

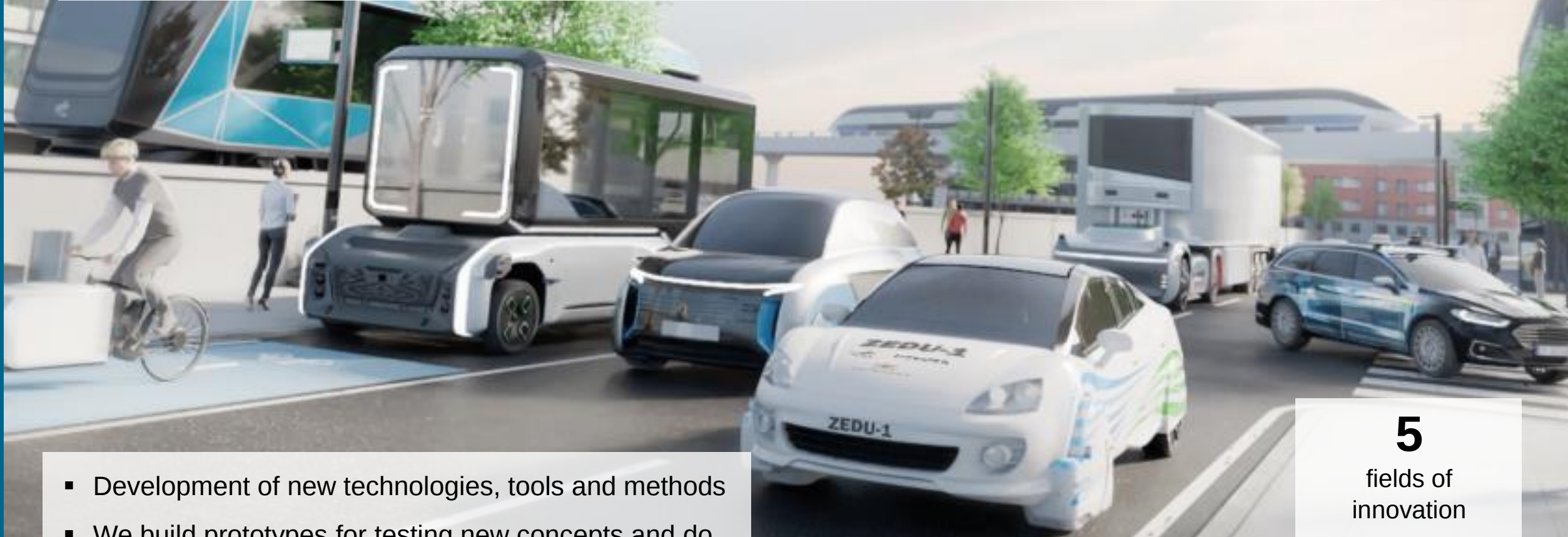


AUTOMATED MODULAR VEHICLES FOR THE LAST MILE

- 
- A photograph of two astronauts in white space suits standing on a lunar surface. They are holding hands and waving. The suits have 'LUNA' written on the chest. The background is a dark, rocky lunar landscape.
1. DLR & Institute of Vehicle Concepts
 2. Research in modularity
 - PODS4RAIL
 - NGC Urban Modular Vehicle
 3. The U-Shift vehicle concept
 4. U-Shift project landscape
 5. Outlook

DLR – German Aerospace Center

Institute of Vehicle Concepts



- Development of new technologies, tools and methods
- We build prototypes for testing new concepts and do technology transfer together with our partners
- DLR is not an OEM, we develop vehicle architectures and lightweight concepts

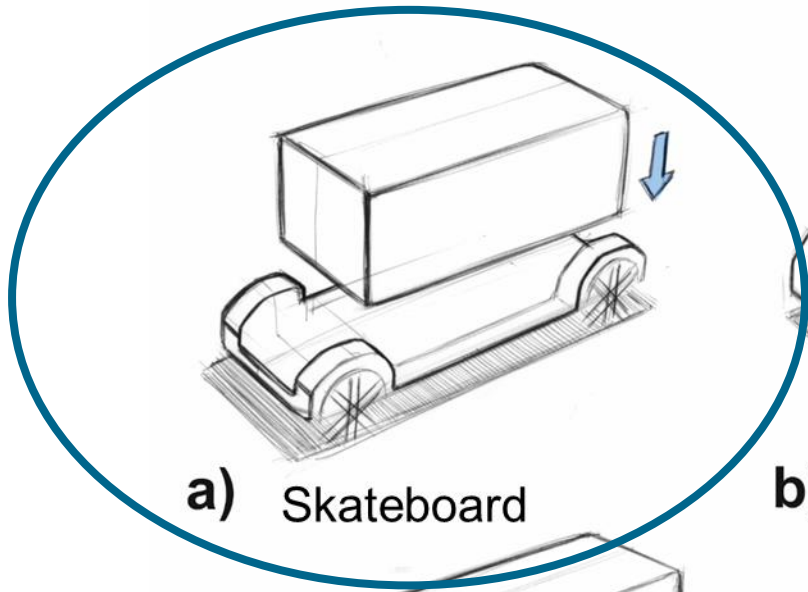
5
fields of
innovation

125
multidisciplinary
researchers

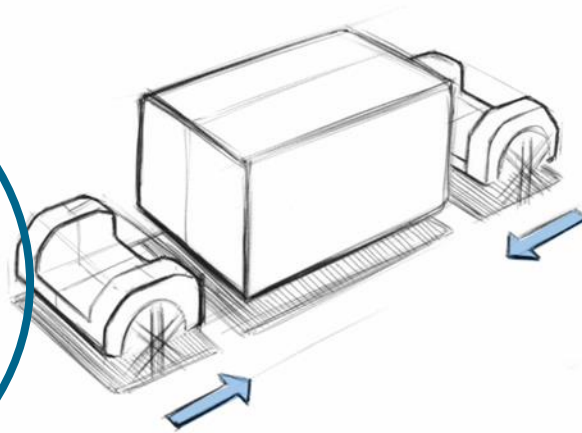
40%
third-party
funding

20 Mio.€
Annual budget

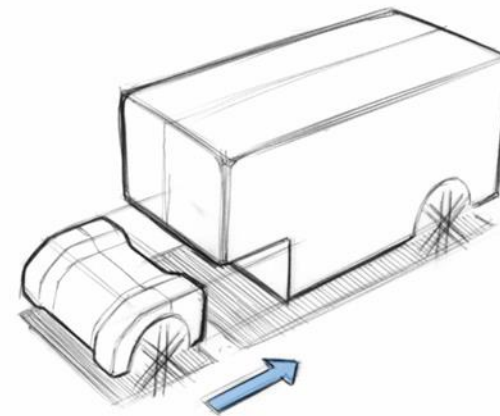
DLR Research in modular vehicle concepts



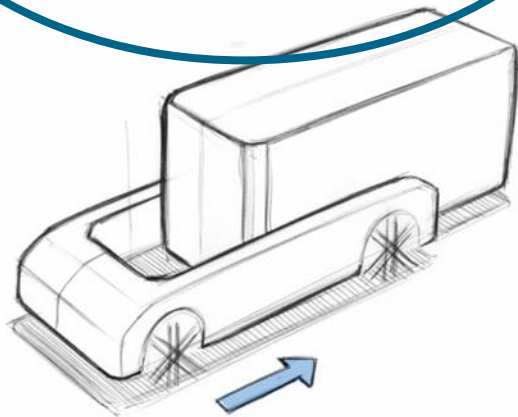
a) Skateboard



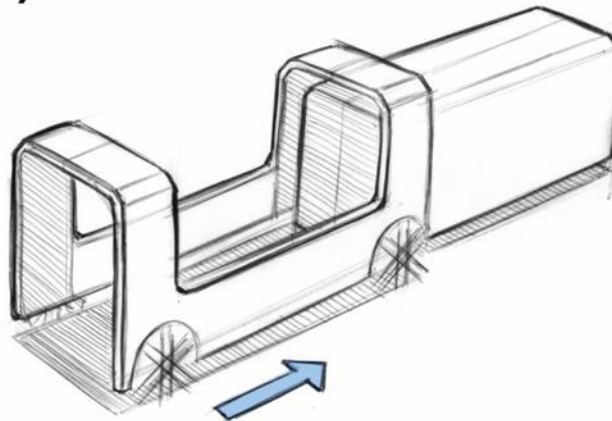
b) Individual autonomous axles



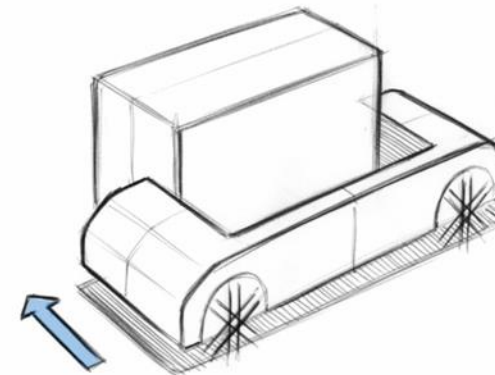
c) Trailer autonomous driveaxle



d) U-Shift / forklift



e) Crane with capsule



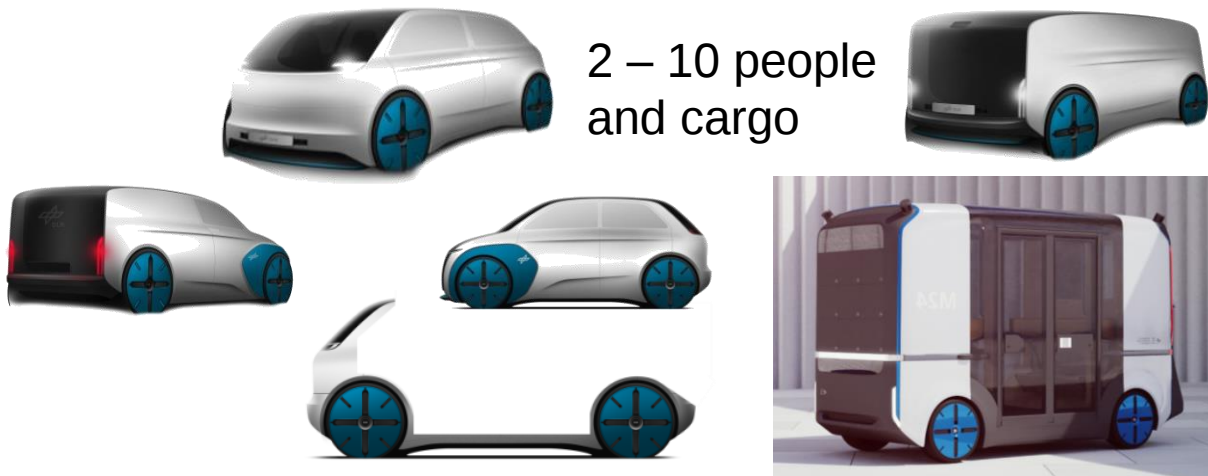
f) C-shape driveboard and capsule

DLR Research in modular vehicle concepts

NGC Urban Modular Vehicle & Pods4Rail



Urban Modular Vehicle UMV



Pods4Rail

Intermodal transport units for safe and seamless transport



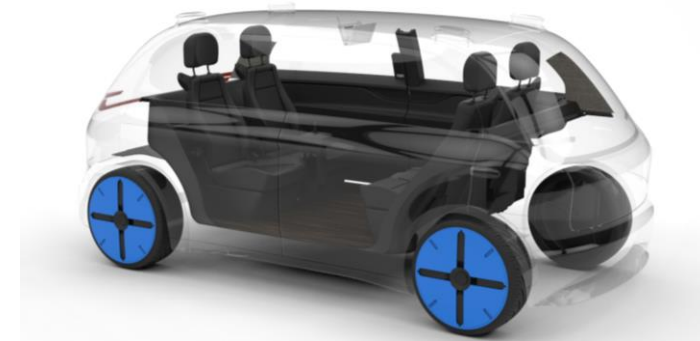
Source: <https://moodle.com/work/siemens-one4all>. Last visit: 12.09.2024

DLR Research in modular vehicle concepts

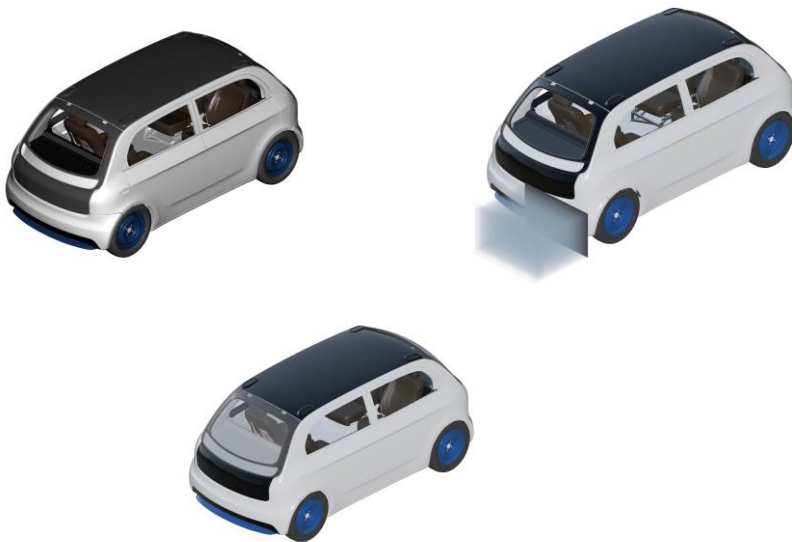
NGC Urban Modular Vehicle & Pods4Rail



- Addressing new safety challenges
 - Additional seating configurations
 - Greater variety of occupants
 - Shuttle to pass M1 safety certification



Urban Modular Vehicle UMV People Mover 2+2



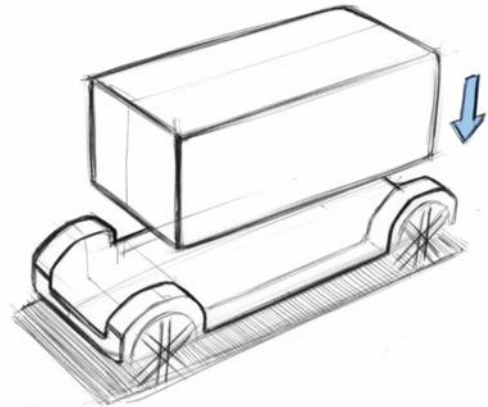
Effects of occupant physical disability on restraint system performance

UMV PM Digital Twin for Integrated safety research

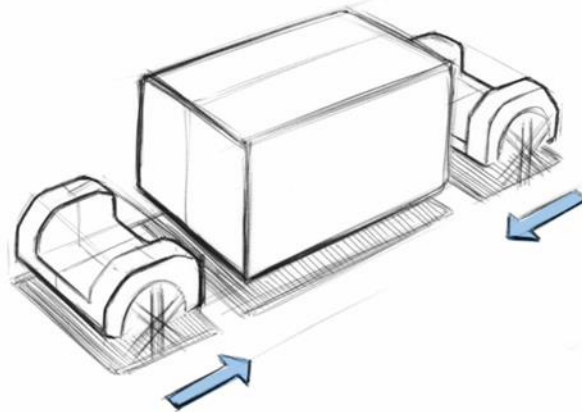


Funded by
the European Union

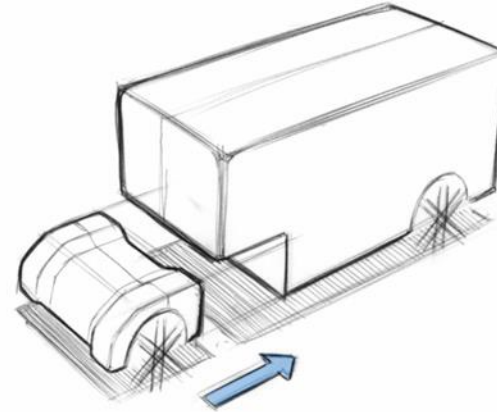
DLR Research in modular vehicle concepts



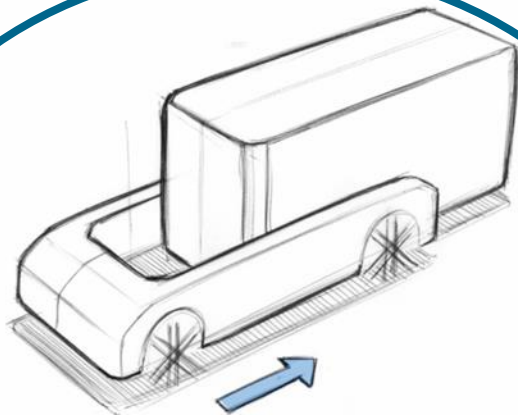
a) Skateboard



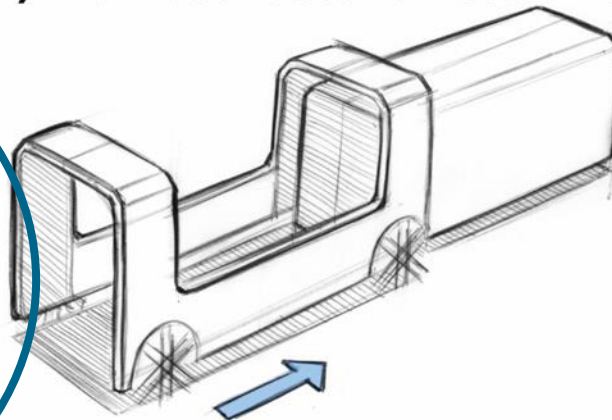
b) Individual autonomous axles



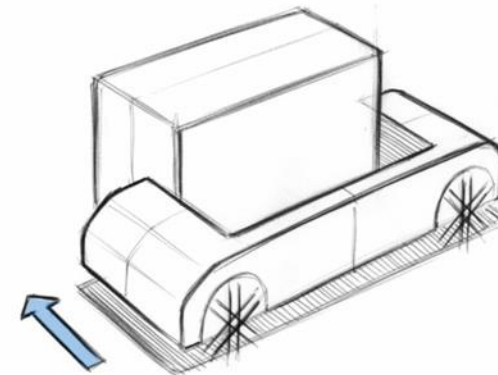
c) Trailer autonomous driveaxle



d) U-Shift / forklift



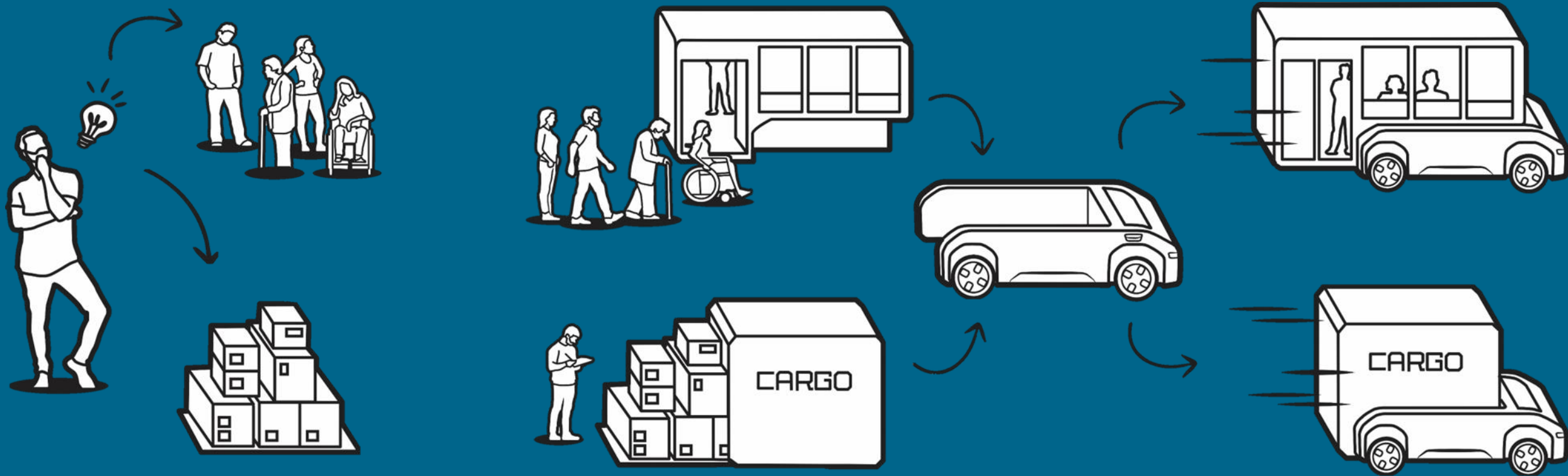
e) Crane with capsule



f) C-shape driveboard and capsule

DLR Research in modular vehicle concepts

U-Shift



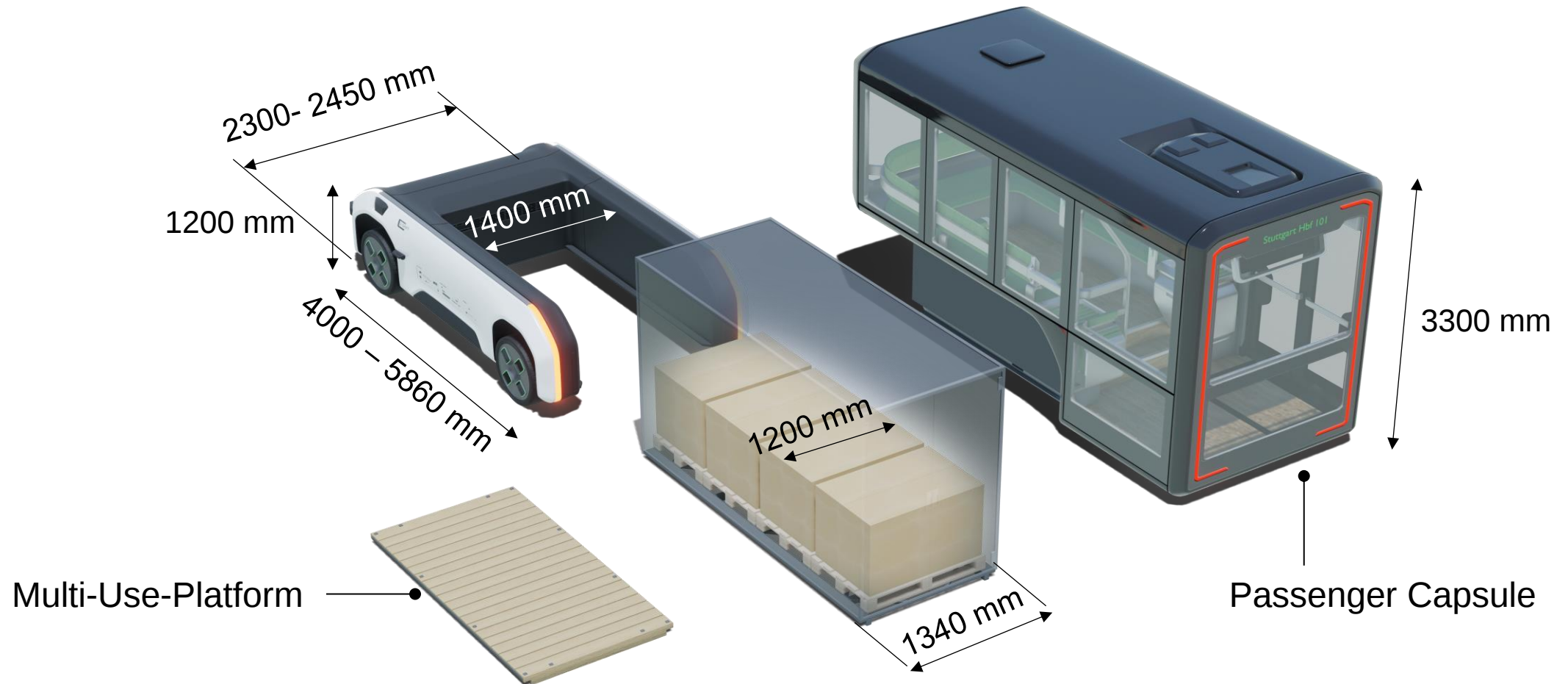
U-Shift Vehicle – Video



Source: <https://www.youtube.com/@DLRde>

U-Shift vehicle dimensions today

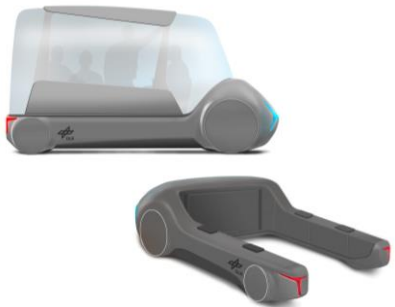
- Optimised for standardised load carriers EPAL euro paletts or grid trolleys



U-Shift – From THE LÄND to the world



**U-Shift
Concept**



**U-Shift I
Mock-up**



**U-Shift IV
First On Semi Public Road**



**U-Shift V / IMoGer
First On Road**



11/2017

09/2020

06/2022

04/2023

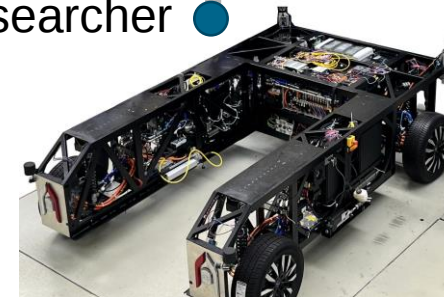
09/2025

07/2027

**U-Shift III
Remote Worker**



**U-Shift II
Researcher**



U-Shift I Mock-up

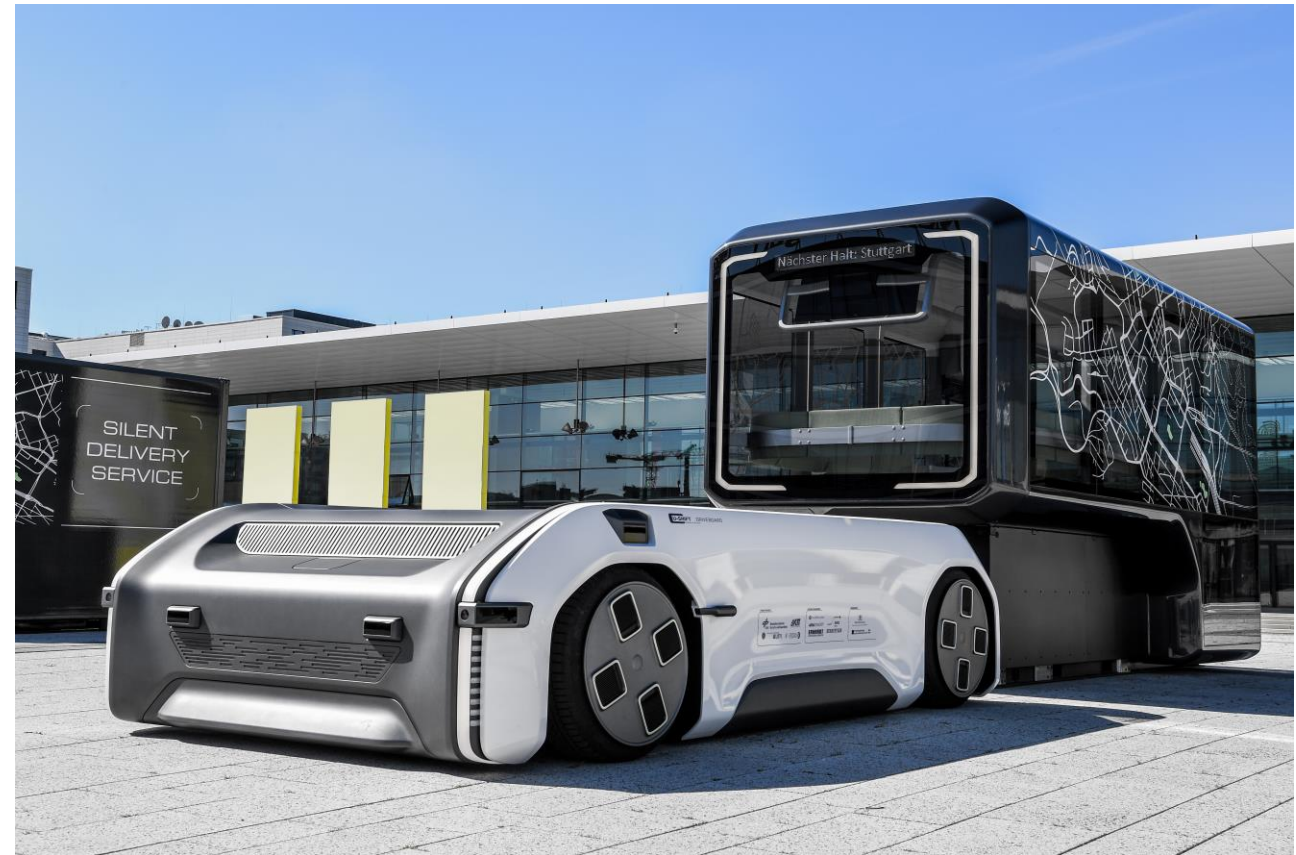
PROJEKTPARTNER



FÖRDERGEBER



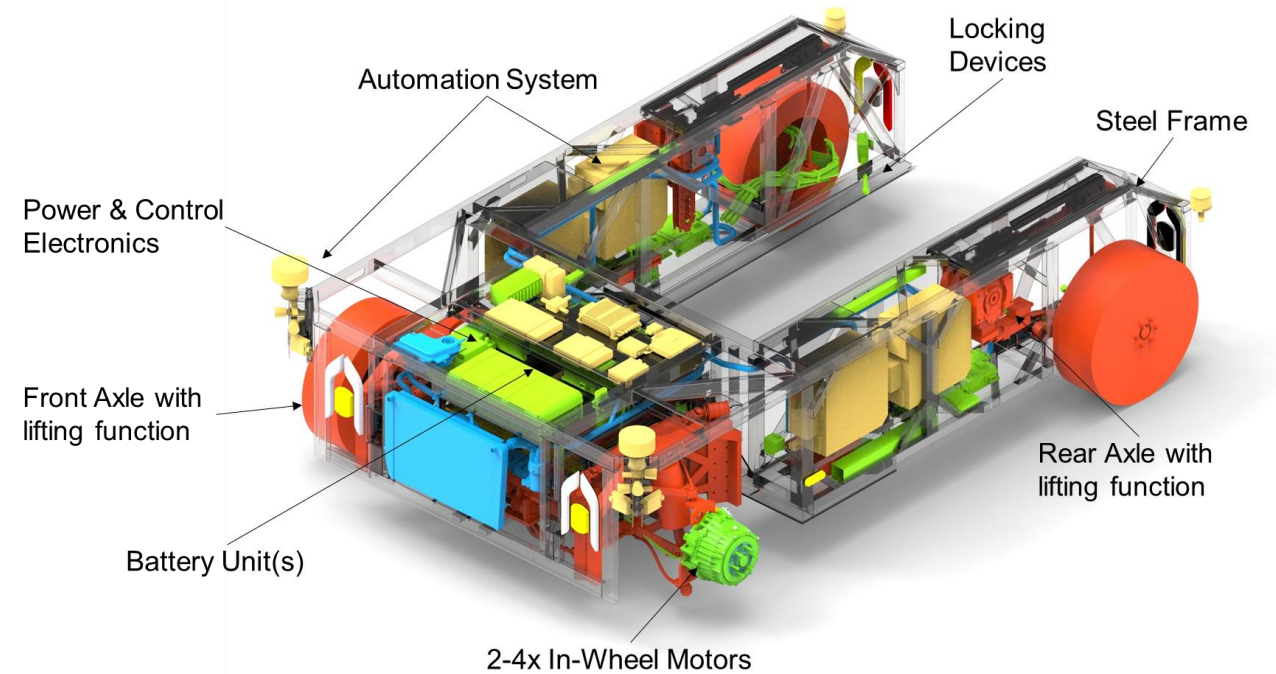
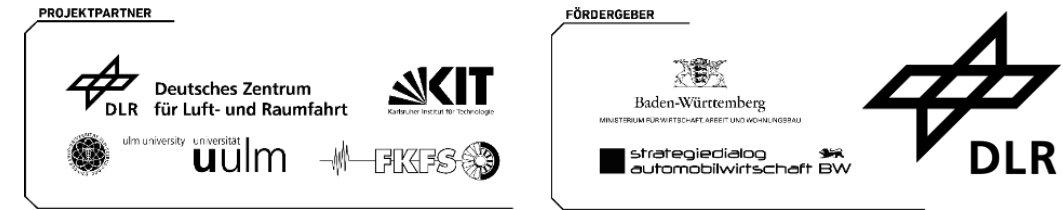
- **First Prototype of U-Shift Concept with remote control**
 - World's first automated, electric, U-shaped modular vehicle on SDA 2020
 - Driveboard (48 V, 2x15 kW, hydraulic liftsystem)
 - Passenger capsule (7 seats, wheelchair users, standing room, onboard infotainment)
 - Cargo capsule (Micro Hub, 4 Euro pallets, payload 2000 kg)



Source: Münster, M., Siefkes, T., Brost, M., Hahn, R., Kopp, G., Schmid, S. (2021) *U-Shift vehicle concept: modular on the road*. In: 21st Internationale Stuttgarter Symposium Automobil- und Motorentechnik, 7. Springer. 2021-03-30 - 2021-03-31, Stuttgart. doi: [10.1007/978-3-658-33466-6_23](https://doi.org/10.1007/978-3-658-33466-6_23). ISBN 978-3-658-33466-6. ISSN 2198-7432

U-Shift II Researcher

- **Driveable prototype with driverless driving with new chassis, EE architecture, vehicle structure, and dialog on the concept with citizen participation**
- Driveboard (48 V, 4x15 kW, approx. 30 kWh, liftsystem electric, mutual steering, sensors u. computers)
- Passenger capsule from U-Shift I with adaptations EE, SOA and sensors
- Cargo capsule (Micro Hub, 3 Euro pallets)



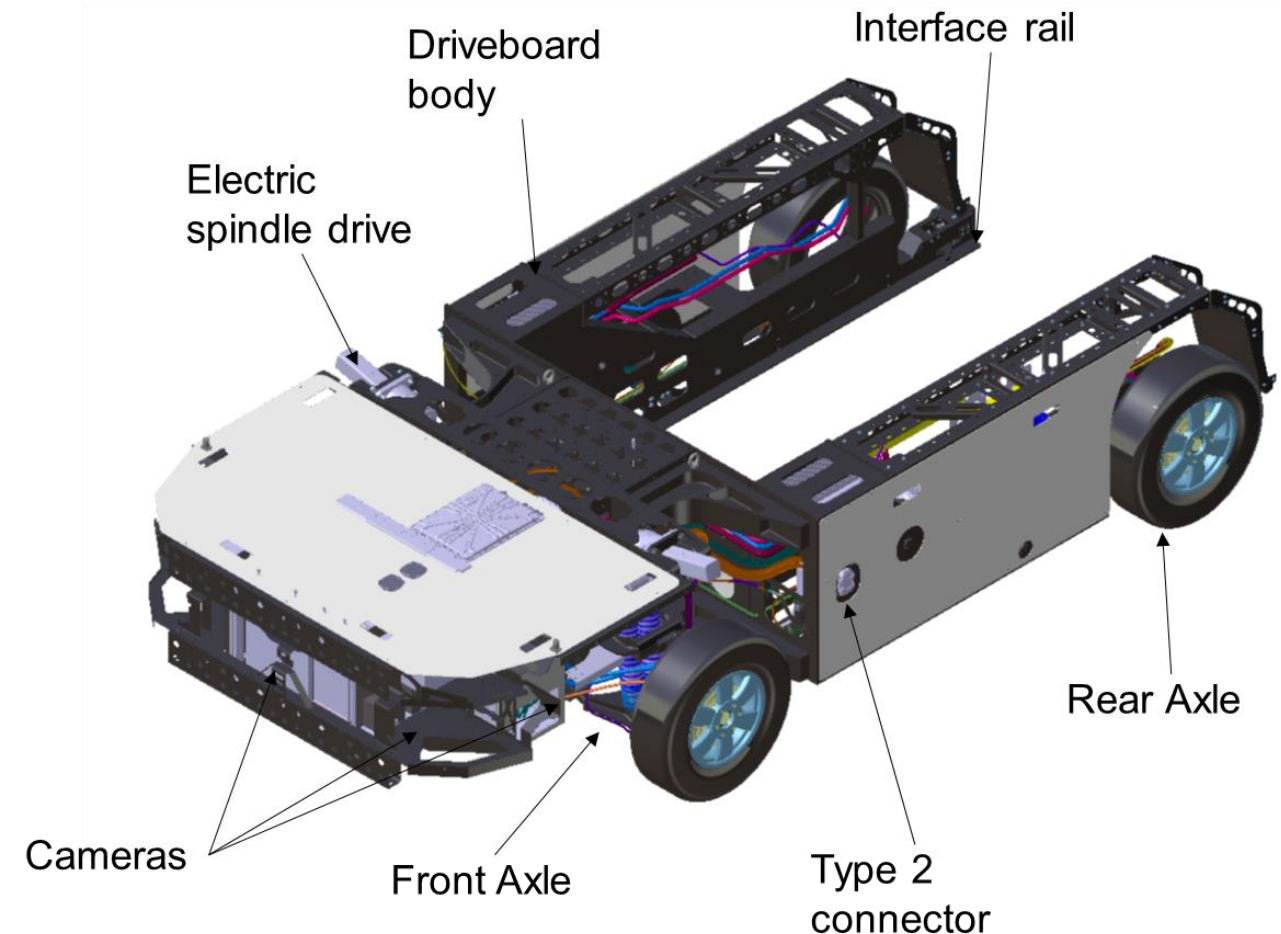
Source: Münster, M., Osebek, M., Siefkes, T. et al. Modulares Fahrzeugkonzept für die Mobilität von morgen. *ATZ Automobiltech Z* **124**, 16–21 (2022). <https://doi.org/10.1007/s35148-022-0906-4>

U-Shift III

Remote Worker



- **Driveable prototype with high performance data for remote & MAD**
 - Driveboard (400 V, 4x60 kW, approx. 30 kWh, electric lift, own steering)



Source: Münster, M., Osebek, M., Siefkes, T. et al. Modulares Fahrzeugkonzept für die Mobilität von morgen. *ATZ Automobiltech Z* **124**, 16–21 (2022). <https://doi.org/10.1007/s35148-022-0906-4>

U-Shift IV / Technology transfer

First On Semi Public Road



- **Driveable prototype with automation with better performance data for real-lab operation and potential for semi public road**
- Driveboard (400 V, 2x60 kW, approx. 36 kWh, hydraulic lift, steer and drive by wire)
- Passenger capsule design of U-Shift I with improvements (stop request buttons, displays, vehicle attendant workplace)

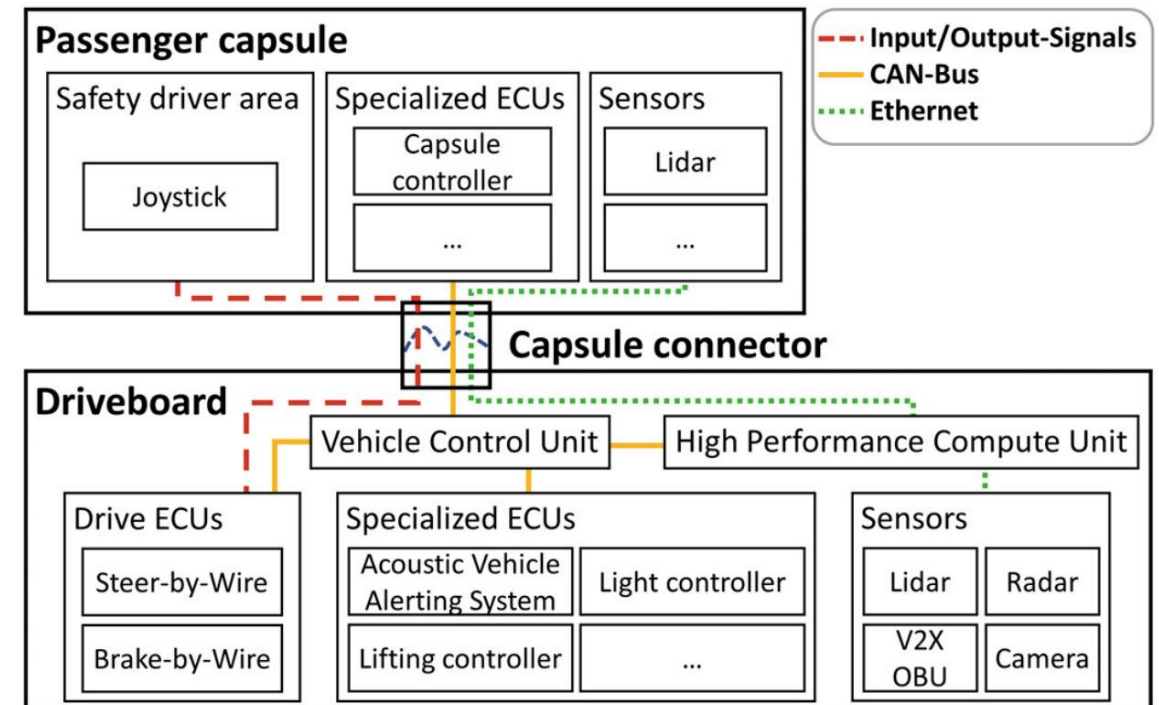


Source: Münster, M., Siefkes, T., Brost, M., Hahn, R., Kopp, G., Schmid, S. (2021) *U-Shift vehicle concept: modular on the road*. In: 21st Internationale Stuttgarter Symposium Automobil- und Motorentechnik, 7. Springer. 2021-03-30 - 2021-03-31, Stuttgart. doi: [10.1007/978-3-658-33466-6_23](https://doi.org/10.1007/978-3-658-33466-6_23). ISBN 978-3-658-33466-6. ISSN 2198-7432

U-Shift IV / Technology transfer

First On Semi Public Road

- **Driveable prototype with automation with better performance data for real-lab operation and potential for semi public road**
 - Software defined Vehicle
 - Automotive grade components and redundant power supplies for safety critical systems
 - Modular Software Architecture
 - Automated data connections between Driveboard and Capsule



Source: Pohl, E., Scheibe, S., Münster, M., Osebek, M. et al., "U-Shift IV: Innovations and Challenges in Autonomous Urban Mobility," SAE Technical Paper 2025-01-0284, 2025, <https://doi.org/10.4271/2025-01-0284>.

U-Shift IV / Technology transfer

First On Semi Public Road



- **Driveable prototype with automation with better performance data for real-lab operation and potential for semi public road**
- Over 178 days, the vehicle covered around 2,800 kilometers and transported approximately 10,000 passengers
- The team engaged in 85,000 conversations and received international coverage



Source: <https://www.youtube.com/@DLRde>

U-Shift IV Driveboard, Passenger capsule
driving scenes on Bundesgartenschau 2023
Mannheim and making of

IMoGer / U-Shift V

First on the Road



- **Innovative modular Mobility Made in Germany**
 - Development of an innovative mobility concept based on the U-Shift concept
 - Creation of a sustainable overall system architecture
 - Transferability to other application areas



IMoGer / U-Shift V

First on the Road



- **Innovative modular Mobility Made in Germany**
 - Legal permission for driving on public roads according to AFGBV §16
 - Demonstration and testing of practical suitability
 - Preparation for regular operation





**Thank you
for your attention!**



Mario Behrendt E-Mail: mario.behrendt@dlr.de
Institute of Vehicle Concepts
German Aerospace Center

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Baden-Württemberg

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aufgrund eines Beschlusses
des Deutschen Bundestages



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aufgrund eines Beschlusses
des Deutschen Bundestages