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IAA
Transportation Special

autoCARGO

unicaragil

autoCARGO

a logistics system for urban areas

The courier, express and parcel services (CEP) sector has been growing steadily for years. As the latest study by the German Federal Association Parcel & Express Logistics (BEIK, Federal Association Parcel & Express Logistics) shows, in Germany 15 million shipments were delivered to 9 million commercial and private recipients daily in 2021. After a yearly amont of 4.51 billion shipments in 2021, BIEK expects up to 5.7 billion shipments in 2026 - only in Germany.

Deliveries are mainly handled by conventional delivery vehicles. Particularly in urban areas with their pedestrian zones, the vehicles of the parcel service providers can become an obstacle if they occupy bike lanes or park in second row while the drivers deliver the parcels. More and more urban areas are traffic-calmed and driving is restricted to narrow time windows for noise protection reasons.

This can be solved efficiently by electrically-driven autonomous delivery vehicles that fill urban warehouses via so-called parcel boxes. If these are located at public transport stops, customers can conveniently drop off their parcels, e.g. on their way to and from work, or take them home. Of course, such parcel depots can also be available at city quarters and apartment buildings, or smaller ones can be set up on private properties on the outskirts of the city. Special concessions are also conceivable for delivery in city centers, awarded to service providers with quiet and environmentally friendly vehicles.

In the research project UNICAR*agil*, we made these the objective for the autoCARGO. This vehicle drives quietly with zero emissions and also handles the loading and unloading of parcels autonomously. This also makes delivery independent of the presence of the recipients.

In this newsletter for the IAA Transportation trade show, we would like to introduce you to one of four autonomous research vehicles from the UNICAR*agil* family in more detail: autoCARGO – the autonomous parcel delivery vehicle for future urban logistics of the last mile.

autoCARGO

part of the UNCIARagil vehicle family

autoCARGO is being developed as part of the UNICAR*agil* research project funded by the German Federal Ministry of Education and Research. The project aims at developing novel and fail-operational software and hardware architectures for automated and driverless vehicles. Four vehicles addressing different use cases are being built up. While three vehicles are used for passenger transport, autoCARGO fulfills parcel logistics.

autoCARGO and autoSHUTTLE are based on the identical large UNICAR*agil* platform. Only the installation of the storage and handling technology distinguishes the two vehicles autoCARGO and autoSHUTTLE on a hardware level. The package handling and storage systems in the autoCARGO occupy the space available to passengers in the autoSHUTTLE. Even a later conversion would be possible.

The autoCARGO use case is being developed at the Institute for Materials Handling and Logistics Systems and the Institute for Measurement and Control Technology at the Karlsruhe Institute of Technology and the Institute for Measurement, Control and Microtechnology at the University of Ulm.

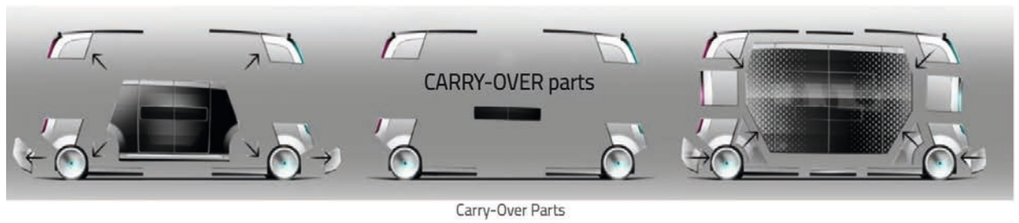
The vehicles are jointly developed and built by several partners of the UNICAR*agil* consortium - see the back cover of this newsletter for a full overview of our project partners.

autoCARGO

autoSHUTTLE

autoTAXI

autoELF



Carry-Over Parts

Hey, read me!

Do you already know our newsletter on Building Four Driverless Vehicle Prototypes?

Not yet? Scan this code:

autoCARGO

a logistics system for urban areas

Not only passenger transport but also urban logistics on the so-called „last mile“ will look different in the future than it does today. It will benefit from research and developments in the fields of autonomous driving and robotics.

autoCARGO is the automated delivery vehicle for parcel delivery and pickup. It drives and delivers autonomously and electrically, is locally emission-free and designed for urban spaces. It makes receiving and sending parcels independent of the presence of its customers. Connected with other vehicles and information systems, autoCARGO can respond flexibly to traffic disruptions. Various fleet and order management systems work in the cloud in the background for this purpose.

On its route, all parcel boxes to which shipments are to be delivered or from which they are to be picked up are targeted. Various private and public parcel boxes can accommodate individual or even very large numbers of parcels. For this purpose an underground parcel storage facility can be connected to the parcel box. In this way, urban space can be used as efficiently as possible.

The associated autoCARGO APP can be used to order the dispatch of parcels. The desired parcel box can be selected individually, easily and flexibly for each shipment (dispatch or pickup). The APP informs about parcels ready for pickup just as reliably as about the delivery to the recipient.

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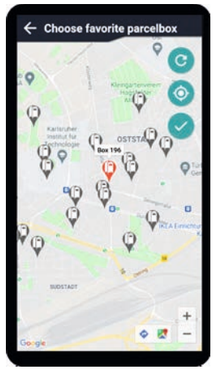
autoCARGO

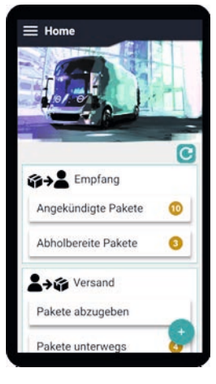
The parcels to be delivered are stacked in the loading container outside the vehicle in a transport-optimized mannewr, i.e., taking into account the acceleration forces to be expected during the journey. This is loaded into the autonomous parcel delivery vehicle at the parcel center. The batteries of the autoCARGO vehicle are also charged independently and inductively in the parcel center.

Overall, autoCARGO is more than a research vehicle that drives autonomously and picks up and elivers parcels on its own. autoCARGO is a logistics system consisting of:

- the actual vehicle with exchangeable parcel storage, the loading container,
- the parcel center,
- private and public parcel boxes for the delivery and collection of parcels by customers
- the autoCARGO APP,
- as well as the components available to the entire vehicle family (cloud, info bees, control room).

autoCARGO's storage system is geared to the current volume ratio of deliveries and collections. The B2C sector dominates, with significantly more parcels being delivered than picked up. Accordingly, the loading containeris significantly more voluminous than the rac ks in which picked-up parcels are stored. Private parcel shipping plays only a minor role overall.



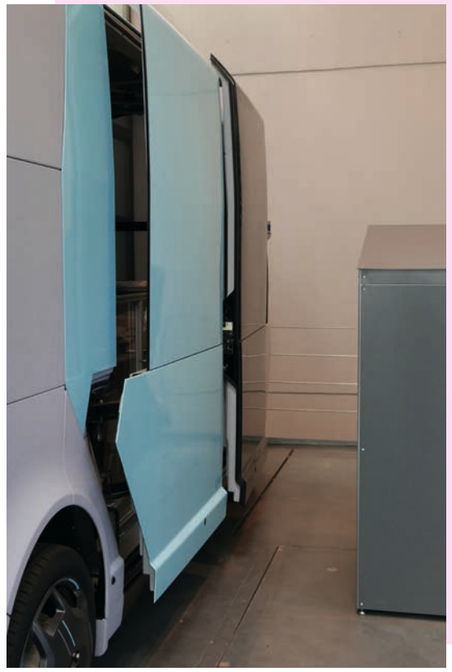


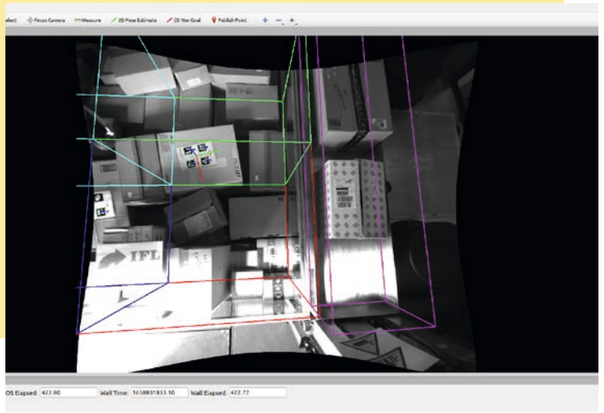
autoCARGO

process flow of the handling technology

arrive and locate

The autoCARGO receives the position of the parcel boxes to be approached from the fleet manager for the procedure. As soon as the autoCARGO has reached the position, it switches to a waiting mode and lets the handling system handle the rest of the delivery process. First, the doors are opened to determine the position of the parcel box in relation to the camera with the aid of a stereo camera. This position is required for the subsequent delivery and collection of the parcels.





localization of the parcels

After the position of the box has been determined, the position of the individual parcels inside the loading container and on the parcel shelves is determined with the help of the four cameras installed in the interior of the autoCARGO. This makes it possible to identify the parcel intended for the box. The optimum suction position for the vacuum gripper can then be determined for the corresponding parcel based on the information about the dimensions of the parcel.

grab and deliver

The determined grip pose is then approached with the help of the path planning. Shortly before contact with the parcel, the vacuum pump is activated to suck in the parcel. The ability to measure the vacuum makes it possible to determine whether the parcel has been successfully sucked. In addition, it can be checked during the entire delivery process whether the parcel continues to be sucked. As soon as the parcel has been successfully sucked, the position of the parcel box determined at the beginning is approached.

opening and closing the parcel box

Meanwhile, the parcel box flap is opened to deposit the parcel. Through data management via the cloud and the respective connection of the parcel boxes and the autoGARGO to the cloud, the process of opening and closing can be controlled via it. After the robot has placed the parcel on the parcel box, it can be closed. In addition, the customer receives a notification in the app that the parcel is ready for pickup.

drive preparation

After the delivery process, the robot moves back to the parking position and the doors of the autoCARGO can close again. The next station can then be approached. The whole process is also carried out for the collection of parcels from the parcel box, where the collected parcels are stored on the side shelves next to the loading container. For the identification and measurement of the parcels on the shelf of the parcel box, another stereo camera is provided in the end effector, which enables this process.

1 BELT DRIVEN BOOM

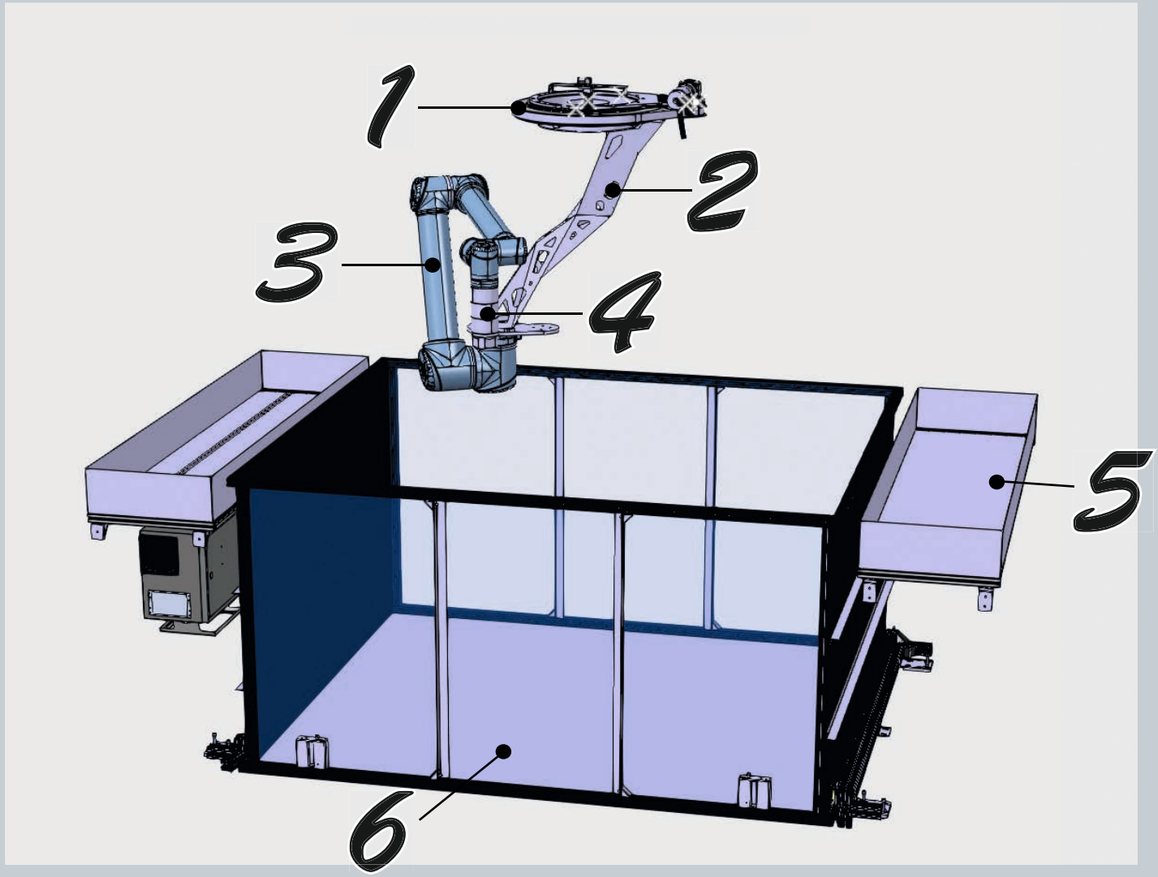
2 BOOM

3 ROBOT ARM

4 VACCUM GRIPPER

5 SHELVES

6 LOADING CONTAINER



autoCARGO

developments for autonomous parcel handling

The requirements for a system that can deliver parcels autonomously and as error-free as possible are enormous. After all, in the event of an error, no one can help on site for a moment. Therefore, high demands are placed on the reliability of the handling technology. But the parcels also have to meet certain basic conditions in order to be processed autonomously. The handling technology of the research vehicle autoCARGO works with a vacuum suction cup and can process packages weighing up to 6 kg.

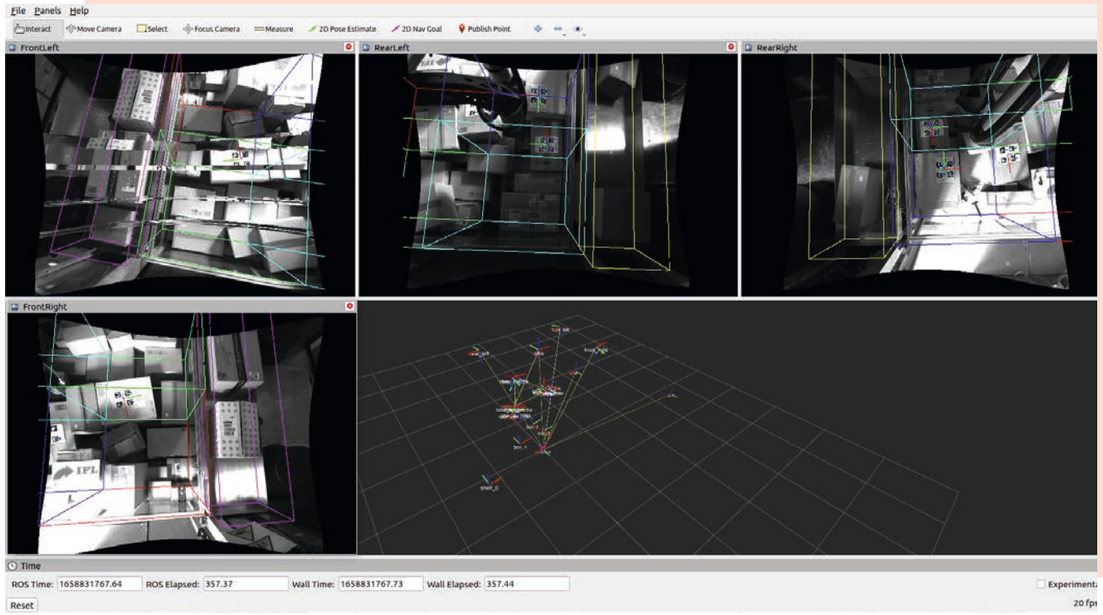
Notable mechanical in-house developments of the handling technology are, apart from the end effector with integrated 3D-RGB camera, the necessary extension of the robot with 6 degrees of freedom (6-DOF) to 7 degrees of freedom and the shape and weight optimized suspension, which holds the robot arm and withstood the simulated crash. In addition, the storage system and the noise-insulated vacuum pump station, for example, are also new developments of the logistics system.

In order to be able to develop and test the hardware and the associated software extensively, safely and before the vehicles are available, a 1:1 model of the interior was set up as the CARGOlab laboratory.

autoCARGO

the vision

Inside, the loading container with the parcels is measured by several monochrome cameras. By doning so, the position and location of the individual parcels is calculated and the parcels are identified. For the localization of the individual parcels, they are provided with ArUco markers in order to be able to calculate the position and orientation of the marker and accordingly of the parcel. To be able to determine the optimal gripping point based on this, the position of the markers on the parcel must in turn be known. For this purpose, there is an initialization process in which the dimensions of the parcel and the position of the markers as well as the height are determined with the help of a depth imaging camera. The area between the vehicle and the parcel box is also monitored by a depth imaging camera in order to prevent third-party interference or to be able to react accordingly. In addition, this camera is used to determine the pose of the parcel box in relation to the autoCARGO.



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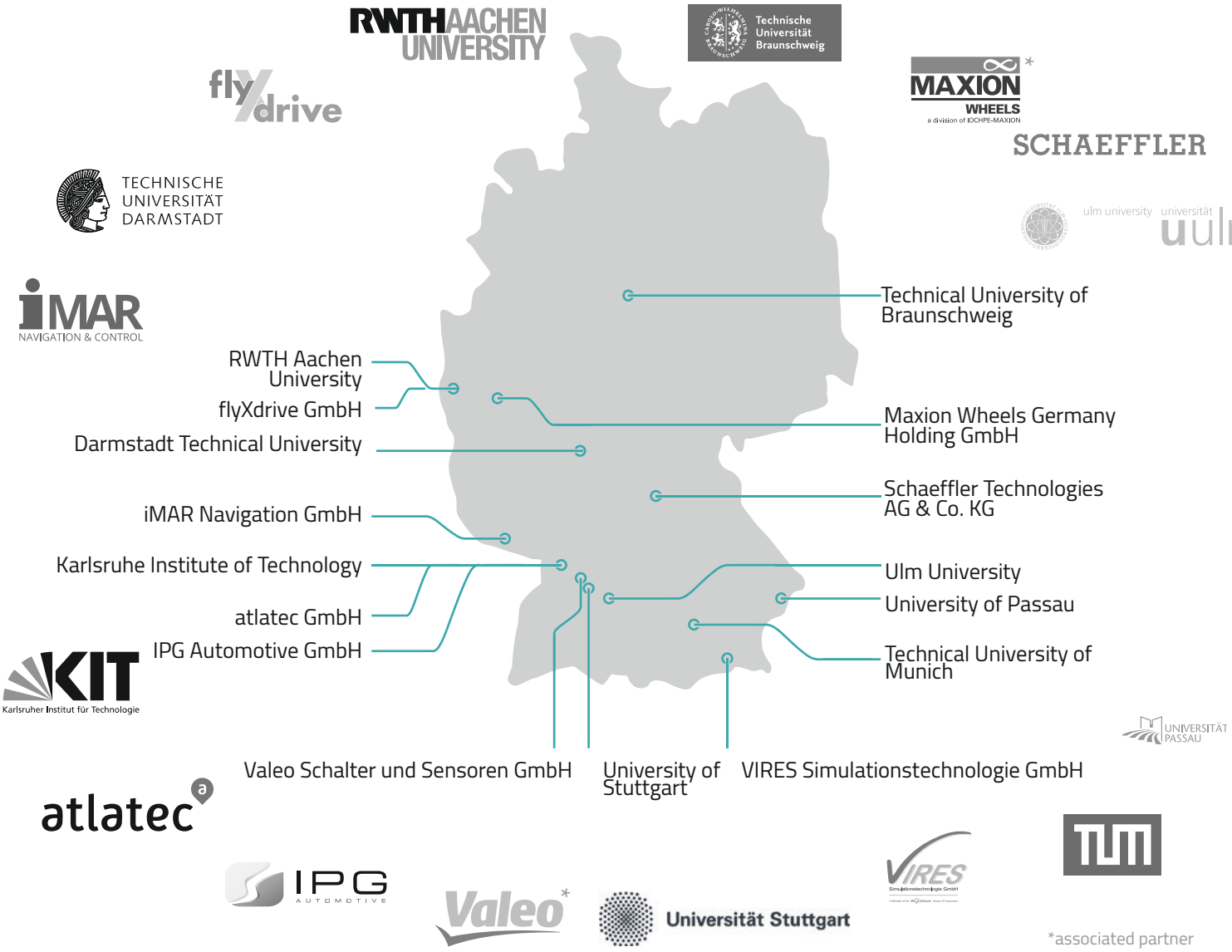
autoCARGO

CARGOlab development laboratory

The vehicles and the parcel handling technology are completely new developments. This requires a high degree of parallel research, development and design processes. In order to be able to build, test and optimize the handling technology hardware and software under the most realistic conditions possible at an early stage, a 1:1 model of the interior of the autoCARGO was built: the CARGOlab. Work on the lab is significantly easier, more flexible and safer than on and in the finished vehicle. Especially in the hardware area it makes sense to test the components. Despite a careful 3D design, manufacturing tolerances or unforeseen assembly restrictions can lead to problems or functional limitations, which can be detected and solved at an early stage byusing the Lab. In addition, prior testing improves the mechanisms and usability of the developed assemblies. Furthermore, the software can be tested not only simulatively but also under laboratory conditions. Environmental factors that cannot be taken into account in the simulation and influence the functionality can be taken into account and intercepted in the CARGOlab.

The Project Consortium



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