

UNICARagil - User-Oriented Design of an Autonomous Shuttle Using Digital Human Modeling

11. Tage der Ergonomie – ecn e.V.

Friedrichshafen, 22. & 23. February

Manuel Kipp

Chair of Ergonomics, Technical University of Munich



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Autonomous Vehicle Concepts

Trends

Autonomous
Driving

Sustainable
Electric Drive

Interior
Concepts

- New interior concepts for SAE Level 5
- Non-driving related activities such as working, relaxing and eating
- Shared and flexible mobility
- Reduction of CO₂ Emissions of electric vehicles



Source: emobilitaet.online/news/forschungsprojekte/



Source: <https://derletztefuhrerscheineuling.com/2018/09/13/volvos-autonome-konzeptfahrzeuge/>

Aldenhoven, Aachen



Konsortium

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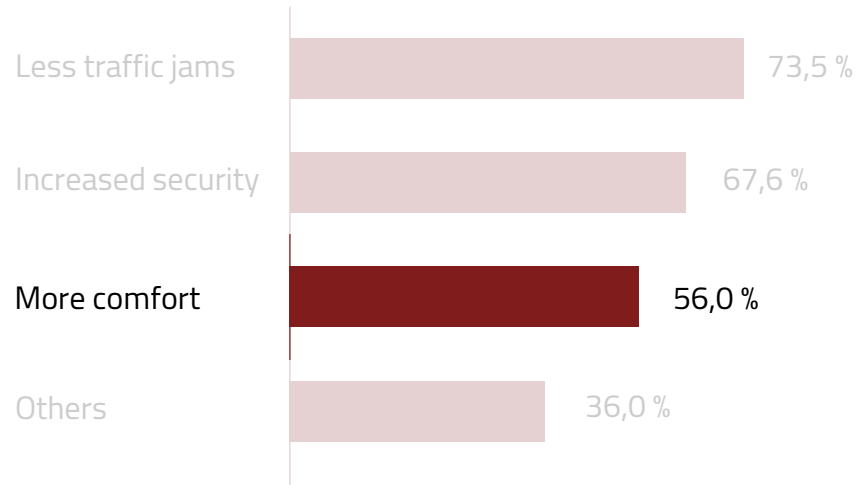


Universität Stuttgart



Overall Survey

What advantages do you expect from autonomous vehicles? N = 619

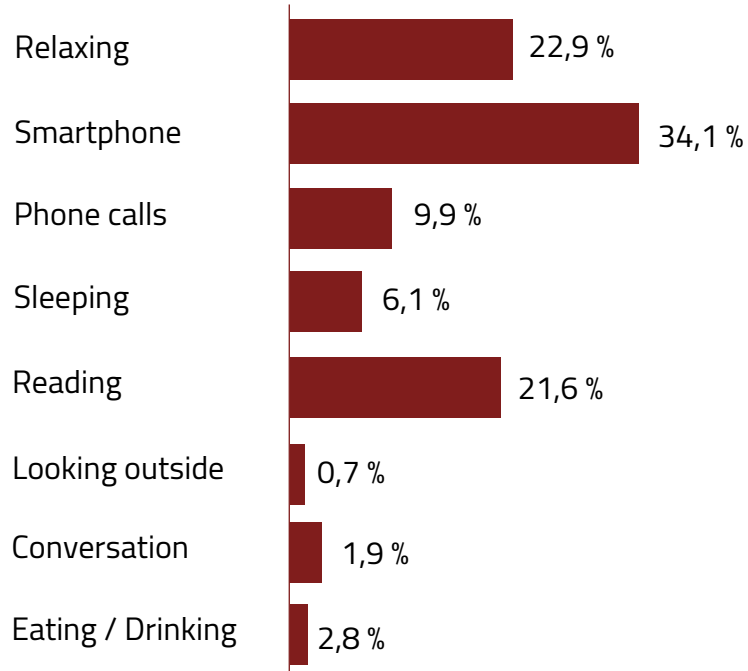


Other mentions (in descending order of frequency):

- More effective use of time during the journey
- Environmental friendliness
- Stress reduction
- No more searching for a parking space
- Cost reduction
- Space savings (e.g. parking spaces), as not everyone has one or more vehicles anymore

Overall Survey

Which activities would you like to pursue in a cab in the future? N = 619



Additional wishes for customized interior equipment at this point:

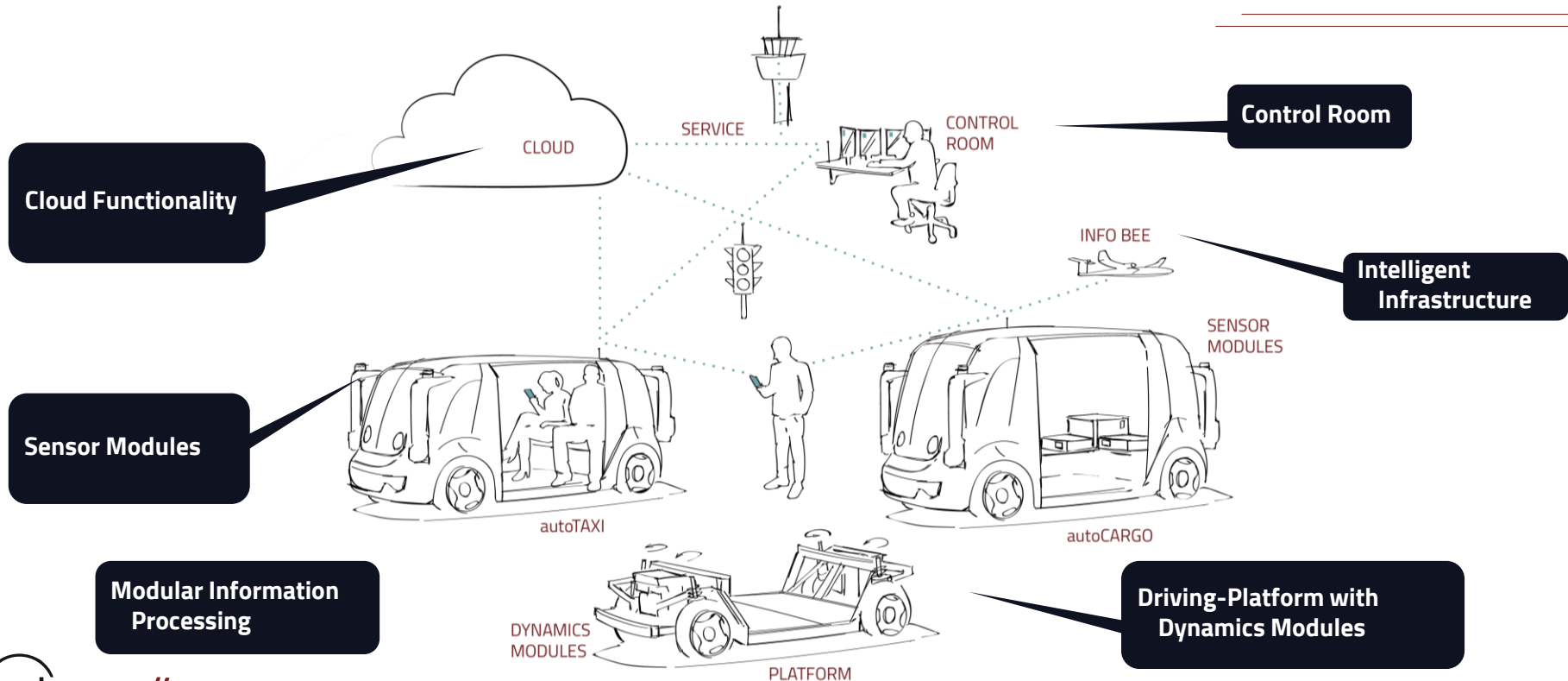
- WiFi hotspot
- power socket
- spacious interior (also suitable for the disabled)
- additional information about the journey (journey duration, price, time, arrival time)
- news on request
- control of music selection
- TV/streaming service offer
- integrated tablet (games/work)

UNICARagil – das Projekt



- Four fully automated vehicles
- Modular

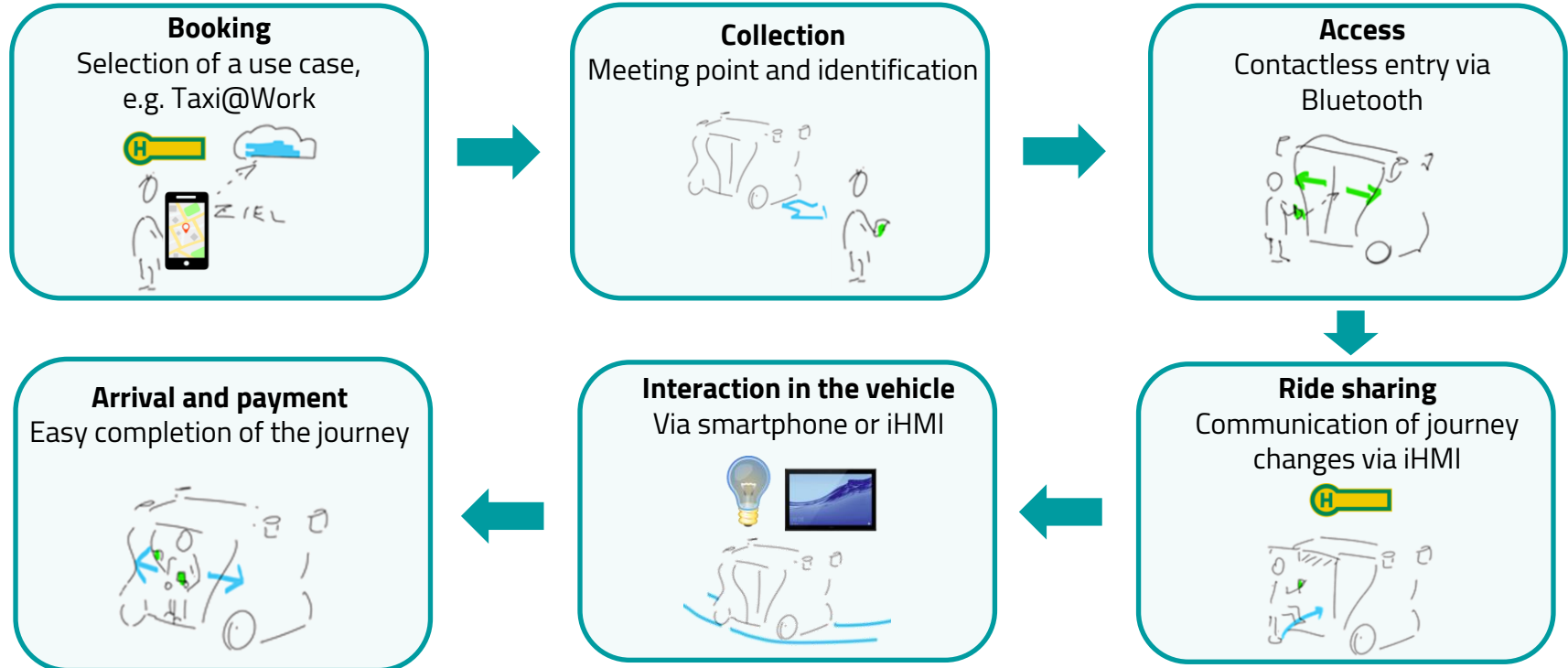
Overall System



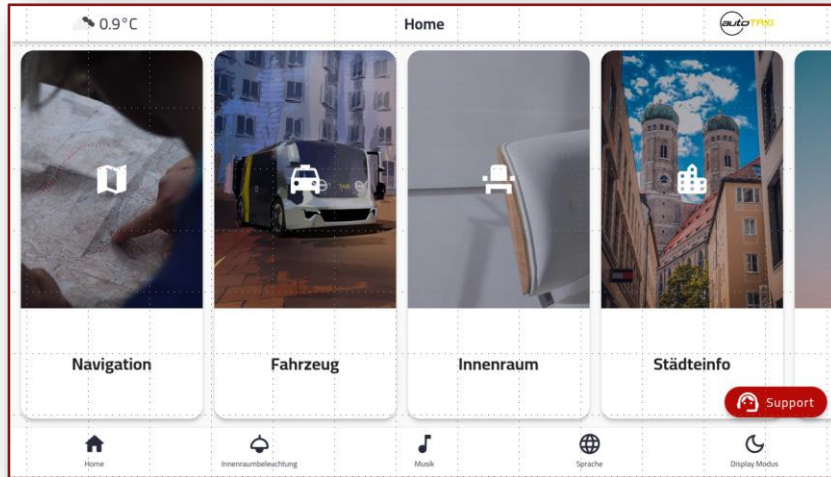
Automatisiertes Mottotaxi



Internal Communication



Internal Communication



Personal journey information can be called up in two ways:

- iHMI - tablet on the driver's seat
- App - on the personal smartphone



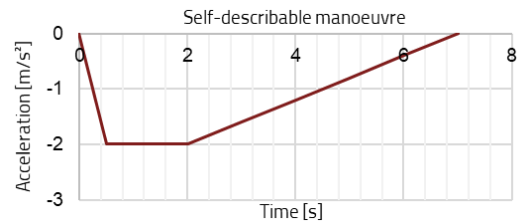
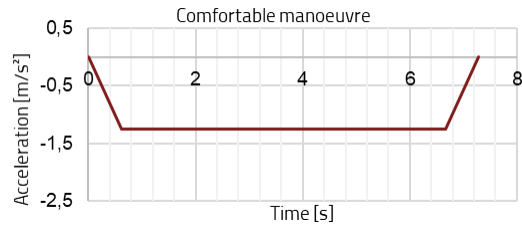
What information/functions does the user want during, before and after the journey?

How can this information be presented in a user-friendly and appealing way?

External Communication

How can you communicate with other road users?

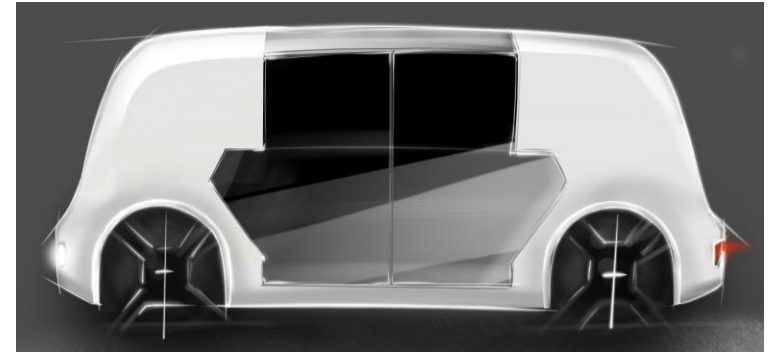
Implicit Communication with dHMI



Examples:



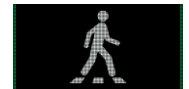
Explicit Communication with eHMI



Stop is approached



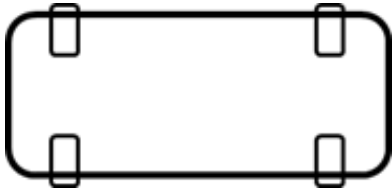
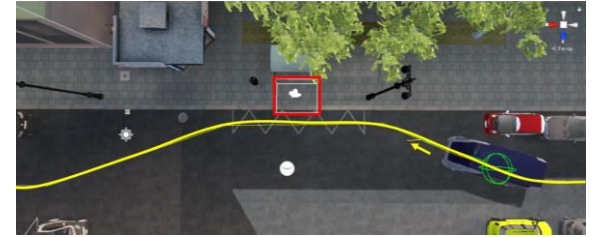
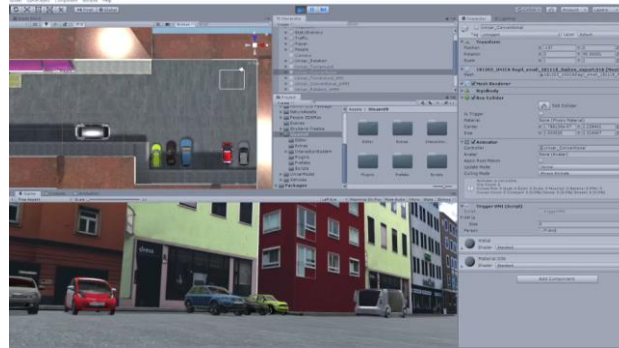
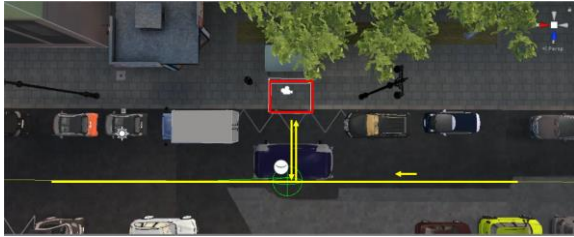
Door closes



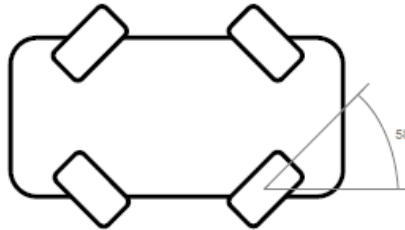
Stop is approached at a 90° angle

Pedestrian crossing

Trajectories



Counter-rotating all-wheel steering
with a steering angle of 90°



Turning manoeuvre Rotation
(turning angle of 58°)



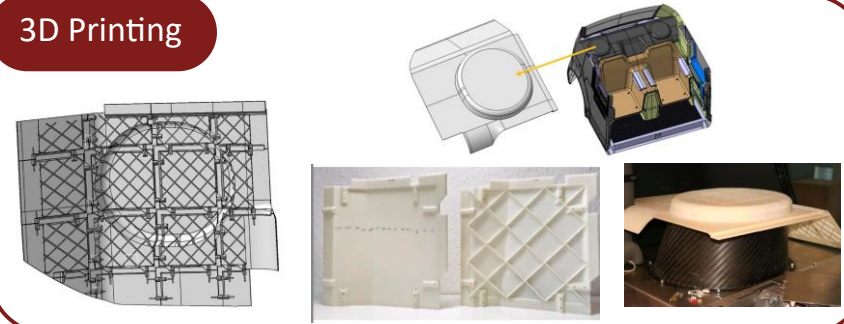
Classic front axle steering

Interior Design

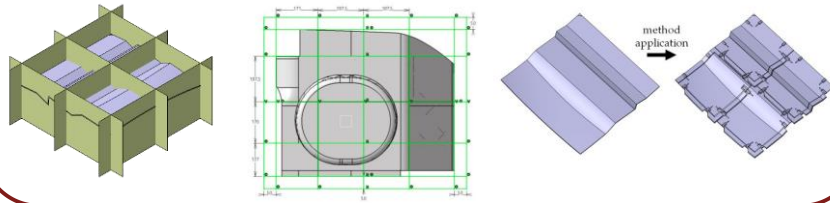
Design



3D Printing



Segmentation and Hybrid Joining of Additive Manufactured Segments



Assembly



Design Concept

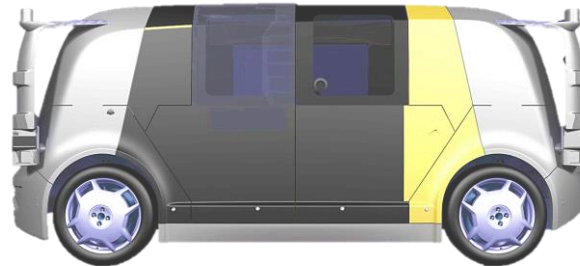
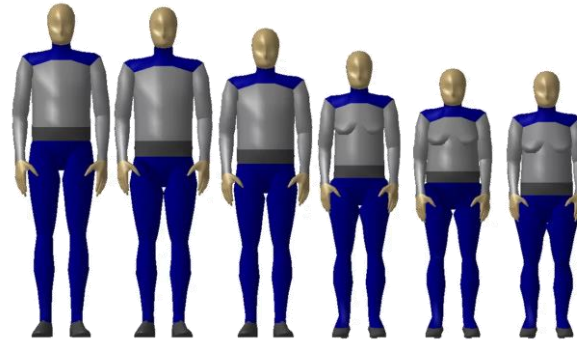


- A total of four seats
 - two fixed main seats in the direction of travel
 - two additional folding seats
- Seats designed according to ergonomic criteria
- Adjustable backrests
- Fold-out work surfaces

Interior Design with RAMSIS

Input

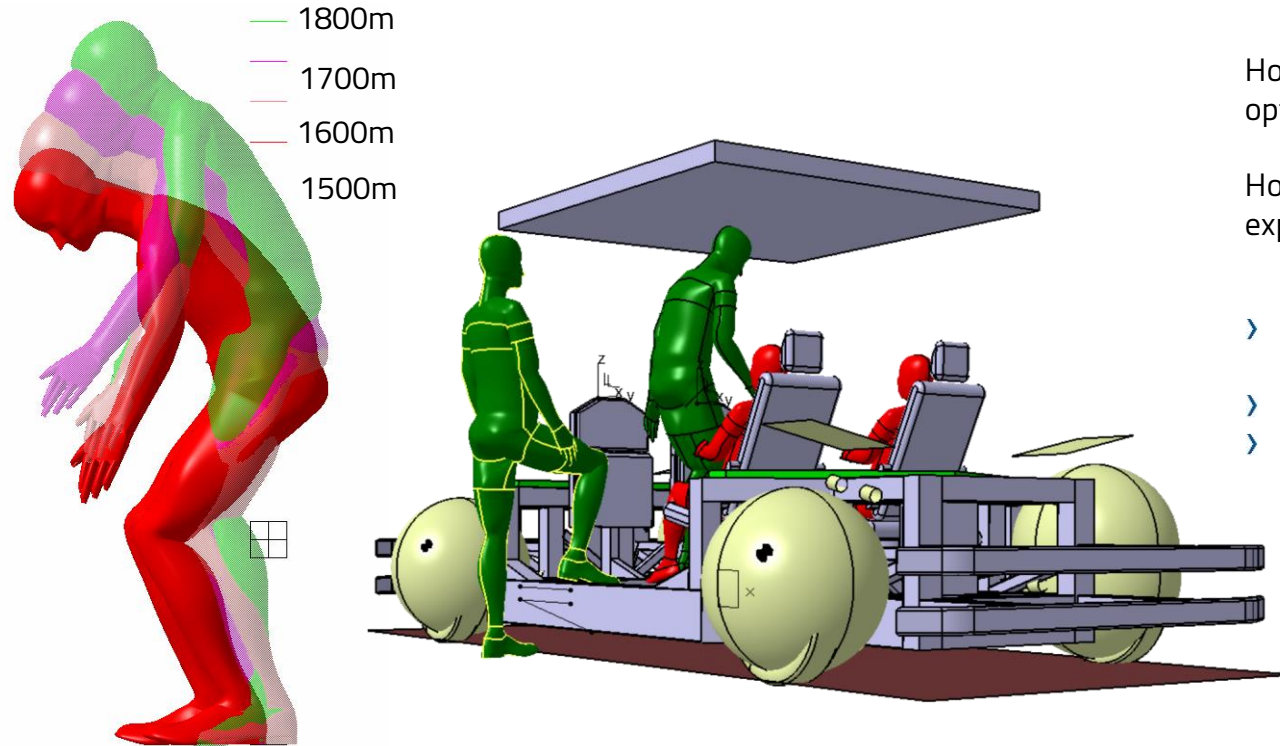
- Geometrical Set
- Anthropometry
- Task
- Test collective



Output

- Anthropometric characteristics
- Posture
- Field of view
- Grasping envelope
- Visualization

Interior Design with RAMSIS



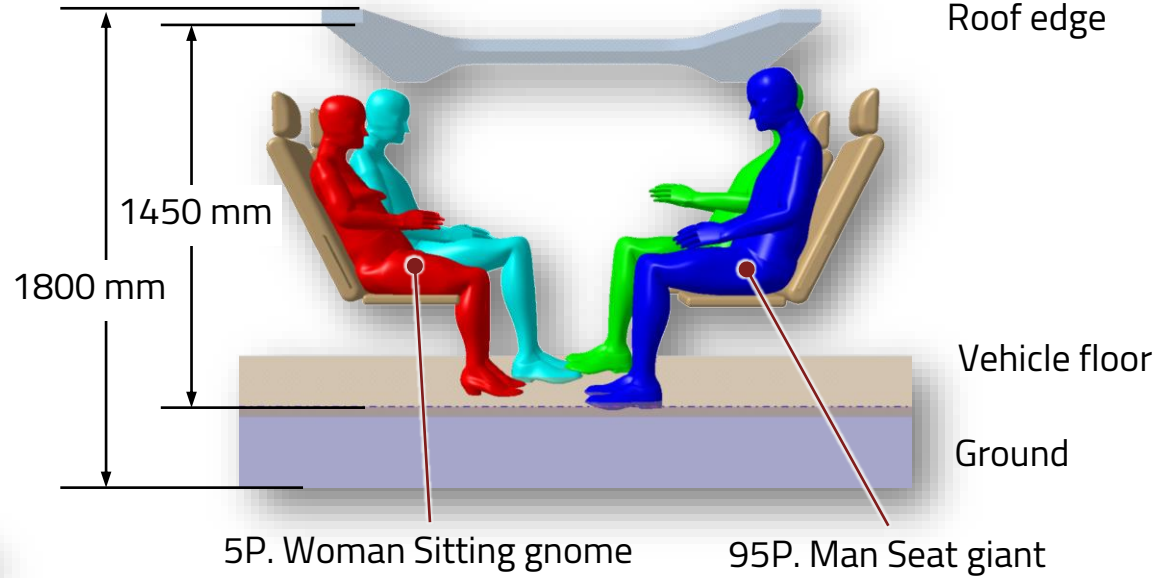
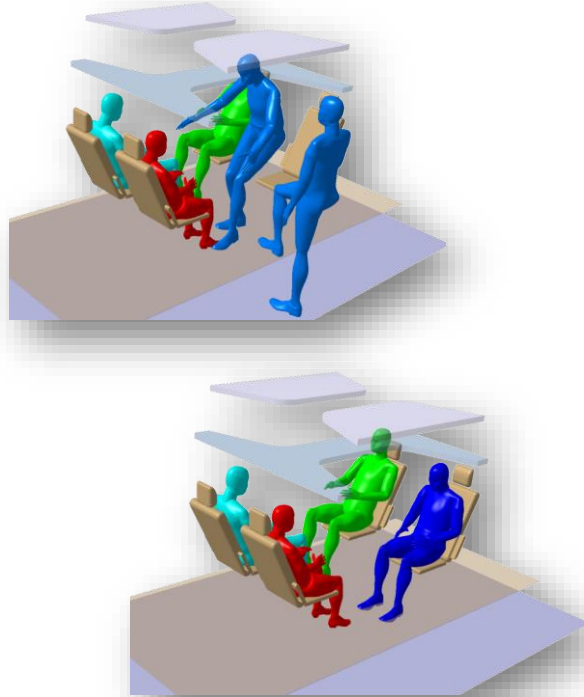
How can the available space be optimally utilised?

How can passengers have a positive experience in the autoTAXI?

- › Design range 5th percentile woman to 95th percentile man
- › Comfortable access
- › View to the outside

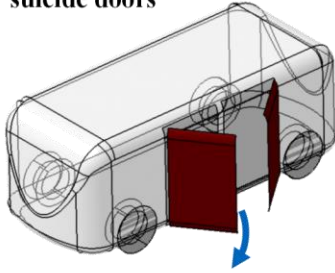
Sill height → 360mm
 Ground clearance → 140mm
 Battery → 180mm

Interior Design with RAMSIS

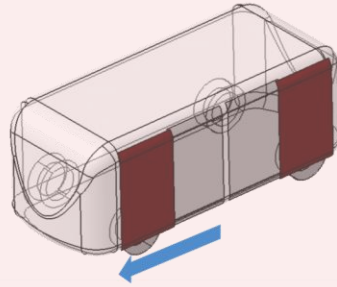


Door Kinematic

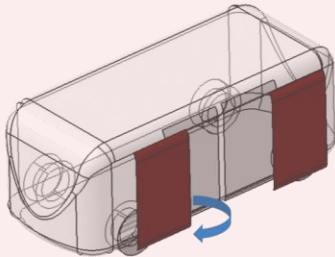
Conventional doors/
suicide doors



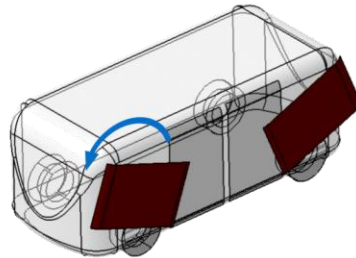
Sliding doors



Coach doors



Scissor doors



Online Survey

Sample:

N= 181 Participants, (66 female, 84 male, 31 divers), $\bar{\mu} = 33,52$ years with $\sigma = 14,64$

Research Questions:

- What are passengers' expectations regarding the seating environment in an autonomous autoTAXI?
- Which features do passengers use in the seating environment during different driving situation?

General Questions

Use of the autonomous working taxi

Vehicle condition and demand

Expectation and needs regarding the seating environment

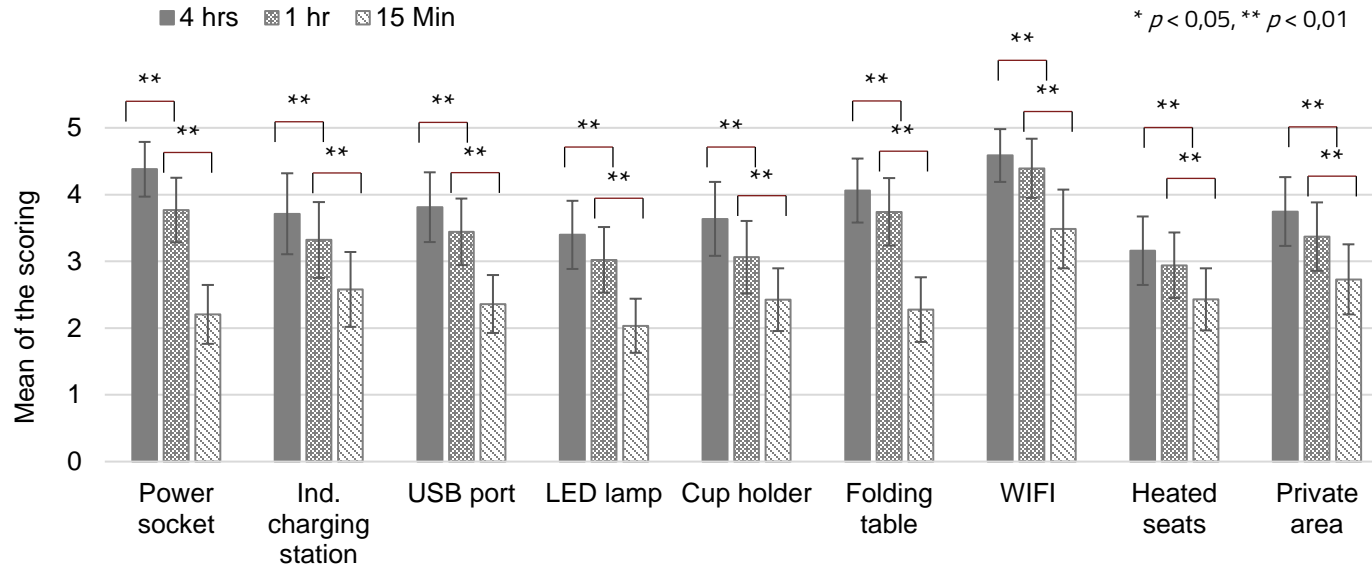
Personal feeling

Purpose & duration
of the trip

Factors

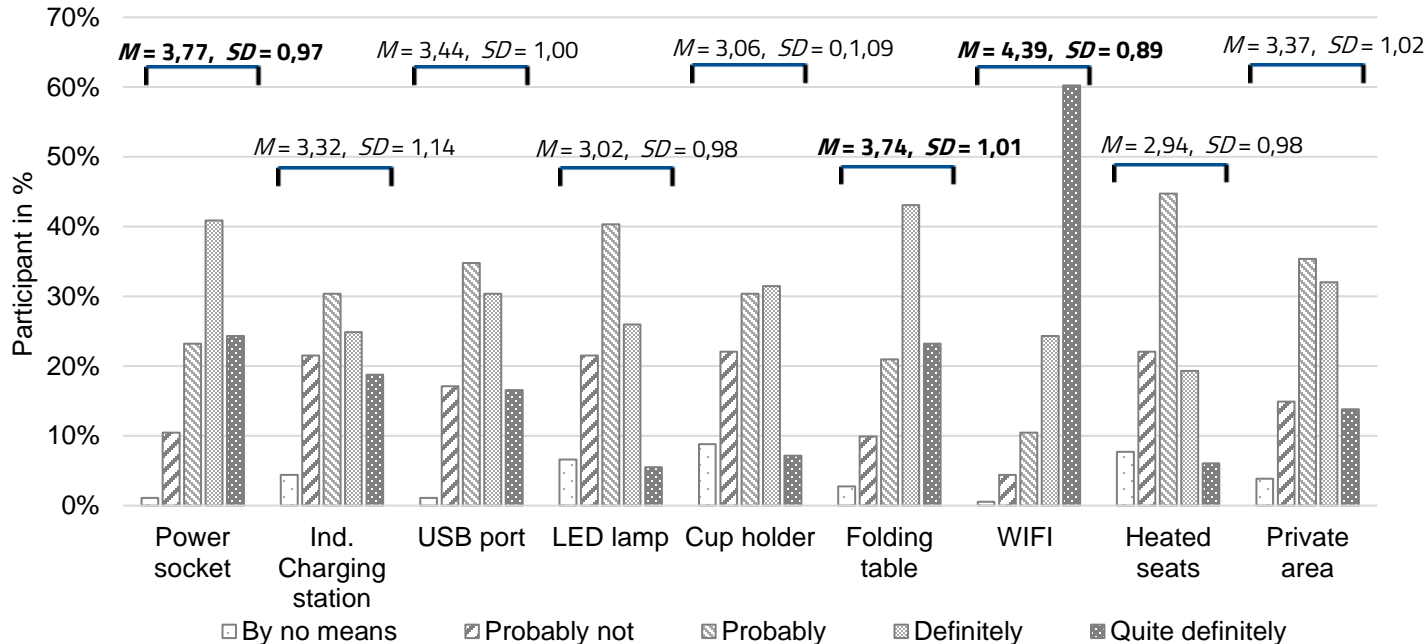
Soziodemographic factors

Expectations according to the trip duration



- Results are strongly dependent on trip duration
- For a 15 minutes trip a cup holder is more used than a folding table
- For longer trips a power socket is more chosen than USB ports for charging

Passengers' expectations on the autoTAXI



- One hour trip with the autoTAXI
- Possibility for using WIFI ist most voted
- Power socket and folding table is also important
- Heated seats and LED lamp are in casual use

Equipment elements

Equipment elements	Overall	Female	Male	Conventional Vehciel	autoTAXI
WIFI	82 %	85 %	82 %	(Yes)	Yes
Power socket	65 %	64 %	65 %	-	Yes
USB ports	61 %	55 %	61 %	Yes	Yes
Folding table	54 %	58 %	57 %	(Yes)	Yes
Waste Garbage can	41 %	44 %	37 %	-	-
Storage space	36 %	32 %	39 %	Yes	Yes
Private area	34 %	36 %	32 %	-	-
Heated seats	33 %	33 %	30 %	Yes	Yes
Inductive charging	33 %	29 %	35 %	Yes	Yes
Cup holder	30 %	35 %	27 %	Yes	Yes
LED lamp	27 %	27 %	30 %	-	-
Snack fridge	3 %	2 %	1 %	-	-
Cigarette lighter	2 %	2 %	2 %	Yes	-

Integration in the vehicle environment

Conclusion Survey

Expectations on the seating environment

- Most important aspect: seat comfort
- Sustainable materials less important for the seating environment
- Features like WIFI, USB Port, Power socket and folding tables important

Use of the equipment features

- All equipment elements can be used appropriately from a driving duration of one hour
- Positioning mainly coincides with the placement in the autoTAXI (except for power socket)
- The purpose, the duration and the private sphere of the trip have an influence on the use of the devices

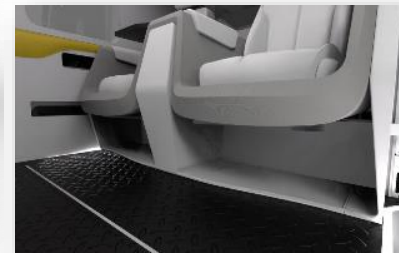
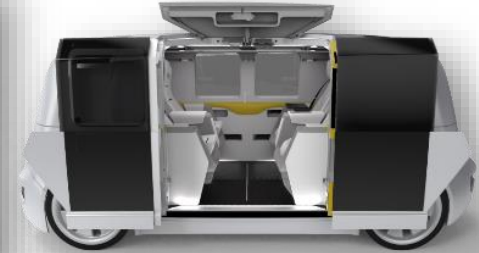
Design Surfaces



Folding seats



Comfortable Entry



Storage space

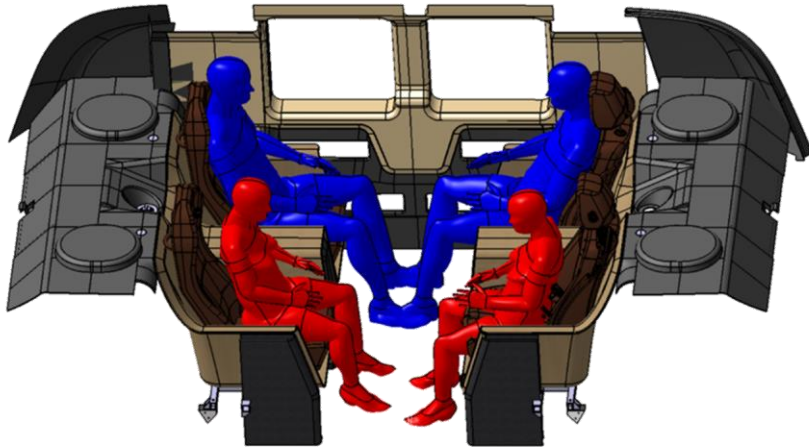


Main business seats

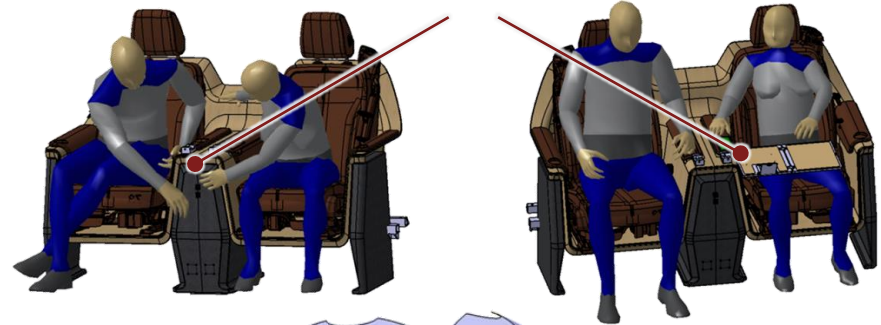
Seat Environment

Ergonomics analysis with RAMSIS™

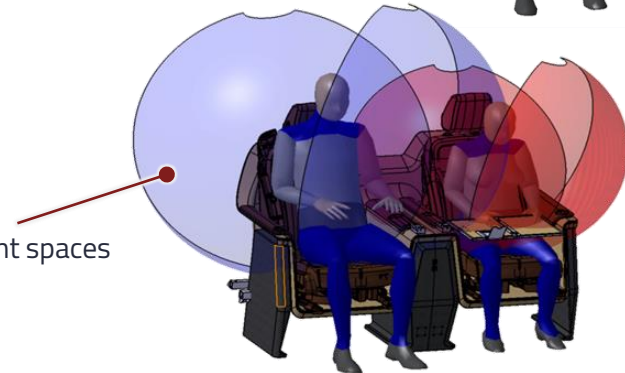
Seat constellation



Integrated features in the seating environment

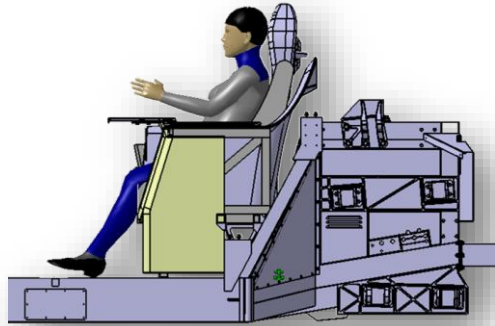


Movement spaces

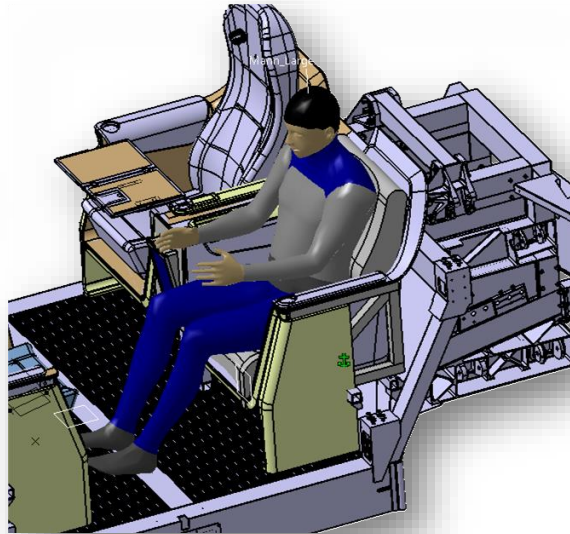
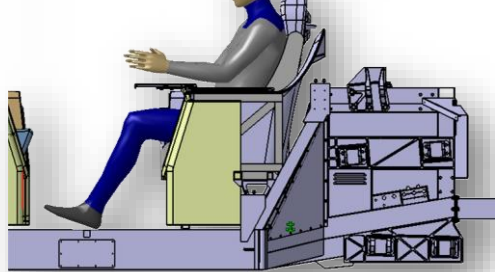


Seat Environment

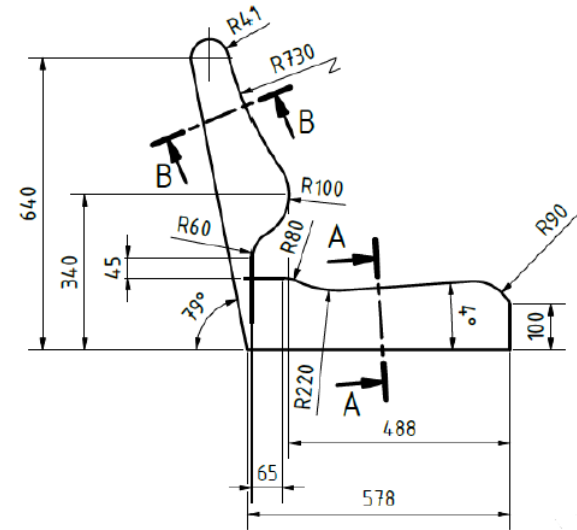
5.P Woman



95.P Man

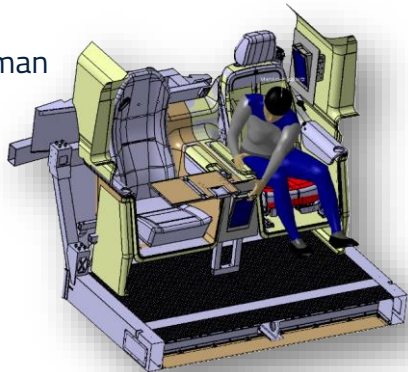


Design – Handbuch der Ergonomie (Schmidtke)

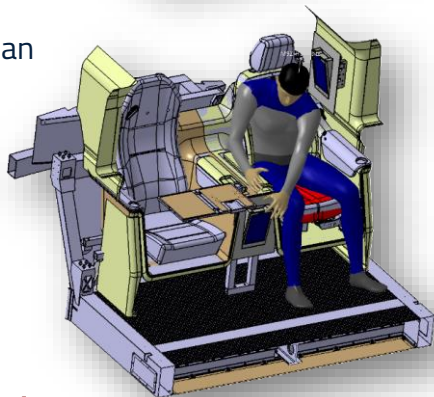


Seat Environment

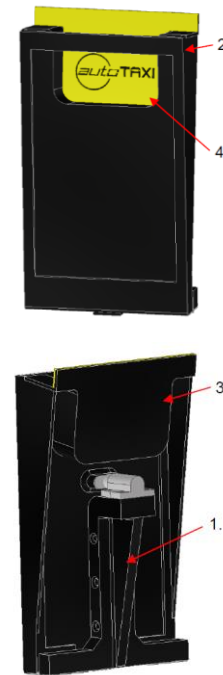
5.P Woman



95.P Man

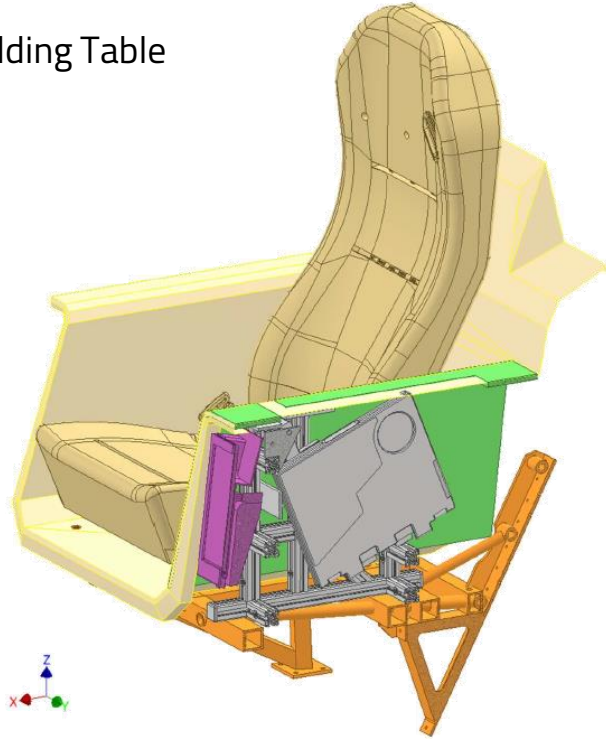


Prototype:

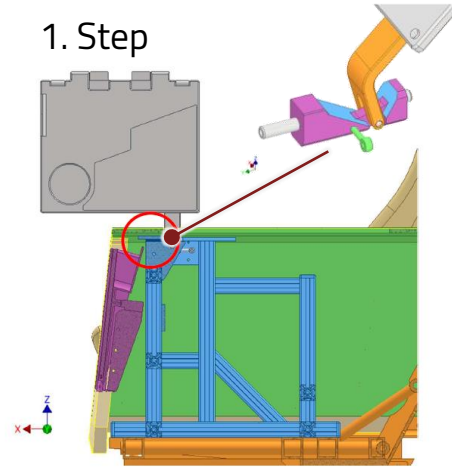


Seat Environment

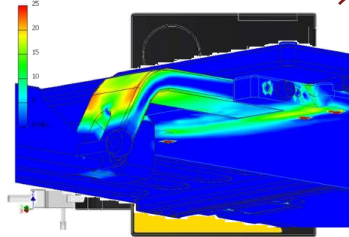
Folding Table



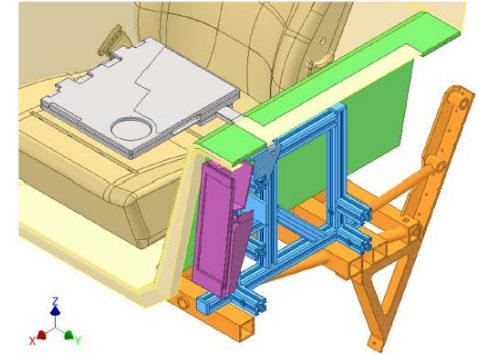
1. Step



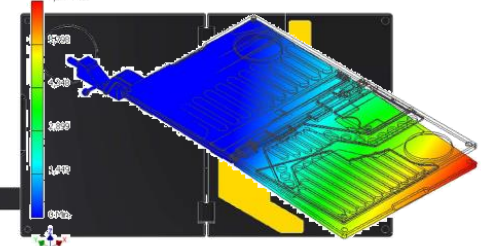
Typ: Von Mises-Spannung
Einheit: MPa
30.11.2022, 21:40:01



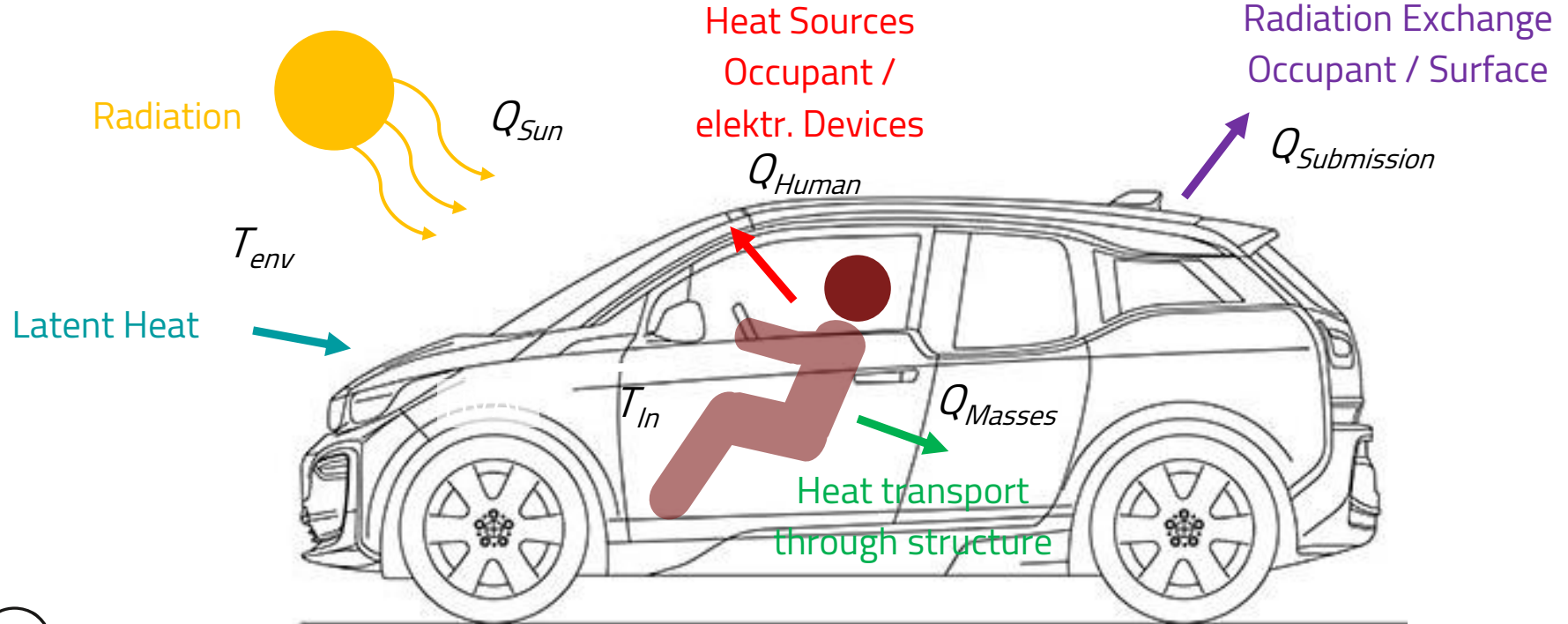
2. Step



Typ: Verschiebung
Einheit: mm
30.11.2022, 21:45:25
7,247 Max.



Thermal Comfort

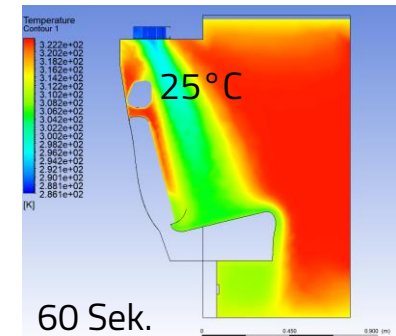
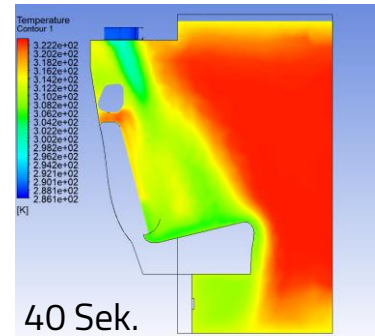
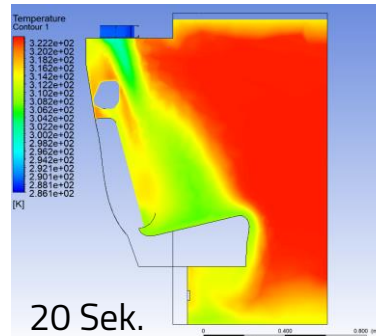
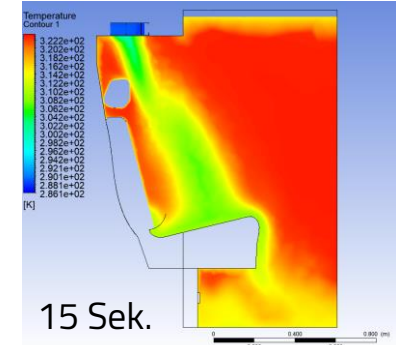
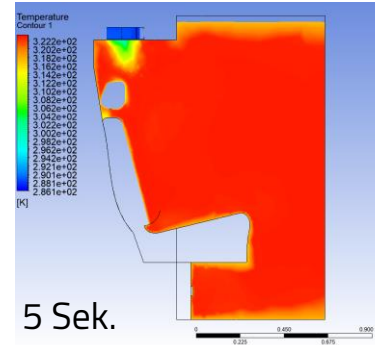
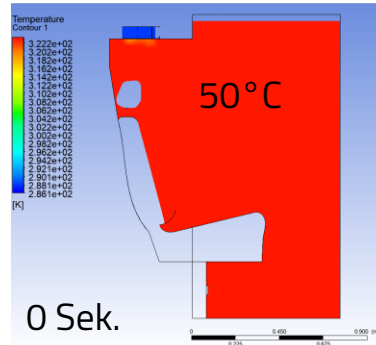
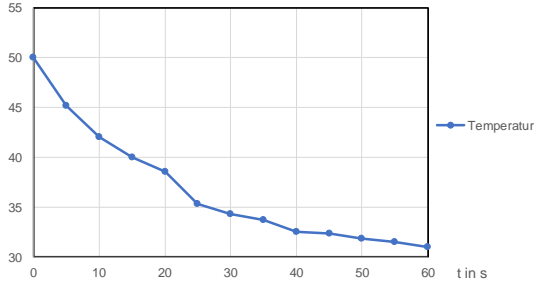


Thermal Comfort

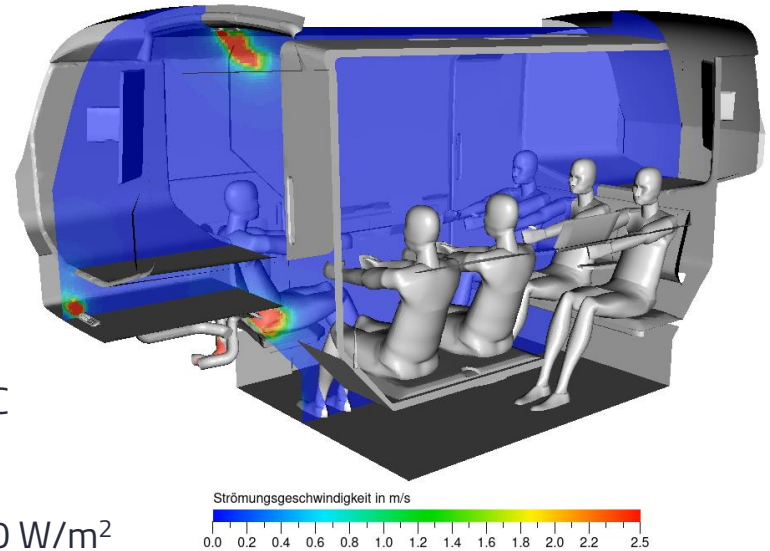
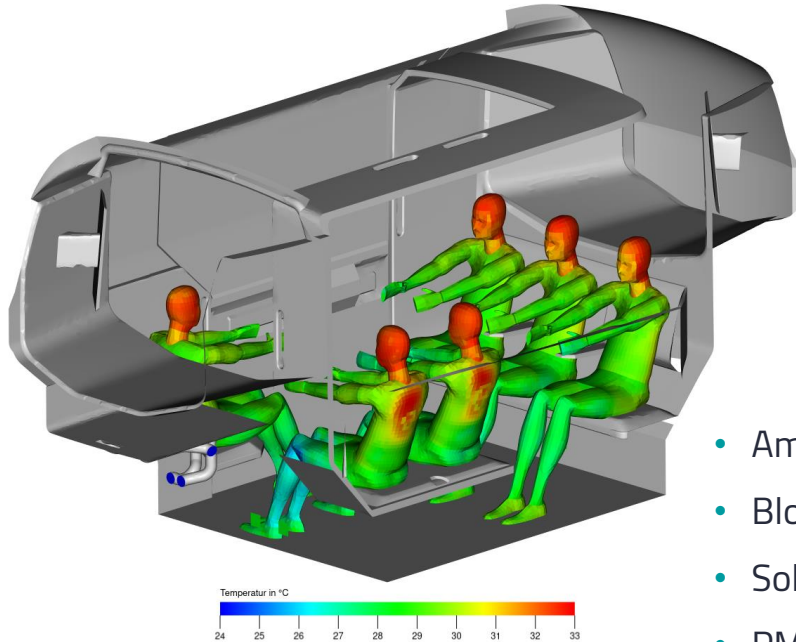
Simulation of a Pull Down:

- Boundary Conditions:
 - 50°C Interior Temperature
 - 15°C Outlet Temperature
 - Velocity: 5 m/s
 - Time step $\Delta t = 0.02$

T in °C



Thermal Comfort



- Ambient: 30°C
- Blower: 33%
- Solar load: 800 W/m²
- PMV/PPD: -0,4 bis 0, 5-8%

Prototyping

Malve Research at FH Salzburg

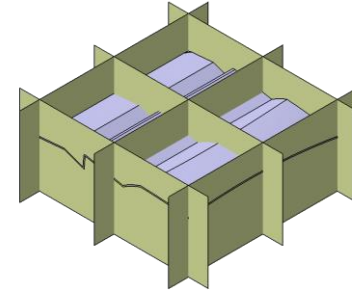
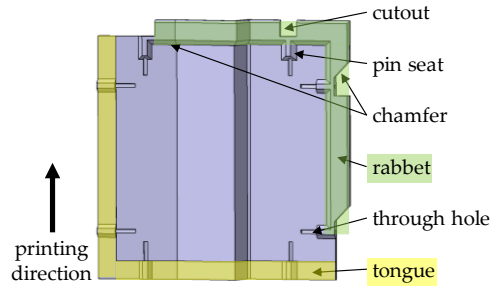
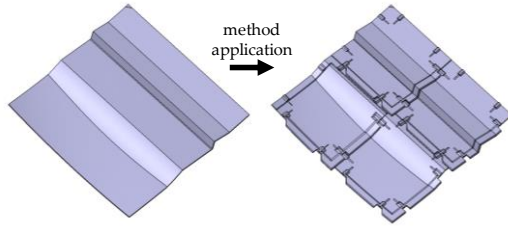


Integration as seat shell

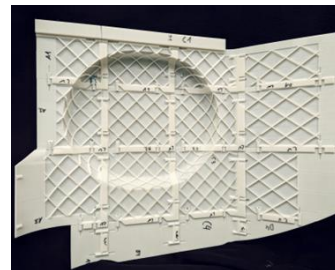
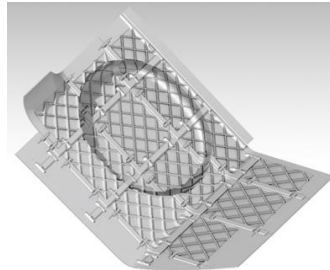
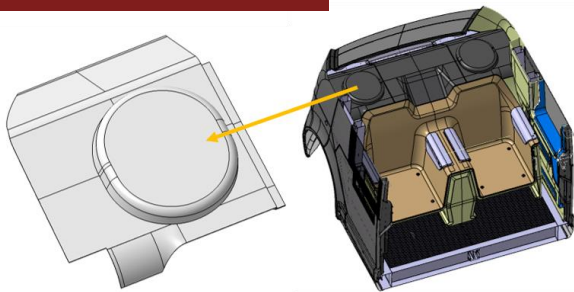


Prototyping

Segmentation and Hybrid Joining



3D Printing + GFK



Prototyping

Assembly



Final Interior

Finale Event, Aldenhoven, Aachen



Approved



Team



When?

Now

Level 5 Truck



<https://ecomento.de/2023/06/14/tesla-semi-wird-wohl-nicht-vor-ende-2024-in-groesseren-stueckzahlen-gebaut/>



eVTOL

2024

2030

2040 +

?



<https://group.mercedes-benz.com/innovation/produktinnovation/autonomes-fahren/systemgenehmigung-fuer-hochautomatisiertes-fahren.html>



Level 3



Level 4

<https://mindy-support.com/news-post/level-4-autonomous-vehicles-where-are-we-now-and-what-can-we-expect-in-2022/>



Level 5 ODM



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Thank you for your attention.
Any Questions?

