall environment model. The objects are referenced in addition to the highly accurate digital map of the vehicle environment. Automated motion planning of the vehicle then takes place based on the interpretation of this environment. The overlapping visual ranges of the individual sensor modules provide additional redundancy in the perception.

Automated Vehicles Symposium 2019 | Orlando, USA

This year's Automated Vehicles Symposium (AVS) took place in Florida, USA from July 15th to 19th, 2019. Every year international scientists, representatives of the automotive industry as well as government agengy meet here to present and discuss the latest topics around automated driving. Our project manager Timo Woopen successfully presented the UNICARagil project and received positive feedback from international visitors.

Timo Woopen | AVS, Orlando

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Vehicle Concepts

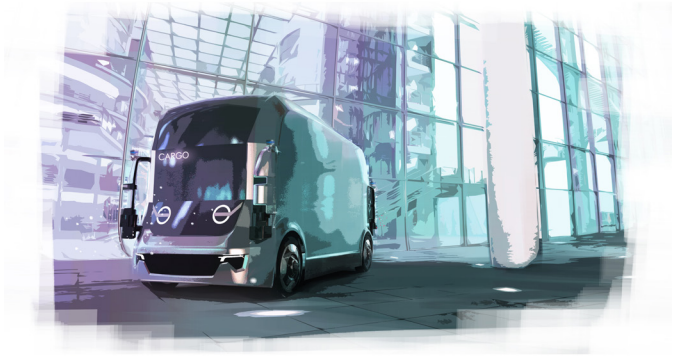
autoSHUTTLE

The autoSHUTTLE offers space for up to eight people and is part of a new and improved public transport system. Optimally adapted to the needs of users at all times, it represents the public transport of the future.

An intelligent routing system is intended to shorten travel times in public transport. The routes of the individual vehicles are planned in a fixed stop network so that passengers' desired starting-points and destinations are approached sensibly and efficiently at the same time. By moving away from fixed timetables and route networks, the shortest and fastest route for the current passengers is selected.

The interior of the vehicles will also adapt to futureconditions. Although six passengers can be comfortably seated, the interior can be transformed to enable other scenarios of use when the number of passengers is higher. Up to three seats maybe stowed in order to be able to use the freed-up space in rush hour as standing room and to increase the capacity of the vehicle to eight people. This space can be used to carry bulky luggage, bicycles or wheelchairs, as well.

The Human Machine Interface (HMI) is being developed with the aim of optimising trust in and handling of automated vehicles. The absence of a human driver is compensated by intuitive interaction and predictable behaviour.



autoCARGO

The autoCARGO illustrates our automated pick-up and delivery vehicle. With its efficient storage system, it takes your shipment to the next level.

Receiving and sending parcels is handled by the autoCARGO regardless of the presence of its customers.

AutoCARGO drives and delivers autonomously and electrically, is locally emission-free and designed for urban environments. Private and public parcel boxes can be approached and operated fully automatically. The desired parcel box can be defined individually for each consignment in the associated app in an easy way. Connected with other vehicles and information systems, it can flexibly react to traffic disruptions. The batteries are automatically inductively charged in the parcel centre.

Like the other vehicles autoSHUTTLE, autoTAXI and autoELF, the autoCARGO has a modular design. autoCARGO differs from autoSHUTTLE in its interior. Instead of the variable interior for up to eight people, it is equipped with handling technology for parcels and a storage room. A special articulated robotic arm is used to safely load and unload the parcels. Parcels are stacked in the exchangeable loading container and can be loaded and unloaded at the parcel centre in a short time.

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Vehicle Concepts

autoTAXI

The autoTAXI is agile and can adapt exactly to the needs of its customer. The various motto taxis offer the right interior concept for every reason to travel.

Studies on autonomous vehicles show that the users of these vehicles wish to be able to engage in various tasks while driving. This statement can be fully applied to autonomous taxis. In addition, taxis will represent a much greater proportion of people's mobility, for example, as they can be called anywhere very easily using apps.

Simple agile ordering of the required taxi enables a fleet of "motto taxis", which are perfectly equipped for the needs during the upcoming trip. Numerous interior concepts from "sleep taxis" to "party taxis" to "tourist taxis" are conceivable.

The autoTAXI, which will be realized within the project, can be considered as „working taxi". It will be adapted to the needs of business people. Deskwork of a single person as well as meetings should be possible through the corresponding interior topology and supporting interior Human Machine Interfaces (iHMI). Thus, autoTAXI shows only one of many variants and stimulates the fantasy to imagine further possible motto taxis of an entire fleet. These will be adapted in their entirety to our needs of tomorrow's mobility.

autoELF

The autoELF represents a completely individual and private family vehicle. With its accessible and inclusive design, all family members can fully enjoy their journeys.

Like the autoTAXI, the autoELF is a smaller vehicle version and is developed to provide as many members of a family as possible with individual mobility and to meet their individual needs while driving. Those needs of individual family members can be very different.

Those who are dependent on the support of a companion who is able to drive a conventional vehicle have particularly high demands. Possible applications are, for example, driving grandparents to a doctor's appointment or driving children to a sports club. In the future, physically handicapped people will also be able to be mobile without barriers and there will be no need for an accompanying person. In this way, autoELF helps its users to achieve new autonomy in everyday life.

The concept of the autonomous family vehicle is completed by an elegant exterior design and a homely interior that is adapted to the diverse needs of its users. Here, individuality is at the forefront.

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1. Issue
09/2019

Newsletter
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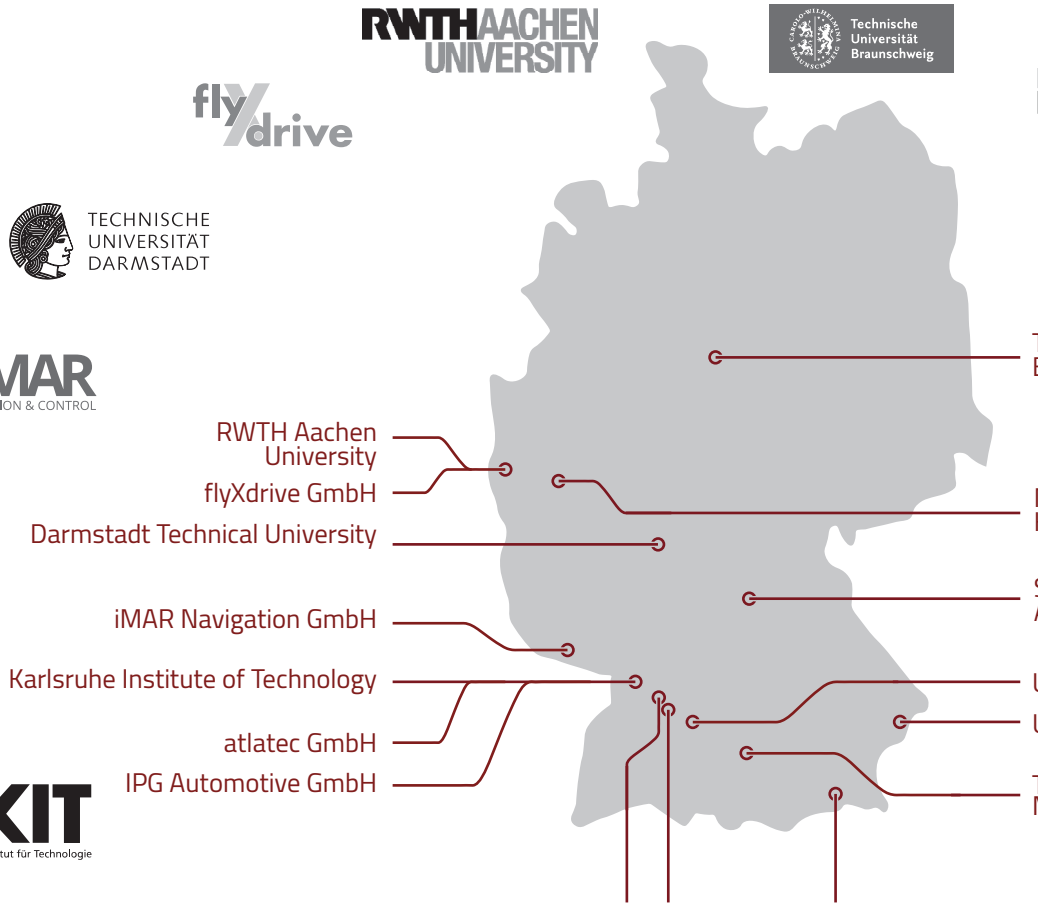
The Project Consortium



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