

Our HÖRMANN innovation vehicle

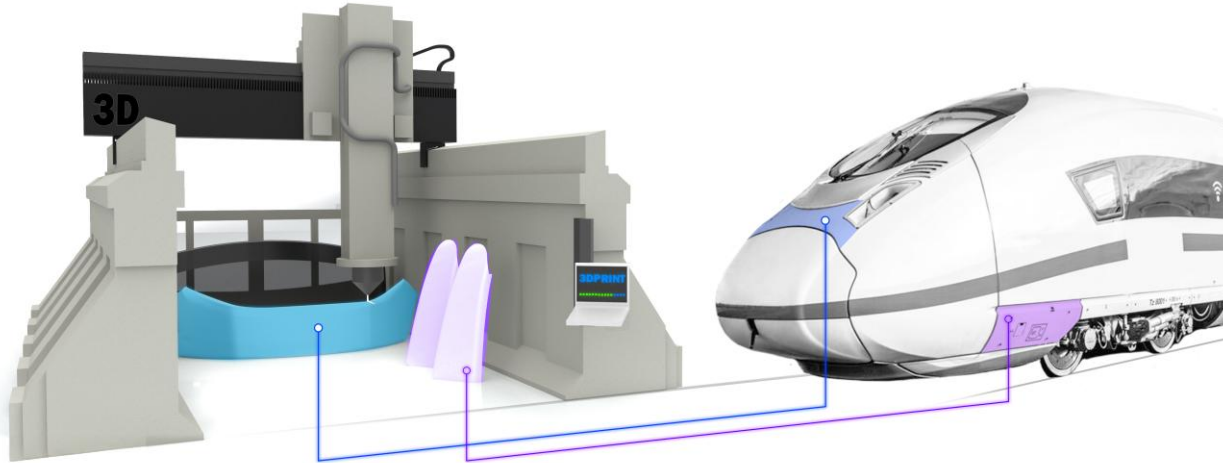
WARAN: *Hydrogen-powered regional train with waste heat utilization*



Empty weight:	93t	Range:	> 800 km
Overall length:	47.000 mm	Max. speed:	160 km/h
Overall width:	2800 mm	Max. acceleration:	1,1 m/s ²
Roof height:	3350 mm	Max. traction power:	1,26 MW
Seating capacity:	142 in total (+ 4 optional)	Installed FC power:	600 kW
	28 TSI / 28 folding seats	Energy storage system :	2 x 120kW LTO
		Max. Auxiliary eqpt. consumption:	120 kW

3D - FiberTrain

3D extrusion printing for large-format and heavy-duty rail vehicle components



-15 %
total
component-
related costs

-20 %
component-
related
production time

-30 %
carbon
footprint

Research Partners:



LAKOWA SIEMENS

Gefördert durch:



Bundesministerium
für Wirtschaft
und Energie



TÜVRheinland®
Genau. Richtig.

aufgrund eines Beschlusses
des Deutschen Bundestages



HÖRMANN
Vehicle Engineering

3D - FiberTrain

3D extrusion printing for large-format and heavy-duty rail vehicle components

GOAL – Development of a tool-free manufacturing process to produce large-scale, heavy-duty rail vehicle components

RESULTS

- **Improved mechanical properties** with minimal weight by using fiber-reinforced tapes
- **Demand-based part manufacturing** without tools
- **Compliance with fire safety standard EN45545**
- **Reduction of overall component costs and carbon footprint**

FACTS FRONT PANEL

dimensions: 1326 x 530 x 16 mm

Weight: 9,8 kg

Material: PC – Blend Listolan™ 060 XL with 20% glass fiber

Printing parameter:

- nozzle temperature 275°C
- printing speed: 2600 mm/min
- printing time: 6 hours



Demonstrator vehicle: ICE 3neo 308

Demonstrator parts: front panel
front mask

Tape-reinforced front panel

RESOLVE

Resource-efficient lightweight seats



< 1 min
Production time
per seat

Research Partners:



Gefördert durch:



RESOLVE

Resource-efficient lightweight seats

GOAL – Development and production of an innovative lightweight seat made from fiber-reinforced thermoplastic semi-finished products

RESULTS

- Lightweight design
- **Significant reduction** in the number of individual parts
- Ergonomic design
- **Flame-retardant** properties
- High **recyclability** thanks to the use of thermoplastics
- **Cost reduction** due to single-stage production process

FACTS

Single seat dimensions: 600 x 440 x 540 mm

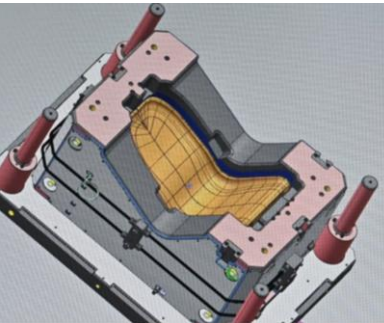
Weight: < 6 kg

Material: PA-GMT

Flame retardant: AKROMID B3 1FR

Pressing time: < 50 s

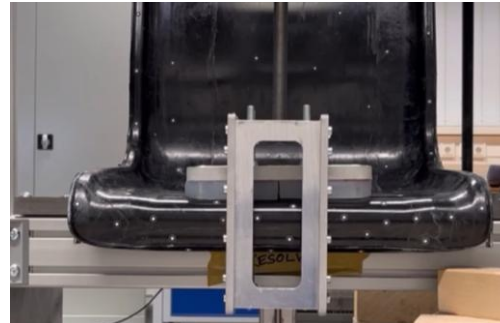
Production costs: < 100 € / Seat



Pressing Tool



Seat Manufacturing



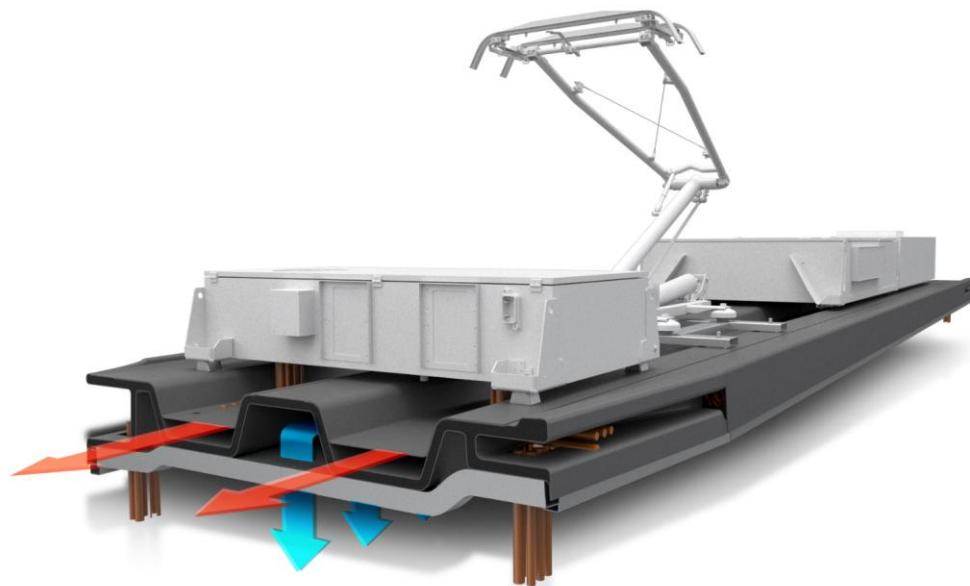
Static and Dynamic Seat testing



Seat Measurement using GOM

INTEGRAL

Innovative lightweight roof



-15 %

Cheaper than
comparable
steel roof

-45 %

Lighter than
comparable
steel roof

Research Partners:



ARNEL



Supported by:



Federal Ministry
for Economic Affairs
and Climate Action



INTEGRAL

Innovative lightweight roof

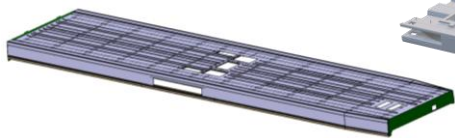
GOAL – Development and production of a lightweight roof with integrated functions for air conditioning and component fastening

RESULTS

- Higher strength compared to a corresponding steel roof
- **Maximum load capacity** with minimal fatigue properties
- Economical roof structure suitable for series production thanks to efficient production technology
- Low **installation effort** due to integrated functions
- **Scalable** in length, width and height



994kg
Overall mass
(incl. components)



Steel roof differential construction



517kg
Overall mass
(incl. components)



vs. Optimised sandwich roof integral construction

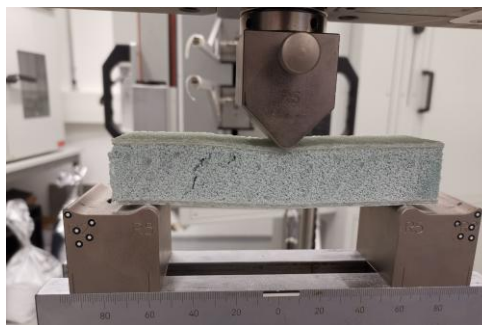
FACTS

Material: Fibre-reinforced composite material (GRP + Foam core)

Production: Vacuum Infusion (VARI)

Fire Protection: DIN 45545

Integrated functions: Cold/hot air ducts
cable ducts and cable glands
Roof drainage
Fastening elements for roof structure



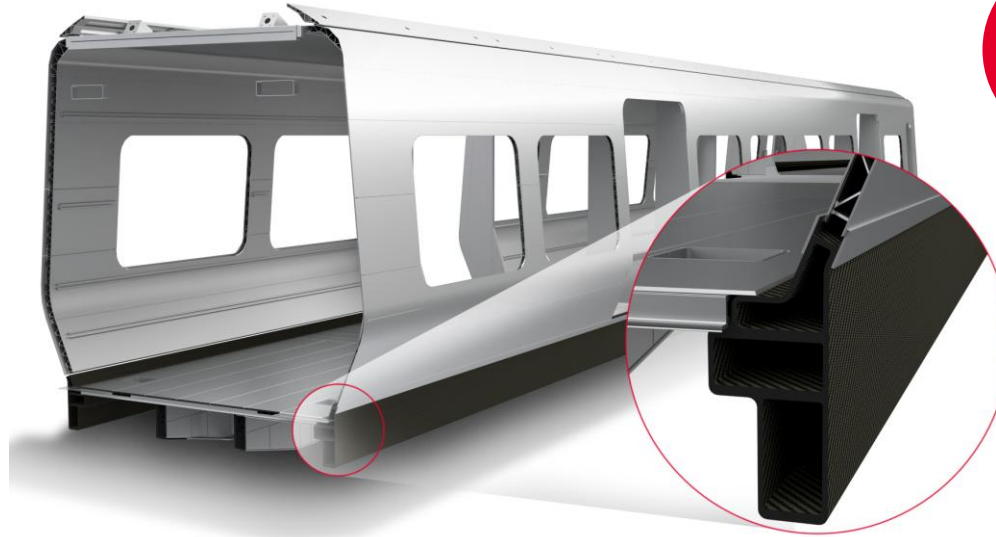
Load test



Fastening element metal insert

FUNPUL

New lightweight construction



-40 %
Lighter than
comparable
longitudinal
beam

-10 %
Less
Life-Cycle-
Costs

Research Partners:

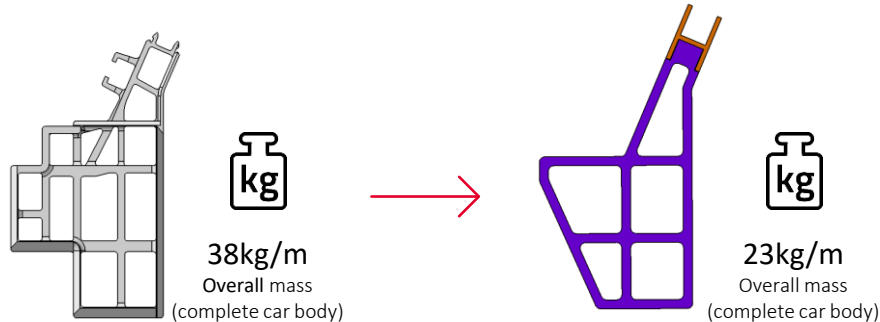


New lightweight construction

GOAL – Development and production of a series-ready lightweight structure for railway vehicle underframes in CFRP pultrusion construction

RESULTS

- **Lightweight construction** with CFRP pultrusion profile
- **Scalable** in Length, width und height
- Economical manufacturing and assembly process suitable for series production
- Low **installation effort** due to integrated functions

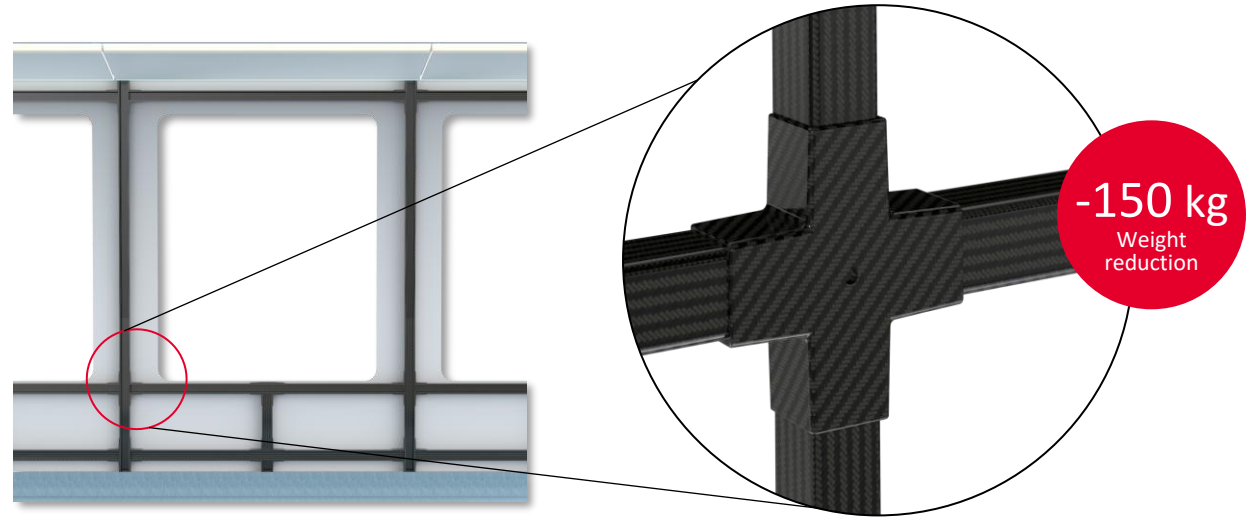


FACTS

- Material: CFRP pultrusion profile incl. interface profile
- Production: single-stage manufacturing process
- Fire Protection: DIN EN 45545
- Integrated functions: Metallic interface on the part of the plastic profile
Interface only allows two degrees of freedom
Flexibility in the type of connection technology

PulPro-SMC

Lightweight construction with pultruded profiles



Research Partners:



PulPro-SMC

New lightweight construction strategy

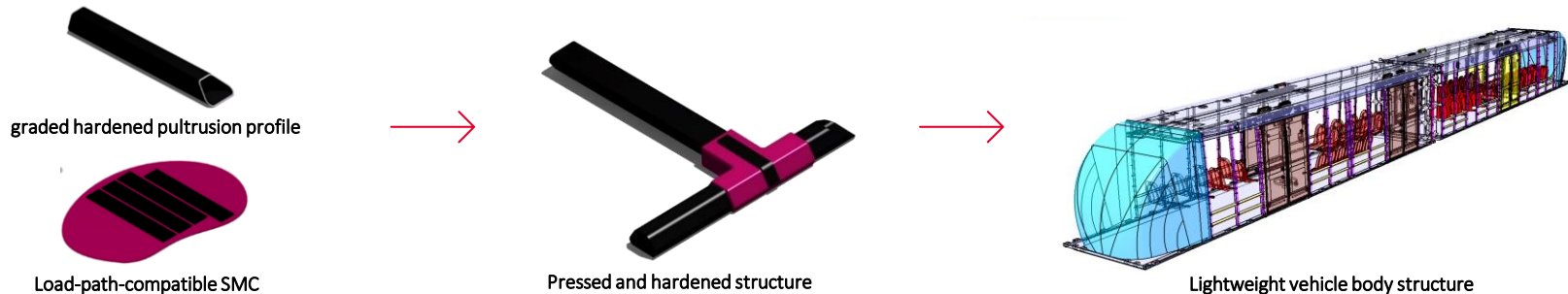
GOAL – Innovative lightweight vehicle body structure using a combination of pultrusion profiles and SMC-manufactured connecting elements

RESULTS

- Combination of FRP processes suitable for large-scale production - pultrusion and SMC pressing
- **Lightweight construction** thanks to FRP design
- **Force flow-orientated design** with maximum performance thanks to FRP
- **Direct material-locked joining** (without adhesive) and simultaneous formation of a node structure
- Wide range of design options
- **Sustainability** due to using recycled materials

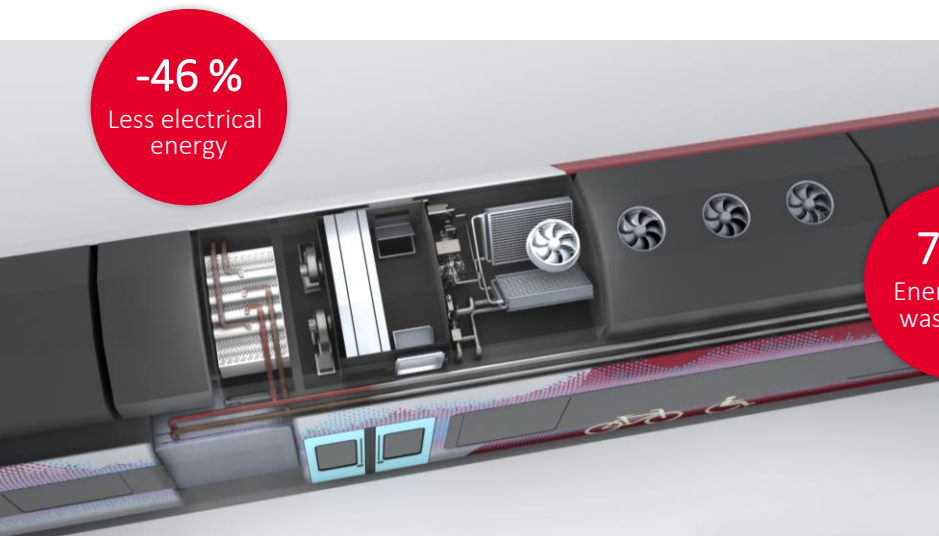
FACTS

- Material:** SMC – Sheet Molding Compound made from recycled CRFP and epoxy-based resin system
TowPregs – impregnated CRFP-Rovings
- Production:** single-stage manufacturing process
- Fire protection:** HL2 R7 through additives
- Price:** Economical thanks to standardised profile designs and modular system



Heat2Comfort

Waste heat based climatization system



70 %
Energy from waste-heat



Research Partners:



Gefördert durch:



Bundesministerium
für Wirtschaft
und Klimaschutz



TÜVRheinland®
Genau. Richtig.



Heat2Comfort

Waste heat based climatization system

GOAL – Utilisation of fuel cell waste heat for indoor air conditioning and achieving thermal comfort

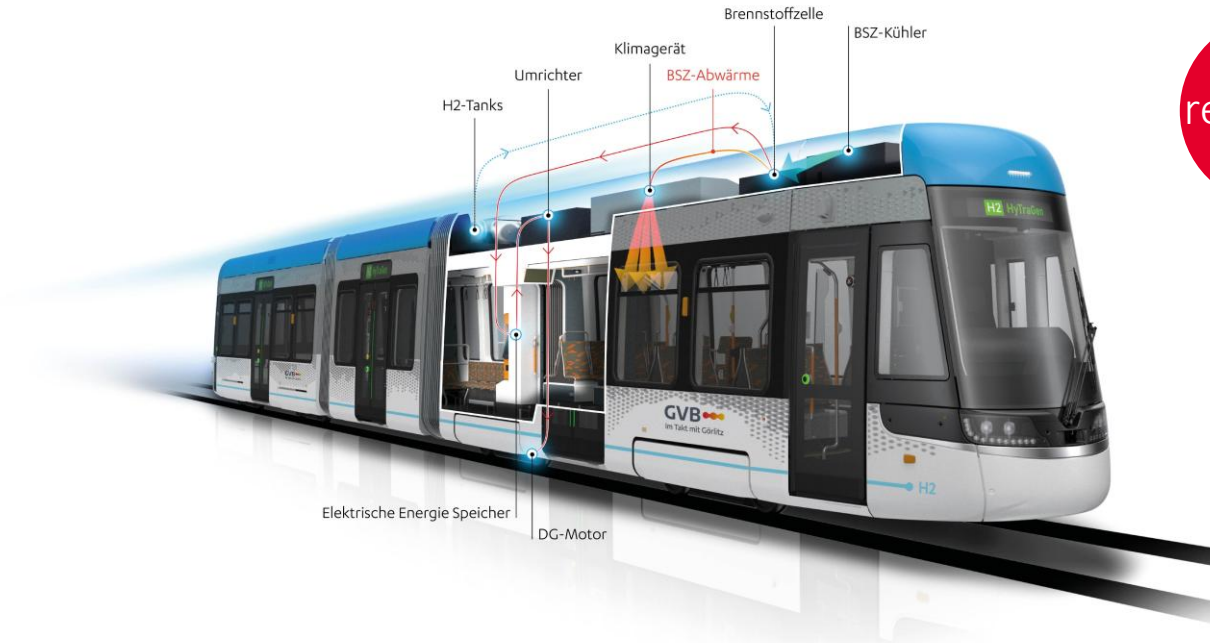
RESULTS

- TAIC – Thermal Active Interior Components and air conditioning system heat and cool the passenger compartment
- Effective use of fuel-cell waste heat for comfort-optimized climatization of the passenger compartment
- Significantly reduce the electrical energy demand for the compression chiller and fans
- Draught-reduced air conditioning



HyTraGen

The first H2 tram in Europe



Short
refuelling
time

Research Partners:



Gefördert durch:



HyTraGen

the first H2 tram in Europe

GOAL – Development and production of an approvable test vehicle with testing under real operating conditions

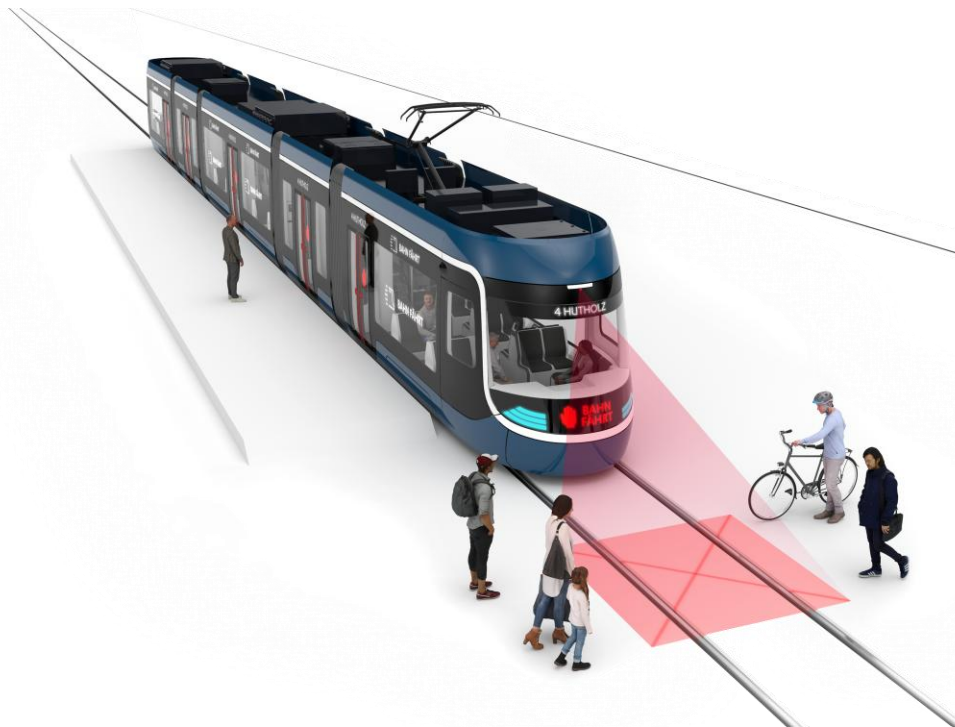
RESULTS

- Proof of function and validation of hydrogen drive systems
- Efficient energy management system and waste heat utilization
- Optimum arrangement of the additional H2 drive components
- Development of a hydrogen refueling and storage concept
- Functional safety solutions for fuel cell trams
- Derivation of certification requirements for fuel cell trams



SmarTram

Autonomous tram



-20 %
Operating
costs

Research Partners:



Gefördert durch:



Bundesministerium
für Wirtschaft
und Klimaschutz



SmarTram

Autonomous tram

GOAL– Investigations into the integration of vehicle sensors and infrastructure data for autonomous operation (GoA 4)

RESULTS

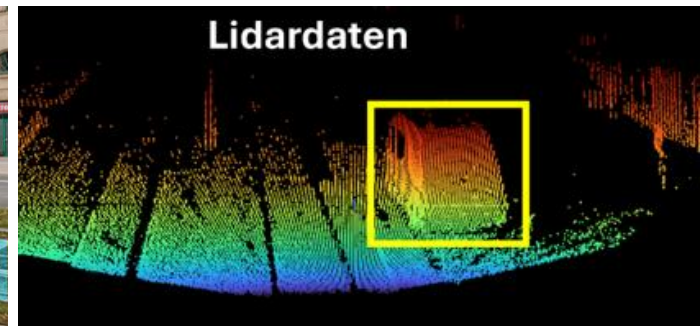
- Analysis of operating scenarios, requirements specification
- Concepts for vehicle interfaces, sensor technology and communication
- Design of a system architecture including infrastructure components
- Development of hardware and software modules that enable autonomous operation of future vehicles
- Test drives to train the sensors and determine the control parameters for driving with a Tatra T3M as test vehicle
- Development of a vision vehicle to demonstrate the potential (communication, ergonomics)



Test vehicle „Tatra T3M” with integrated sensors and control components



Visualisation for sensor control of a tram



RailAIXs

Rail Automation with Artificial Intelligence for detection of exceptional situations



Research Partners:



Funded by:



Rail Automation with Artificial Intelligence for detection of exceptional situations

GOAL – Evaluation of the reliability of object detection and vehicle response on secondary routes

Development of approaches

- Approval-ready operation of AI-supported mainline railways on branch lines

Evaluation

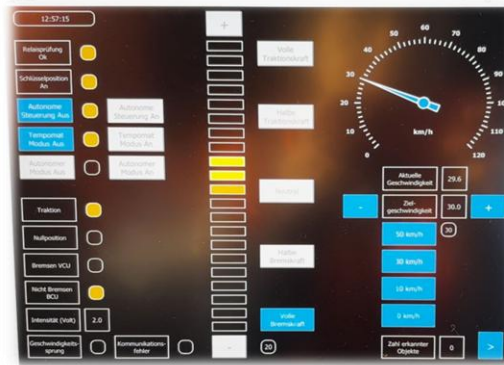
- Selection, placement, and data fusion of sensor types with a focus on object detection

Successful test run

- Autonomous operation on the Rurtalbahn line



Test vehicle on the Rurtalbahn line



Interface to vehicle control



Visualization of recognized objects

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