Breakout Workshop: Human Factors
in automated mobility services, 2021-10-29

User-needs-based design of public transport with autonomous vehicles

User-centered research in the project HEAT
(Hamburg Electric Autonomous Transportation)

DLR

The HEAT project

Integrated research

Technological feasibility and safety
Can driverless vehicles (minibuses) be operated safely on regular public transport services?
Is the technology needed for that already available:
- with a permitted top speed of 25 km/h?
- on a defined route on the public roads?

Acceptance
How do users of public transport and other road users react to this new service offer? What are the main adjustments needed?

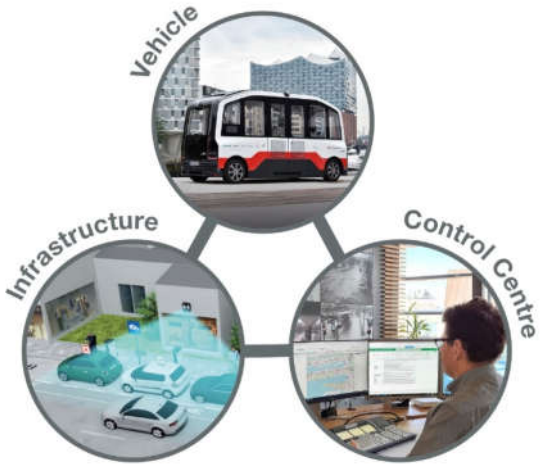
New business and operation models
How can new operator models and new service options for the sustainable deployment of automated self-drive vehicles for passengers be created as part of a public transport network?

HOCHBAHN · automotive engineering iav · SIEMENS Ingenuity for life

Hamburg · hySOLUTIONS Innovative Antriebe für Hamburg · DLR Deutsches Zentrum für Luft- und Raumfahrt · IKEM

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
based on a decision of the German Bundestag
Erneuerbar mobil

Stepwise system development, integration and testing



Phase 1
Vehicle trials without passengers at one traffic intersection

Phase 3 Service with passengers on entire route (1.8 km) Aug. to Oct. 2021

2018 — 2019 — 2020 — 2021 — 10/2021

Project starts

Phase 2
Service with passengers on partial route (0.8 km) - Oct. to Nov. 2020

Showcase at ITS World Congress

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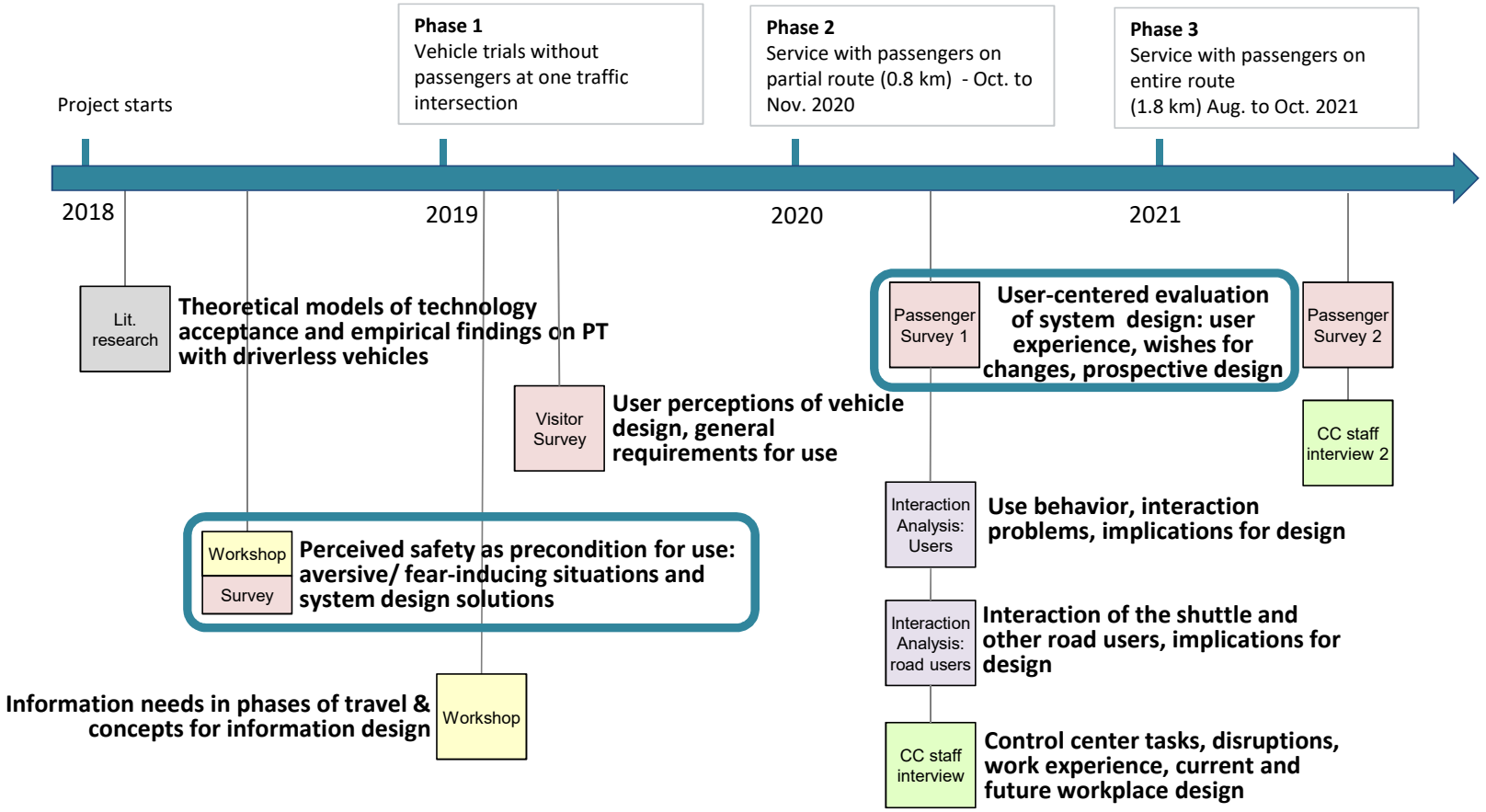
Accompanying user-centered research



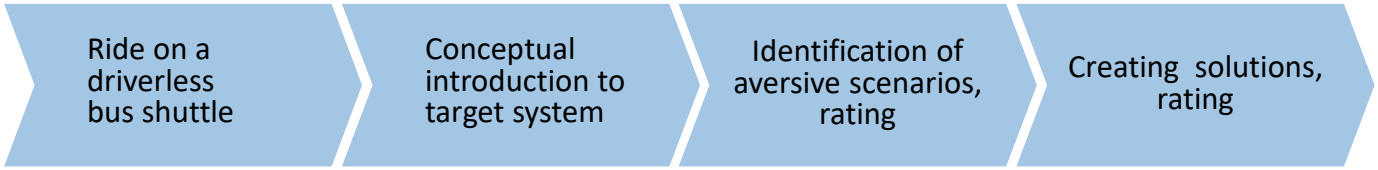
Perceived safety - user workshops and survey

Research questions

What impacts the personal safety experience (PSE) of prospective users with regard to autonomous and flexible bus shuttles?
How could a future system and service be designed to cope with existing concerns/fears?

Method

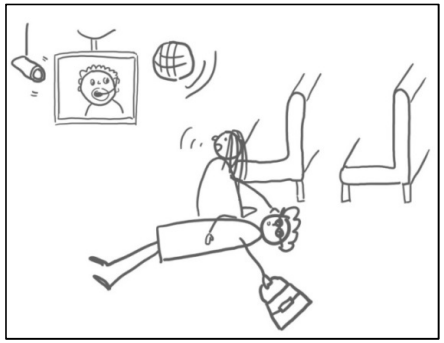
1. **Workshop** with potential users to identify concerns/fears and collect measures to counteract them.

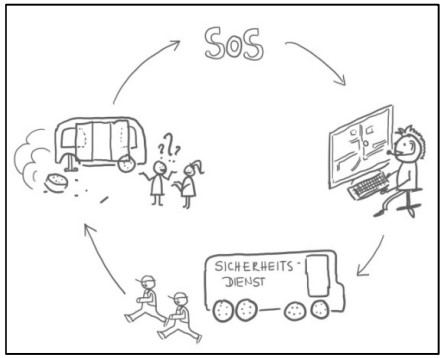


2. **Online questionnaire** to quantify the PSE for concerns/fears and estimate effectiveness of the design solutions

Results: Concerns and preferred solutions

Most-preferred solutions imply strong link to control/service center
=> New tasks and workplace design





Scenario

Design solution

Scenario	Seat monitoring system	Individual cabin	Locking system	Emergency brake	Mobile security service	Video assistance system	Mobile application	Navigation interface	Passenger training	Information system	Head-up display	Panic button	Telephone
Sensor Failure				*	*	*			*	*	*	*	
Blocked exit				*	*	*						*	*
Critical group dynamics		*		*	*	*	*					*	*
Unpleasant passenger	*	*		*	*	*	*					*	*
No help in emergency				*	*	*						*	*
Physical violence		*		*	*	*	*					*	
Bad area		*	*		*	*	*	*				*	*
Vandalism		*		*	*	*						*	*
Unexpected stop					*	*	*	*			*	*	*
Theft in shuttle					*	*						*	
Puncture				*	*	*		*					
Unknown route					*			*		*	*		
Crowded shuttle				*	*	*						*	
Personal data security													
Inability to intervene				*		*						*	
Unpuntuality													
Bad maintenance							*			*			

Concerns/fears regarding…

- **Other passengers**
- **System intransparancy**
- **Technical safety**

Grippenkoven, J., Fassina, Z., König, A. & Dreßler, A. (2019). Perceived Safety: a necessary precondition for successful autonomous mobility services. In D. de Waard, K. Brookhuis, D. Coelho, S. Fairclough, D. Manzey, A. Naumann, L. Onnasch, S. Röttger, A. Toffetti, and R. Wiczorek(Eds.): Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2018 Annual Conference. ISSN 2333-4959 (online). Available from http://hfes-europe.org

User experience – passenger survey

Research questions

How do users experience the ride on the self-driving vehicle?
What do they require and wish for in future systems design?

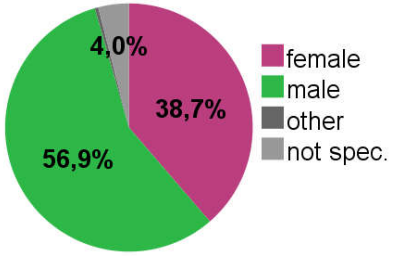
Method

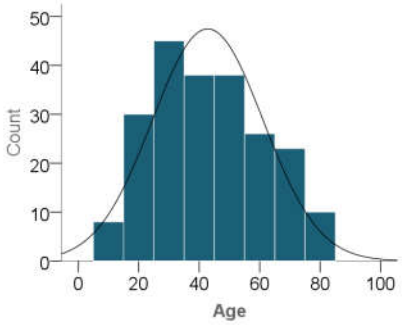
On-site survey in phase 2 (Oct-Nov 2021) with HEAT passengers at stop „Magellanterassen“, immediately after ride (paper-pencil or online questionnaire)

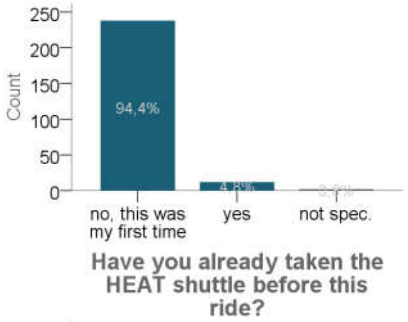
Survey topics: user experience (perceived pragmatic and hedonic qualities), perceptions of driving style, information design, qualitative feedback on vehicle design, use intention and conceptions for application of autonomous vehicles in public transport

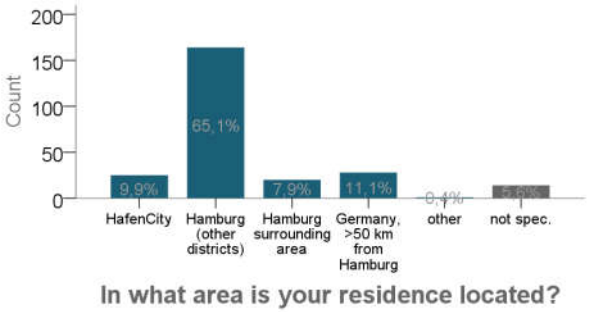
Respondents

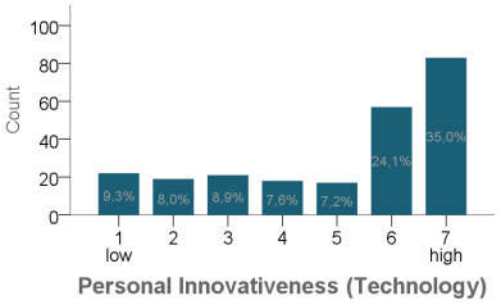
Questionnaire filled by 225 persons aged between 7 and 82 years
(*M* = 42.0; *SD* = 17.8)

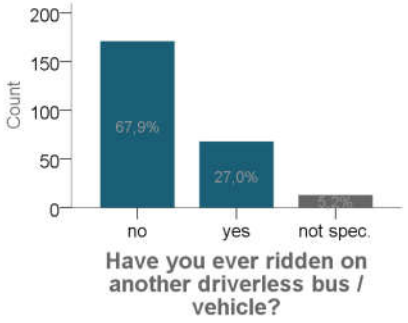




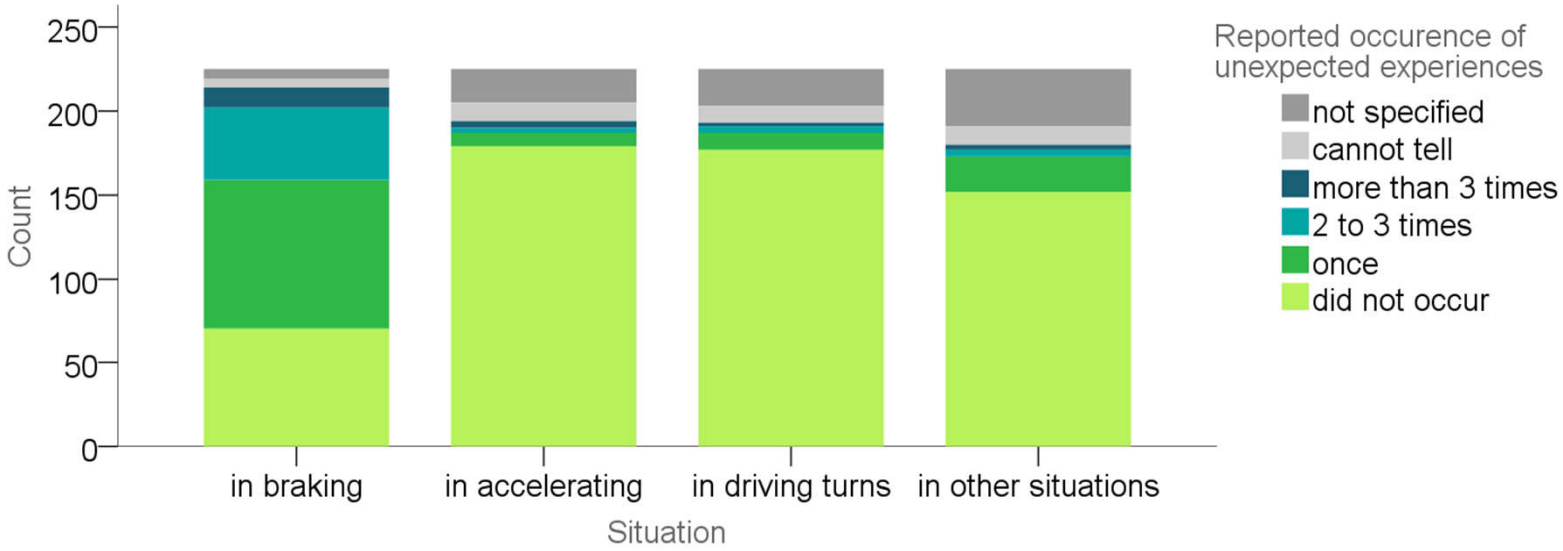






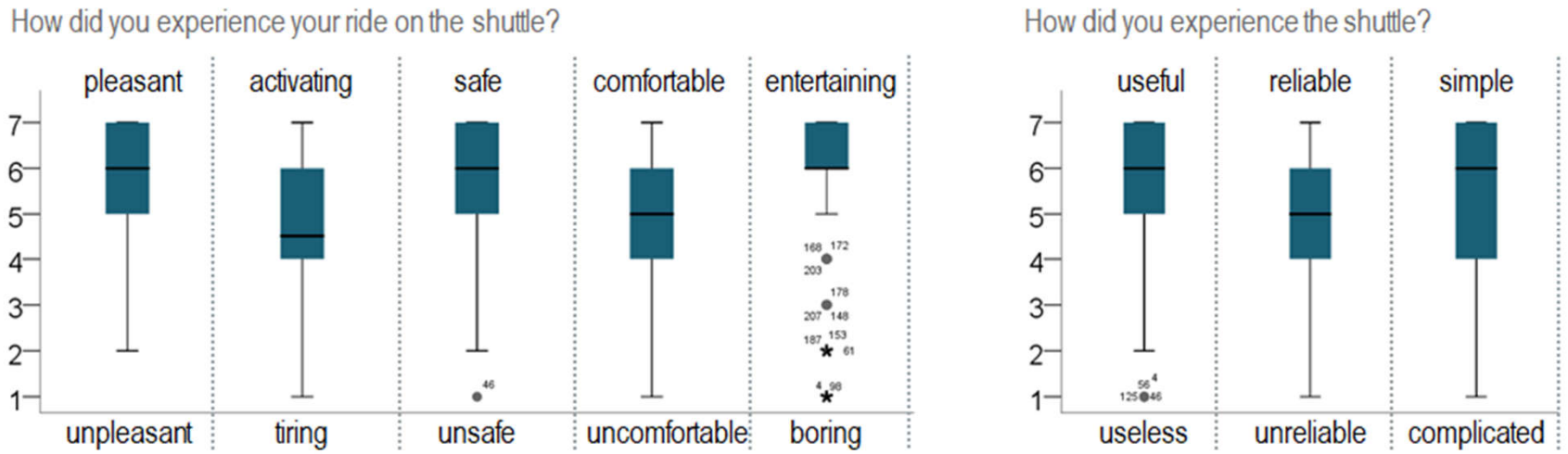


Perceived driving



Reported frequency of unexpected experiences regarding the shuttle's way of driving in four maneuver / situation categories.

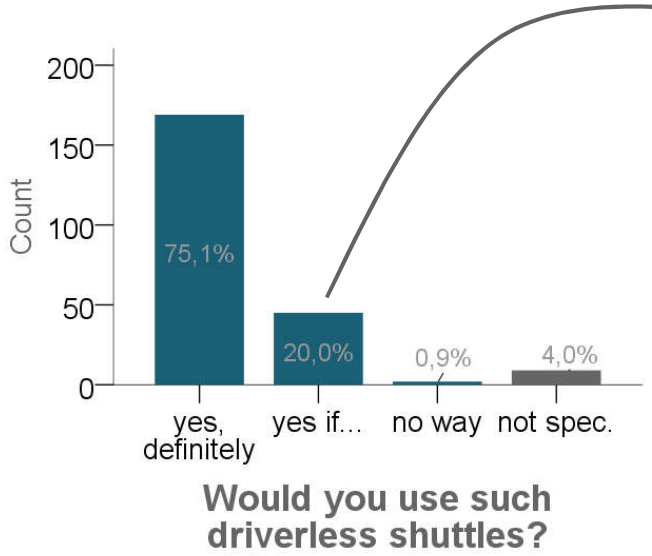
User experience



User experience of the ride and the shuttle. Boxplot of user assessments on the bipolar items concerning emotional valence and arousal, perceived safety, comfort and hedonic quality of the ride (left) and perceived usefulness, reliability and ease of use of the shuttle design (right).

Use intention

Driverless shuttles like the HEAT shuttle could become one of the normal mobility options in the future.



Use if...

technically proven / mature / safe	**15**
more efficient	**12**
faster	7
softer braking	2
bigger fleet	1
larger network coverage	1
more transparent technology	1
fastest option	**3**
necessary / only option	**3**
bad weather (instead of walking)	**1**
used for ridepooling	**2**
Total	36

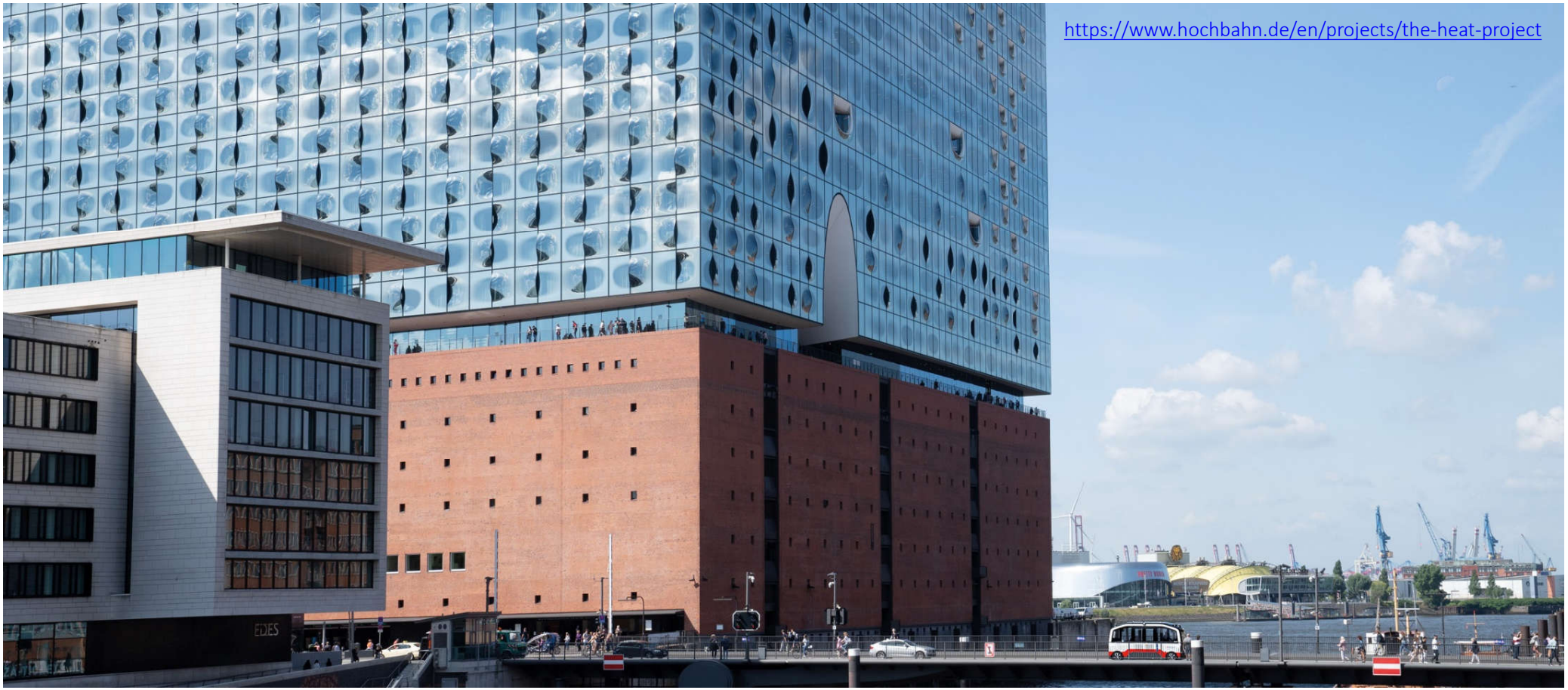
Passenger survey - summary

- Overall positive user experience (safety, usefulness, fun)
- Wishes for optimization in fluency of driving (anticipation of other road users‘ behavior / adaption of deceleration), comfort (e.g. seats), accessibility (e.g. enhanced possibilities to hold on to handle, further development of ramp, space)
- Overall positive assessment of user information
- To be considered in interpretation and use of results:
  - Sample not representative for all potential users (e.g. self-selection, gender, technology affinity), but broad spectrum of users represented
  - For future applications consider the presence vs. absence of vehicle attendants on board (functions such as system expert providing helpful information, instance of supervisory control, contact person in case of exceptional situations; Dreßler et al., 2019)

- Passengers obviously took account of a to-be-expected development status in their evaluation: They are positive about the technology overall and understanding about some current constraints, but they also expect that these be resolved in future applications to make self-driving shuttles a competitive transport option
- Results underscore perceived usefulness as most important criterion in choosing a means of transport

- **What is the most important research question/challenge?**
  - How can we use the current possibilities in technology to create efficient mobility offers capable to compete with individual transport?
  - How can we make these offers accessible to all?
- **What aspects should/can be internationally standardized?**
  - ?
  - Validation procedures for testing autonomous driving functions
  - Requirements for communication vehicles/passengers and control/service center
  - User-centered design process

Thank you for your attention



annika.dressler@dlr.de