SKETCHING AN INCLUSIVE MOBILITY FUTURE FOR SHARED AUTONOMOUS VEHICLES

Catharina Wasić

Alexandra König, Johanna Strube and Stephanie Rascher

Motivation

- Driverless vehicles of SAE level 5, so called full automation (SAE, 2016) or robotaxis, are predicted a promising future for a more efficient, safe and user-centered transportation system (Fraedrich, Beiker, & Lenz, 2015; Greenblatt & Shaheen, 2015).
- Research is only at the beginning to analyse the effects of shared mobility and autonomous vehicles in regards to their effects on accessibility and equity (Eppenberger & Richter, 2021).
- First explorative studies point to relevant accessibility concerns of people with disabilities when imagining using robotaxis (e.g. Bennett, Vijaygopal & Kottasz, 2019; Cordts et al., 2021; Patel et al., 2021)
- Most robotaxi pilots are not considering the needs of people with disabilities

It is a crucial moment to develop and test autonomous shared vehicles according to the needs of people with disabilities.

Source: Hamburger Hochbahn: https://www.hochbahn.de/de/projekte/autonomer-busverkehr/das-projekt-heat

Research gap

- Studies regarding the needs and general attitudes of persons with disabilities regarding robotaxis are still limited and restricted to a spatially localized use case (Zhong et al., 2024) or specific forms of disabilities, such as visually and physically impaired persons (Hwang & Kim, 2023).
- Research is needed to approach the attitudes and needs of persons with disabilities regarding robotaxis and to collect their wishes and suggestions for making them more accessible

Research questions

1. How do people with disabilities assess robotaxis in terms of their accessibility and intention to use?

2. What influence does gender, age and kind of disability have on the evaluation of robotaxis in terms of their accessibility?

3. What do people with disabilities suggest to improve accessibility of robotaxis?

The Horizon2020 project *TRIPS*

- TRIPS (TRansport Innovation for vulnerable-to-exclusion People needs Satisfaction)
- Funded for 3 years by the EU Horizon 2020 (02/20 – 01/23)
- Key objective: Understand disabled citizens' mobility needs, mobility barriers, and attitudes towards future mobility solutions

11 partners

7 cities

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme Under Grant Agreement no. 875588.

Methodology

- European-wide survey available in 15 languages during winter 2020/21 and summer 2022
- Addressed topics:
  - Intention to use: *Would you use this system, if it would be available in your city?* (yes or no)
  - Assessment regarding five dimensions of Mobility Divide Index (Bagnasco & Repetto, 2021):

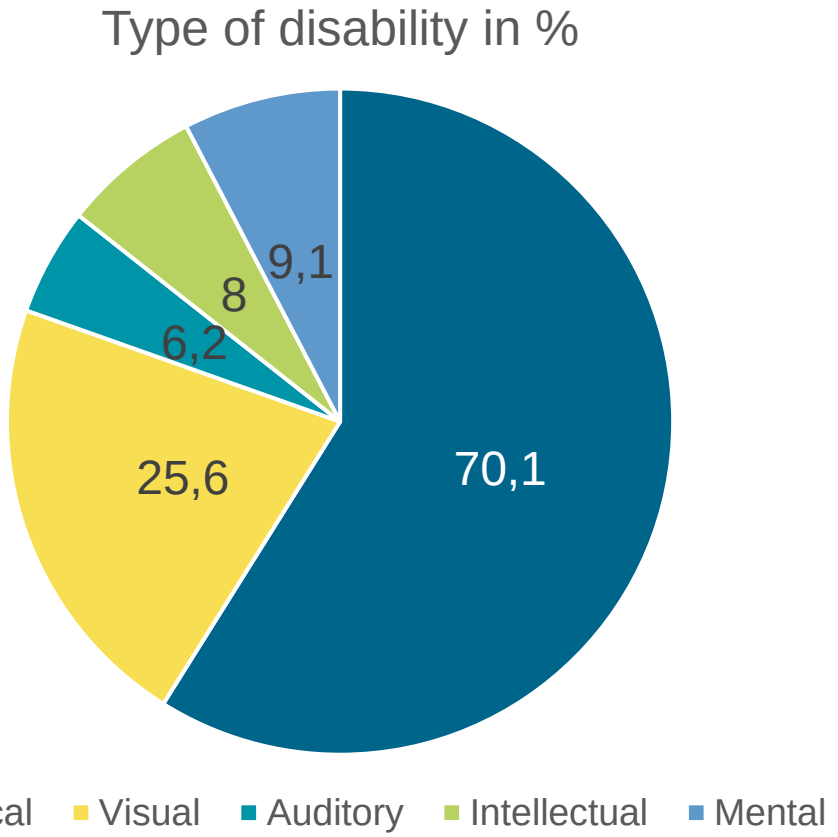
autonomy	convenience	journey time	comfort	safety

  - "*If this mobility service would be available in your city, would it mean that you could ... travel more independently*?" on a five-point Likert scale (options "no", "rather no", "don't know", "rather yes", "yes“)
  - Open question for suggestions for improvements: “*What would you need to make this system work for you?*”

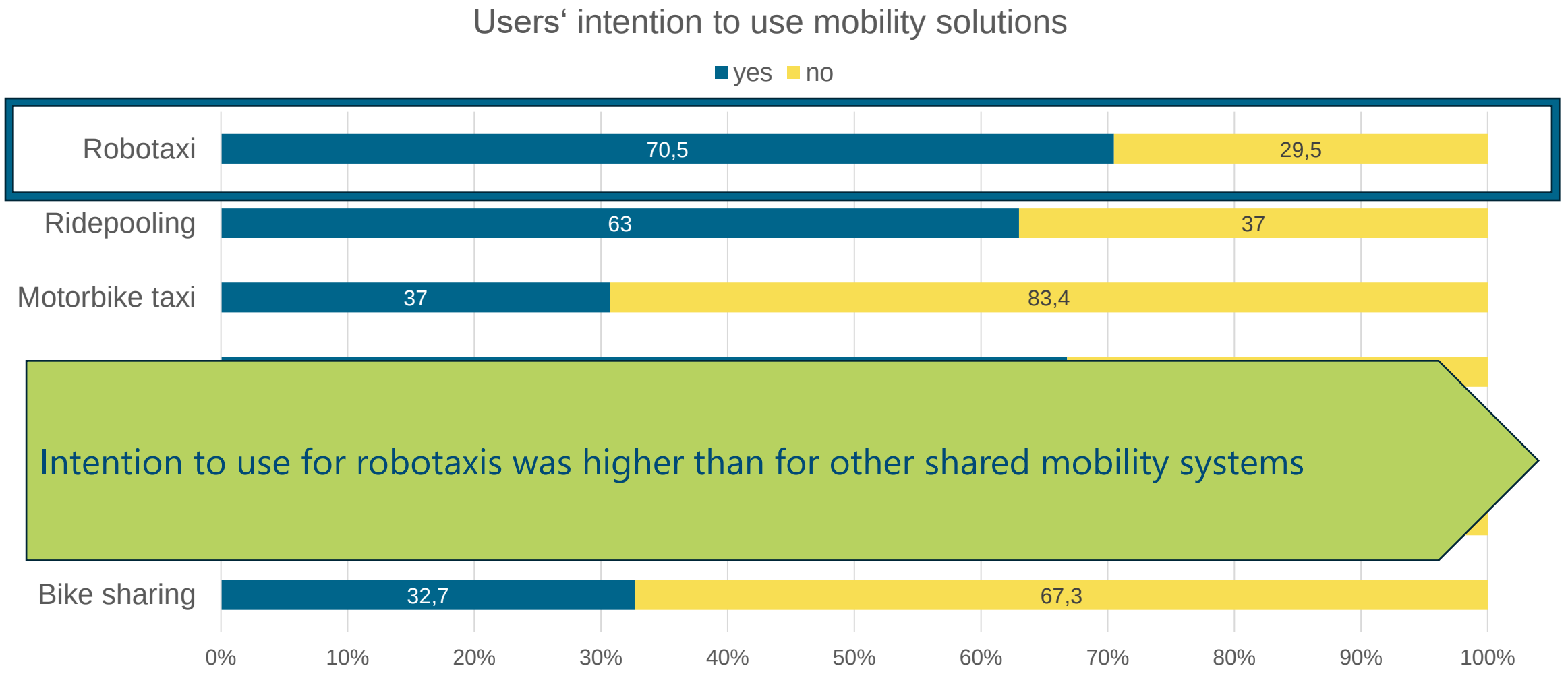
Methodology

Sample:

- N = 273 people with disabilities and 317 without impairment
- from 21 European countries
- 55% female participants
- Mean age: 48.8 years (*SD* = 18.1)



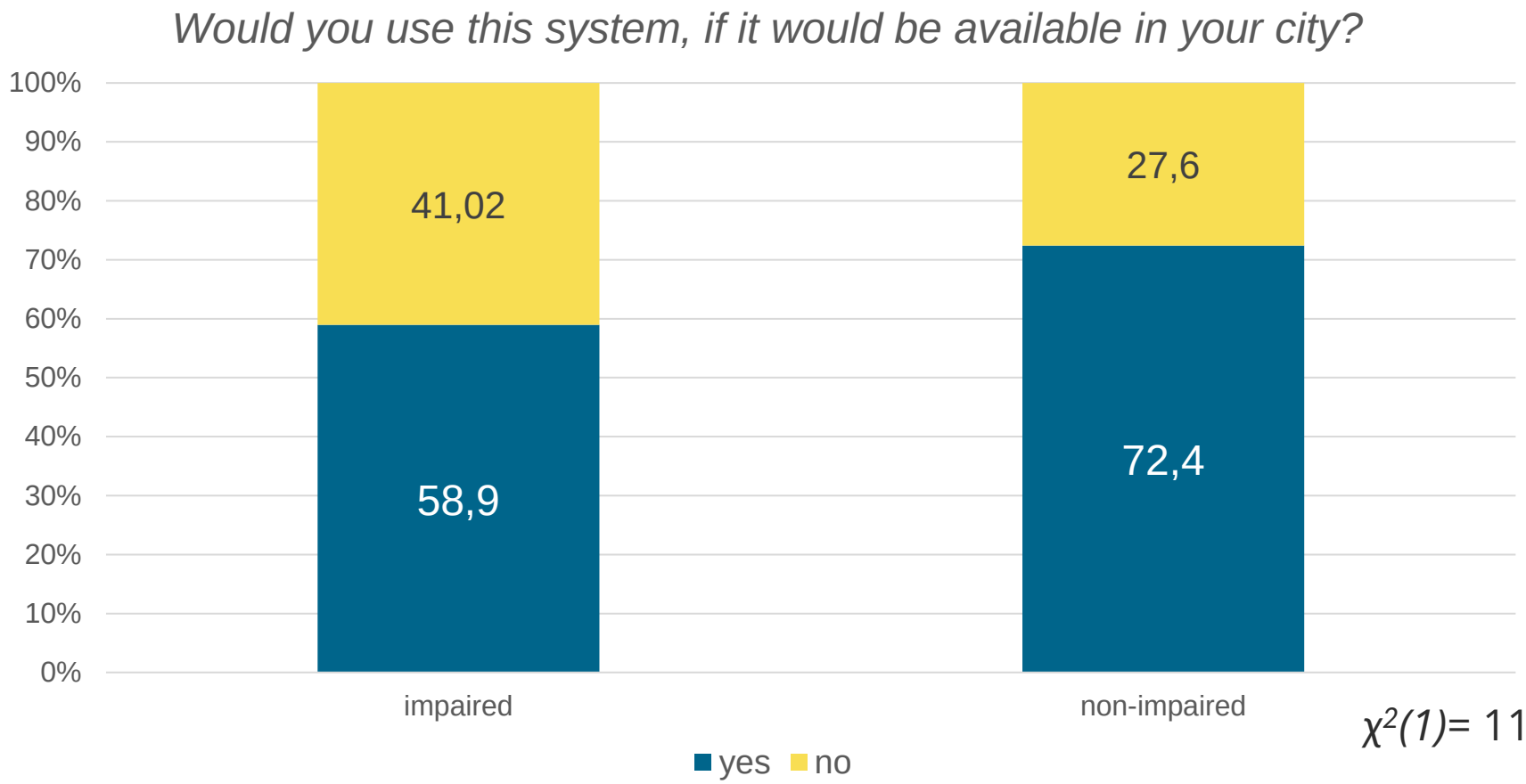
Findings
Intention to use



→ More findings regarding other mobility solutions in Goralzik, et al., (2021)

Findings
Intention to use

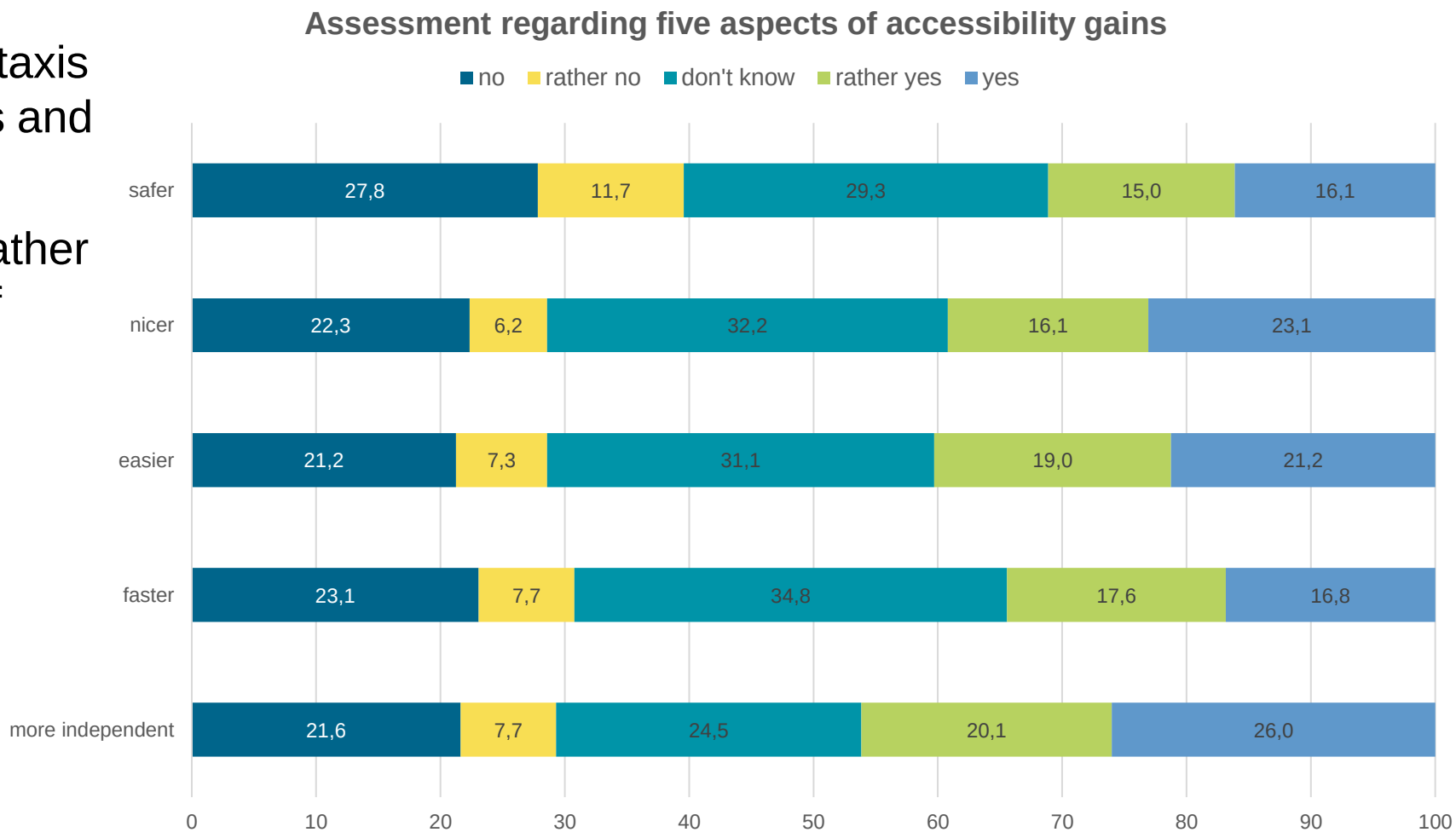
- Despite higher intention to use for robotaxis than for other future mobility systems, use intention of impaired persons is lower than for non-impaired persons



$\chi^2(1) = 11.784, p < 0.01$

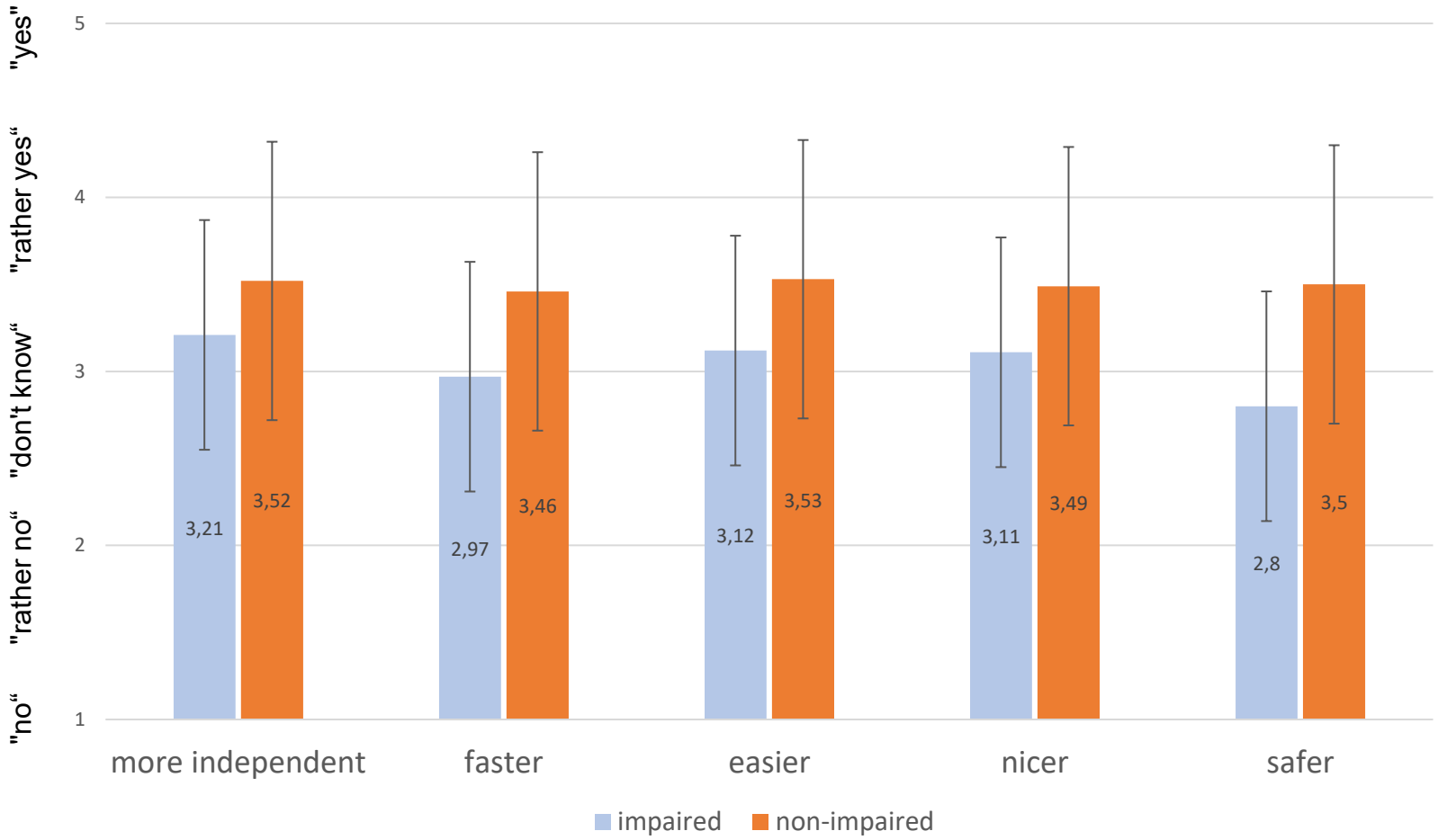
Findings
Assessment according to MDI dimensions

- People‘s assessment of accessibility gains of robotaxis was rather heterogeneous and wide-ranging
- Accessibility gains were rather perceived for autonomy of travel



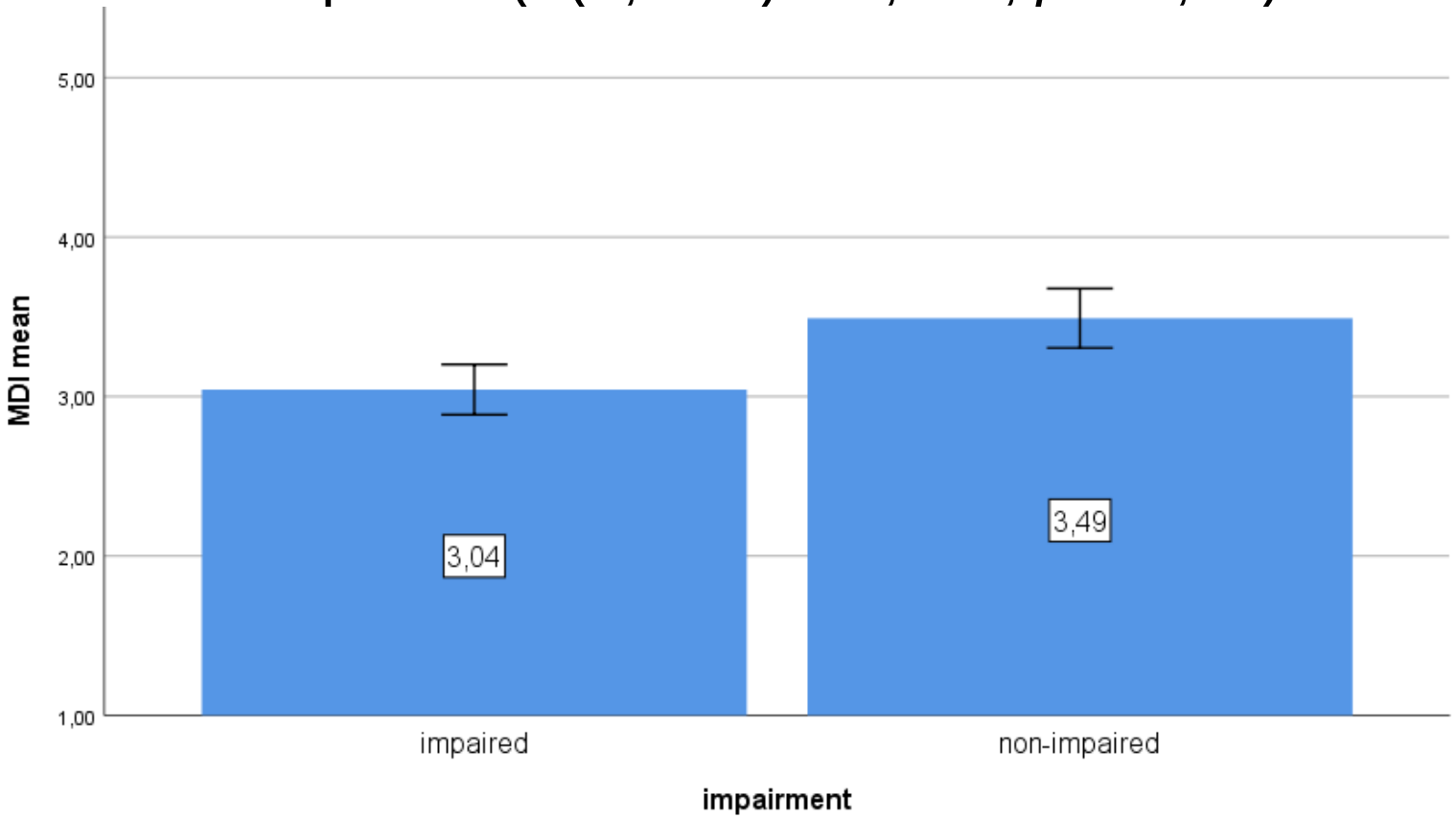
Findings
Assessment according to MDI dimensions

- All differences were statistically significant on $p < .05$



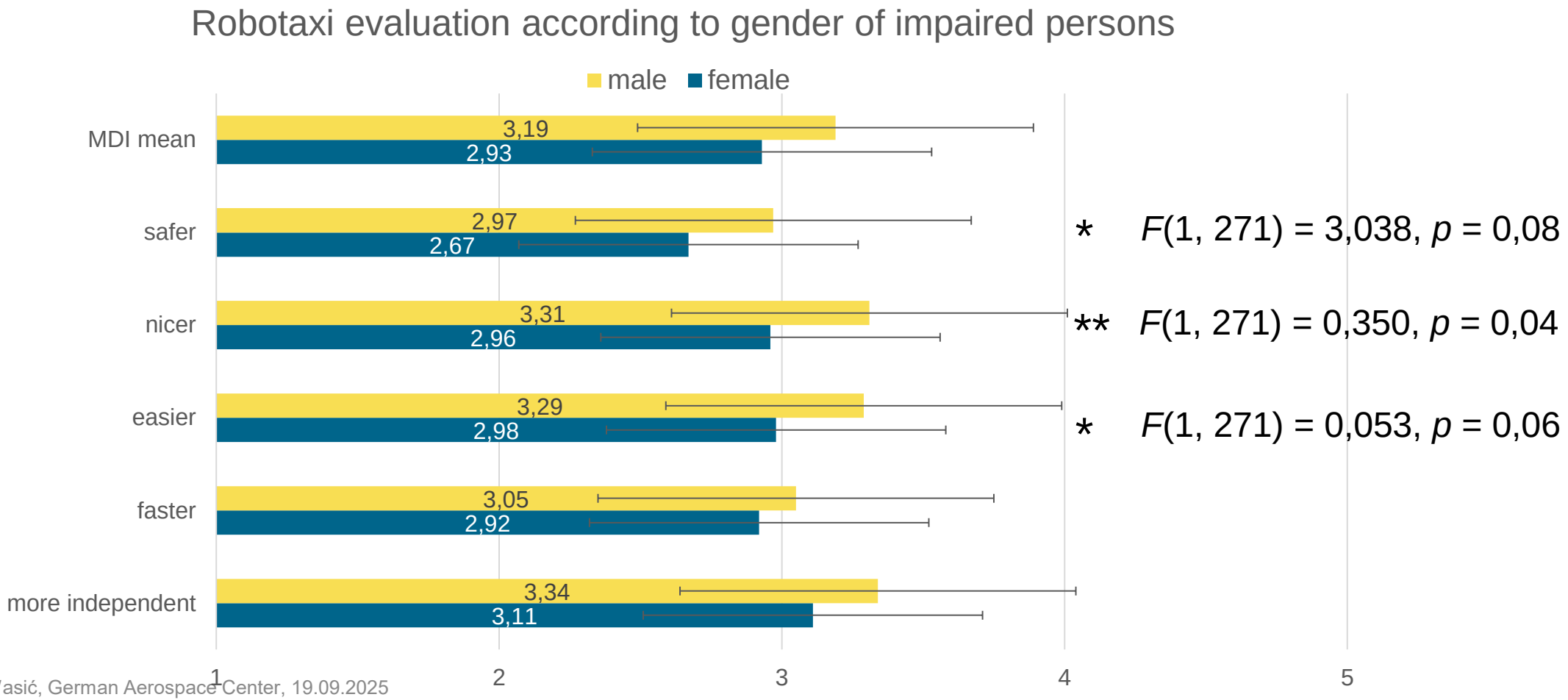
Findings
Assessment according to MDI mean

- Respondents with disabilities assessed robotaxis less favourable based on MDI mean than non-impaired ($F(1, 583) = 4{,}224$, $p = 0{,}04$)



Findings
Gender effects

- Female tend to assess robotaxis less favourable than male with regard to expected benefits for convenience and a tendency for safety and comfort.



* $F(1, 271) = 3{,}038$, $p = 0{,}08$

** $F(1, 271) = 0{,}350$, $p = 0{,}04$

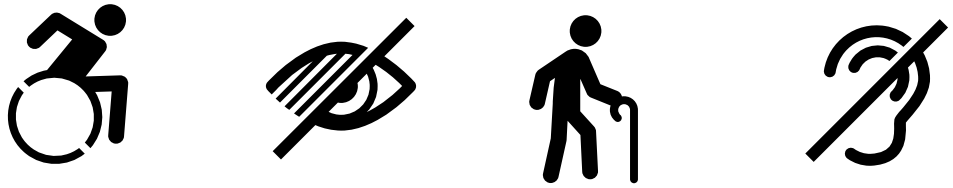
* $F(1, 271) = 0{,}053$, $p = 0{,}06$

Findings
Age effects

- A binary logistic regression showed no age effect on intention to use robotaxis ($\chi 2(1) = 0.329$, $p = .566$)
- There was no significant correlation between age and the assessment of robotaxis in terms of the five dimensions, except a tendency for younger respondents to assess benefits for independency higher than older respondents ($r_s = -.102$, $p = .093$, $n = 273$)

Findings
Type of disability effects

- Findings showed a slight tendency for people with intellectual or multiple disabilities to assess robotaxis worse in terms of accessibiliy. But no significant effects of type of disability were found.
- Possible reasons:
  - low number of respondents in certain groups (e.g. mental health issues and intellectual disabilities)



Recap of quantitative findings

- Intention to use for robotaxis was higher than for other shared mobility systems
- However, people with disabilities showed a lower intention to use and assessed them worse than non-impaired users
- People with disabilities rather perceived positive effects for their autonomy of travel but saw safety losses
- Women tend to assess robotaxis less favourable with regard to expected benefits for convenience than men
- Age and type of disability seem to play a less important role for the assessment of robotaxis

Suggestions for improvements

- Qualitative findings regarding the suggestions for improvement were analyzed using qualitative content analysis method according to Kuckartz (2016).
- Nearly 300 suggestions for improvements were analysed and clustered into 12 categories:
  - trust
  - safety & security
  - on-board staff
  - entry and exit
  - availability of accessible information
  - costs
  - travel time
  - routing information
  - availability
  - wheelchair compatibility
  - app usage
  - other accessibility issues

Categories of suggestions with examples

Trust

- Societal readiness: “*In the distant future, it may work well. Society needs to be ready for that*.“

Availability of accessible information

- Voice commands: “*Imagining it has a monitor or voice command or Alexa type.”*
- Braille information: *“A monitor for visually impaired, such as PCs, possible to connect their own braille bar to it”*

On-board staff

- Human assistant: “*As a wheelchair user, I often need help. That's not available here. Thus a human assistant on board*”

Categories of suggestions with examples

Entry & exit

- Enough time for boarding: „*That the boarding and disembarkation times be flexible to accommodate my individual speed*”
- Close stops: “*Stop no further than 200m from the apartment*”

Safety & security

- Help in emergency situations: “*Real and perceived safety particularly for women, children and vulnerable users. How to call for help or ask for assistance in the absence of staff?”*

Costs

- Affordable prices: “*The price for use should not be higher than the price for using traditional taxis*”

Categories of suggestions with examples

Travel time

- Speed: “*My experience with driverless buses is that are really slow and not really ready for normal use. If they were faster, I would definitely like to use them*.”

Routing information

- Signal tones for identification of location: „*notification when the vehicle is at the address and waiting for me to signal me through an audible signal where it is physically, so that I can detect it among other cars and get on”*
- Routing information: “*I would like to understand how to correct a possible misroute*”

Availability

- Availability in remote areas: “*To be introduced in many places, not just in big cities, as many older people live in villages, in the countryside or in small towns*”

Categories of suggestions with examples

Wheelchair compatability

- Electric ramp: “*Have an electric ramp for wheelchairs*”

Accessible app

- Alternatives to app-based booking: “*Reservation must also be possible through accessible systems: digital, but also by phone* “

Other accessibility issues

- Self-localisation: “*An app that can make the robot cab find me even when I don't know the address I'm at*”

Recap of qualitative findings

- People with disabilities strongly depend on human assistant from staff or an accompanying person → ways to replace this role must be researched and tested
- The findings suggest that accessible multi-channel information provision is essential for persons with disabilities when using robotaxis
- Thus, information transparency must be ensured in future robotaxis, e.g. by providing information on real-time routing.

Most of the suggestions for improvements, such as alternatives to app-based booking and real-time routing information, would also benefit people without disabilities.

Summary

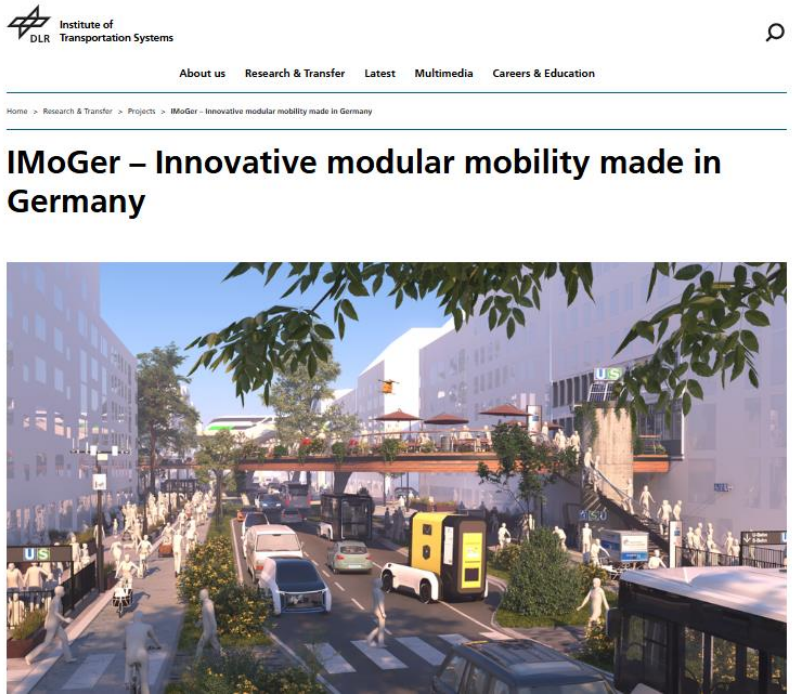
People with disabilities showed a lower intention to use and assessed them worse than non-impaired users.

People with disabilities perceived some positive effects of robotaxis for independent travel but recognized safety issues.

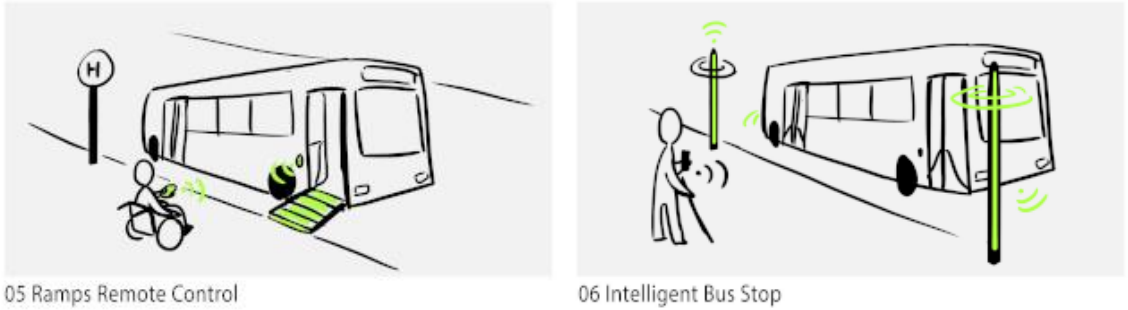
Building trust and promoting acceptance of these vehicles is needed to enhance the intention to use robotaxis.

Outlook

- People with disabilities have specific needs when using autonomous public mobility, e.g. due to the loss of personnel on-board and this needs to be researched
- We need more projects to co-design future mobility autonomous mobility solutions together with users and to bring their ideas to the streets



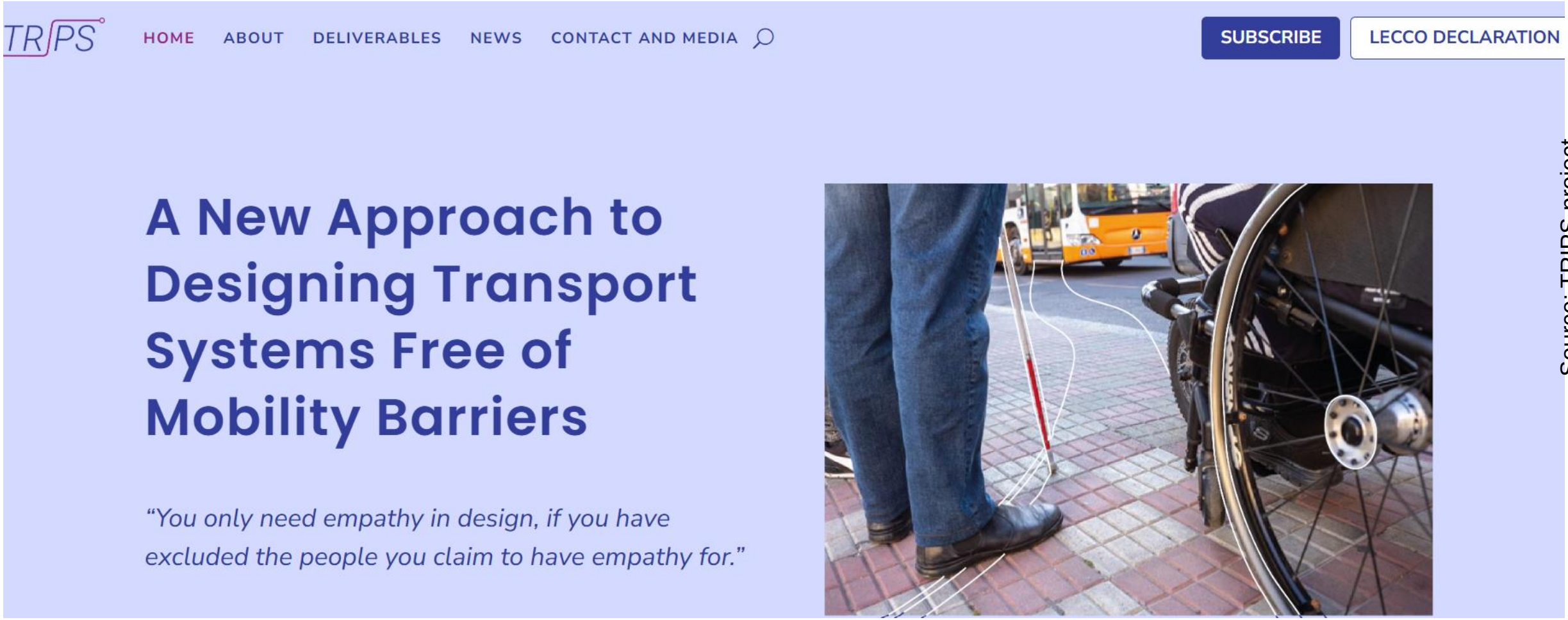
Source: DLR



Source: TRIPS project

More information

Visit project website for more information: https://trips-project.eu/



Source: TRIPS project

References

- Fraedrich, E., Beiker, S., Lenz, B., 2015. Transition pathways to fully automated driving and its implications for the sociotechnical system of automobility. Eur. J. Futures Res. 3 (1), 11. https://doi.org/10.1007/s40309-015-0067-8
- Goralzik, A., König, A., Alčiauskaitė, L., Hatzakis, T. (2021). Shared mobility services – an accessibility assessment from the perspective of people with disabilities. European Transport Conference 2021, 13-15 September
- Greenblatt, J.B., Shaheen, S., 2015. Automated vehicles, on-demand mobility, and environmental impacts. Curr. Sustain. Renew. Energy Rep. 2 (3), 74–81. https://doi.org/10.1007/s40518-015-0038-5
- Repetto, C. et. al (2020). D3.1 Report on Mobility Services Trends Impacts and Related Policies. TRIPS project. Available online: TRIPS-D3.1-Report-on-Mobility-Services-Trends-Impacts-and-Related-Policies.pdf
- Repetto et al., (2021). D4.1 MDI – Mobility Divide Index. TRIPS project. Available online: https://trips-project.eu/wp-content/uploads/2021/04/D4.1-MDI-Mobility-Divide-Index-TRIPS.pdf
- SAE (2016). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. SAE Standards J3016_201609. https://www.sae.org/standards/content/j3016_201609/

Imprint

Topic: **Sketching an inclusive mobility future for shared autonomous vehicles**

Date: 2023-09-19

Author: Dr. Catharina Wasić & Dr. Alexandra König

Institute: DLR Institute of Transportation Systems