Master's Thesis
Sofia Lewandowski

Interaction Design
College for Creative Studies, Detroit

Thesis topic:
Inclusion and personalization
for autonomous mobility.

Proposed by: Sofia Lewandowski

Supervisor: Paul Pangaro
Advisors: Conrad Albrecht-Buehler (BMW Designworks),
Dat Truong (P3), Paul Green (UMIC), Ray Smith (Detroit
Government Affairs Associate) and Aaron Harris (Zan Mgt.)

Thesis beginn: Sept 9th 2017 | Deliverable due day: March 26th, 2018

Inclusion and personalization for autonomous mobility.
IXR - Individual eXperience Room.

Proposed by: Sofia Lewandowski
Major: Interaction Design
Student ID: 603479

Supervisor: Paul Pangaro, Chair of Interaction Design Department at College for Creative Studies, Detroit

Advisors: Aaron Harris (Zan Mgt.), Ray Smith Blast (Detroit Government Affairs Associate), Conrad Albrecht-Buehler (BMW Designworks), Dat Truong (P3), Paul Green (UMIC)

Thesis start day: **Sept 9th, 2017**
Thesis Due Day: March 26th, 2018

Acknowledgement

I would like to thank all of my supporters and advisors along the thesis development.

FH Joanneum and Marshall Foundation gave me the chance and support to participate in the exchange program with College for Creative Studies in Detroit and work on this thesis project.

College for Creative Studies and my supervisor Paul Pangaro supported me in the thesis concept development.
They made sure I got appropriate academic support. They made it possible to have freedom to decide which classes will best support the thesis.

A special "thank you" is addressed to Aaron Harris who introduced me to VR and different user interfaces in VR games. He always was available for any kind of advice, brainstorming sessions, support in the development and availability of necessary equipment. Aaron worked on the VR execution of the project for later concept introduction to the wider audience.

Ray Smith, a brand manager and a person with mobility challenge reviewed the thesis concept and gave his constant professional advice and feedback. He organized User Testing with a wide variety of disabled people in the Rehabilitation Center.

Conrad Albrecht Buehler gave his professional opinion on the project realization from his automotive perspective.

FH | JOANNEUM
University of Applied Sciences

Home University
FH Joanneum
Alte Poststraße 149,
8020 Graz, Austria

CCSMFA

Exchange University
Graduate Studies Department
College for Creative Studies
201 E, Kirby
Detroit, MI 48202-4034

**AUSTRIAN
MARSHALL PLAN FOUNDATION**
VIENNA | AUSTRIA

Marshal foundation Scholarship
Austrian Marshall Plan Foundation
Marschallplan Jubiläumsstiftung
Walcherstraße 11A
1020 Wien
Austria

Table of contents

1. Introduction

- Vision
- Abstract
- Design process

2. Empathize

- Target group
- Universal Design
- Focus group
- Research results

3. Define

- Research conclusion
- Needs and goals
- Persona and environment definition

4. Ideate

- Idea development
- Final concept
- Business case
- Why VR?

5. Prototype

- Overall concept
- Analysis
- Journey map
- VR scene
- UI development

6. User Journey

7. User Testing

8. Summary and conclusion

8. Poster

10. Appendix

Content

1. Introduction

- Vision
- Abstract
- Design process

The concept is meant to create a **VISION** of how future **autonomous transportation** will support **inclusion** through personalization.

- Autonomous
- Inclusive
- Personalized

#Dog lover room

#Piano room

#Office room

All
Cathegories
Samples ×

piano room
21 ★★★★☆

office room
89 ★★★★★

dog lovers
2 ★★★☆☆

Abstract

Pitch
The thesis is meant to create a VISION of how future autonomous transportation will support inclusion through creation of personal spaces. Universal design is not a perfect solution - "one size fits all". Universal design is an approach and a goal. Creating a single product solution would restrict user in his opportunities. Designing an environment for user to create will enable him to define his personal spaces for his special needs.

Description
In the year 2030, fully autonomous vehicles (AVs) will be the main transportation method in major mega cities. The cities have no patience for traffic jams and accidents caused by humans. They will only allow full autonomous mobility of level 5 inside of cities. Vehicle accidents will be reduced by 99%.
This assumption will allow the creation of discretionary spaces inside of vehicles. Autonomous vehicles will be classified as Recreational Vehicles (RVs) with automobile experience.

The concept will work as follows: The companies will provide different platforms/packages. The users will pick one of the provided vehicle sizes (packages) and create their own experience rooms (interior spaces) on wheels with help of professional AI assistant, that will guide them through the creation process and ensure the newly purchased objects will have safe positions.

The generative design will give users variation on products and attach the products to the car interiors so that they will pass the safety tests. The interiors will be built in virtual reality.

A virtual environment for users with special needs will be created to enable them to define their own experience rooms on wheels. Virtual reality is a tool for the creation of personal spaces in autonomous vehicles. The virtual pallet with choices of options and the AI assistant leads the user through the creation process.

The creator "walks" through the virtual shops without dealing with crowds and without mobility challenges. The customer will be able to DO instead of verbally explaining what he needs.

The user will be able to create his own room for his special needs like he/she does for his/her personal living room at home.

The approved 3D model will be generated and sent out to 3D printing factory. The self created vehicle will be ready the next day.
Once the user creates an extension of his home he will spend more time inside traveling around while working on his projects or just work from his office on wheels on the riverfront with a wonderful view. When the user isn't using his vehicle while at the office he/she could rent it out like an accessible airbnb room.

Improving the quality of life

The thesis supports Inclusion for people with mobility challenges in 21st Century Mobility. One of the thesis advisors Ray Smith was injured after a motorcycle accident and lost his ability to walk. The inclusion topic became very personal for him. He is convinced that accessible and enjoyable autonomous vehicles will **improve the quality of life of disabled people**. A lot of disabled people experience every day challenges, disappointments and rejections. Even if it is "just" an inaccessible subway without an elevator forces people with mobility challenges turn around, look for other opportunities to reach their destinations or go back home. It costs their time and energy. Every disabled person has experienced depression at least once in life. The world's inaccessibility forces a lot of people with limited abilities to stay at their homes and be partially or fully isolated from society.

People without any disabilities enjoy riding bikes, swimming or jet skiing. Ray says: "I love riding bikes but after my accident I am not able to do it anymore. I am an active and energetic person. I had to be creative and find my ways to enjoy life in a different way. I had to find new hobbies." There are not many opportunities because the world does not spend much time on designing disability friendly spaces, products or environments.

Abstract

Ray wishes for the whole disabled society to be more independent, enjoy travel experiences and improve quality of their lives.

We as designers have the responsibility to know accessibility issues and include the solutions into our designs from the beginning. Accessible products can also be sexy when they are not add-on features.

Designing for disabled society is designing for ourselves. Being temporarily sick, being a child with limited abilities, old or pregnant can all be considered as disability. Anyone can become disabled, is disabled right now or will gain a disability while aging.
The goal is to bring disabled society out of loneliness, depression and isolation. The goal is to get them out and give them special mobility experience. Entertainment, business and home experience while traveling will improve their perception of the outside world and let them participate in life events as any other people do.

Why designing the world more accessible.

With the trend toward privatization of services, like Uber and Lyft instead of yellow cabs and people staying in Air BnBs instead of hotels, people with mobility challenges can't mostly be a part of it because of private inaccessible offerings. People with disabilities who will create their special and accessible interiors will be able to rent our their homes on wheels to other people with similar challenges while not using them.

Even if a person without a current disability will build his own interior on wheels the VR system in the "Individual Experience Room" **(IxR)** project will remind him to build in some accessible features so that he could rent out his vehicle to anybody. It will also remind a user that the accessibility is something he or his family might need. Elderly people, parents with strollers and children will benefit from accessibility features built in in the vehicle from the beginning. Once the user realizes that he needs an additional accessible feature it won't have to be an added on and ugly designed feature but will be integrated in the interior through generative design from the beginning.

Victor Calise, Commissioner at New York City Mayor's Office for People with Disabilities: "The biggest challenges in these plans and programs are costs. If we look at civil rights, changing programs, and services…it all comes with a price tag. Interpreters, hearing loop systems, ramps: they all cost something! But if we think about it in a strategic way and make it part of the process, we can do better. We're making sure it is included in all of our requests for proposals.
There are 800,000 people or 10% of the population in New York with disabilities not counting elderly people. If we will design more accessible life, so many more people could participate which could also boost the economy.
Sometimes access isn't done in a thoughtful way. I remember an issue where a lot of public housing had installed accessible features in people's apartments like wider door frames and grip bars, but that the buildings themselves didn't have functional elevators or ramps, so people ended up virtually trapped in their accessible apartments. Building new is relatively easy. If you don't think about the costs upfront, you may end up with higher costs due to law suits and remediation. You want to plan in the beginning!"

During the IxR building process in virtual reality anyone will be able to build accessible interiors and will be motivated to do so. For instance a creator without any disabilities will be introduced to a short movie before starting a process how to make the world a more accessible place. The system will make suggestions about what are the most needed accessibility features and methods.

Abstract

Interior samples in VR.

Automotive experiences started small. Ford first introduced one car in one color. It was the Model T. With the user's needs interiors started to change: "I want to have a cup holder, I want to have this and that…"

With three different interior samples the concept shows that it is possible to give people different experiences in their mobile rooms. The interior samples create different environments for entertainment, home or business experiences. Having the opportunity to access enjoyable interior environments and get work done while being on the way from point A to point B will enable people to travel on their own and have memorable experiences. The goal is to bring disabled society out of loneliness, depression and isolation.

Design process

The thesis is following the structure of user centered design process. It is about consistent communication with the user. User input and feedback is important to receive and understand to be able to create best solutions for him to be able to use and enjoy. The designer does not have disabilities and needs to put himself in his user's shoes. The repeatable iteration process and designing together with the user is the key to the best results.
The thesis process walks through following steps: empathizing, defining, ideating, prototyping and testing.
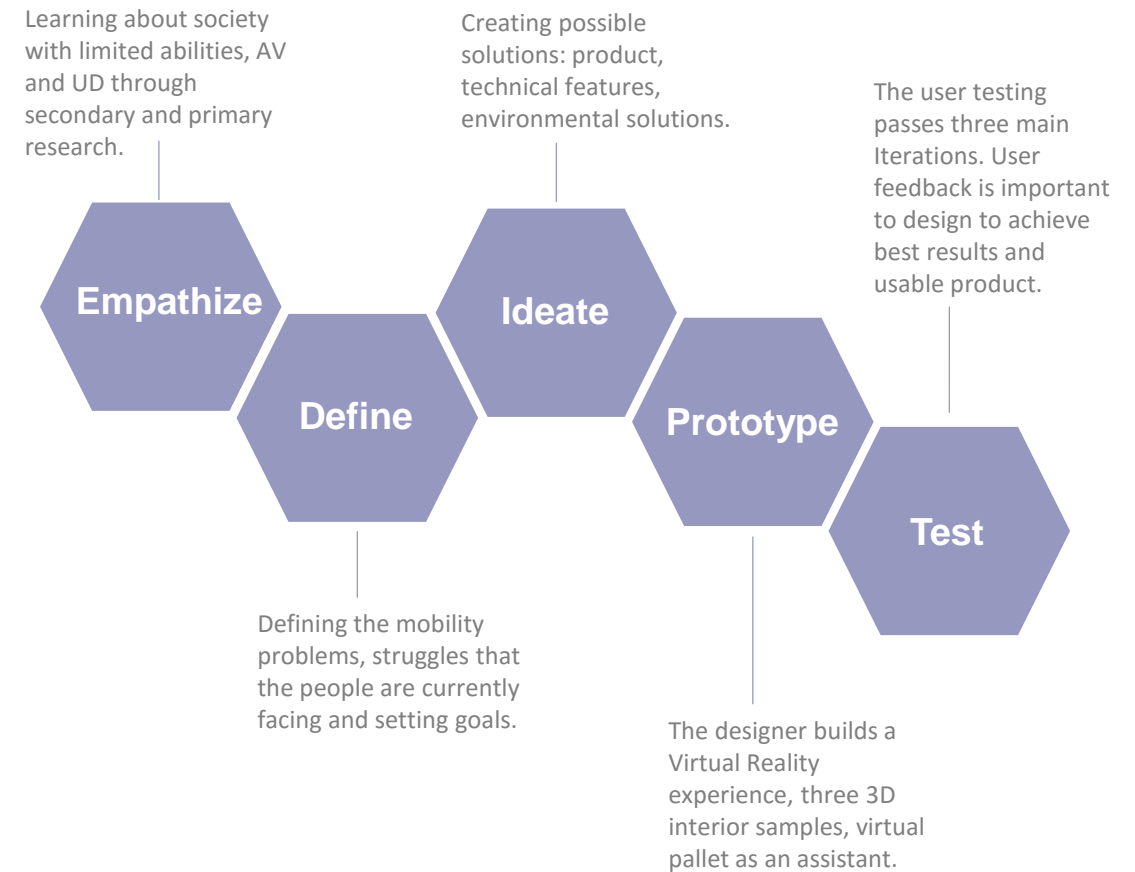
Empathizing: Who are we designing for? The designer learns about the target audience and it's problems. The designer does primary research in form of the interviews and surveys. The secondary research gives an overview of already discovered problems, methods to approach them, statistics and engineering requirements.

Defining: The designer creates a point of view, sharpens key questions, creates personas, their pain points, role objectives, decisions and challenges.

Ideating: The designer brainstorms, creates as many wild and different solutions as possible. He shares the ideas with his advisors, gets feedback from his target group, designs new solutions and does new research if necessary and shares again.

Prototyping: The designer builds a representation of the idea: user journey, VR scenario and the virtual pallet. He builds three different sample themes of possible autonomous vehicle interiors based on the information from user interviews.

User testing: The process walks through three main iteration loops. The first one includes user testing with three different interior samples in software called Unity and uses the designer as an assistant. The purpose is to see if the concept makes sense for people with disabilities and to measure their involvement. The test also reveals what additional features will be needed for a better access to include in the selection options. The second user testing includes the same Unity models and a paper pallet that will replace the designer as an assistant in the future VR project. It shows how the usability of the pallet can be improved. The third iteration is the VR prototype where the user doesn't even need to talk to a designer but can create the special interiors for himself on his own.

Learning about society with limited abilities, AV and UD through secondary and primary research.

Creating possible solutions: product, technical features, environmental solutions.

The user testing passes three main Iterations. User feedback is important to design to achieve best results and usable product.

Empathize

Define

Ideate

Prototype

Test

Defining the mobility problems, struggles that the people are currently facing and setting goals.

The designer builds a Virtual Reality experience, three 3D interior samples, virtual pallet as an assistant.

Content

2. Empathize

- Target group
- Universal Design
- Focus group
- Research results

Who are we designing for?

Aging society

The statistics in the US reveal that in 1900 more than half of the population was younger than 25. One in three was younger than 15 and only one in five was older than 65. Age demographics have shifted. In 2016 only one in three people in the US is younger than 25.

Aging society
Globally

2016   Older than 65   2050

8.5 %   16.7 %
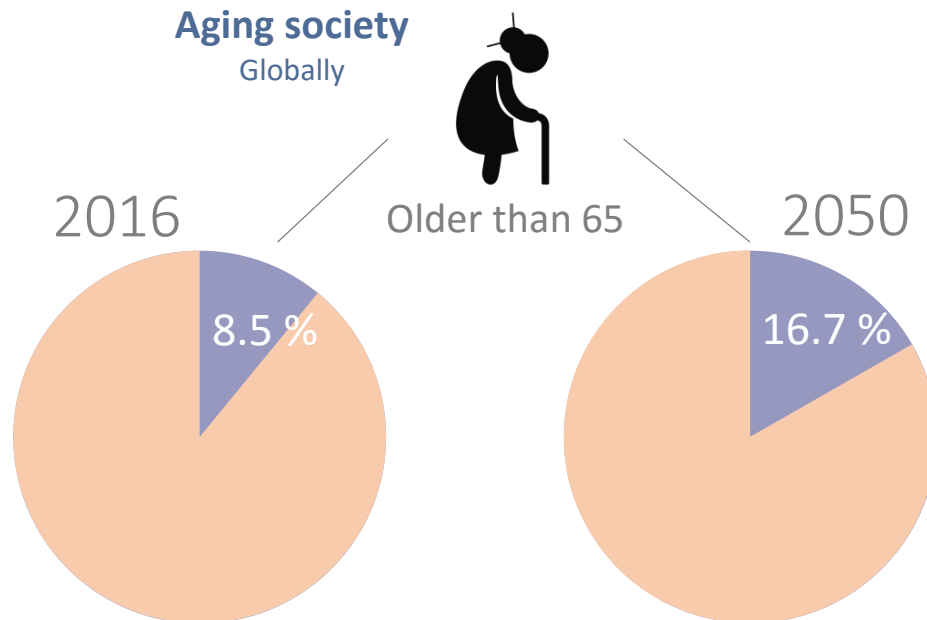
Disabled society

According to the Social Security Administration one out of every four 20-year olds will become disabled before they retire.
Our population has aged. We need to consider this fact by designing universal products. Disabilities increase with the age of people. The universal design is needed now more than ever before.

Disabled society
US wide

2016

1/5
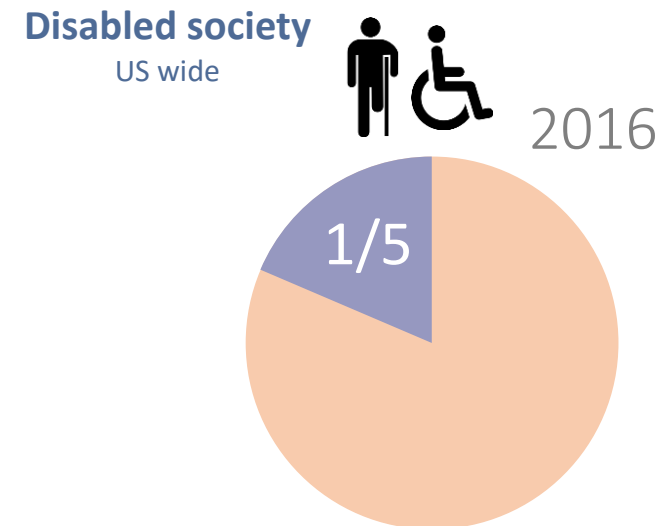
These facts are expressing the need for universal design, but the society is not aware of that yet. For example, less than half of all housing has no-step entry. How can we change that?

→ The aging society and early disability shows the need for universal design.

Who are we designing for?

Impermanent limited

We a re not only designing for disabled people and aging generation but for people with temporary limited abilities, for anybody and basically for ourselves. We all can experience temporary disabilities if we are sick and can't move, if we burn a finger, break one of our bones, if we are pregnant or have hands full of groceries. Parents with children experience some limitations as well when they have to deal with strollers accessing public or private transportation. Young children are not able to do many things on their own and depend on parent's assistance.
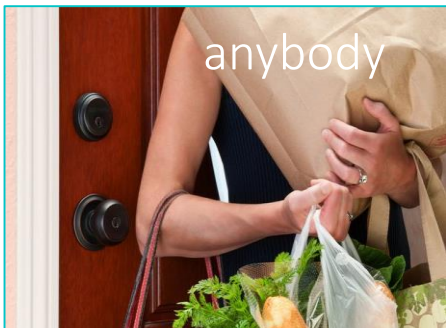
Future generation - Gen Z

We are also designing for the generation Z which is the generation of digital natives. They grow up with smart technologies and are intuitive in dealing with user interfaces.
This generation also pays more attention to internal values and permanently works on self improvement. It likes feeling comfortable and doesn't care a lot about other's opinions. They care more about interior comfort where they can get some work done and relax.
The older generations impress their community with luxury vehicles with great exterior looks. The new generation switches to comfortable vehicle interiors that can support their interest and give them opportunities to develop themselves. Vehicle interiors are becoming more important than their exteriors.

pregnant

parents with children

anybody

digital natives

GEN Z

self improvement

Preference towards comfortable interiors

Who are we designing for?

Anyone can become disabled one day, is disabled right now or will gain more disabilities while aging.

Designing for the diverse society means designing for anybody. Anybody can benefit from accessible designs and find it even more attractive and luxurious than usual designs .
The next research step reveals the variety of personas with different disabilities, their profiles, mobility habits and pain points. The personas were created based on information from secondary research, interviews, surveys and insights at the Inclusion Summit 2017 in Boston.

Please see the detailed persona building in the appendix section.

Blind

Mobility challenged

Deaf

Little person

Elderly

Diverse society

Paralyzed

Mothers

Children

meet
Donald

VITALS

Mobility challenge

Age:
48
Occupation:
Part time mental health councilor
Income:
$30,000 - $35,000
Marital status:
Divorced
Children:
Lara, 12 & Jacob, 19
Vehicle:
Sports car, Chevy SS
City & population:
Detroit, 700.000

PROFILE

Personality:
- Open personality, but often experiences disappointments from the society.
- He likes the feeling of independence but often has to ask for a ride.
- He works two times a week.
- He used to play basketball before his disability and is still very proud of it.
- He can walk for a bit but it is painful.

Hobbies:
He likes to go to karaoke bars, he deejays occasionally and plays billiards. He organizes a lot of activities for disabled people like: bowling, hand cycling, sky diving and swimming.

Social:
He loves visiting his friends, playing games and partying.

Responsibilities:
He needs to bring his children to school and pick them up. He organizes events for the disabled community. He listens to them and helps them to overcome their worries.

Technology:
He uses his smartphone on a daily bases, he checks out innovative technologies for his personal pleasure.

MOBILITY HABITS

He loves driving his sports car. But he only can consider this transportation mode if he does not have to walk a lot before getting in and after getting out. He figured out how to drive without special hand controls. But some people think that it is dangerous. He does not want to totally lose his independence. It is too important for him.
He loves old cars. He likes to cruise around. He likes to show off with his car in order to be attractive to women. He thinks that is the way to show his independence and "**hide**" his wheelchair. Donald doesn't want to have autonomous car because it will take away his fun.

PAIN POINTS

- He doesn't like if people pay attention to his disability. He wants to be a normal part of the society.
- He would like to meet the woman of his dreams, but as soon as women see his wheelchair they don't treat him as a potential candidate. They think they will have take care of him.

- His wheelchair restricts him in opportunities to be time flexible, to socialize more, to travel and to have a full time job.
- He wishes he doesn't have to break down his wheelchair every time he gets in the car – it's time consuming.

Do you see me or my disability?

meet Liliete

VITALS

Blind person

Age:
36
Occupation:
Outreach Worker-NY Connects,
Center for Independence of the
Disabled in New York (CIDNY)
Income:
$35,500 – $49,000
Marital status:
Single
Children:
None
Vehicle:
None
City & population:
New York, 8.5 Mio

PROFILE

Personality:
- Very happy and positive person. Her siblings and especially her father taught her everything and how to have fun.

Hobbies:
- She loves reading, spending time with family, going to cinemas with friends and doing volunteer work.
- Cinemas are attractive to her. It is not about what she sees but about the atmosphere, popcorn, people she goes with and the conversations about the movies afterwards.
- She likes to go to Baseball games. Her father explained to her how the rules work. She listens to the moderator and to the reactions of the crowd.
- Lilly likes traveling to different countries. Beautiful counties are those that have a nice smell, good songs, friendly people.

Social:
She loves talking to people. She can tell if it is a "beautiful" person based on how engaged the person sounds during the conversation.

Responsibilities:
Lily has to clean up her room based on her touch feelings. Her mum doesn't like if her room looks messy.

Technology:
Lilly has a special software that reads to her emails and messages on a high speed. She dictates the answers or types with the braille keyboard.
The new iPhone enables her to type messages. She doesn't only rely on new but especially on accessible technology.

MOBILITY HABITS

- The type of transportation that she uses is called Access A Ride, managed by the MTA for people with disabilities.
- She actually loves taking subways because she can meet people there. She is happy to live in New York. New York is a very international city. Talking to international people is much fun.
- She wishes autonomous and accessible cars would come out sooner to bring her to places. But she is afraid of a thought: "What if an accident will happen. What will she do then?"

PAIN POINTS

- She has to call "Access a Ride" service a day before. She can't be spontaneous. She often has to call Uber or yellow Cab instead. It is expensive.
- She used to take the subway, but due to the lack of accessibility, she fully depends on "Access A Ride". A lot of stations don't have elevators.
- Once she was a "blind" moderator. She did well but had to remember the whole agenda. She can't take a look at her notes. As some advisors talked in her hearing device to let her know about spontaneous agenda changes, she was distructed.
Also as people raised their hands to answer some of her questions questions she couldn't see them. The audience had to learn another way of communication by interrupting her and letting her know that they have something to say.

meet
Lora

PROFILE

Personality:
Lora is an energetic person. She believes in people and loves talking to them.

Hobbies:
Lora likes spending time with her disabled niece and teach her how to overcome circumstances. She loves dancing.

Social:
Lora has a big dream of being helpful to people. She is aware of accessibility issues that disabled people are facing and wants to contribute to this topic and has an idea.
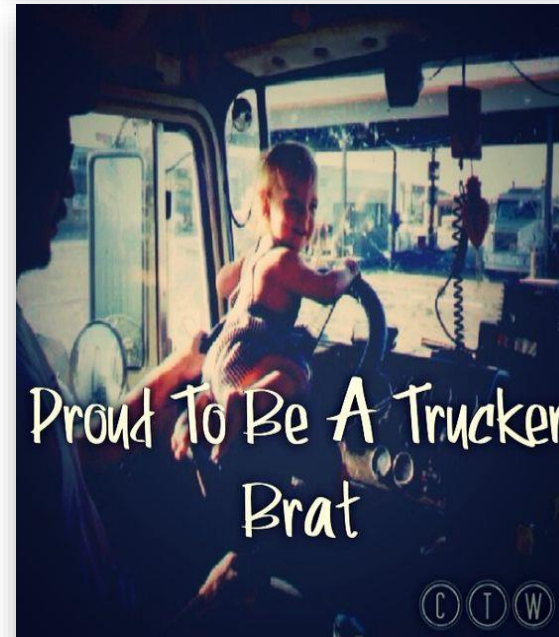
MOBILITY HABITS

- When Lora was a child, her parents couldn't afford a nanny so she traveled a lot with her father in his truck. He told her a lot of stories. They ate, slept and played in the truck. Since than she loves riding.
- Lora has a vision to combine her passion for making good coffee, talk to people and ride. She Is looking for autonomous cars being released so that she can open her local business.

PAIN POINTS

- Lora wants her niece to be able to ride sometimes with her in her futuristic Starbucks on wheels.
- Lora does not know how to create an accessible, good looking and safe autonomous vehicle. She wants to be a designer or a co-creator, define the proportions, components and make sure that the vehicle will be safe.
- The people could spend time with lots of pleasure traveling from point A to point B in her Starbucks on wheels.

Freelancer - Vendor

Age:
25
Occupation:
Vendor
Income:
$30,000 - $40,000
Marital status:
Single
Children:
None
Vehicle:
Van
City:
Portland, 670,000

Local businesses

Universal design (UN)

Universal Design definition

A National Disability Authority says: "Universal Design is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability."

We are designing for an aging, disabled and developing society. We should have a Universal Design approach by designing products to enable as many people as possible to use them. Universal design is not a perfect solution. Universal design is an approach and a goal to include as many users as possible. Every designer should know and think about Universal Design principles while creating solutions. The nine simple principles should be the guideline for the design process. On every step of the development the designer should question if his solution fulfills the UD principles.

Principles of universal design
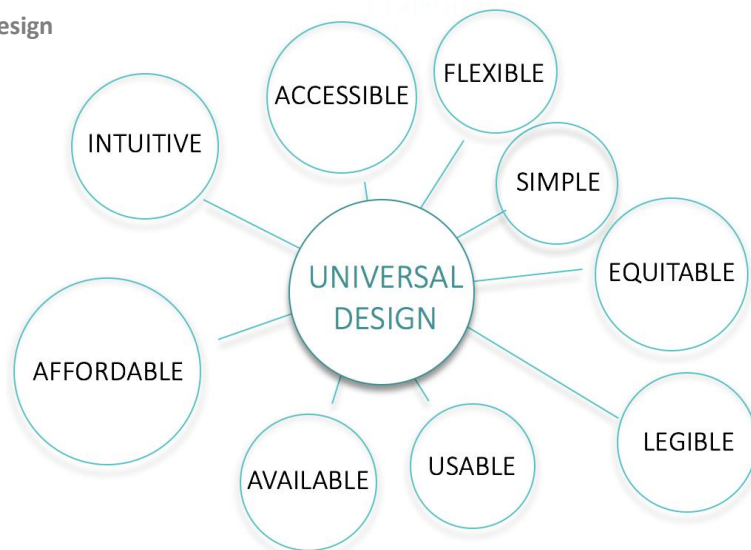
Main criteria of universal design to follow during a design process:

Is the created design universal, accessible and usable?

Design can be accessible but not usable. The user is able to get inside of an elevator and reach buttons but it is not clear which button to press if it is all in Japanese or only in Braille.

Design also can be usable but not accessible. The graphical design and the user experience of the new ATM is great, but it doesn't make much sense for a wheelchair user if he can't reach the interface or for a blind man who isn't able to see it.

If the design is universal and functional but the target group can't afford it, then it is not accessible and the target group can't use it.

Permanent checking of design if it fulfills universal design criteria is important to create a useful product.

If your design is functional and the users love it but it is not profitable for the manufacturer, the design project might fail. Universal design is a design for everyone. The manufacturers might like it if your design may be used not only by disabled people but by all users, which is universal.

Focus group

I started to develop my concept with an idea of enabling people with disabilities to feel more independent and travel on their own, especially people in wheelchairs. People need improved mobility solutions when they are struggling with the access to private and public transportation. But a general question is who will we be designing for in the future?
These are not only older people and people with disabilities. At some point during any activity, every person experiences some form of limitation in ability. These can be: medical injury, unfamiliarity with a product or environment, lack of understanding as a foreigner, or physical attributes like height or size.

Creating a solution for only one disabled group would exclude other people from the use of the product. That's why I decided to create a design solution for everyone using the Universal Design Principles.

I decided to pick a representative group of people with special needs which are people in wheelchairs. They are restricted in their mobile opportunities.
I will mainly work with the focus group "People in Wheelchairs" but also consider the Universal Design Principles in order to include as many people as possible into my concept.
My concept will help anybody to create their mobile and individual space.
People in wheelchairs don't feel independent. They always depend on somebody to take them out. They cannot move independently, stop everywhere and explore, visit their families and friends or do very simple tasks like shopping if they want to purchase bigger items like furniture. They are restricted in their possibilities and are neglected by the designers of everyday services. They have to signal from below to be noticed by the receptionist behind the counter, they are not always able to withdraw money at ATMs because they cannot reach the interface surface, they don't have the flexibility to go by bus because they have to compete with mothers with strollers for the only one accessible spot on the bus.
The experts report that in India for instance there is no way for people with disabilities to travel. People in wheelchairs travel by car with hand controls. They break down their wheelchairs and put them into the trunk. They crawl through the trunk or along the doors to the driver's seat. As a result, they leave a lot of scratches on their cars. The car is always dirty as are the hands of disabled people. Even if it is possible for some of them to travel on their own, it is very hard and sometimes frustrating.

LOW   HIGH

STRETCH

MOBILITY

VISION

HEARING

VOICE

COGNITION
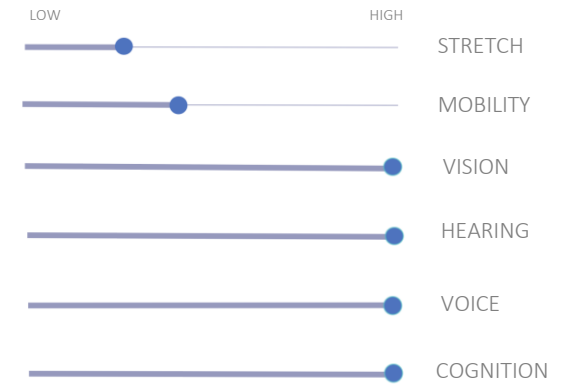
Transportation and disabled society

Need of accessible autonomous transportation options for people with disabilities.

There are more than 57 Million people with disabilities in the United States. One in every five people has a disability. The disability inhibits people from traveling to work and being flexible in their opportunities. Every disabled person has experienced at least once depression while only 11% of people without disabilities dealt with depression.
Because the accessibility of the transportation is so difficult, 3.8 Million people with disabilities never leave their homes, which leads to their social isolation.
The diagram below shows that the **people with disabilities use the transportation less often** than other people. But the transportation like Taxicab or motorized personal transportation is used more often by the disabled people than by other people.
If the people with disabilities have a job, then they earn much less and have many more expenses for the transportation. The families with a disabled person have more expenses for the transportation but all in all less than other families because they travel much less.
The families with a disabled parent have trouble when traveling. The paratransit can only drive a disabled person with one tender (helper).
The evaluation of the transportation needs and challenges of those with disabilities are necessary to make a first step for the development of the concepts.

"The Ruderman's Family Foundation will work with automakers and technology developers to build accessibility into vehicles' design and human-machine interfaces whenever possible to benefit those with disabilities and older adults. For wheelchair users, engineering changes may make it easier and cheaper to retrofit vehicles in the future. Those who are blind or deaf may benefit from specific oral, tactile, or visual cues that help them interact with the vehicle. This PPP should work with manufacturers to specifically develop further guidance on how principles of universal design can be implemented into vehicles with level 4 and level 5 functionality." - Henry Claypool Amitai Bin-Nun, Ph.D. Jeffrey Gerlach January 2017.

Figure 4 - Transportation Modes Used in the Past Month for Local Travel

Persons without disabilities utilize all forms of transportation modes more than persons with disabilities, with the exception of taxicabs and motorized personal transportation.

Source: DOT, Bureau of Transportation Statistics

How to design a universal access to the transportation?

Research abstract

Objectives

Through both qualitative, quantitative, and secondary research the goal was to gain understanding on how to design a perfect mobility solution for long-term wheelchair users. This solution must be affordable, accessible, and reliable.

Sample Size

For qualitative research, seven long-term wheelchair users were interviewed. The sample consisted of two women and five men. In the quantitative research 19 wheelchair users from the Rehabilitation Center in Detroit, people from a wheelchair basketball team, people who were met randomly on the streets, in the grocery shops, museums and friends of friends were involved in the survey process.

Methodologies

For the qualitative research, verbal interviews were conducted. For the quantitative research, verbal and pictorial methods were used in order to find out user's needs and complaints. For the validation part, mostly the pictorial methods were used in order to explain the design proposals and the vision so that intervieweers have the same images of the concept as the designer did.

Specific needs

- To travel independently
- The desire to travel to work quickly, without any public transportation issues
- Have an accessible and a very personal space
- Be supported in special needs
- To make the modification of private vehicles easier
- To save time and have less stress
- To be able to consider jobs far away from home

- To fit into the car if they have a special size of a wheelchair
- Support but not from people
- Acceptance from people
- Better public / private transportation enabling a very personal space
- Flexibility in traveling
- Safety

- Mental and physical needs from people in wheelchairs:
  They wish to have more support but not from people. They do not like asking people for help because they fear to lose their friends.
- They wish to have support from the technology: AI, automation (automatic opening doors, autonomous cars).
- They wish to have easy and usable technology (smartphones are complex to operate). They also wish to have more flexibility and to get anywhere, anytime.

Key Findings

It was possible to found out that the people have some basic needs on accessibility, availability, convenience and affordability of transportation modes. There is a big area for improvement on the product design and the service design level. Users will use public transportation as an option but many prefer private transportation, however private transportation is more costly. Many long-term wheelchair users have low incomes.
It was also possible to find out that people like to have their private spaces and a personal vehicles. **Personalization (modifications of personal vehicles) and access** are the most important aspects that were always mentioned by participants during the research phase. That is the area that the thesis will mainly focus on.

Mobility options in Detroit

Findings from Interviews with 19 people with mobility challenges about their usual transportation modes and their issues with those in Detroit.

Most commonly used transportation for people with mobility challenges:
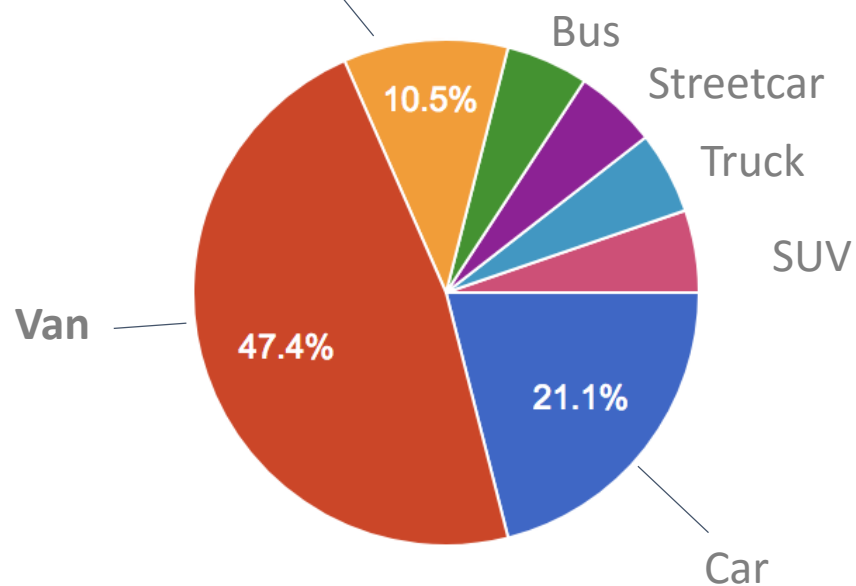
People with mobility challenges in manual or electric wheelchairs prefer to have their own vehicles to be time flexible and independent. They prefer to have modified vans so that they have enough space to enter the vehicle, turn around, switch to the driver's seat and store safely their wheelchairs. The modification of those vehicles is not a cheap option. It also requires a lot of time investment to find necessary parts for modification and to do obligatory driver's training.
Some people in manual wheelchairs decide to slightly modify their cars. It is a cheaper option but they face some troubles to enter once they have to break down their wheelchairs and store them on a passenger seat or wherever they are able to reach and store them.

However there are a lot of people with disabilities who are not able to drive at all and depend only on public transportation or mobility services. Special mobility services are not time flexible. People with mobility challenges need to make calls at least two days in advance for a reservation to be picked up. They are only allowed to make a reservation for paratransit service if they need to see their doctors or want to go to Rehabilitation Center. Once they are done with their appointments they usually have to wait up to two hours for the paratransit service to come back and pick them up. They get angry, frustrated and look sometimes for other opportunities to get around or just stay at home. It causes their isolation from the society.

Some people have half paralyzed bodies and can steer the vehicle only with one hand.
People's **independence** is more important for them as even their and other's safety. They drive on public roads and put themselves and others in danger.

Observation from Interviews with people with mobility challenges.
Providing a mobility solution is not about technical solutions but about the user experiences.

Analyzing user behavior and their needs for the improved public transportation it was observed that it is not about providing the society with the technical solutions and features, but it is more about their perceptions and experiences. Perceptions and experiences define the usage of the opportunities.

Mobility options in Detroit

In big cities as New York there is traffic congestion. In Detroit, there is not much. Some would say: "There are no alternative options for cars in Detroit". There is a difference between "alternatives" and "**perception of alternatives**".

Even though there are busses in Detroit people don't consider them as alternatives.

Q-Line, the first streetcar in Detroit (running from June 2017) has become very popular. In comparison to the bus, the streetcar is perceived as more transparent because the route is limited due to the track and the user can see it on digital displays at each stop. If the rider gets lost, the streetcar will turn around and return to the original stop.

By busses the traveler needs to figure out at first how to use it. He cannot track busses in real time and don't know when they will arrive.

Ford defines a new way of thinking. "**Comfort**" was always seen as a physical factor. The User Experience Designers at Ford give it a new **"mental"** meaning.
Comfort, trust and understanding how to get somewhere is more important than just going from A to B. People say that it is not safe to travel by busses because the city is not safe. The question is then "**How to provide the safe public mobility**". **However t is more important to have mental comfort rather than physical comfort.**

Providing the society with technical solutions like creating a bus system might not be successful not because people love their own cars and don't want to use the public transportation but because they don't consider busses as an alternative.

Another problem with public transportation is that some people don't have data volume to check out their next destination or to open Google maps. The question would be then: "**How to provide people with internet in order to give them a desire to travel**". The solution would be "Wi-Fi in the Q-Line and the Q-Line stations". This solution is also good for tourists from other countries who has no internet connection for a few weeks they are staying in a foreign country.

→ The main question is: "**How do you use the new technology to change the system**". Does the usage of your chosen technology make sense, is it justified and does it tell a story?

Voices of disabled people

"It is nice to be driven around but I always have to wait forever."

"Paratransit service only brings me to my doctor appointments and Rehab."

"Paratransit is not time flexible. I have to book two days in advance. I get angry when I have to wait for two hours to be picked up."

"If I take paratransit service, I spend time in the back of the car. It is not a welcoming interior. I feel like cargo."

"I still drive and modified my vehicle because my independence and flexibility is more important to me."

"The getting in and out process is so difficult."

"I wish my wheelchair could break down automatically and jump into the car trunk."

"Sometimes I am not sure if I can drive, but I do anyways."

"People offer me help. But I want to be as independent as possible."

"I don't want to feel like a disabled person. I want to be considered as an equal part of society and enjoy little moments."

Voices of disabled people

Everyday challenges
Isolation from the society
Depression

Is that the place I belong in?

Give me
INDEPENDENCE

Thank you for your help…
But I want to be as
independent as possible.

Can the technology adapt to me so that
I have easier access?

- Always late
- Part time jobs or no jobs

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

Interview with Eric
37, New York

Why are you not able to achieve your desired state?

I can't get around. I am always late.

Why are you **always late**?

I ask **my friend** to bring me places. He is a wheelchair user as well. It takes forever to get started. Him and me **switch from wheelchairs** to the seats. Break down the wheelchair. Put it in the back. Sometimes he is not available.

What do you do then?

I try to get **public transportation**. But I often have troubles. Sometimes I have to look for **accessible** subway stations with elevators. Sometimes there is no free spot during the rush hours. I often give up and go home. It is discouraging and exhausting.

Why don't you have your own car with special controls?

To drive a **modified car** I need a **special training**. It costs time and requires money. Then I need to find the parts I need to rebuild my car. It is expensive, needs time and research. I think it is complicated. I don't even want to deal with it.

Would you prefer your own car or public transportation?

I would prefer my **own car** then I could decide when and where I should go and wouldn't need to deal with crowds.

Do you think self driving cars would give you a chance to be on time?

Yes, a car is not a human being that I could bother. I can always ask it to bring me places.

Will the autonomous car solve your independence problem and a time problem?

Yes, **but will they be also accessible? Will I have to break down my wheelchair or will I be able to just get in and start riding? Will every autonomous car have an accessible ramp? Will be there enough space for me to turn around or to store my wheelchair? Will I have a safe spot there? Will I be able to interact with the interior?**

User Journey with current paratransit service

- Eric reports:
- Call paratransit two days ahead before your journey to reserve the spot.
- Possible destinations: Rehab, Doctor (no grocery shopping).
- Paratransit parks in the driveway and the driver knocks on the door. The wheelchair user comes out.
- Driver opens the door, lets the ramp down, pushes the person in wheelchair in, locks the wheelchair, fastens the seatbelt and closes the door. It takes about 5 minutes.
- During the ride the person in wheelchair sometimes talks to the driver. Sometimes they don't get along well and spend time in silence.
- The passenger knows where the driver will bring him. He always drives the same route.
- People in wheelchairs spend time inside of the vehicle which doesn't have a very welcoming interior. They don't feel comfortable. They feel more like cargo being placed inside. Some people care and don't enjoy their ride. Some people don't care because they accept that they don't have a better opportunity anyways.
- At arrival the driver gets out, opens the door, unlocks the wheelchair, helps the wheelchair user to move backwards and closes the door. It usually takes about 5 minutes.
- The driver knows where the passenger has to go and knows that the building will be accessible. He leaves knowing that the person won't have troubles to access the building.
- Once the person in wheelchair is done with his appointment, he would call the paratransit manager. The manager informs the driver. It usually takes 45min – 3 hours until the driver picks up the person after his appointment. People are annoyed and angry that he has to wait for such a long time. Sometimes they only need 30min for their doctor appointments but have to wait up to 3 hours. They wish the driver could wait for them. But driver has a lot to do and has a busy schedule.
- Some people call their family members to be picked up.
- Once the driver is there for the pick up he gets inside of the building to find the person. Some drivers make a call to find the person. Some people who have to be picked up wait outside especially if they smoke.

Conclusion:

For people without ability to drive, paratransit is one of the limited options to get around. It is not a very convenient option since they have **long waiting times** and have to make reservations way ahead before the actual traveling days.
Some people don't get along well with drivers and wish not to have one. But they **depend on driver's help** to assist them by getting in and out and locking down the wheelchair.
The passengers also **don't feel comfortable** inside of these vehicles. They feel like being a permanent patient. It reminds them of their disabilities and their special situations that separates them from the society. But they wish to be a part of the society and not the opposite.

Need:

The disabled people's voices scream for help. They have a big desire to be more time flexible, independent and get around on their own without any external help. They would love to spend time in welcoming interiors and do whatever they would like to do during the ride.
However the current user journey in paratransit shows that the driver has to help the passenger to get inside of the vehicle and lock down the wheelchair and actually drive.

Opportunity:

The advanced autonomous vehicle technology will allow people in wheelchairs to move around independently. Only communication to the vehicle will be necessary. The autonomous vehicle will assist users any time and will give them time flexible opportunities to travel. The interior architectures of autonomous vehicles offer more space and can be designed in a more accessible and flexible ways.
Dirk Steudle, the director of Transportation Department of State of Michigan expresses his support and concerns. He considers it of vital importance to design future autonomous transportation more accessible to give the people with disabilities a chance to equally participate in life. However he expresses his concerns: How will autonomous vehicles replace driver's assistance, how will people in wheelchairs get in and out, what other challenges will they face along the way and how to design the interaction with those challenges?

Autonomous vehicles research

Autonomous cars and decision between Level 4 and Level 5 autonomy.

Level 4 indicates that the driver doesn't have a responsibility to drive the vehicle. The vehicle moves on its own and makes decisions based on learned algorithms. It operates only in operating / mapped areas.
The vehicles are already extremely intelligent but only in certain situations. They will need millions of miles to prevent the probability of accidents. The driver has to take over the control in not mapped areas. Including both self-driving features and driver-operated controls is redundant and costly. The vehicle pulls off the road if the system fails.

Big players:
• Waymo is already offering Level 4.
• Volvo and Ford will offer Level 4 before 2021.
• BMW: iNext driverless car. Production readiness: 2021.

Level 5 autonomy would allow anyone to ride independently without a need to overtake the control at any given time.

HANDS OFF
MIND OFF

OPERATING AREA
Production readyness 2021
Production readiness: 2030
Level 5   Level 4

The autonomous technology could help people who are restricted in their abilities to become more independent, to get their work done and travel on their own.

The big goal is to enable people to do something they weren't able to do before.
The **designer's responsibility** is to create a mobility solution which is easier, simpler, and more accessible than the existing ones.

Possible traveling scenario for Eric with an autonomous car   **Touchpoints**

- Eric travels to see his daughter from Brooklyn to Jersey City. His daughter has a birthday.   → Independency / flexibility
- Eric has some items with him: a cake and a gift.   → Accessible storage
- Eric wants to switch to a comfortable seat during his ride.   → Personal interior set-up
- He wants to stop at a grocery shop and get tomatoes his daughter asked for.   → Benefit: Private vs Public
- He accidentally drops one of the items and is not able to pick it up from the floor.   → Supportive features
- He wants to pick up his mother so that she can join the event.   → Benefit: Private vs Public
- On the way to her place he watches news on a big screen in front of him.   → Personal entertainment
- He picks up his 79 year old mother from Long Island and heads to New Jersey.   → Flexibility, Independence
- She takes a seat on a couch and talks to him.   → Personal interior set-up

Conclusion:
Eric travels with an autonomous car. The scenario gives an overview on what he has to accomplish and troubles he might face. The thesis would offer Eric an improvement of his travel experience with an autonomous vehicle working on the improvement of the listed touchpoints.

Smart home - smart car

HOME EXTENSION

HYUNDAI, SHOW CAR, CES 2017

AI SUPPORT

BMW, ALEXA

MODULAR OWNERSHIP

JAGUAR, STEERING WHEEL OWNERSHIP

Connection between smart home - smart car is becoming a big trend. Hyundai, BMW and Jaguar demonstrate the benefits of the vehicle – home connection in their concepts.
The concepts offer atmospheres created at home to the vehicle to feel more familiar, comfortable and mentally connected. Spending time in such interiors the users don't even realize that they leave their homes and keep on doing their usual assignments while on the way to their destinations.

People with disabilities see the concept of cars attached to their homes as a big advantage and a chance of improving their experiences.
During Interviews with disabled people the interviewees reported that especially in winter they wish the transportation could be much closer to their homes so that they don't have to freeze in the cold while waiting for transportation or transferring themselves, breaking down their wheelchairs and storing them. "It would be great if the autonomous cars could attach themselves to the entrance doors of our homes" – they say.
They also wish that they could feel as comfortable in cars as at their homes.
The closer the cars are to their homes the better access they have to them to design with familiarity of home, to clean the interiors, modify it anytime and be picked up without even going outside in the cold, rain or heat.

Content

3. Define

- Research conclusion
- Needs and goals
- Persona and environment definition

Research conclusion

Decision:
There are many different disabilities but due to time constrains of the thesis and personal motivation to work with people with mobility challenges because of their accessibility struggles the decision was taken to narrow down the scope.

Statement:
It is possible and necessary to improve the quality of life of people with mobility challenges. People without disabilities can ride bikes, jet ski, swim or do some other activities. But people with limited abilities can't even consider these opportunities. They need to be creative to find out what can replace all these activities and accept that they are not able to do what others do. Unfortunately there are not many alternatives because the world does not care much about accessibility topics.
People with mobility challenges also have limited access to jobs and some are in poverty. People with mobility challenges have to find joy in different things. The thesis is proposing to them a new mobility experience in order to find a way to bring them out of isolation and depression.

General goal:
The goal is to improve the quality of life of disabled people in 21st Century Mobility and achieve a higher percentage of inclusion.

Mission:
The mission is to enable people with mobility challenges to do something they weren't able to do before.

Problem:
People with mobility challenges have troubles accessing transportation modes.

Specific problems:

After interviews and surveys with more than 19 participants some specific problems were identified. Disabled people have some issues with personal vehicles as well as with mobility service interiors.

Personal vehicles…
- … reveal access troubles when breaking down their wheelchairs.
- … need some special modifications which needs time, knowledge about the needed parts and where to find them and a long and pretty expensive special driver's training.

Mobility service..
- … interiors are not welcoming and enjoyable. People feel like they are a part of the vehicle interior, cargo like.
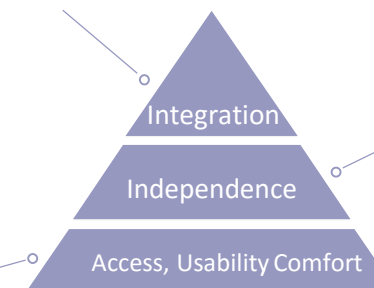- … is not time flexible. The travel reservations have to be made 2 days in advance.

"Every day challenges has led to my **depression** and **isolation**"

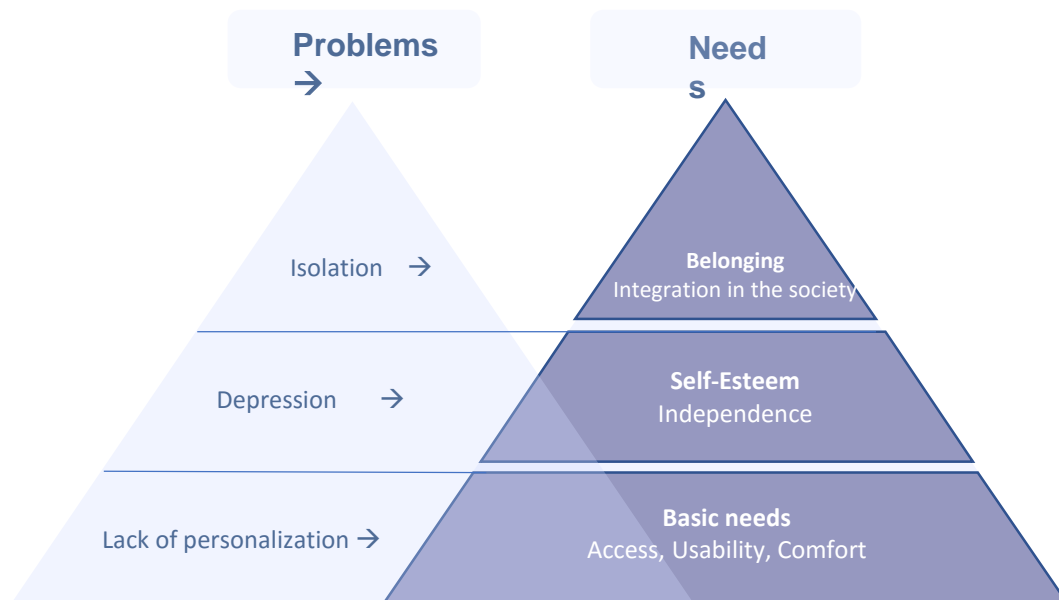"I need help but want to be **independent**"

Integration

Independence

Access, Usability Comfort

"I have to break down my wheelchair"

"I don't feel welcomed. I feel like cargo"

Needs

The identified problems of people with disabilities led to identification of needs of society with limited abilities. The lack of personalization causes the basic needs of people with mobility challenges such as access, usability and comfort. Depression of disabled people causes their need for more independence and self-esteem. The integration into the society though creating accessible and enjoyable experiences will bring people out of their isolation and will motivate them to leave their homes during the day.

Problems →

Needs

Isolation →

Depression →

Lack of personalization →

Belonging
Integration in the society

Self-Esteem
Independence

Basic needs
Access, Usability, Comfort

© Sofia Lewandowski

Goals

Improve quality of life of disabled people through creation of…

- **accessible**
- **and enjoyable**

… transportation experiences.

Opportunity:

Creating a single product solution would restrict user in his opportunities. But creating an environment for user to create will enable him to define his personal space for his special needs.

Proposal:

A virtual environment for users with special needs will be created to enable them to define their own experience rooms on wheels.

Eric Green
37, New York

Consultant

Basketball player

Dog lover

Singer

Environment assumption

Pilot program in
Mega Cities
2030

Level 5
Cities

L3,4

L2

Suburban areas

Freeways

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

Persona and environments

The desired state of a perfect world and the ability of participation for people with mobility challenges was created based on interviews with disabled society members. People expressed their desires, needs and wishes that are reflected in the mood boards on previous pages..

A created persona named Eric is an example of how people with limited abilities imagine themselves in the future world.
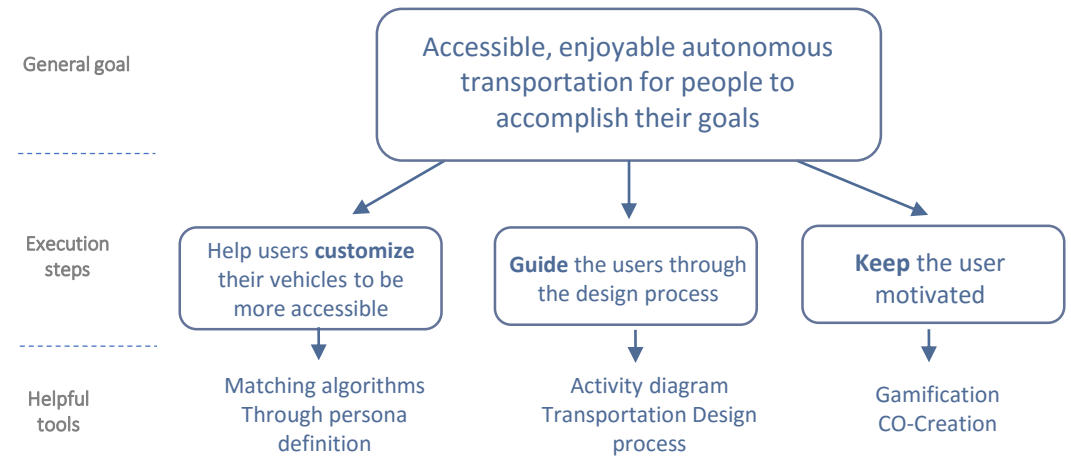
The scenario plays in year 2030, where Level 5 autonomy is allowed only.
Eric is 37 years old. He is single. He has an annual income of $70,000. He lives in one of the mega cities New York. He is a consultant and travels from customer to customer during his working hours. He spends a lot of time in his vehicle while being on the way from one destination to another. He is proud of the ability to be mobile and have a full time job.
Other than his job he loves spending time with his dog, traveling and hiking around.
He is a very active person and plays wheelchair basketball. He also likes playing piano and practicing his singing skills.

Eric wishes to have an autonomous vehicle that will be specifically designed for his special needs, give him enough space, support his interests and improve the quality of his life by providing best automotive, business, home and entertainment experiences.

Refining needs

Needs	**Comfort**	+	**Access**	+	**Usability**
	Mental, physical				
Methods	Definition of topics and features, methods		Definition of tools and distance		User Testing

Refining goals

| General goal	Accessible, enjoyable autonomous transportation for people to accomplish their goals		
Execution steps	Help users **customize** their vehicles to be more accessible	**Guide** the users through the design process	**Keep** the user motivated
Helpful tools	Matching algorithms Through persona definition	Activity diagram Transportation Design process	Gamification CO-Creation

Content

4. Ideate

- Idea development
- Final concept
- Business case
- Why VR?

Idea development

Concept 1: An universal design element.

The research on Mobility as a Service concept showed that the vehicles won't belong to the users in the future, but instead the user will call and use a vehicle service only on demand. The idea of personalization of experiences inside of vehicles offered an opportunity to develop a universal design element. The element is the only part of the vehicle the user owns. It represents the connection between smart car and smart home. The special universal design tool supports users in accomplishing their special tasks and supporting their special needs. It is simple and intuitive in operation, consistent in design and supportive through the AI assistance. The universal design tool can be anything: a smartphone app, a steering wheel, a diamond, a drone, an e-tattoo or a modular element.

UNIVERSAL ELEMENT

SMART HOME   SMART CAR
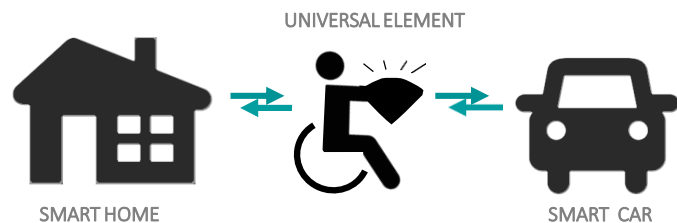
There was a need for the universal design tool to have an environment to control. It was defined that it has to be surrounded by five different layers: Car interior architecture, infotainment,

CAR INTERIOR ARCHITECTURE
INFO- / ENTERTAINMENT
FEATURES / SMART DEVICES
SEAT / CHAIR
USER
THE SIXT ELEMENT
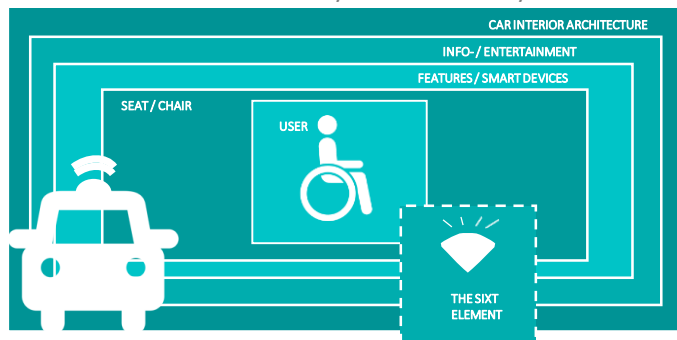
entertainment, features and smart devices and a seat. The five layers have to be designed to fit to the purpose of the universal design tool, a so called sixth element. However the concept was refused. The tool would be most certainly a communication and navigation tool. That wouldn't solve the accessibility problem of people in wheelchairs.

Concept 2: Supportive technologies

The concept was created for public transportation purposes or Mobility as a Service concepts. A universal design environment inside of an autonomous vehicle with different technologies was proposed in order to support every disability. The basic vehicle interior with accessible elements like ramp, rails and a rotating stage was created for an easy access and convenience. The interior supports different disabilities with different technologies: voice recognition, eye tracking, haptic feedback, gesture recognition and emotion detection.

Voice recognition
Eye tracking
Haptic Feedback
Gesture recognition
Emotion detection
CONVERTIBLE BENCH
AUTOMATIC OPENING DOORS
STAGE
RAMP
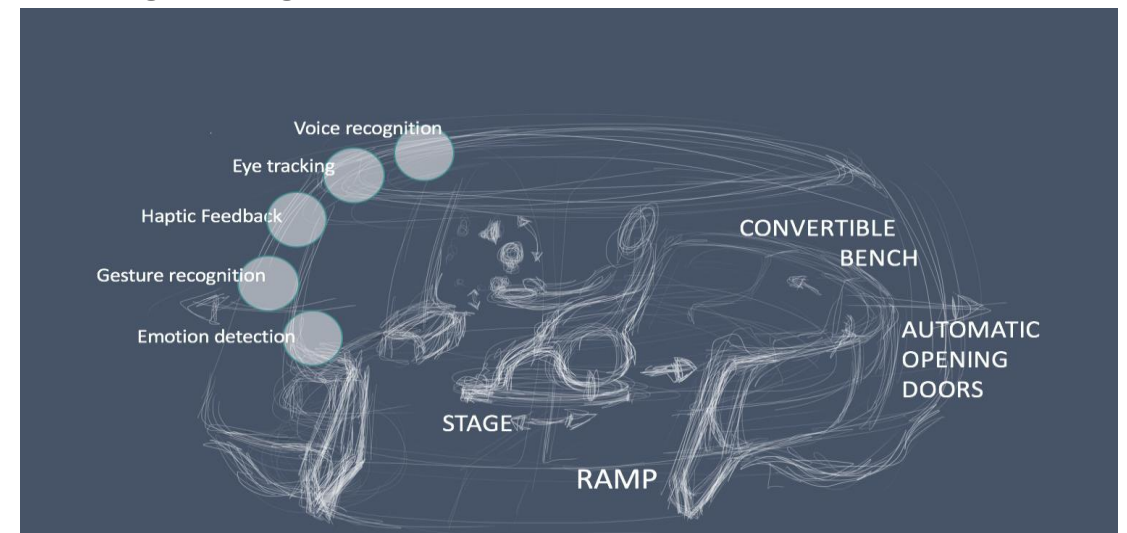
The concept is technology oriented and not user oriented. The smart devices couldn't support all disabilities. "One solution fits all" is a very expensive one if all the technologies would have been built inside of one single vehicle. The lecture by Daniel Rosenberg and the interpretation from Paul Pangaro helped to understand that looking for a single product solution can lead to a restriction of user's opportunities. Since the designer was looking for a product solution, the questions asked in the interviews weren't helpful and were misleading. "Creating an environment for user to create" was an inspiring insight and led to further concept development.

DO YOU WANT TO BE A MUSICIAN AND PLAY SOME PREDEFINED SONGS?
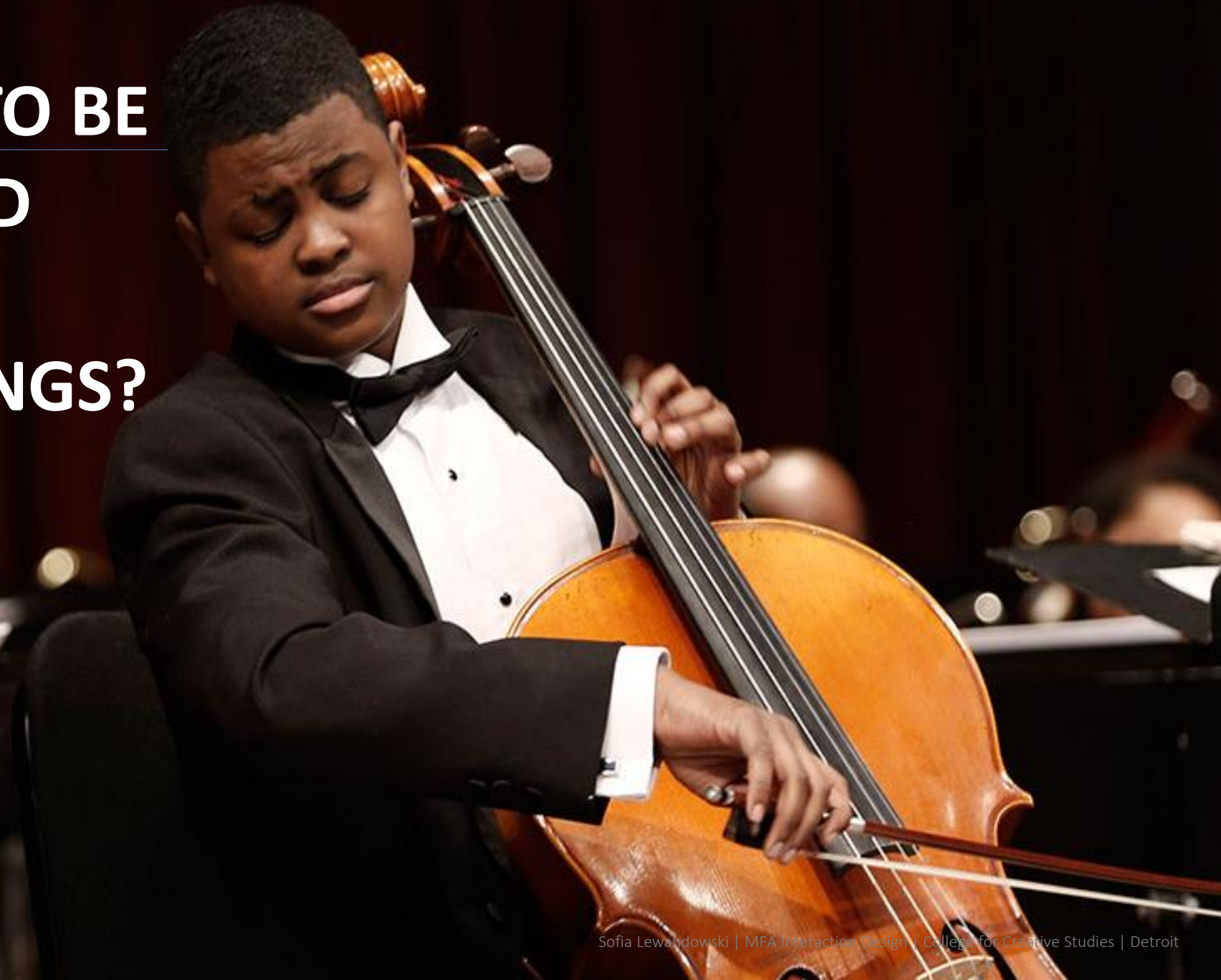
... OR DO YOU WANT TO LEAD THE WHOLE ORCHESTRA?

Idea development

Not a product creation which can restrict user in his opportunities but a creation of an environment that can enable user to be creative.

USER = CREATOR

- Personalization
- Inclusion
- Flexibility

ENVIRONMENT

Products are created by a product designer. But a predefined product can restrict a user in his opportunities and exclude other users from the use of the product. If the product designer creates an environment for the user to create his own product and thus his own, very personal experience, it would make the user a designer. The user would be enabled to create his own piece of art. Letting the user be the creator will contribute to the personalization, inclusion and flexibility.
This insight helped to make the next very important step on the concept development.

The interior architecture in autonomous cars will change completely and differ from the interior architectures of traditional cars. In autonomous cars, the passengers will not have to face the road. The seats and the whole interior can be anything user wants it to be. There will be freedom to design a new room of experiences. BMW displayed a show car as an example of a such living room on wheels at the Consumer Electronics Show (CES) 2017.

The final design concept will offer users a platform to create their own experience rooms on wheels. Users desire is to have his personal vehicle with a personal space that can be decorated as his own living room or office.

BMW concept CES 2017

OFFICE

GYM

LIVING ROOM

The interior architecture of autonomous cars differs from the current vehicle interior architectures and offers more freedom for designers to design.

Concept 3: A virtual environment for users with special needs will be created to enable them to define their own experience rooms on wheels.

Final concept

A **virtual environment** for users with special needs will be created to enable them to define their own experience rooms on wheels.

According to research and to reports from experts from an automotive company in Las Vegas called "Local Motors" nowadays it is possible to print the whole car within one day. Local Motors proved it with a 3D-print of Olli bus, the world's first accessible bus that will be introduced first in Singapore in year 2019. They say that a vehicle can be 3D-printed in different materials at the same time. It would give a chance to the car producers to create very personal vehicles for their clients within a very short period of time.

In the Individual Experience Room project (IxR) the user will find himself in a virtual autonomous vehicle. The user will "walk" through the virtual shops and grab what he needs for his special vehicle interior. He will adjust the position, size and color of elements. A digital model will be created. It will go through a validation process and pass safety tests. The model will be 3-D printed in real size and be ready in 24 hours.

The product designers will provide their digital products (created in Rhino, Solid Edge, Alias or others) to the virtual shops. The users will have more choices on variety of colors, materials, shapes of the products since the products will only have to be printed on demand.

Benefits
• Personalization for the disabled society (ramp, foldable seats, gesture control and elements – testing)
• No walking and being bothered by the crowd
• No waiting in the line
• No need to carry heavy furniture
• Immediate evaluation of new furniture inside of the car
• Their own piece of art / their own creation
• Production of the car the same day
• Save the digital model, show to your family and get their opinion
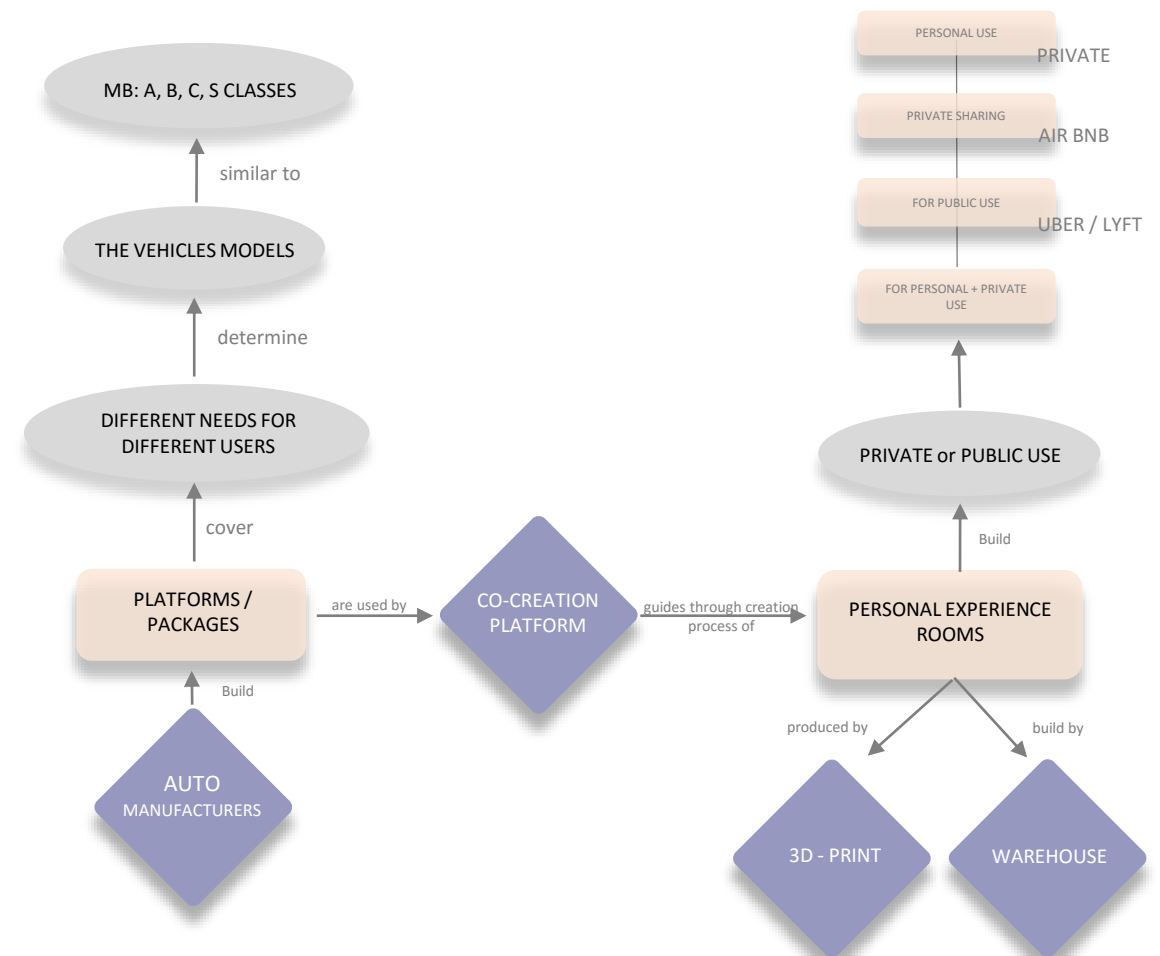• Change the model anytime in the VR shops or at home
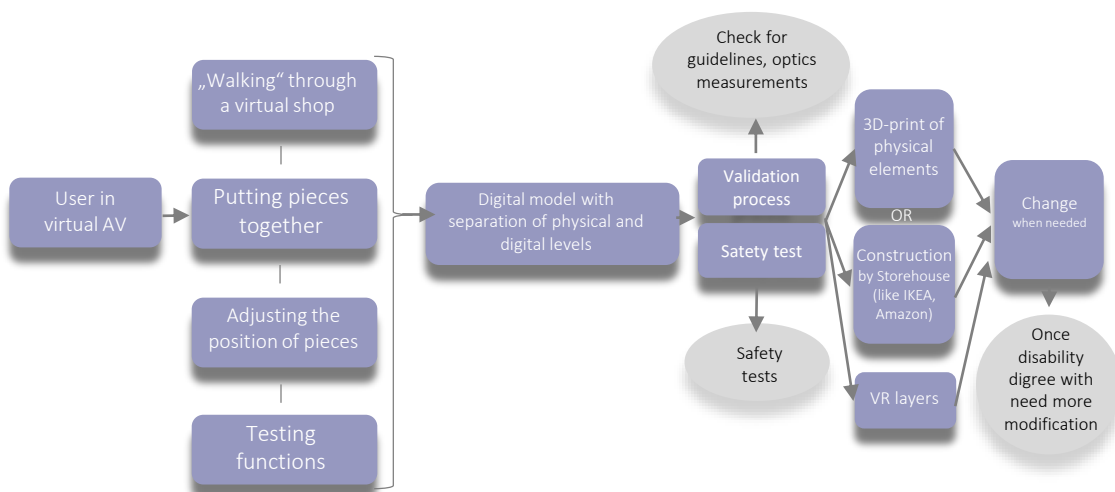
Business case

The concept would work as following: Auto manufacturers would provide platforms in form of packages. The packages will be created for different users with different needs. They will provide platforms for new created target groups similar to the creation of existing models for example Mercedes Benz A, B, C, S and GL classes.
The variety of options on platforms will be shown to the customers in virtual reality as the first step of the vehicle interior creation. The customer will create his personal experience room which will be 3D-printed in the future. The elements that can not be printed out will be provided and build in in warehouses.

The new created vehicles will be used privately or publically. The owners will be able to rent out their vehicles through Air BNB, Uber, Lyft or similar service providers.

MB: A, B, C, S CLASSES

similar to

THE VEHICLES MODELS

determine

DIFFERENT NEEDS FOR DIFFERENT USERS

cover

PLATFORMS / PACKAGES — *are used by* → CO-CREATION PLATFORM — *guides through creation process of* → PERSONAL EXPERIENCE ROOMS

Build

AUTO MANUFACTURERS

produced by → 3D - PRINT
build by → WAREHOUSE

PERSONAL USE — PRIVATE
PRIVATE SHARING — AIR BNB
FOR PUBLIC USE — UBER / LYFT
FOR PERSONAL + PRIVATE USE

PRIVATE or PUBLIC USE

Build

Why VR?

- Proximity
- 3D space (more Levels)
- User's engagement (vs 2D videos)
- More intuitive way of operation
- Real scale for unexperienced users

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

Content

5. Prototype

- **Overall concept**
- Analysis
- Journey map
- VR scene
- UI development

Main VR flow

The rough scenario with more details later will offer a user an experience of building his own experience room on wheels. The user will experience three main phases: He will select the vehicle size and vehicle package provided by auto manufacturers.
The user will find the desired themes depending on his hobbies, interests and responsibilities. The user will switch through some predefined vehicle interior samples similar to predefined living spaces in IKEA stores.
Furthermore the user will be able to select some features from the option menu. He will add or delete elements in the scene, change the size, color and materials.

In the virtual reality environment the user will have a smart assistant that will help the user with recommendations about what to do next. The assistant will be activated or deactivated by pointing and clicking on him.
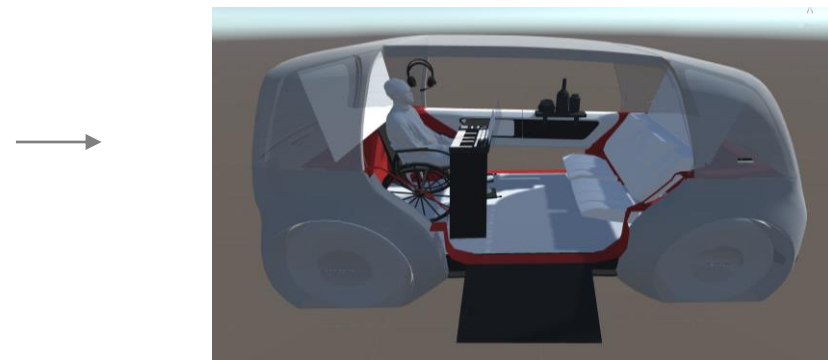
I WILL ASSIST YOU ANYTIME
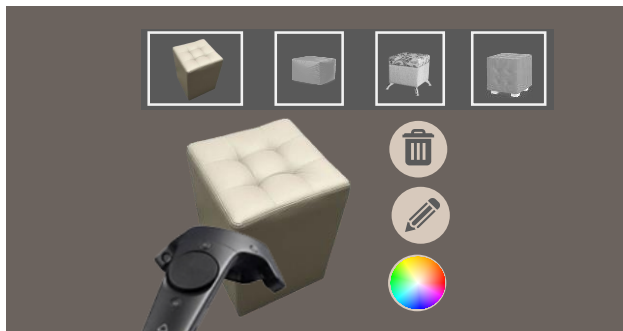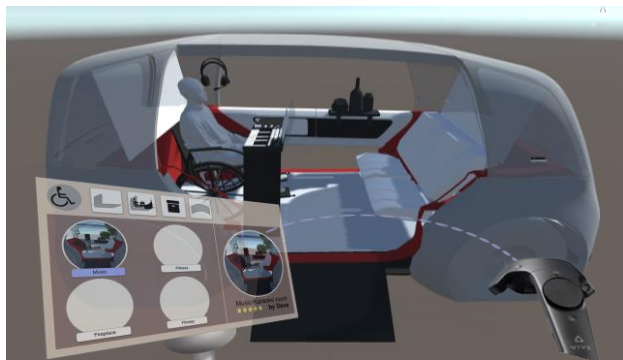
3D Model
For the building of virtual reality experience of defining personal vehicle interior spaces, a Volkswagen Cedric model was purchased. Necessary modifications of interior space were executed in Autodesk Maya before the model was exported in Unity Engine.
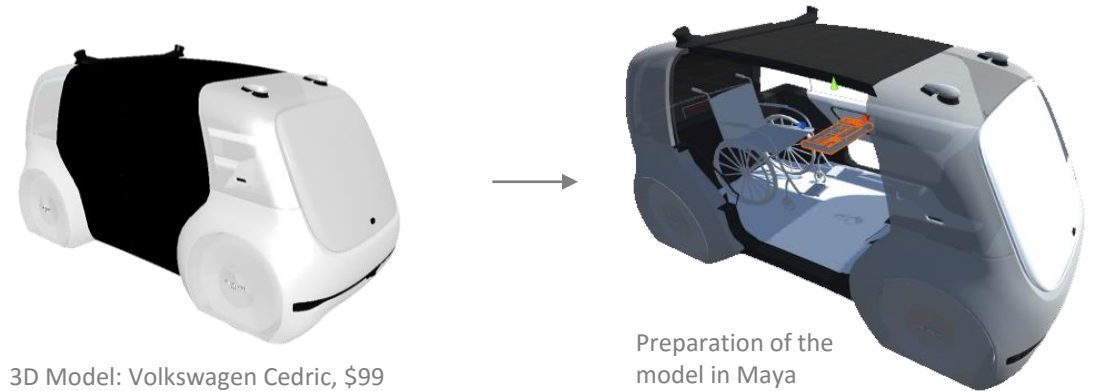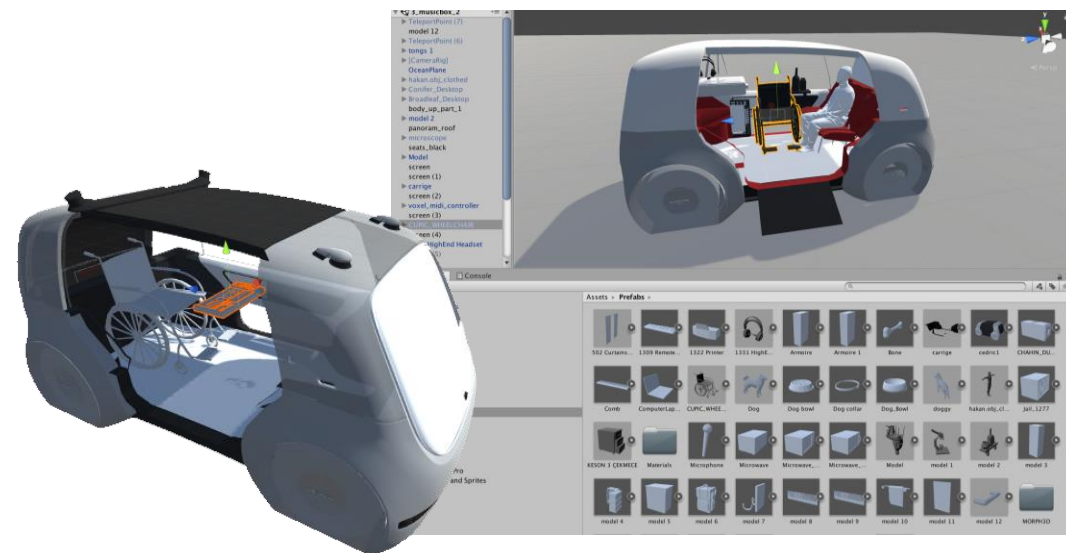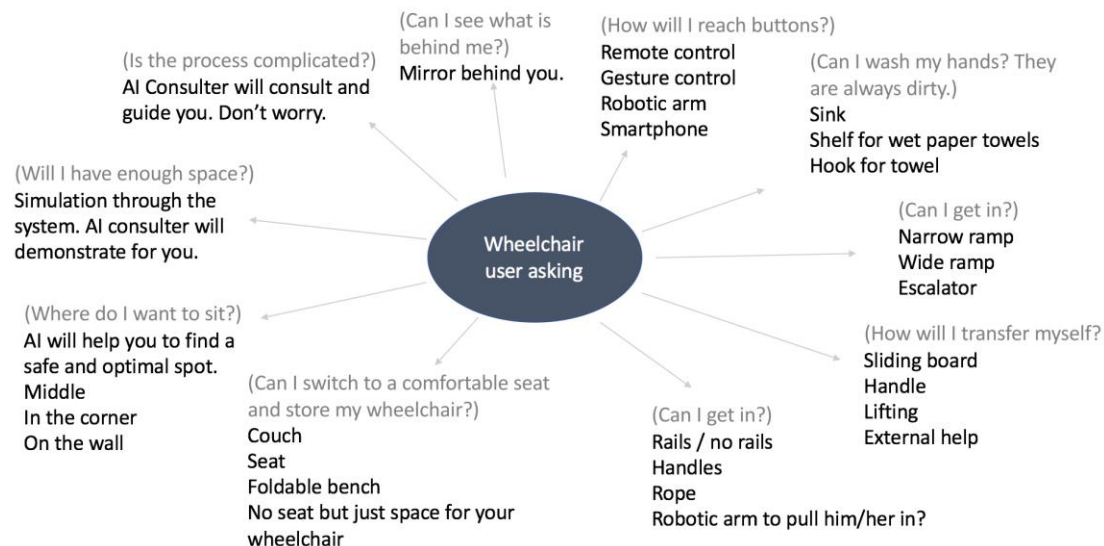

3D Model: Volkswagen Cedric, $99

Preparation of the model in Maya

Model exported to Unity and filled out with elements

Features

Different furniture pieces and accessible features were defined based on user interviews.

(Can I see what is behind me?)
Mirror behind you.

(Is the process complicated?)
AI Consulter will consult and guide you. Don't worry.

(How will I reach buttons?)
Remote control
Gesture control
Robotic arm
Smartphone

(Can I wash my hands? They are always dirty.)
Sink
Shelf for wet paper towels
Hook for towel

(Will I have enough space?)
Simulation through the system. AI consulter will demonstrate for you.

(Where do I want to sit?)
AI will help you to find a safe and optimal spot.
Middle
In the corner
On the wall

(Can I switch to a comfortable seat and store my wheelchair?)
Couch
Seat
Foldable bench
No seat but just space for your wheelchair

Wheelchair user asking

(Can I get in?)
Narrow ramp
Wide ramp
Escalator

(How will I transfer myself?)
Sliding board
Handle
Lifting
External help

(Can I get in?)
Rails / no rails
Handles
Rope
Robotic arm to pull him/her in?

The features were exported from GrabCAD and Google Poly to offer user variety of options. The objects were stored in the prefab folder in Unity.

cedric1   CHAHIN_DUMPSTER   Comb   ComputerLaptop_1...   CUPIC_WHEELCHAIR

Export of features to Unity

Interior Samples

The thesis creates a vision and gives an idea of definition of personal spaces created through people with limited abilities for themselves.
Automotive experiences started small. Ford first introduced one car in one color. It was the Model T. With the user's needs interiors started to change. "I want to have a cup holder, I want to have this and that…"

With three different interior samples the concept shows that it is possible to give people different experiences in their mobile rooms. The interior samples create different environments for entertainment, home or business experiences. Having the opportunity to access enjoyable interior environments and get work done while being on the way from point A to point B will enable people to travel on their own and have memorable experiences. The goal is to bring disabled society out of loneliness, depression and isolation.

Interior samples

The predefined samples were build with the imported objects and desires from people with disabilities based on interviews and secondary research. While creating interior samples it was important to keep in mind the question: Is the interior comfortable, accessible and usable?

Sample 1: The user's desire is to practice his music skills while being on the way from home to the office. This is the only time for some people to be on their own without any duties at home or in the office.

Sample 2: People without disabilities are able to ride bikes, swim and jet ski. People with mobility challenges are not able to have these hobbies. They have to be creative to find new ways to have joy in their lives. Sample 2 shows a dog lovers room. The space is designed for people who spend a lot of time with their pets, go on hikes with them and teach them commands.

Sample3: While being on the way somewhere some people like to keep on working on their projects, check and answer e-mails. The office room was created for people who like to accomplish their work while traveling.

© Sofia Lewandowski

Sample2:
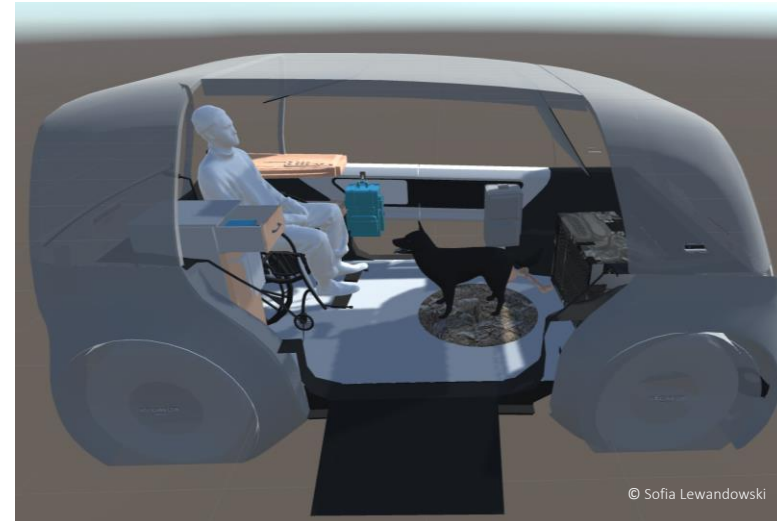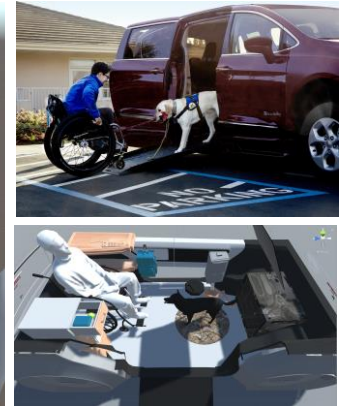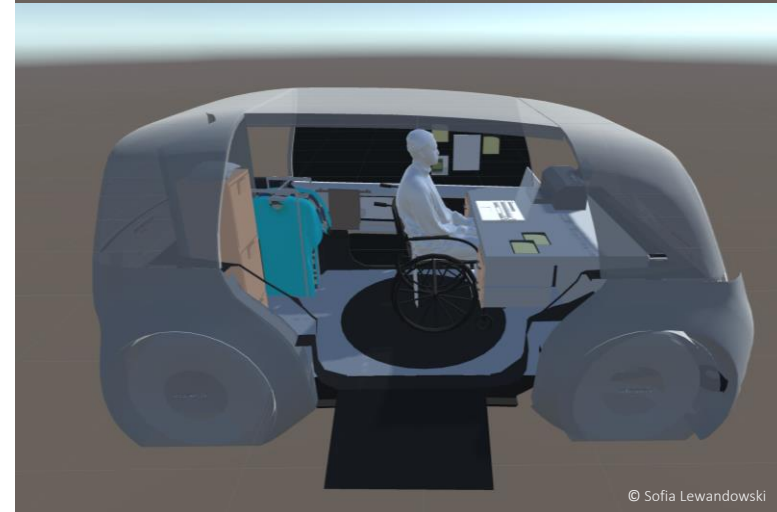Dog lovers' room
#Dog #Pets #Guide dogs
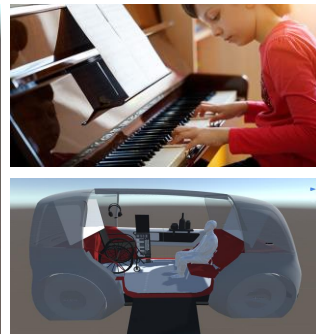
© Sofia Lewandowski

Sample1:
Piano room

#Music #Piano #Practicing
#Singing #Music #Music box

© Sofia Lewandowski

Sample2:
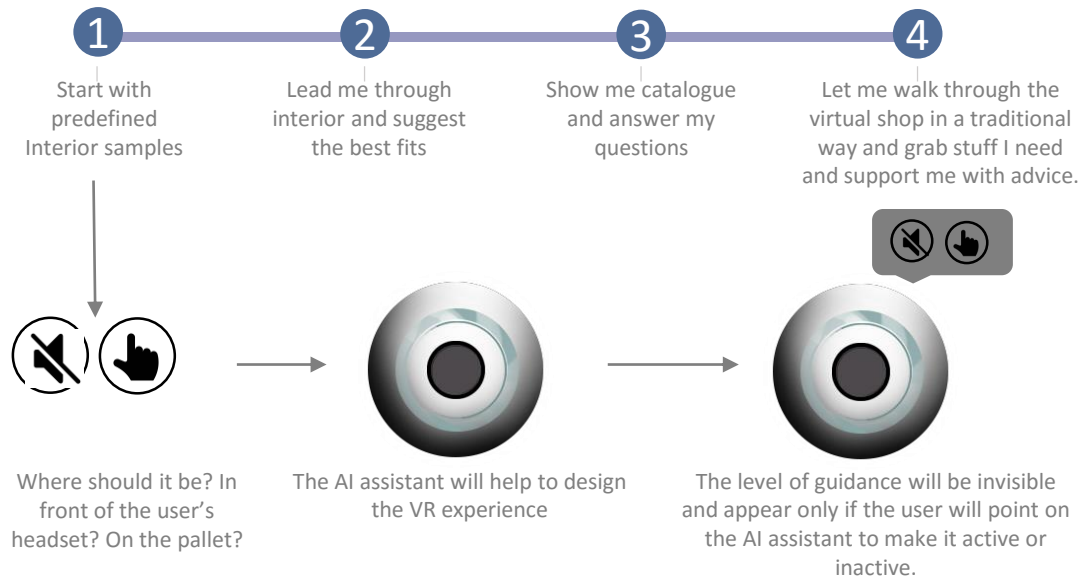Dog lovers' room
#Dog #Pets #Guide dogs

Level of guidance

Letting inexperienced users design their own experience rooms on wheels might be a challenging task for them. The AI assistant will make sure that they will be supported and guided through the design process. The AI assistant will help out based on created user profile information. The matching algorithms will suggest the best fit. When designing the role of the virtual helper, it was necessary to define level of guidance. The creation of level of guidance was based on research and existing examples in automotive and other areas. The final definition was achieved by going through some development steps. In the beginning the level of guidance was very task oriented and was created for more or less experienced design users, lazy and motivated users, as well as for people with different disability levels.

1 — **2** — **3** — **4**

1	2	3	4
Start with predefined Interior samples	Lead me through interior and suggest the best fits	Show me catalogue and answer my questions	Let me walk through the virtual shop in a traditional way and grab stuff I need and support me with advice.

Where should it be? In front of the user's headset? On the pallet?

The AI assistant will help to design the VR experience

The level of guidance will be invisible and appear only if the user will point on the AI assistant to make it active or inactive.

During the research phase and decision making process the level of guidance was reduced to two modes mute/unmute AI assistant and active/inactive pointer. The AI assistant would highlight areas that are suggested to pay attention to. To activate or deactivate the level of guidance the user would point at the AI guide in a natural way.

Avatar is created to support matching algorithm.

LET'S CREATE YOUR AVATAR

Age
Limitation
Type
Hobbies
Occupation
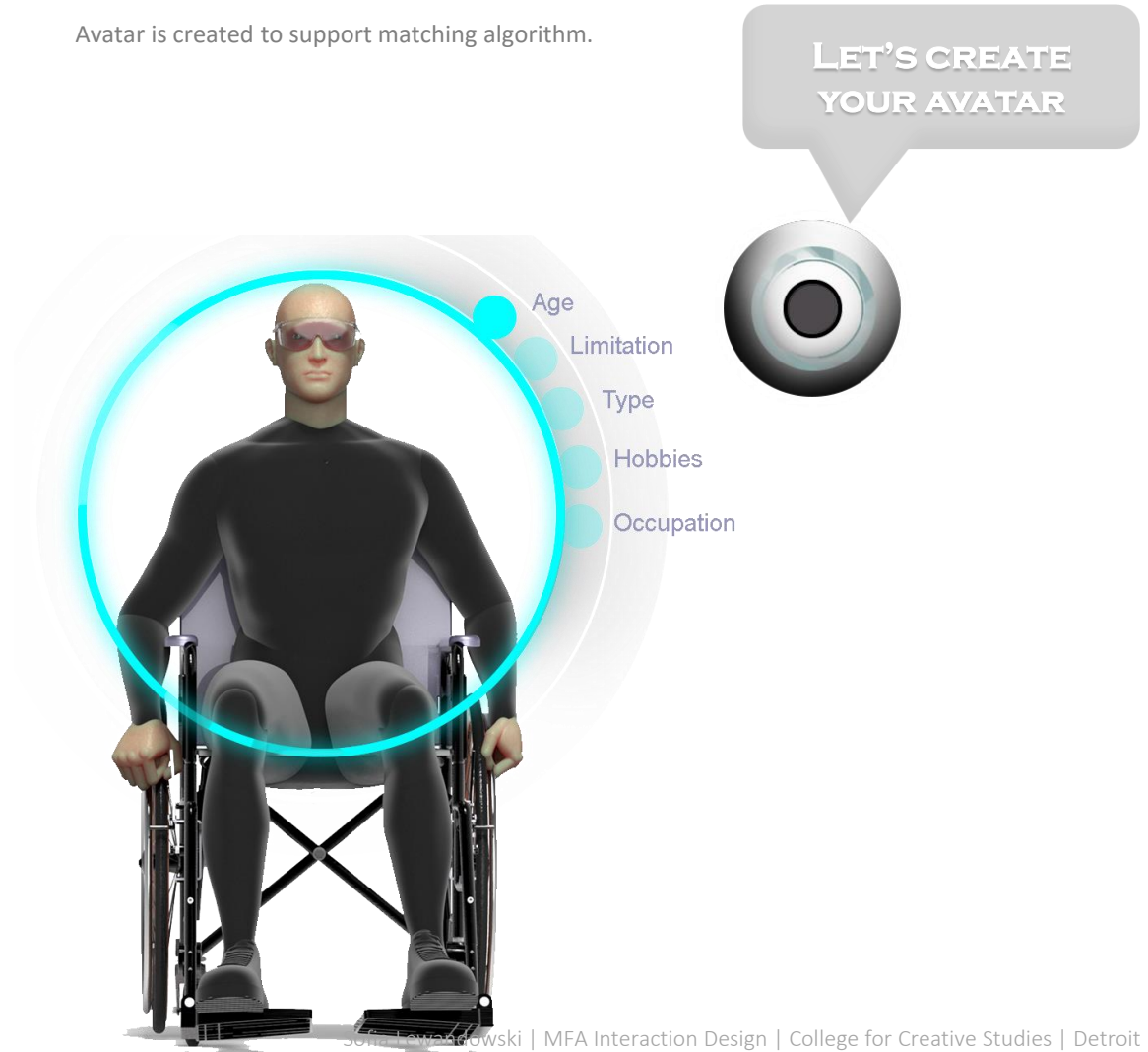
Content

5. Prototype

- Overall concept
- **Analysis**
- Journey map
- VR scene
- UI development

Process creation

To build a whole experience in VR that makes total sense for the user and supports him in his disabilities the analysis of similar processes and research was necessary to build a user journey in VR.

1. **Flow: Activity diagram** helps to understand how to guide the user through the process.
2. **Design Process: Transportation Design diagram** helps to understand how to support the user during the design process.
3. **Motivation: Co-Designing diagram** shows what can motivate the user.
4. **Similar processes** of designing through users.

1. Flow: To define the flow of the happenings in virtual reality and to build a guide for the AI so that it knows how to support the user best during the design process an activity diagram from a getting in to a getting out process from a vehicle was created and analyzed. The activity diagram will help to understand how to guide the user through the process.
Findings: The user usually passes five different main stages while riding a vehicle: getting in, setting up, navigating, getting comfortable and being entertained. After testing the diagram, the insight was that the AI's role should be asking the user "what if" questions and give him some options on solutions to chose from.

2. Design process:
To understand what all is necessary for the user to jump into the role of a designer and support him in the best way with necessary features and guidance, a design process from a transportation Interior designer was created.
Findings: The insight is that before the actual design process it is important for the system to know as much as possible about the user to support him in his needs. Also giving the user some inspirational scenes is helpful to get more ideas and be motivated to create and shop.

3. Motivation:
How to keep user motivated to work on the vehicle interior creation is a challenging assignment. After research about similar processes and good examples of co-designing and others, some insights were gathered and applied to the IXR concept.
Findings: The usual motivation of users to participate in co-designing projects is social recognition, learning process, gaming experience and monetary rewards.

4. Similar processes:

Some research on similar design processes were done in order to figure out what users usually struggle with and how to improve those struggles. The following processes were analyzed: creation of personal webpages, creation of vehicle interiors, customization of vehicles through online configurators, online grocery shopping at Meijer and a walk through IKEA.

Identified problems:
*   The customers usually don't know what they want.
The customers have emotional connections to some objects and topics but don't know what they are exactly.

Questions for designers:
*   What is your process while designing for a client?
*   Can you design with the client to simplify the process?
*   How would it work?
*   What would you need in your car to be accessible for you?
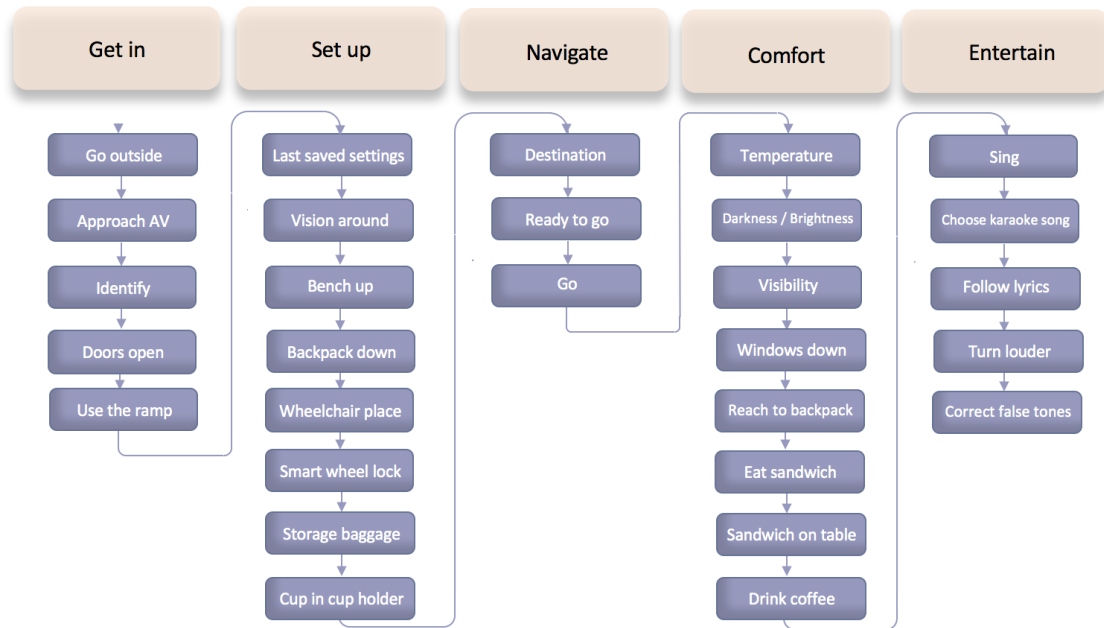
What the customer knows:
*   He knows what content should be inside. He knows that it should look good, be easy and usable in operation.
*   Based on previously experienced troubles the customer would know what he doesn't want.
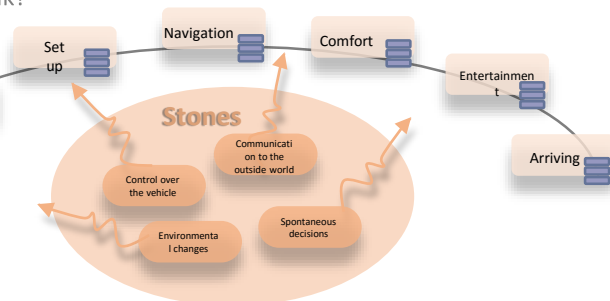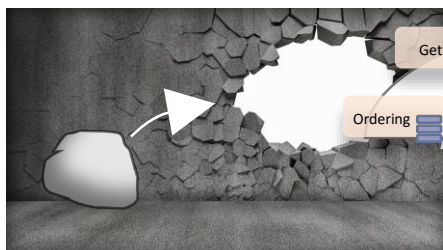
How can AI help to make decisions:
*   Give an option to see some existing examples from the library.
*   Show best practices – what do the interiors of famous people look like.
*   Show them their rooms in their homes to bring some familiar pieces inside of their cars.
*   Scan their room to use generative design to create a unique design of chosen objects.

Flow & Activity diagram

1. **Flow: Activity diagram** helps to understand how to guide the user through the process.

Stones towards activity diagram.

Get in	Set up	Navigate	Comfort	Entertain
Go outside	Last saved settings	Destination	Temperature	Sing
Approach AV	Vision around	Ready to go	Darkness / Brightness	Choose karaoke song
Identify	Bench up	Go	Visibility	Follow lyrics
Doors open	Backpack down		Windows down	Turn louder
Use the ramp	Wheelchair place		Reach to backpack	Correct false tones
	Smart wheel lock		Eat sandwich	
	Storage baggage		Sandwich on table	
	Cup in cup holder		Drink coffee	

Stones	Desire: User wants...	AV's action
The sun changes position	...to darken up	Darken up the windshield
It starts to hail	...to go home suddenly.	Hide the car somewhere under a roof or to go home
There is a sandstorm	... to turn around	AV slows down, Turns around, Finds the best route to avoid the sandstorm
Eric gets a heart attack	... to get help	Eric presses the button. AV changes the route, switches on the emergency mode, increases the speed, brings Eric to hospital
There are robbers in front of the vehicle	...to switch on the "protection" button	AV creates an electroshock field around itself and calls police
Someone parked to close	...to get inside of the car	AV backs up and let the user come in
... sees his friend	...to say "Hi"	Slow down or stop — Say "Hi", AV should greet, wink or beep
... feels hungry	... to get some food	Which restaurant
... needs to go to the restroom	...to stop asap	Find the first restroom and stop
... doesn't see the city view because of the tree	... wants to have a nice view	Change parking spot. Move 4 meter to the right
... doesn't want to walk a lot	...to park as close as possible to shop entrance	Find the closest parking spot to shop entrance
... doesn't want to go home	...to stay in the car and relax	Find the closest parking spot to entrance
... doesn't want to go home	...to stay in the car and relax	Find the closest parking spot to entrance
... needs a selfie	...AV to take a selfie from him	Eric tells AV to focus on him standing in front of the car and take a picture

Prove the system: Where will the system break?

Flow & Activity diagram

1. **Flow: Activity diagram** helps to understand how to guide the user through the process.

| Stones	Desire: Eric	Problem	Opportunity	Solution suggestions
Eric gets a heart attack	… to get help	Eric can't reach the button	Design a solution for Eric in reachable distance	Button in reachable distance, voice command, camera system that tracks user's pulse rate
Eric drops his glasses	… to pick them up	Eric can't reach to the floor	Design options for picking up objects	Tangible surfaces, robotic arm, gravity thing,
Eric have to secure his ride	… to lock down his wheelchair	Eric can't reach the floor	Design automatic wheels lock	
Eric has a pie in his backpack	… to back up to get to his space	He doesn't see what is behind him	Design opportunities for vision extension	Visual, acoustic cues (beacon), cameras, mirrors.
During the long ride Eric feels uncomfortable in his wheelchair	… to switch to the seat.	Wheelchair needs to be stored safely	Design opportunities for wheelchair storages	Robotic arm that breaks down the wheelchair and stores, a box, drawer.
Eric feels cold	… to switch on the heater	Eric can't reach the buttons	Design the interaction elements around Eric	Voice, Gesture, remote control, UIs, buttons depending on his disability and age
Eric always have dirty hands from wheels	… to have clean hands	Eric doesn't want to make his car interior dirty	Design opportunities for Eric to clean up his hands	Sink, Shelf with tissues, gloves

After analyzing as many use case scenarios as possible and identifying some troubles the user might experience in his vehicle the system suggests to improve some accessibility issues. The smart AI walks with the user through the process of autonomous vehicle creation. It always asks him if he has thought about certain cases.

For example: The user gets closer to the vehicle and wishes to access. The system asks which access method for user identification and opening the doors the user would like to use: finger print, facial recognition, NFC technology or a code via sms. It will depend on user's ability. If the user is not able to reach to the door for a finger print identification, then he might use the facial recognition method.
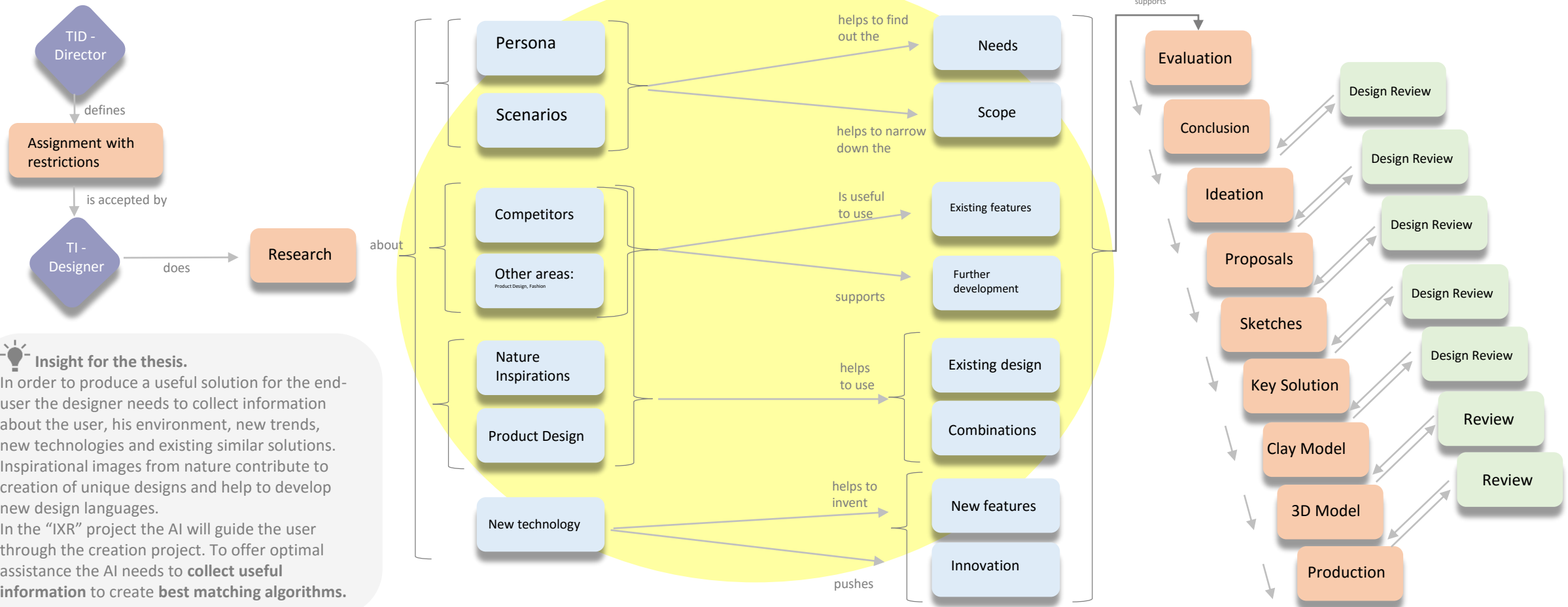
The system also will try to figure out if the user has thought about some details. The AI would ask the user: "You just dropped your glasses. Will you be able to pick them up?" If the user won't be able to perform this action the system would suggest to implement some auxiliary tools: pick up tool, tangible floor, robotic arm and so on.

The AI would also ask the user to reach to a created control panel. If the user won't be able to perform the AI will suggest to bring the panel closer, design physical buttons on the side, create a User Interface in augmented reality and so on.
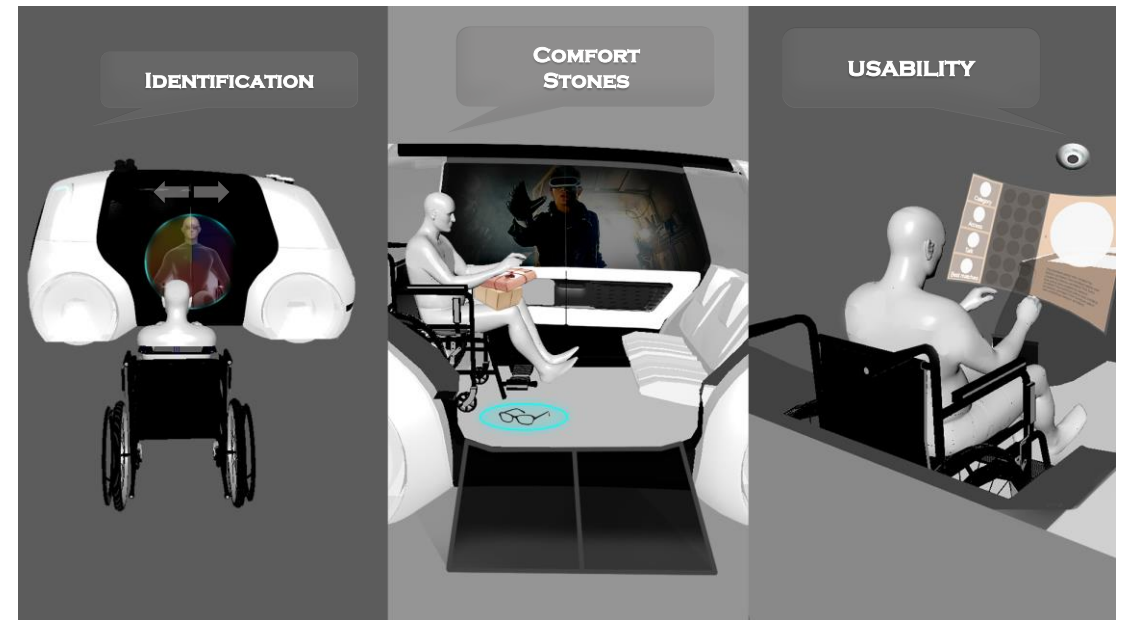
Design Process & TID

2. **Design Process: Transportation Design diagram** helps to understand how to support the user during the design process.

TID - Director

↓ defines

Assignment with restrictions

↓ is accepted by

TI - Designer → does → **Research**

💡 **Insight for the thesis.**

In order to produce a useful solution for the end-user the designer needs to collect information about the user, his environment, new trends, new technologies and existing similar solutions. Inspirational images from nature contribute to creation of unique designs and help to develop new design languages.

In the "IXR" project the AI will guide the user through the creation project. To offer optimal assistance the AI needs to **collect useful information** to create **best matching algorithms.**

about

Persona

Scenarios

helps to find out the → **Needs**

helps to narrow down the → **Scope**

Competitors

Other areas:
Product Design, Fashion

Is useful to use → **Existing features**

supports → **Further development**

Nature Inspirations

Product Design

helps to use → **Existing design**

Combinations

New technology

helps to invent → **New features**

pushes → **Innovation**

supports

Evaluation

Conclusion

Ideation

Proposals — **Design Review**

Sketches — **Design Review**

Key Solution — **Design Review**

Clay Model — **Design Review**

3D Model — **Review**

Production — **Review**

Motivation & Co-creation

3. **Motivation: Co-Designing diagram** shows what can motivate the user.

Co-creation is associated with communities, crowdsourcing, social media and user generated content.
How does the user benefit? Why should the user care and how can co-creation be beneficial for designers' work?
The users, expert stakeholders and partners develop concepts together with a designer.
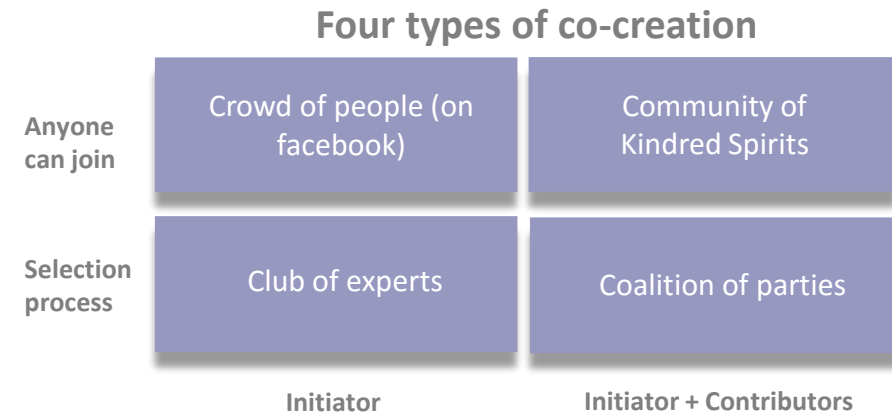Albert Einstein argued: "You cannot solve a problem within the same thinking that created it."
Bill Joy argued: "No matter how smart you are, most of the smartest people always seem to work for someone else."

There are five guiding principles:
1. Inspire participation (why should people care?)
2. Select the very best (calculation of people and ideas)
3. Connect creative minds
4. Share the results (important to acknowledge, inform and reward your participants)
5. Continue development (co-creation is great but it is only one of the tricks)

Co- creation is great for: fresh ideas, new perspectives and great energy. It is about involving the outside world in a new way.

In 2010, Local Motors developed a car named Rally Fighter in a record 18 months, which is about 5 times faster than what a conventional car manufacturing process takes. By empowering a community of over 2000 designers to submit their designs while still placing some constraints on the basic design, color schemes etc., Local Motors effectively utilized the co-designing model of customer co-creation. The winning design was chosen by the designer community through voting. An interesting bit of trivia about Local Motors is that it doesn't even have a design team. All the designing is done by the public itself. Local Motors created the world's first accessible bus Olli in the same way.

Four types of co-creation

	Initiator	Initiator + Contributors
Anyone can join	Crowd of people (on facebook)	Community of Kindred Spirits
Selection process	Club of experts	Coalition of parties

Co-designing

benefit

New Insights

produce

Best solution

Social recognition

produced by

are accepted by

User

Learning process

give

Firms

Assignments and restrictions

produce

User

Solutions

Selected by

Public

votes for

receives

Rewards

Gaming

User

Monetary reward

received from

💡 **Insight for the thesis.**
Motivation is the main aspect at the co-creation process. Social recognition, learning process, gaming experience and monetary rewards motivate users to participate.
Let people play with the application, give them rewards and the opportunity to share.
Example: User buys his features – it costs something for him. He can collect bonus points when he purchases accessibility features. He also gets points if he shares his completely self-created solution with the community by saving it to a public library.

Similar processes

How do you design a homepage for a customer when they don't know what they want?
Usually the customer doesn't know what the homepage should look like. The customer tells what the homepage should roughly include. The designer creates proposals on some basic requirements and communicates with the web designer or a web developer back and forth. The customer criticizes what he or she does not like. The developer improves and "guesses" what the customer might want trying to meet the expectations. The conversation might be long.

How do you design a vehicle interior with blurry vision? The users usually just design something.
Through some meetings with marketing representatives, engineers, and other participants the new need of a new design is defined. The defined need is sometimes not specific enough. The design director tells his team that the new design is needed. Everyone starts working on the new concept. Let's say 5 designers would work on the same topic. They would present 10 of their best sketches. Only one will be chosen by the design manager and design director. Everyone will start working on the new chosen design proposal to create as many alternatives as possible. After a meeting a new proposal out of 50 will be chosen. Every time the designer will try to guess which direction it should go and whether or not the design manager and director will be happy with the proposed solution. A lot of times it is about guessing more or less based on research from the internet or internal sources.

How do you customize your vehicle through a limited online configurator?
Online configurator usually allows you to change some colors, materials and some parts like rims. It does not really allow the customer to freely decide what will go inside and what the interior will look like. The process is pretty easy but doesn't give you lots of opportunities to create a customized interior.

How do you shop for groceries at Meijer online? Often you know what you want through previous experience, but the search can take a long time.
Based on my usual habits and preferences (**previous experience**) I usually buy the same products to save time on searching and reading.
I type in the search bar the product names I already know. I also look up the product names on my shelves at home and type them in to find out if they are available online.

How do you shop at IKEA? There is usually a long search and long walk. Customer wonders around and has too many options and no spontaneous exit.

The customer looks for a special product. It can be a table. The customer doesn't know what exactly the product should look like. He expects at IKEA to see some **examples** of already predesigned rooms. IKEA does a good job at that.

Sometimes the customer knows what functions the desired product should have based on the **experienced needs**: It has to have a **storage space**. My documents are everywhere in my room and I have to stand up, pick them up from a shelf or from my closet and go back to my table. It is inconvenient. My table should have a bright color so that it **matches** well **to my other furniture pieces** in the room. The customers go to the IKEA with some expectation and requirements but don't know exactly what they will find and finally like. The designer designs something based on his information of what the user might expect and tries to **guess** what the potential user might like.

It would be great if there would be a scanner that would analyze my room or favorite objects to suggest the designs I might like or create new designs for me using "**generative design**".
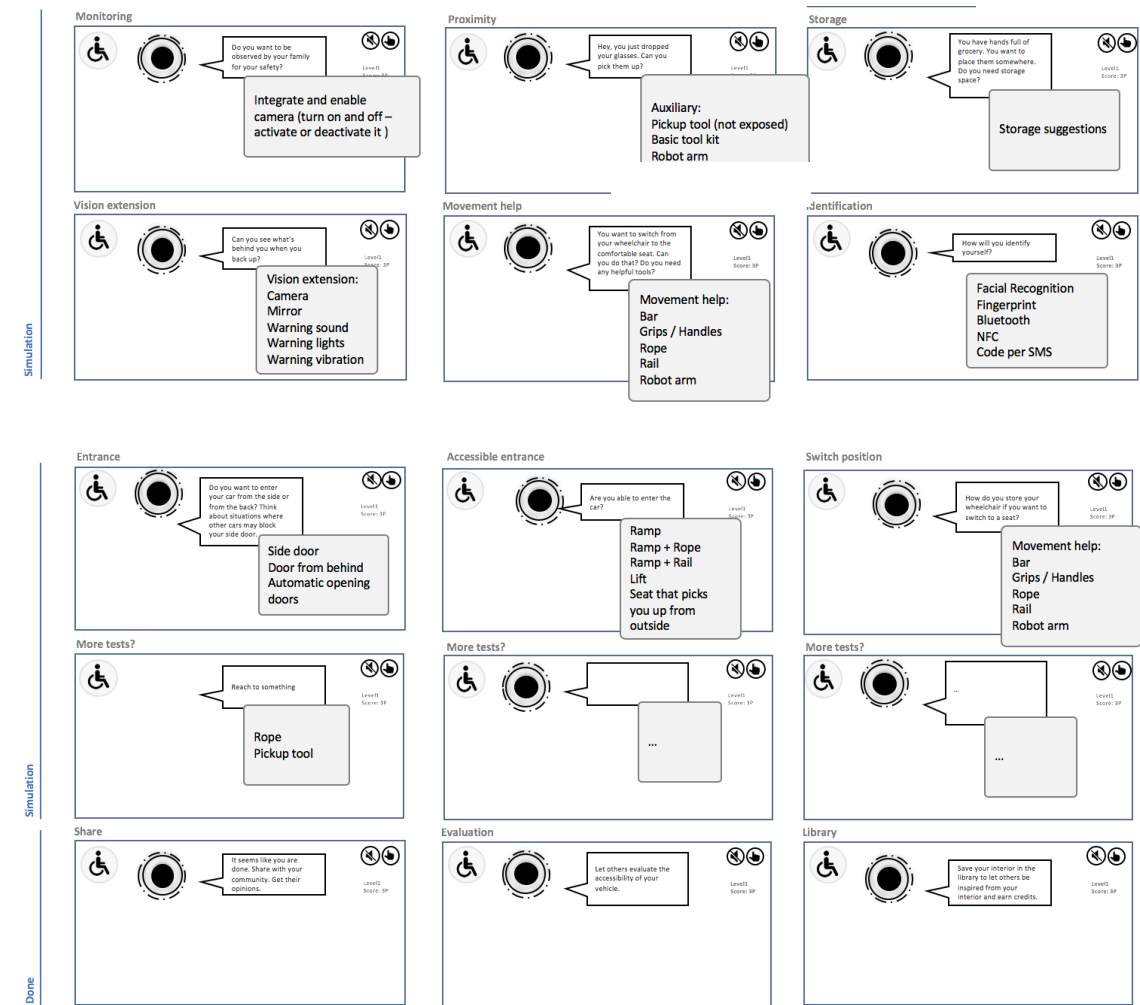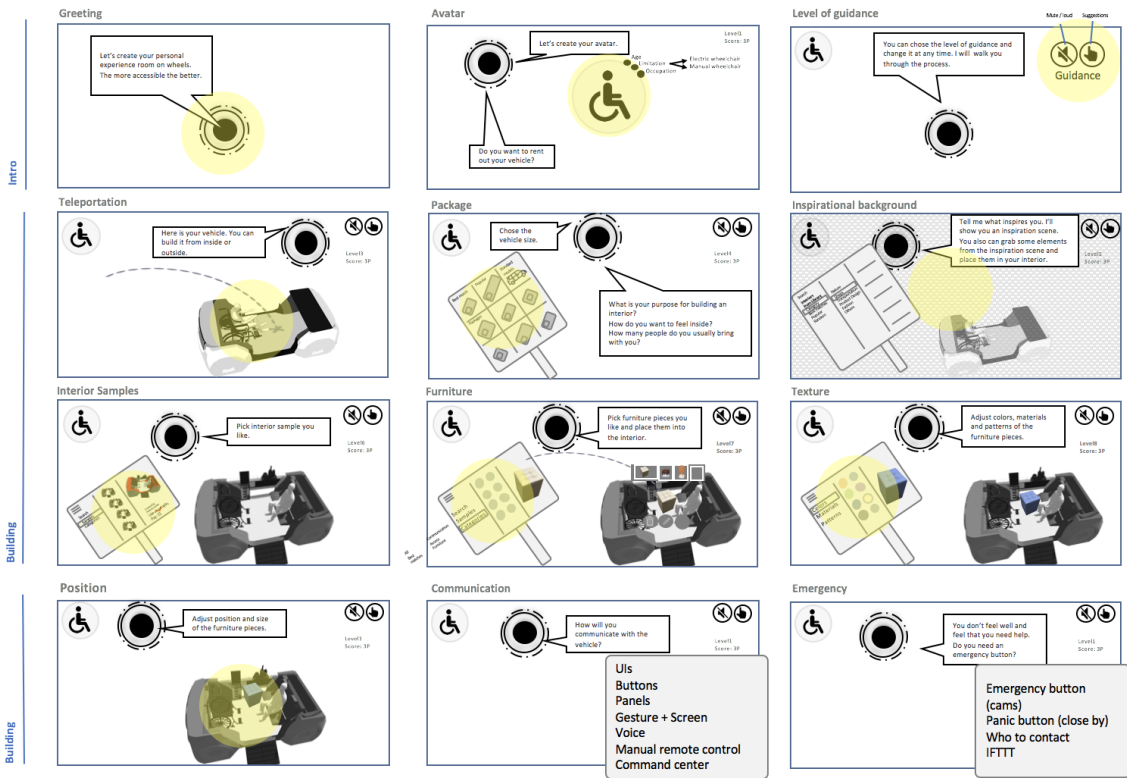https://www.autodesk.com/solutions/generative-design
https://www.autodesk.com/redshift/what-is-generative-design-2/
https://autodeskresearch.com/projects/dreamcatcher

Content

5. Prototype

- Overall concept
- Analysis
- **Journey map**
- VR scene
- UI development

User Journey map

User journey for virtual reality was created to specify the flow in the virtual experience. It is a orientation guideline for the meta designer to design the necessary environment for user to create. It involves the AI assistance leading user through the process. It shows the pallet with necessary features and questions the AI will ask during the creation process.

Intro

Greeting — Let's create your personal experience room on wheels. The more accessible the better.

Avatar — Let's create your avatar. / Do you want to rent out your vehicle? / Age, Limitation, Occupation → Electric wheelchair, Manual wheelchair / Level1 Score: 3P

Level of guidance — You can chose the level of guidance and change it at any time. I will walk you through the process. / Mute/mud, Suggestions / Guidance

Building

Teleportation — Here is your vehicle. You can build it from inside or outside. / Level2 Score: 3P

Package — Chose the vehicle size. / What is your purpose for building an interior? How do you want to feel inside? How many people do you usually bring with you? / Level4 Score: 3P

Inspirational background — Tell me what inspires you. I'll show you an inspiration scene. You also can grab some elements from the inspiration scene and place them in your interior. / Level5 Score: 3P

Interior Samples — Pick interior sample you like. / Level6 Score: 3P

Furniture — Pick furniture pieces you like and place them into the interior. / Level7 Score: 3P

Texture — Adjust colors, materials and patterns of the furniture pieces. / Level8 Score: 3P

Position — Adjust position and size of the furniture pieces. / Level1 Score: 3P

Communication — How will you communicate with the vehicle? / UIs, Buttons, Panels, Gesture + Screen, Voice, Manual remote control, Command center / Level1 Score: 3P

Emergency — You don't feel well and feel that you need help. Do you need an emergency button? / Emergency button (cams), Panic button (close by), Who to contact, IFTTT / Level1 Score: 3P

Simulation

Monitoring — Do you want to be observed by your family for your safety? / Integrate and enable camera (turn on and off – activate or deactivate it) / Level1 Score: 3P

Proximity — Hey, you just dropped your glasses. Can you pick them up? / Auxiliary: Pickup tool (not exposed), Basic tool kit, Robot arm / Level1 Score: 3P

Storage — You have hands full of grocery. You want to place them somewhere. Do you need storage space? / Storage suggestions / Level1 Score: 3P

Vision extension — Can you see what's behind you when you back up? / Vision extension: Camera, Mirror, Warning sound, Warning lights, Warning vibration / Level3 Score: 3P

Movement help — You want to switch from your wheelchair to the comfortable seat. Can you do that? Do you need any helpful tools? / Movement help: Bar, Grips / Handles, Rope, Rail, Robot arm / Level1 Score: 3P

Identification — How will you identify yourself? / Facial Recognition, Fingerprint, Bluetooth, NFC, Code per SMS / Level1 Score: 3P

Entrance — Do you want to enter your car from the side or from the back? Think about situations where other cars may block your side door. / Side door, Door from behind, Automatic opening doors / Level1 Score: 3P

Accessible entrance — Are you able to enter the car? / Ramp, Ramp + Rope, Ramp + Rail, Lift, Seat that picks you up from outside / Level1 Score: 3P

Switch position — How do you store your wheelchair if you want to switch to a seat? / Movement help: Bar, Grips / Handles, Rope, Rail, Robot arm / Level1 Score: 3P

More tests? — Reach to something / Rope, Pickup tool / Level1 Score: 3P

More tests? — ... / Level1 Score: 3P

More tests? — ... / Level1 Score: 3P

Share — It seems like you are done. Share with your community. Get their opinions. / Level1 Score: 3P

Evaluation — Let others evaluate the accessibility of your vehicle. / Level1 Score: 3P

Library — Save your interior in the library to let others be inspired from your interior and earn credits. / Level1 Score: 3P

Done

Scenario in VR

Scenario in VR for the prototype

- ❑ The experience starts in the office room. The camera is positioned from the perspective of the person in a wheelchair.
- ❑ AI greets and suggests to use the remote control and pallet to browse through scenes "Hi! Use your pallet to browse through some interior samples." – Similar to 4D-UI in Tilt Brush. In Tilt Brush all 4 interfaces are available to give user freedom and not to restrict him in his choices of the designing process. The system suggests to use "samples – interface" on the 4D pallet by flashing the interface.
- ❑ It is possible to point to mute/unmute on the AI and let it highlight elements that are recommended to try out or use. The standard setting in the VR demo for AI will be "unmute" and "highlight".
- ❑ User browses through samples/scenes.
- ❑ (AI suggests) User tries out highlighted functions on elements. For example: In the office room on the desk he presses a flashing button and printer will appear or disappear. Similar to kitchen storage areas in a VR game called "Job Simulator".
- ❑ (AI suggests) User changes the position of elements, colors and textures.
- ❑ (AI suggests) User replaces existing furniture pieces with other furniture pieces, deletes them, changes colors by pointing directly on furniture, not on the pallet.
- ❑ (AI suggests) User uses the pallet to find new elements he needs for his interior.

Technical requirements for VR execution

- ❑ Elements should snap to surfaces they can be attached to.
- ❑ Elements that will be 3D printed are scalable, color and texture changeable.
- ❑ Electronic elements or products that have to be purchased as a whole won't be scalable. The change of colors and materials will depend on suppliers' options and will be limited.
- ❑ Each element will reveal User Interface when pointing on it and pressing a button at the same time. The options will include: delete; show alternatives and change color or change size.

30 second video definition – to focus on the main idea

1. Browsing through three different samples / different interior environments
- ❑ UIs
- ❑ Three Unity environments

2. Delete what you don't like in samples
- ❑ Complete scene: including environment around, car interior, remote controls and UIs on the object from outside

3. Place new elements, change position and colors

5. Prototype

- Overall concept
- Analysis
- Journey map
- **VR scene**
- UI development

Designing the VR scene

© Sofia Lewandowski

Use the pallet

Teleport yourself.
LEVEL 5
SCORE: 600
© Sofia Lewandowski
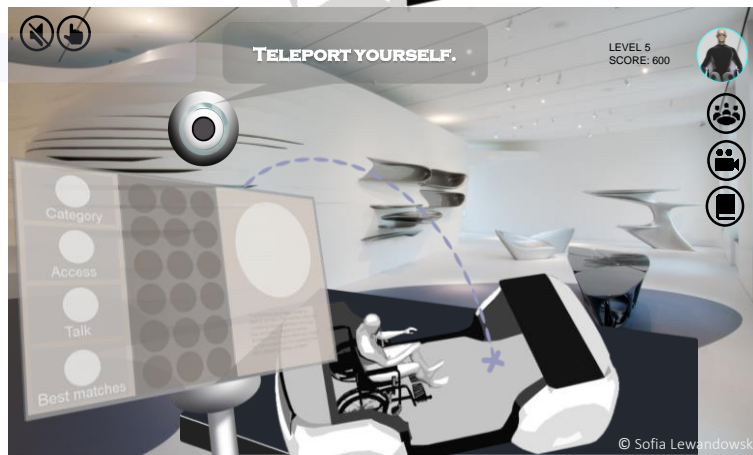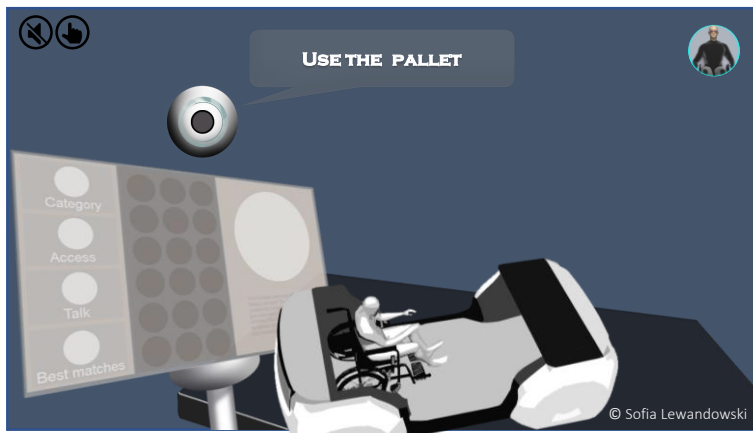
Pallet / AI / Environment

The VR scene includes the vehicle interior with an avatar of a person who is currently building his interior. The avatar is there for user to be able to see himself from the side perspective to be able to evaluate the space and distance proportions better. The scene also includes the virtual pallet which has placeholders for this given moment of development to include necessary elements inside. The AI assistant flies around and helps the user make choices. The environment around can be changed on user's request. The environment is meant to inspire the user to be more creative. The icons on the right side reveal the user's profile, sharing the creation with the community, recording the final vehicle interior design and saving the created product to the public library so that the library can grow.

To motivate the user in the car creation the meta designer uses a gamification principle. The user has to complete some levels of designing process and gets scores depending on the achieved results.

LEVEL 5
SCORE: 600
© Sofia Lewandowski

LEVEL 5
SCORE: 600
© Sofia Lewandowski

Sofia Lewandowski
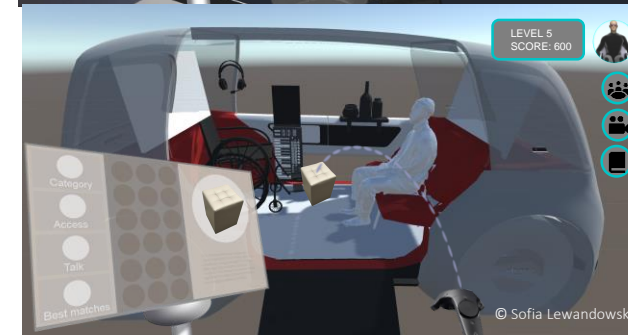
Different perspectives

The user is able to teleport himself anytime and design from different perspectives.
He is able to place elements inside the vehicle from the virtual pallet and position them anywhere in the interior. The user can substitute the elements from the option menu which appears above every object.
He can delete elements, change the color and materials as well as resize the elements.
Also the position from the avatar may change depending on where the user will decide to spend time during the ride.
Once the user teleports himself to the place where the avatar sits it will disappear on collision.
Since the system will already know the profile of the user and visually scan his disabilities it will suggest best matches for features, furniture pieces and accessibility tools.
For example: the system scans the user and recognizes that the user is in a wheelchair. AI will suggest some options that apply to this person: ramp, lift, sliding board, rails or lock downs for the wheelchair.

Designing the VR scene

© Sofia Lewandowski

© Sofia Lewandowski
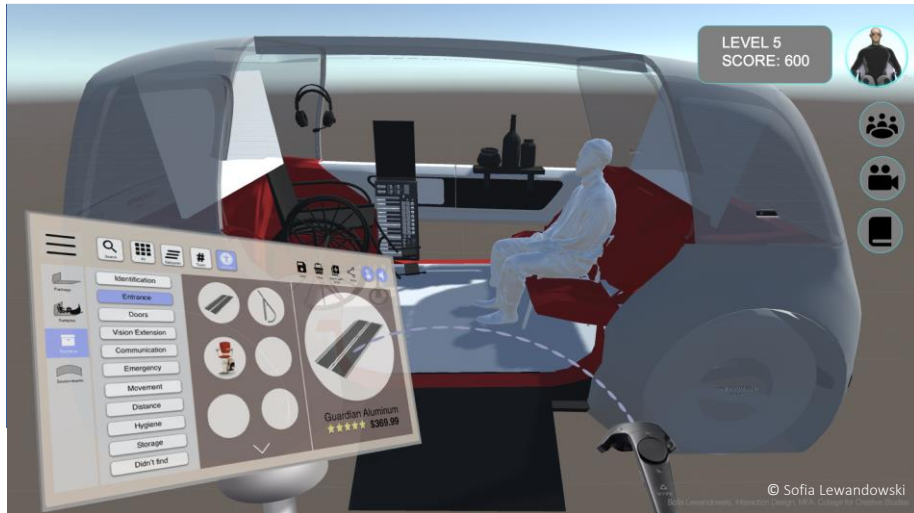
Perspectives

In the later development process it was decided not to restrict user though defining certain positions from where he can design. The user can teleport himself anywhere around the vehicle.
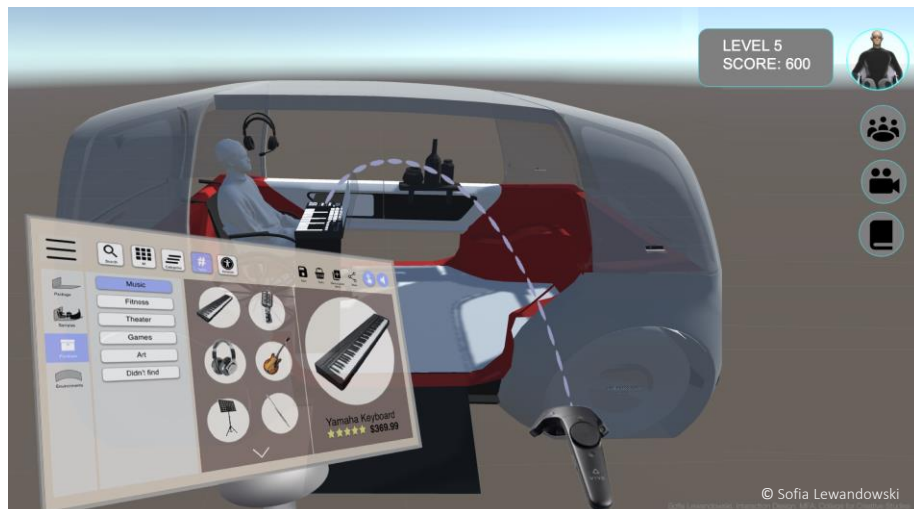
Virtual pallet

A lot of work was also done on the virtual pallet. It changed from a very complicated information architecture to a more simple one.

© Sofia Lewandowski
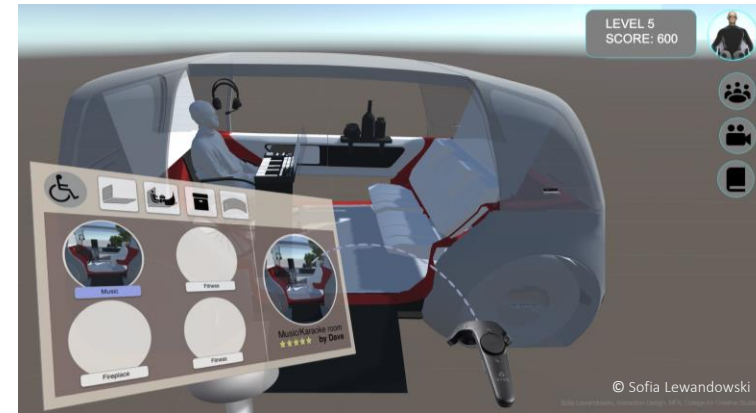
Interaction

Not only did the pallet information architecture change but also the way of interacting with it. During some user testing it was observed that the user intuitively grabs elements from the pallet instead of pointing to and selecting them with the laser pointer.

© Sofia Lewandowski

Content

5. Prototype

- Overall concept
- Analysis
- Journey map
- VR scene
- **UI development**

UI Development

At first a wireframe prototype was created for the virtual pallet, that was divided into sections: categories, all products in a chosen category and a selected product with more detailed information.

In the later steps what information is important for the user to find in the pallet and what is important to include into the pallet in order to make the best product or scene suggestions was analyzed. The pallet went from very complicated architecture to a more simple one.
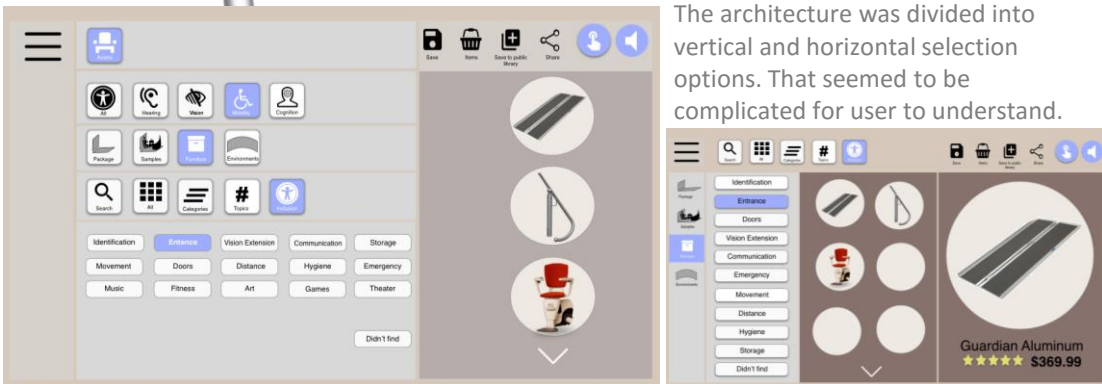
The architecture was divided into vertical and horizontal selection options. That seemed to be complicated for user to understand.
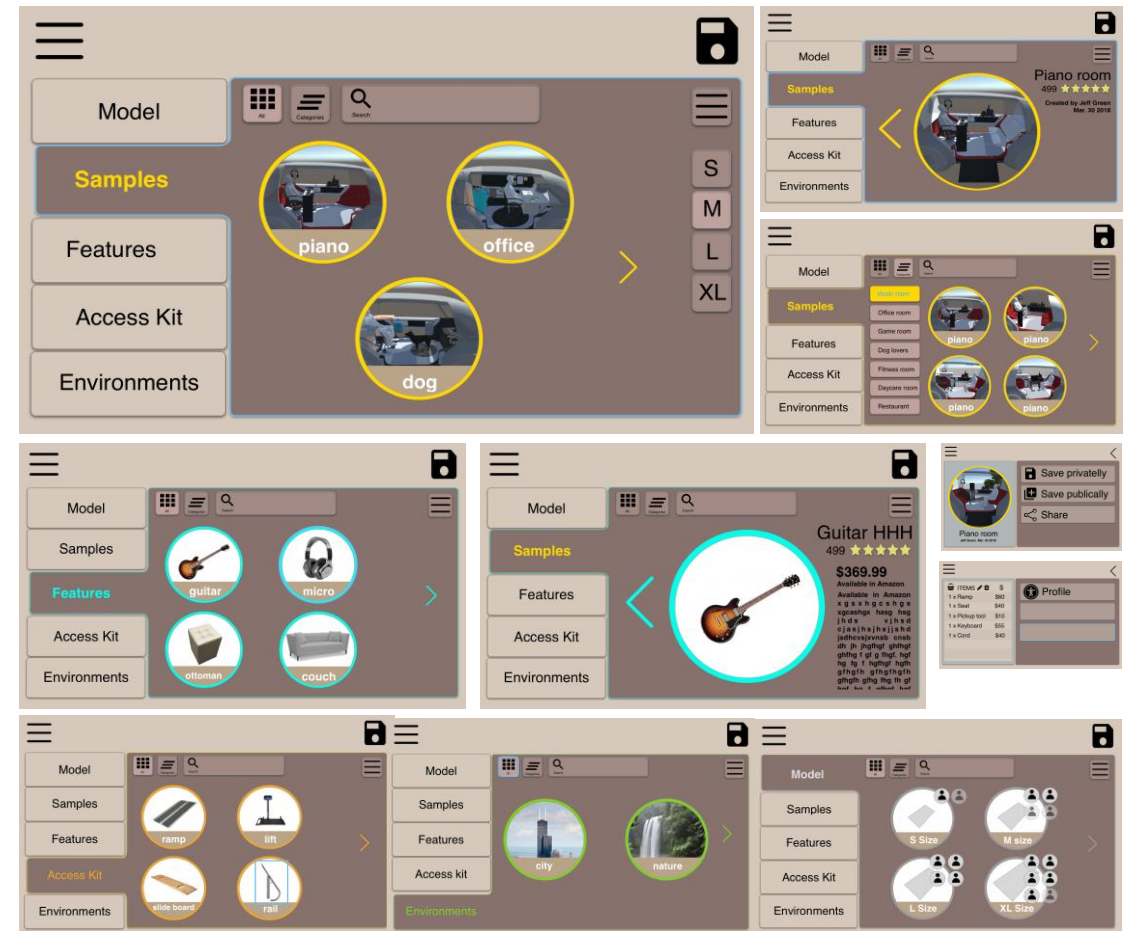
There were five different information blocks identified that could be useful for the user to support him during his design process: Model / package size, interior samples, features, accessibility kit and environments.

UI Development

During the user testing it was observed that users were using mainly two tabs: "Samples" and "Features". The pallet was simplified based on customer's feedback.

At one of the advisory meetings an advisor pointed out that the 2D pallet doesn't seem to fit into a 3D-world. On later steps 3-D features were integrated into the pallet for a better evaluation through the user before placing those into the virtual scene.
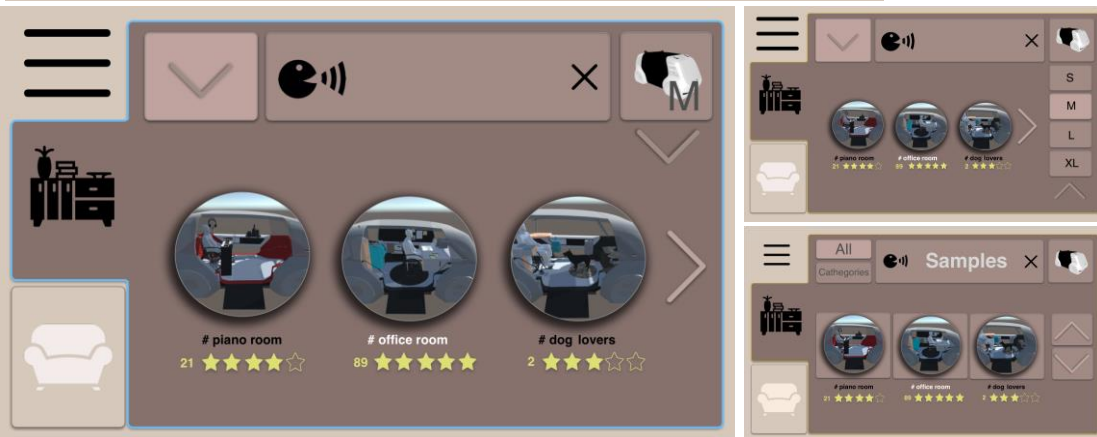
The pallet was simplified and designed in a more logical way, where the user sees the most important tools at first and can select other options in an extra menu if needed.

VR prototype contained samples and features on the same interface surface to test quickly interactive functions . The samples were packable with the pointer and the features were grabbable with the controller. Later the pallet was split in two separate user interfaces: samples and features.

Menu above objects

Prototype for the menu appears over every object once the user hovers over it. The menu is created for the user to have more options: to delete, resize or substitute the products. It is also possible to change colors and materials of the products.

The menu created for the VR prototype img1. differs from the menu created for the concept. In the menu created for the concept it will be possible to chose multiple colors rather than just three different colors. The user will get a separate screen on color and materials options as soon as the color or materials options is activated.
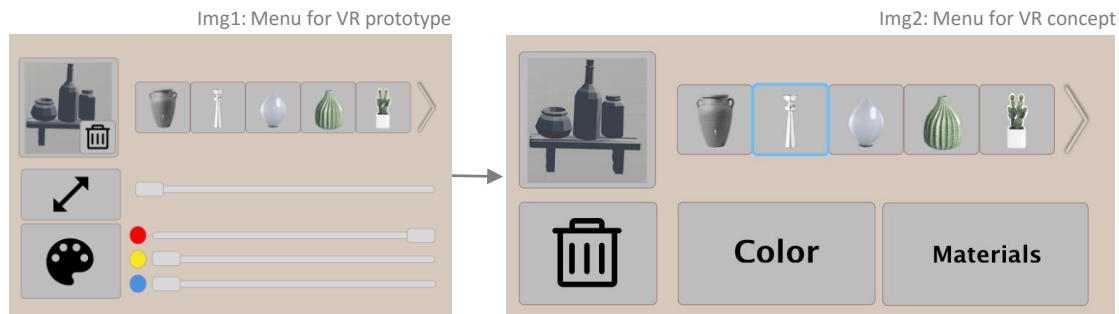
Img1: Menu for VR prototype   Img2: Menu for VR concept

Content

6. User Journey

Eric, 37

Level 5
New York

Consultan
t

L3,4

L2

Dog lover

Suburban areas

Freeways

© Sofia Lewandowski

67

User Journey in VR

IxR - Individual Experience room is a virtual reality experience where Eric can design his autonomous vehicle. Eric has support and guidance to define his special virtual space. After Eric enters the virtual autonomous vehicle he picks his vehicle size with the right package for him provided by auto manufacturers.

IxR

© Sofia Lewandowski

© Sofia Lewandowski
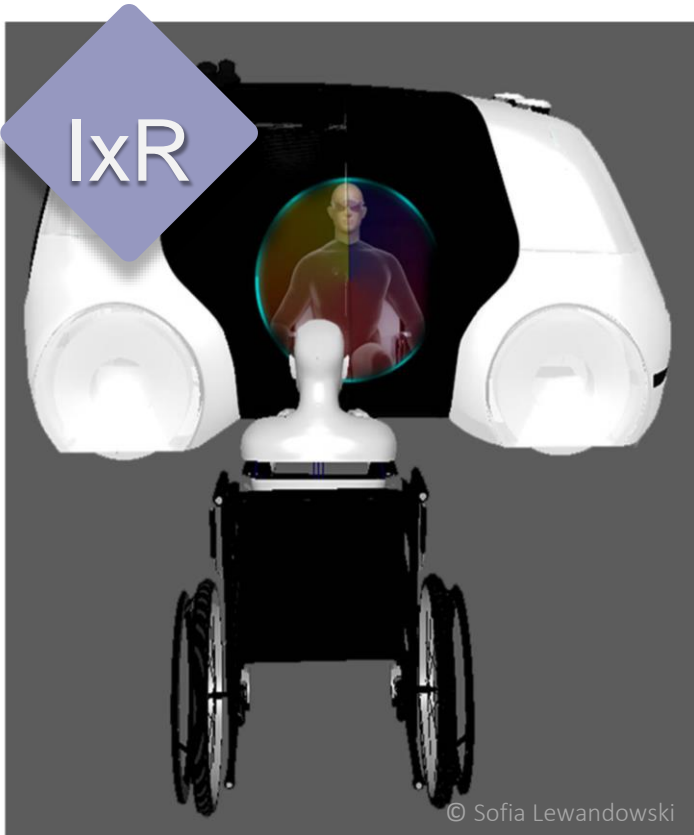
#Piano Room

Eric cycles through some predefined
interior samples saved in the public library.
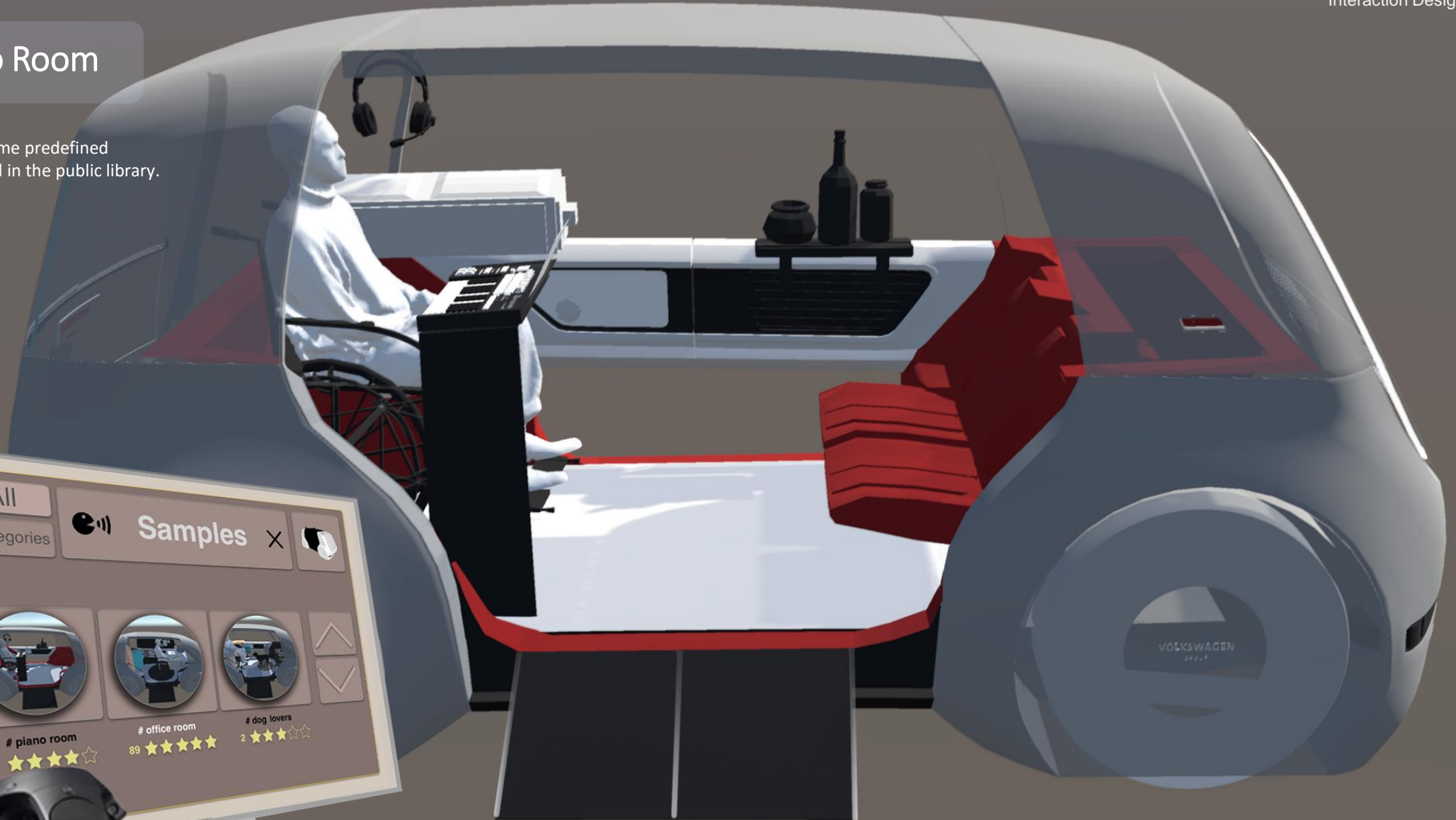
#Office Room

All

Cathegories

Samples ✕

piano room
21 ★★★★☆

office room
89 ★★★★★

dog lovers
2 ★★★☆☆

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit
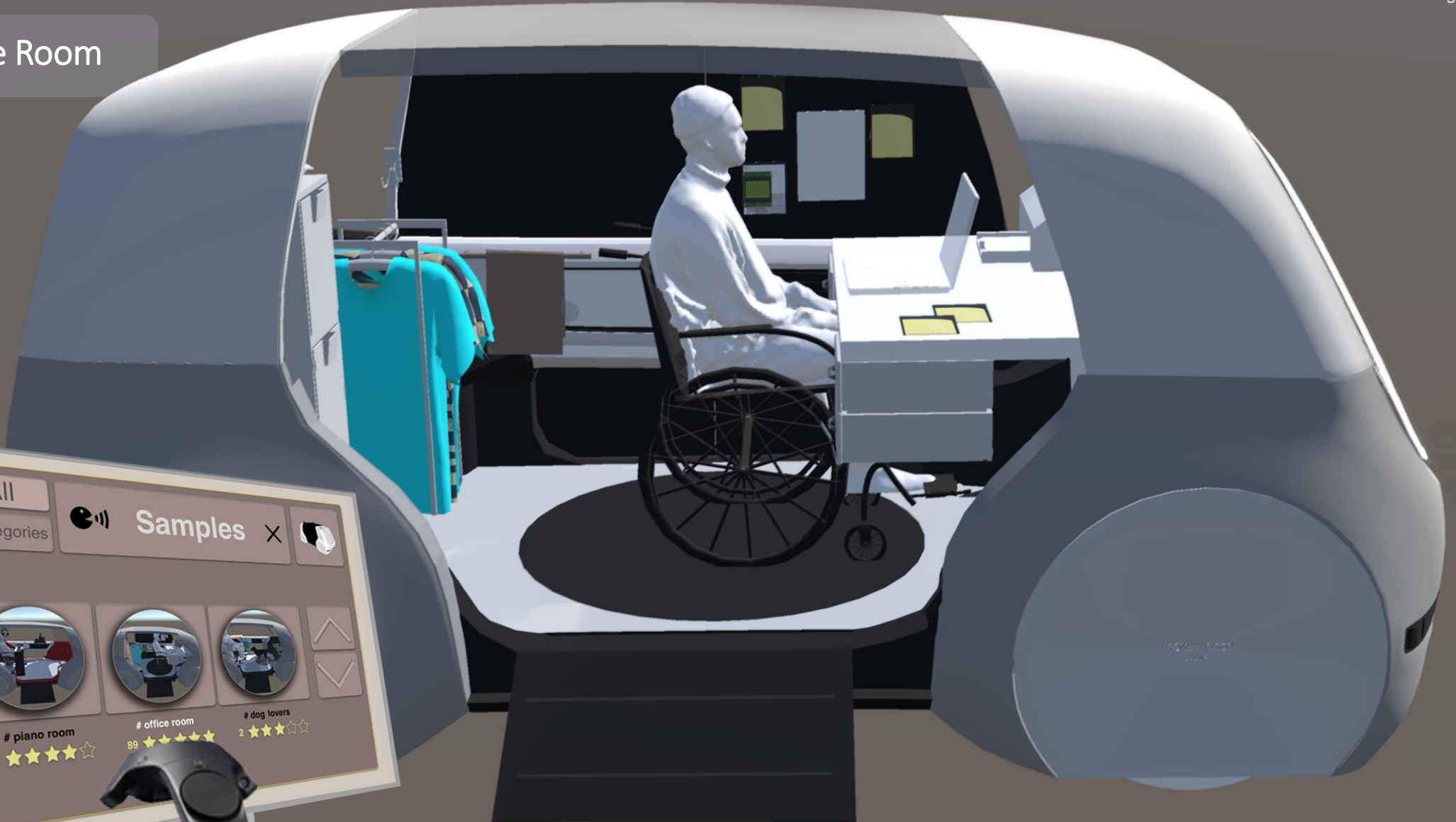
#Dog Lovers' Room

Vehicle Interior creation

Eric picks one of the predefined interior samples and redesigns it adjusted to his needs. He deletes elements he doesn't need and places elements inside of the vehicle interior. He spawns elements into the scene through a natural way of communication: voice control, powered by IBM Watson. The pallet is a helpful tool in addition to voice communication. He grabs features from the pallet and put them inside of the vehicle.

Color

Materials

All

Cathegories

Seat

seat
21 ★★★★☆

seat
14 ★★★★☆

seat
5 ★★★★☆

Create a seat!

Save

Save privatelly
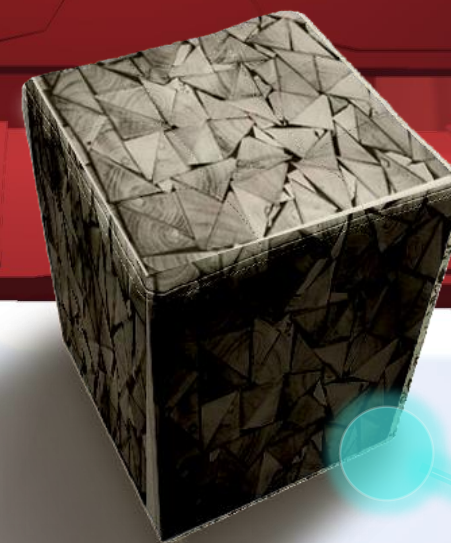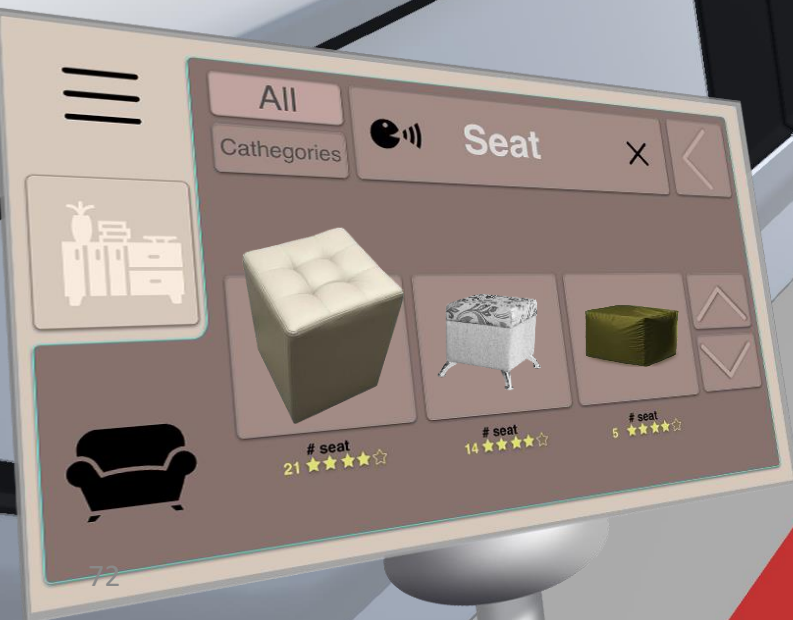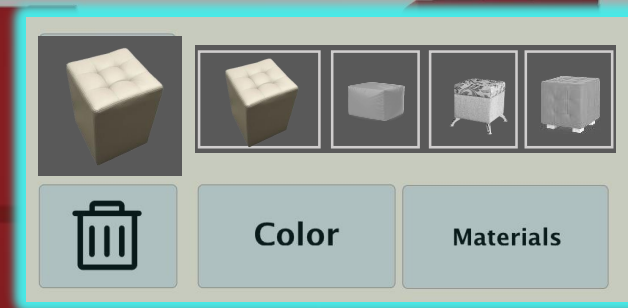
Save publically

Share

Piano room
Jeff Green. Mar. 30 2018

After Eric is done with his vehicle interior creation he saves the interior sample to the public library so that other users can be inspired by his creation. Eric's personal room on wheels will be 3D printed within 24 hours for his pleasure.

Enjoy

Improved quality of life

Autonomous mobility gives Eric a chance to be more independent, to have more flexibility with his time, and to have more participation in society. He can more easily meet his friends, run his errands, and enjoy his ride more by spending the time on activities he enjoys.

© Sofia Lewandowski

Content

7. User testing

User testing conclusion

The role of the virtual reality designer:

The designers feel comfortable working in 2D spaces. There are many helpful tools to support prototyping process to prepare user testing and optimize the user experiences with products.

The 3D virtual reality space was just recently introduced to the world. Mostly developers work on the ideation and development of virtual spaces. Not many user experience designers are involved in the design VR creation process yet.

How much coding should a designer know in order to be able to create working prototypes to demonstrate the idea, to do user testing and improvement of the experience?

As a Virtual Reality User Experience designer it is important to be familiar with the 3D virtual software. It is beneficial to know how coding works and to be able to use helpful kits like Virtual Reality Tool Kit (VRTK). At the time of this document VRTK already offers 41 examples where the coding scripts are available for simple interactions.
It is a big advantage for a designer to be able to (optionally: find) import 3D models in the scene, create different scenes, and create some simple button - object interactions.

Five iteration loops of usability testing:

Test1   Test2   Test3   Test4   Test5

Prototype 1   Prototype 2   Prototype 3 (In VR: Prototype 4 (In   Prototype 5 (Voice
(Interiors in Unity +   (Interiors in Unity   responsive Interiors   VR: Responsive   control)
Designer)   + paper UI)   + non responsive UI)   UI and menu)
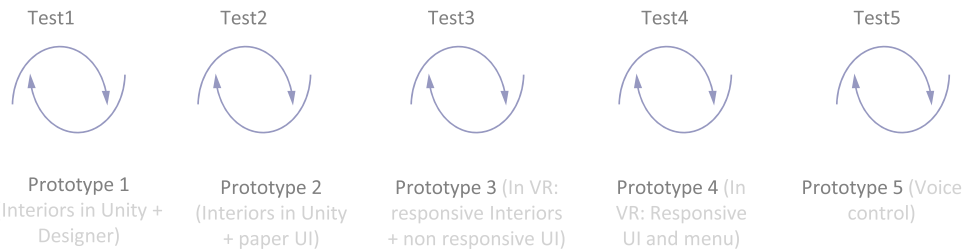
While preparing user testing for the VR experience for the thesis project it was clear that there are no prototyping tools for the designers developed yet. A Virtual Reality designer has to be creative to invent some techniques of how to prepare user testing without much coding experience. During the thesis different methods on different development stages were used. The designer accomplished five different iteration loops.
 1. The designer showed the users a 3D Unity model on a 2D screen. The designer adjusted the vehicle interior to a desired environment based on users' requests while sitting next to each other.
2. In the next stage the designer showed a 3D vehicle interior model in Unity to the user. The user used a paper pallet to let designer navigate through the design process. The user commented what he was doing, whether something was missing in the environment and pointed to the desired features on the pallet. The designer rearranged the interior based on the user's interaction with the paper pallet.
3. In the third stage of the VR experience development the user was able to see the vehicle interiors from inside, interact with some elements and hold the virtual pallet in the hand, pointing to nonfunctional buttons. The designer assistance was necessary. The designer added elements from the prefabs folder into Unity scene in real time on user's request.
4. The fourth iteration round was executed in Virtual Reality environment using a responsive virtual pallet attached to the left remote control for navigation.
In addition to the virtual pallet in user's right hand the menu for single objects was created for more options to a product category. The menu included also delete, change colors and size functions.
5. Voice control changes the user's experience drastically. The user is more engaged and more focused on the interior creation rather than on the pallet menu.

Importance of user testing:

User testing at any point of time is a necessary approach of how to design a better experience.
User testing on early stages makes a lot of sense and gives helpful insights for further development. It gives an idea for the designer if users are interested in the proposed concept, if they are motivated and engaged. By observation of user testing it is possible to find out if the users can find what they want or need and if they use some options more than others. The testing results can give designer a better idea of how to design a better information architecture, visual cues and guidance.

User testing conclusion

Pallet creation for the overall concept:

The creation of the virtual pallet was based on information from user interviews, analysis of travel activity diagram and later on conversation between user and the designer while redesigning predefined vehicle interiors together in Unity. In the beginning the pallet created for the design of vehicle interior architectures included all information on the same page that was discovered from the secondary and primary research as well as from iteration loops of usability testing. During further development and more usability tests, the pallet changed the **information architecture** based on the permanent feedback from users regarding its usability.
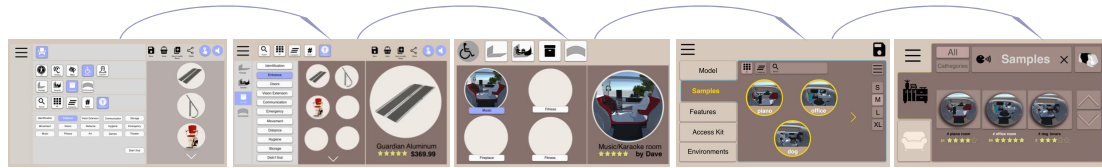
Img.1: Pallet development for the overall concept

Pallet creation for VR prototype:

For a demonstration of the concept idea, a simpler version of the virtual pallet was created to analyze the usability and interaction design of the pallet contents.

Img.2: Pallet development for VR prototype

Abstract of findings:

The findings thorough user testing with paper prototypes of the pallet helped to redesign the information architecture. The VR prototype helped to understand which interactions (like grabbing, pointing and teleporting) work well for a restricted user and which don't. It is important to understand for a later execution through virtual reality software engineers.

Details about interaction design part in the VR prototype:

The user testing in VR shows that the user naturally tends to grab elements from the pallet after he figures out that he has to point with the laser to elements and press a trigger to select. It is not intuitive. That is something the UX designer should work on and improve.

The next problem incurred by the observation the user grabbing elements from the pallet and placing them somewhere in the interior space. The mobility challenged person restricted in his movements will not be able to bend and reach to the floor to place elements.

The next problem is that teleporting backwards doesn't work well for people in a fixed position (chair or wheelchair). The environment should move around the user on request.

The last problem is that the user still tends to talk to the designer to ask for some guidance and advice. The user seems to be a passive user and would prefer to talk to the system than just to find what he needs in the virtual pallet. Because of that the IBM Watson's voice interaction was integrated into the project.

User testing 1
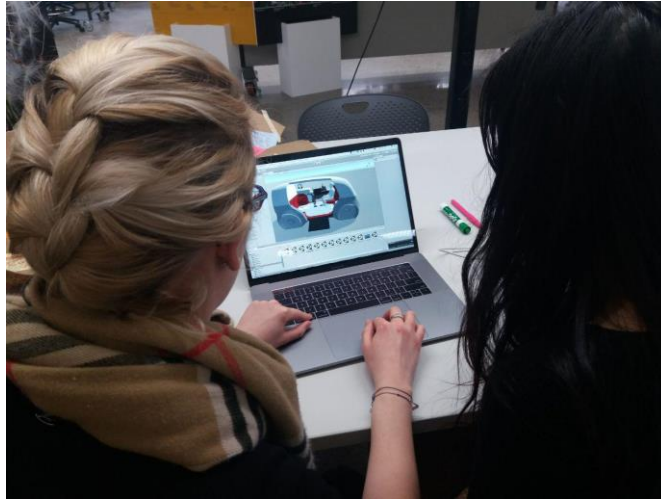
Prototype 1 (Interiors in Unity + Designer)

Stimuli:
3D model in Unity
Designer as an assistant

Participants:
4 people in wheelchairs

Purpose:
To see when the user gets stuck.
What additional features will be needed.

Findings:
- **User prefers to start with samples.**
- **Asking questions helps user to design.**
- **The creation process is not as much about special features.**

From user created interior samples
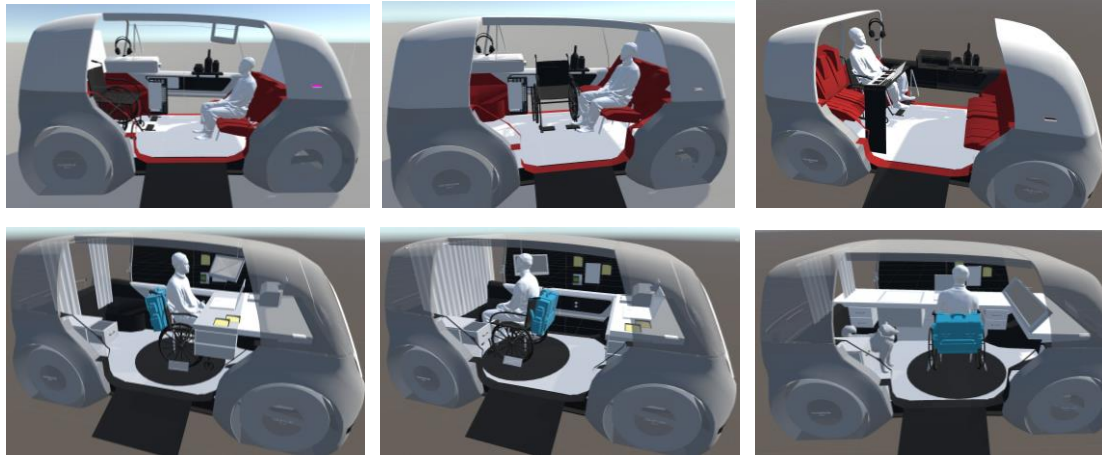
User testing2

Prototype 2 (Interiors in Unity + paper UI)

Stimuli:
3D model in Unity
Paper pallet with UIs

Participants:
3 people in wheelchairs

Purpose:
To see when the user will get stuck in order to understand how AI assistant and pallet can be improved.

Findings:
- **The Accessibility Kit should be the part of the standard package.**
- **Samples and Features tabs are the most used ones.**
- **Search command after categories.**
- **Simpler to decide about vehicle size by passenger sample.**
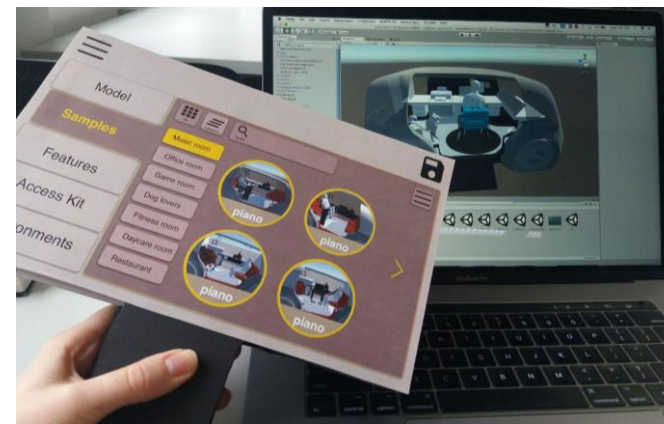
Prototype in Virtual Reality

VR building experience.

The vehicle interior and the mannequin inside of virtual reality required a lot of adjustments to make them look more accurate and closer to the real scale model. The designer set up the camera views, teleportation areas, controller functions and first simple working interactions.
The experience was adjusted to a sitting person, that interacts with the objects and the environment itself from a sitting position.

The mannequin in the scene represents user's avatar that is created by the system through scanning the user's proportions before the VR experience.

User testing3
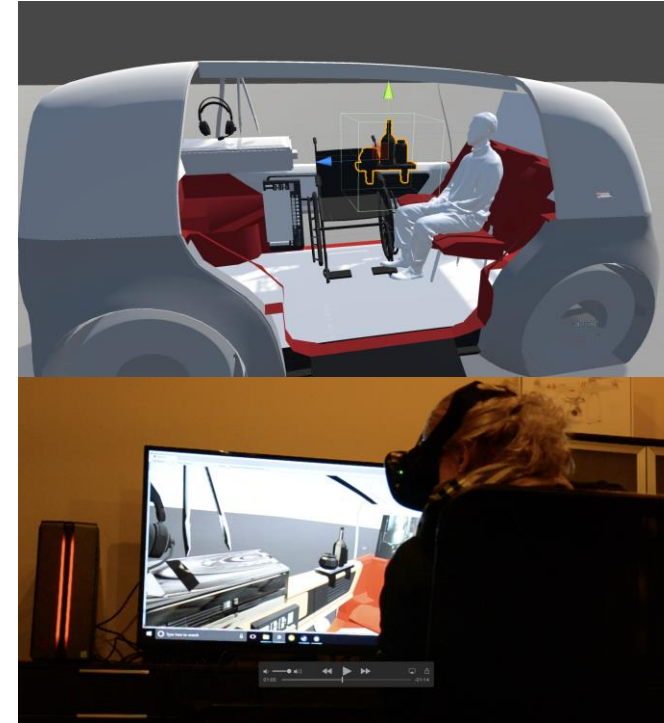
Prototype 3 (In VR: responsive Interiors + non responsive UI)
User in VR with non interactable pallet, teleporting, pointing on objects, grabbing objects and placing them somewhere else. Designer as an assistant for additional features and environment (shop).

Stimuli:
User inside of VR
Image of the pallet is attached to one of the controllers.
Designer as an assistant to bring more elements in the VR scene manually using Unity in real time. If the designer doesn't have some user desired objects then he gives him some shapes like cubes, spheres, planes and user imagines that it is something that he wishes. The designer takes a note in the 3D space on a canvas above the object what is to replace it later with a real object.

Participants:
3 users without disabilities

Purpose:
• To prove the readability of the pallet.
• To find out if the distance and the position of the pallet from user is enough. (Possible improvements: attach to head, to remote controls and fix the position of the UI).
• To understand if arbitrary teleportation makes sense or should it be restricted?

Findings:
• Elements should be snapped to certain areas where the elements are allowed to be.
• If the user is in the chair it's difficult to teleport himself backwards. There should be an icon (maybe attached to the headset as a menu) to turn around.
• The user starts wondering around and is distracted if he can teleport himself further than the vehicle.

User testing 1
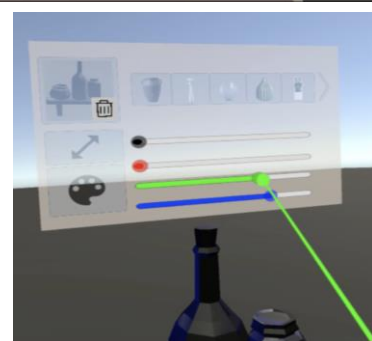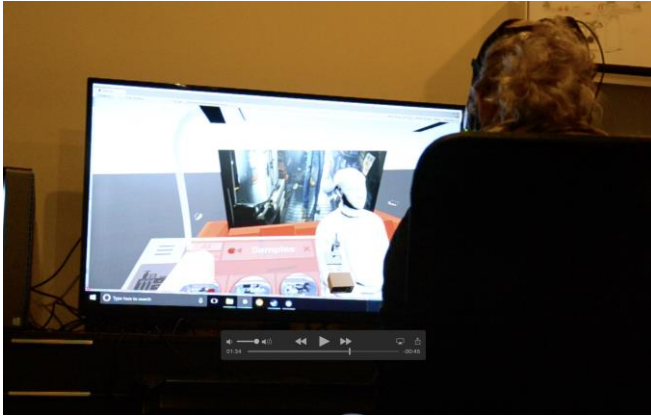
Prototype 4 (In VR: Responsive UI and object menu)

Stimuli:
User inside of VR
Interactable pallet with three grabbable features and three samples on the pallet that user can browse through. Some elements are interactive. It is possible to grab them and place somewhere else.

Participants:
3 users without disabilities

Purpose:
• To interact within the virtual works

Findings:
• The user was trying to **grab interior samples directly** from the pallet. The designer had to explain that it is necessary to use the touchpad to point with the laser on the pallet and then press the trigger to activate the button. The selection process is not intuitive yet.
• Users liked to **grab** features directly from the pallet. But as soon as they had to place the items somewhere else it was **difficult** and sometimes not possible **to do it without leaving the chair.**
• User **teleported** himself far away from the car accidentally. Restricted area of teleportation should be defined in advance.
• The user didn't know where to place the objects. Users wished to build some pedestals and define the size and shape.
• It important to have a delete option.
• It all beautiful but demonstration of accessible feature in the demo would be nice.

User testing2
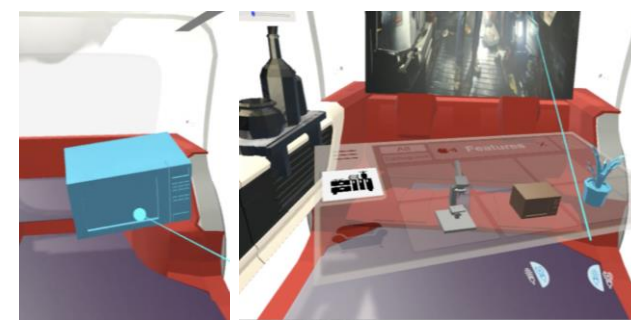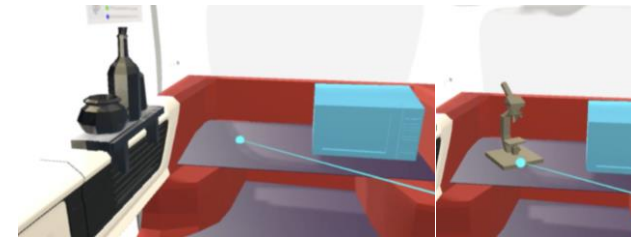
Prototype 4 (In VR: Voice commands)

Why voice interaction:
The IBM Watson concept. Through user testing it was clear that different users / people with mobility challenges with different disabilities are not fluent in operation of the virtual pallet. Working with the pallet for the first time they have troubles to interact with the pallet, they are not patient and would rather talk to the design assistant to get what they need. For more information like rating, price, brand and feature options they take a look at the virtual 2D pallet.
Conclusion:
A more intuitive and natural way of communicating is desired.

Proposal: The voice interaction would allow users to ask for what they need and design faster.
A "What-if" problem: What if the user doesn't know what he might need. The virtual pallet with options and the AI assistance which can offer options will be helpful.
Implementation: IBM Watson released SDK for HTC Vive for voice interaction in 2017. The user can let the system create, delete, resize and colorize the objects. The objects are spawned to places where the user points with the laser. The pallet adjusts the contents depending on user's voice commands.

Stimuli:
User inside of VR and operates via voice
Participants:
3 users without disabilities

Purpose of user testing:
• To see how helpful or intuitive the voice control in VR is.

Findings:
• Voice control is more intuitive
• Visual cues are needed to symbolize that the system listens and understands.

Findings

Improvement of interactions within VR.

Problem:
Turning around/**teleporting backwards** in the chair doesn't work well because the process of physically turning is not feasible for all users. There should be a different and an intuitive way to do it.
Existing solutions:
Press and hold both grip buttons and turn both controllers to rotate the environment.
Press touchpad right or touchpad-left to turn-around.
❑ *Proposals:*
Click on the little menu button attached to the headset to turn 180 degrees.
Perform a very quick movement with the controller in hand to turn in the desired direction incrementally.
Press only left grip button on the left controller if left direction is the desired one.

Problem:
The user accidentally and unintentionally teleports himself somewhere far away from the vehicle.
❑ *Proposal:*
The teleporting area should be limited and visually recognizable.

Problem:
The user tends to **grab** or touch elements in the pallet to activate. The laser pointer is usually used to do something from a distance or for teleporting.
❑ *Proposal:*
Touching the scenes works but the scene-buttons should be highlighted and give a touch feedback, so that the user knows what he is selecting at the moment. Selection will be performed by pressing the grip button or by holding the controller at the same position for 2 seconds.
➢ Comment from the designer/developer: It is not very intuitive.

❑ *Proposal:*
The user slides his finger on the touchpad up and down to extend or shorten the laser pointer. The elements which are always parallel to the floor or to the approached surfaces turn around on the laser pointer. The elements snap to the highlighted areas as soon as the button is pressed.
Problem extension:
By selecting scenes it's not visually clear if the right scene is selected.
❑ *Proposal:*
Design 3D buttons for scenes on the pallet that work like buzzers. It should be highlighted if touched and react/jump if pressed/selected.

Problem:
The menu attached to the left hand controller includes too many elements.
❑ *Proposal:*
It should be possible to switch to the feature tab in the menu to get another menu for features. Method: If feature icon in the pallet is pressed, the sample pallet becomes inactive and the feature pallet activates. (Hide/unhide method).
➢ Comment from the designer/developer: successfully executed.

All in all interaction improvement:
The selection of elements should happen in a more intuitive way for inexperienced users.
❑ *Proposal:*
Voice control should be included in the navigation methods to call features.
User will say: "Watson, create a couch". One of the couches with best ratings will appear. The object menu will give more options for the selection.
What if:
The user will request some elements. How will it be connected to the pallet? The name of the called element will appear in the search bar and will be shown highlighted on the pallet as well as appear in the remote control. What if the elements are not existing in the library and won't be able to be found? Will the system just fail and be silent or will it assume the user said something else and pretend it didn't understand or will it not understand and let the user know and give some other options? Will these options be useful?

Findings

Improvement of interactions in VR.

Problem:
The user **grabs features** from the pallet and they appear in the right hand control placed centrally. The user has difficulties to place elements on the floor or spots further away from him.
❏ *Proposal:*
The user grabs 3D menu-features on the pallet. The features appear in his right hand control on a slightly extended laser pointer. It should be visible that the laser pointer can be extended.

Problem:
The user doesn't see any specific solutions for his disability.
❏ *Proposal:*
Show on the pallet accessible features for example: adjustable table where the user can test the functions by pushing a part of the table underneath and make it shorter and give the user more space to be able to turn.

Problem:
There currently are not many surfaces to attach elements from the pallet to.
❏ *Proposal:*
Design extra tab for surfaces, shelves, walls and maybe for user arbitrary designed shapes, for example like Google blocks.

Problem:
Object menu is always visible. It blocks the vision on the entire interior.
❏ *Proposal:*
Should appear and disappear on touch. The object menu should appear and disappear on the side in a semi horizontal position.
Allow the user to point on objects and correct from distance with laser. It means that the object menu would appear above the object in a vertical position. Also make them grabbable and let the object menu appear from the side.

Problem:
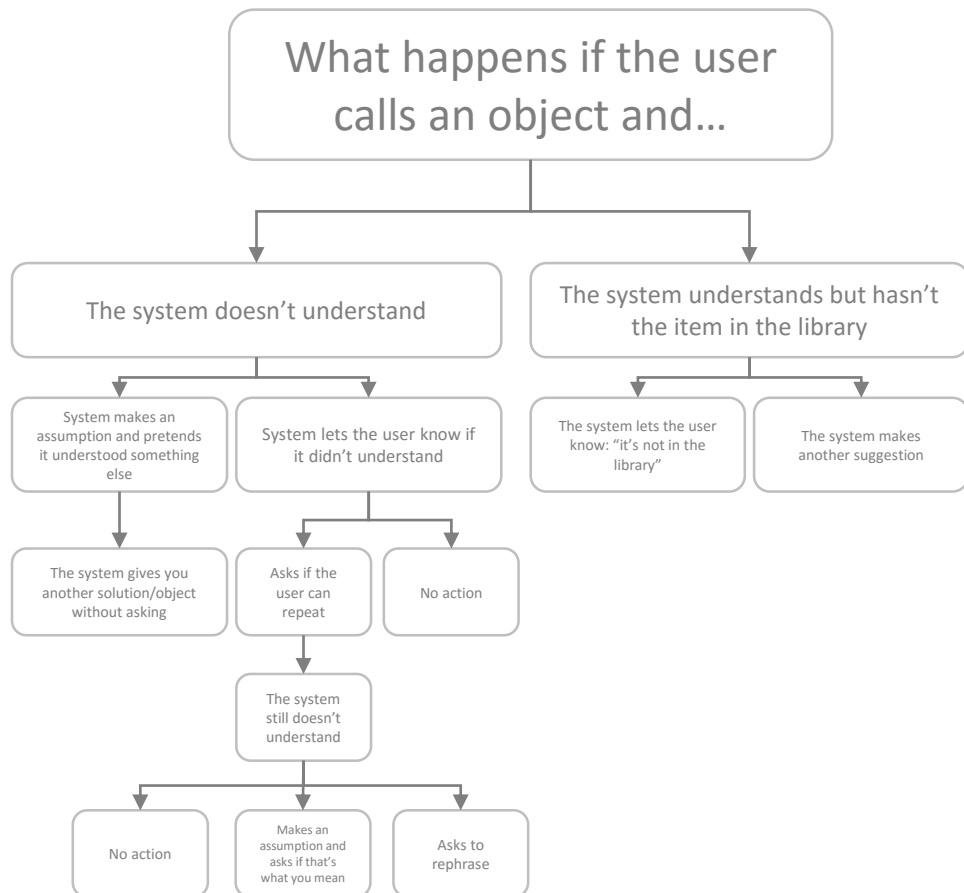The user deletes an element accidentally. The user teleports himself somewhere where it's not easy to come back from.
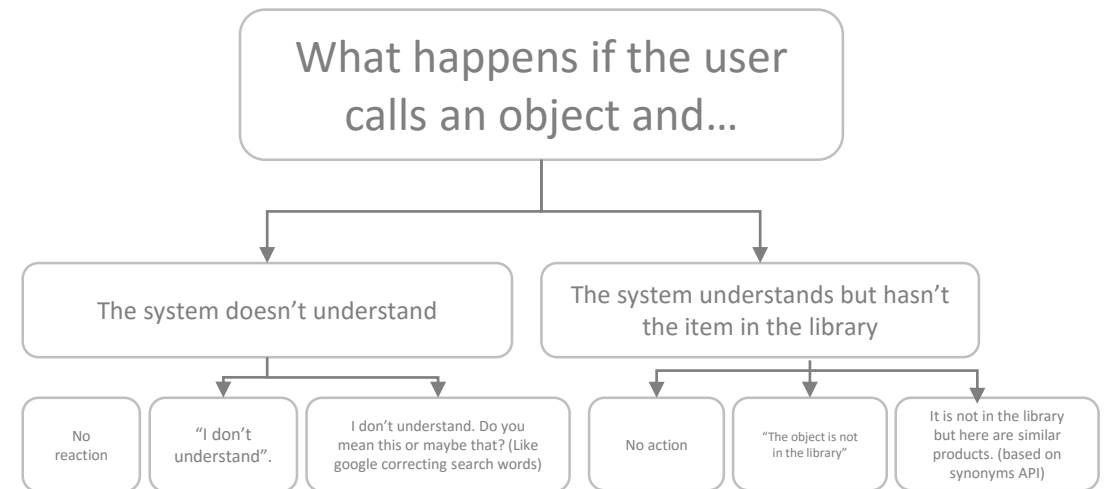❏ *Proposal:*
"Go back" function.

"What ifs"

To prove where the system might fail it is necessary to ask some "what if" questions in order to get insights and be able to suggest some possible solutions.
1. Virtual pallet reaction:

1. IBM Watson reaction to a "what if" case:

What happens if the user calls an object and…

The system doesn't understand

The system understands but hasn't the item in the library

System makes an assumption and pretends it understood something else

System lets the user know if it didn't understand

The system lets the user know: "it's not in the library"

The system makes another suggestion

The system gives you another solution/object without asking

Asks if the user can repeat

No action

The system still doesn't understand

No action

Makes an assumption and asks if that's what you mean

Asks to rephrase

What happens if the user calls an object and…

The system doesn't understand

The system understands but hasn't the item in the library

No reaction

"I don't understand".

I don't understand. Do you mean this or maybe that? (Like google correcting search words)

No action

"The object is not in the library"

It is not in the library but here are similar products. (based on synonyms API)

Content

8. Summary and conclusion

Improved quality of life

QUALITY OF LIFE

Improved quality of life
Autonomous mobility gives Eric a chance to be more independent, to have more flexibility with his time, and to have more participation in society. He can more easily meet his friends, run his errands, and enjoy his ride more by spending the time on activities he enjoys.

projects supported by media and features he integrated in his room on wheels. He feels to be an equal part of the society being able to participate and share with his community.

He participates in AV meetups where he communicates with other people without even exiting his vehicle. He makes new friends also at the EV charging stations showing others his office on wheels and drinking coffee together.

Eric is a proud owner of his vehicle. He created it by himself and loves it as much as his living room at home. He can change his physical and virtual interior any time by visiting the VR studio where he would add new needed features that will be 3D-printed on demand or delivered on his earliest convenience if not printable. In the VR studio he is able to try out new AR interfaces that he can add to his concept or update if he included AR previously.

The personal interior on wheels improved his quality of life. He is able to create an enjoyable environment and be mobile. He can not swim or ride motorbikes because of his physical restrictions but he is able to create a new hobby environment for himself inside of his autonomous vehicle that can bring him to places.

Eric created his personal vehicle interior adjusted to his personal and very specific needs. He is able to consider full time jobs because now he has no troubles with transportation modes and doesn't waste his time on waiting for it. Compared to the previous experiences with paratransit service he doesn't need to spend hours of waiting for the driver picking him up and bringing him to a few destinations only. Eric enjoys his personal interior much more than any other generally designed interiors for people with mobility challenges. He spends a lot of time in his vehicle while working on his office work, watching movies and playing with his dog. He travels from one destination to another without waiting for his next stop. He keeps himself busy while enjoying what he does. He meets his friends and is happy to take them for a ride while discussing common

Automotive solution

Society awareness

The question to answer is if the proposed solution of self-created vehicle interior is an automotive solution. Automotive companies expressed their concerns regarding the safety problems. The elements created by users can randomly fly around and kill passengers inside of the vehicle in case of an accident.

Further research and concept development is needed. Possible solutions could be considered for further research:
- How reliable and advanced is generative design? Generative design is able to build safe constructions while knowing some attach points. Generative design can also build a lot of different product variations.

- How much testing and redesigning is needed to be done by automotive designers and engineers after the users' self creation of auto experience rooms to make it safe for the public roads?

- How similar is the concept to the Recreational Vehicle (RV) solutions where we speak about mobile living rooms with loose elements inside. Is it the matter of classification? Is it possible to give the self created vehicles another classification to make it ready for roads? Autonomous vehicles created by users would have a RV classification with automotive purpose that will improve people's experiences on autonomous roads.

How can society be made aware of necessity of accessible transportation solutions and enjoyable travel experiences? How can be society be educated and influenced?

Older generations grew up on cartoons that were affecting and educating children's minds.

Educating the society about the importance of inclusion and change of transportation interior architectures will draw people's attention and have an impact on their awareness on early stages of their development. According to the research findings we are designing for the future Generation Z. Educating children of Generation Z / digital natives means educating the future target audience: future politicians, future consumers, future creators and designers. In the past children were influenced and educated through cartoons. A good example is "The Jetsons" cartoon from 1962 – 1987 as part of The Funtastic World of Hanna-Barbera. This children's show shows visualizes future transportation. People on early stages of their development get inputs on how their future might look like and makes them familiar with the topic and incurred issues. The new generations are not as much interested in cartoons as in virtual games. Creating virtual games for educational purposes about inclusive transportation interiors will educate the new generation (Gen Z) about the vital importance of inclusion in autonomous transportation which will improve the quality of life not only of disabled society but everybody.

From 1962

From 2018

TV influence

VR games for educational purposes
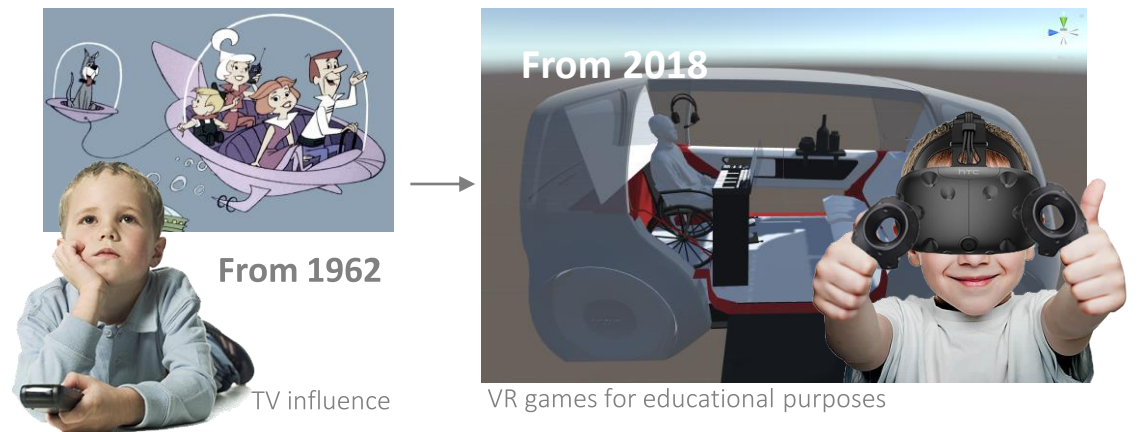
Covered topics

Following topics were covered while working on the IXR project:

- Overall concept creation: Improving the quality of life of disabled people.
- Business model of building virtual and later physical environments.
- Automotive solution.
- Information architecture of the UI in the virtual pallet.
- Improvement of physical interactions in VR (moving around, turning, interaction with elements: grabbing, pointing and pressing a trigger).
- Voice control integration to design the designing experience of users.

Different topics were covered during the thesis time. However there are areas that need more research and more detailed solutions. The thesis proposes some solutions on how to make a proposed vision appropriate for public roads and safe for passengers. The solution for automotive purposes need more research that will have to be done outside of thesis restricted by the limited time.

Content

9. Poster

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

IXR - INDIVIDUAL EXPERIENCE ROOM

- Autonomous
- Inclusive
- Personalized

The concept is meant to create a **VISION** of how future **autonomous transportation** will support **inclusion** through personalization.
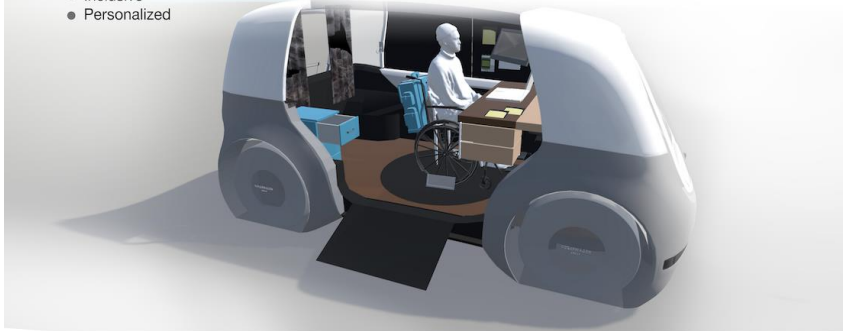
RESEARCH

Facts
Who are we designing for in the future?
Anyone can become disabled by accident or through aging.
From Census Bureau:

Disabled 2016 20%
Aging 2016 8.5% / Older than 65 2050 16.7%
Anybody

Universal Design
A National Disability Authority says: "Universal Design is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability."

We are designing for an aging, disabled and developing society. We should have a Universal Design approach by designing products to enable as many people as possible to use them.

Target group
People with mobility challenges.

Problems
Based on interviews and surveys with 19 participants:
People with physical challenges experience difficult access, feelings of confinement and lack of life enjoyment.

"Every day challenges have led to my depression."

"I need help but want to be independent."

"I have to break down my wheelchair."

"I don't feel welcomed. I feel like cargo."

Pyramid of needs

Mission
Improve quality of life for people with physical challenges through accessible and enjoyable autonomous mobility experiences.

Integration
Independence
Access, Usability, Comfort

ASSUMPTION 2030
DESIRED STATE

Level 5
New York

Suburban areas
Freeways

ERIC, 37
Consultant

active

interested

Eric lives in New York, one of the major mega cities, where only full autonomy is allowed.

Eric is 37 and has a full-time job. He works as a consultant and travels from one customer to another. He is very active and has diverse interests and hobbies.

BUILD YOUR IXR

IxR is a virtual room for Eric to design his autonomous vehicle that is created through a meta designer.

A creation of an environment with support and guidance for user to design his special space enables him to define his personal experience.

digital model
3D PRINT

#Dog lover room
#Piano room
#Office room

BROWSE THROUGH SAMPLES
The user cycles through some predefined interior samples saved in the public library. The user defines his room via voice control with the combination of virtual pallet as navigation tool.

Poster

CUSTOMIZE YOUR OWN SPACE

Sofia Lewandowski
Interaction Design

CCSMFA

Using natural way of communicating:
Voice commands.

Using natural way of operating:
Manipulating elements.

Some accessibility features are invisible and not very different from features we all use. Eric doesn't specifically look for accessibility elements but just for handle to transfer himself from one position to another. His vehicle package already includes a ramp, a pick up tool and a sliding board.

After Eric is done with his vehicle interior creation he saves the interior sample to the public library so that other users can be inspired from his creation. Eric's personal room on wheels will be 3D printed within 24 for his pleasure.

Create a seat!

QUALITY OF LIFE

Improved quality of life
Autonomous mobility gives Eric a chance to be more independent, to have more flexibility with his time, and to have more participation in society. He can more easily meet his friends, run his errands, and enjoy his ride more by spending the time on activities he enjoys.

ITERATION PROCESS

User testing with 3D model in Unity and designer assistance.

Conclusion based on findings:
- The virtual assistant (pallet) that should replace designer's help will be defined based on questions and responces from the user.

User testing with Unity model, paper pallet and designer assistance.

Conclusion based on findings:
- Only 'Samples' and 'Features' tabs are used. The rest is overwhelming and needs to be reduced.
- There are not many special accessibility elements. It is all about personal adjustments.

Building the experience in virtual reality.

Virtual reality tool kit (VRTK), a plug-in in 'Unity' is a helpful tool to create first interactions for a designer to test the functions of user interfaces and objects.
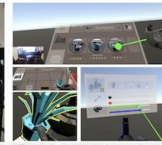
Testing of user's interaction with virtual pallet and objects in virtual reality scene.

Conclusion based on findings:
- Due to user's desire for more intuitive interaction with elements, laser pointer will be replaced with grab-attach mechanism.
- User still wishes to ask for more features in conversation instead of having to make choices from the pallet. The voice command integration into VR will make the creation process easier and more intuitive.
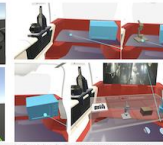
Testing of voice commands via IBM Watson in virtual reality.

Conclusion based on findings:
- Voice commands in combination with virtual pallet give users broader communication platform and greater chance to design fast and find what is needed.
- Watson should be better trained to understand accents and synonyms for commands.

Time plan

Sources

[1] Self-Driving cars. The impact on people with disabilities. Issued in January 2017
[2] Diseno para todo / design for all, published 2008
[3] Mobility talk with a representative from Ford, Techstar Start-Up, Integrated Design Chair Maria Luisa.
[4] Design for All 5 Senses | Jinsop Lee | TED Talks
[5] The need for universal design for all | Leacey Brown | TEDxRapidCity
[6] http://universaldesign.ie/What-is-Universal-Design/
[7] Center for Excellence in Universal Design http://universaldesign.ie/What-is-Universal-Design/The-10-things-to-know-about-UD/
[8] Victor Calise reports about his Sunday: https://www.nytimes.com/2015/11/15/nyregion/how-victor-calise-disabilities-commissioner-spends-his-sundays.html
[9] Interview with Victor Calise: http://newswhistle.com/accessible-nyc-an-interview-with-commissioner-victor-calise/
[10] Census: https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html
[11] Disability statistics: http://www.disabilitystatistics.org/
[12] Annual Report 2016: https://disabilitycompendium.org/sites/default/files/user-uploads/2016_AnnualReport.pdf
[13] Ruderman's white paper: http://secureenergy.org/wp-content/uploads/2017/01/Self-Driving-Cars-The-Impact-on-People-with-Disabilities_FINAL.pdf
[14]Universal Design principles

[15] Next future-transportation: https://www.linkedin.com/company/next-future-transportation/
[16] Generative Design: https://www.autodesk.com/solutions/generative-design
https://www.autodesk.com/redshift/what-is-generative-design-2/
https://autodeskresearch.com/projects/dreamcatcher
[17] Interior Creation: http://store.steampowered.com/app/621500/TrueScale/

10. Appendix

Table of contents:

1. Thesis topic decision
2. Research Abstract
3. Qualitative Research
4. Quantitative Research
5. Further interviews
6. Persona creation
7. Existing AV concepts
8. Package development

Appendix

1. Thesis topic decision

Thesis topic decision

Based on the desire to work on autonomous accessible vehicles there were alternatives to proceed with:
- "Get in and out process";
- Communication inside of autonomous vehicle between AI and the passenger;
- A concept about accessible vehicle interior architecture.

The decision was taken to proceed with the third option.

AV and Accessibility
3 different options

Get in and out	Communication inside	Accessible architecture
Why this one?	Why this one?	Why this one?
To access the car and to make last meter decision	To be able to assist the user during the ride	To create universal and personalized platforms for users
UI	UI/AR	IxD in VR
conversation with the car before I enter	conversation with the car while traveling	conversation while building an environment

Appendix

2. Research Abstract

Research abstract

Research Abstract
Objectives

Through both qualitative, quantitative, and secondary research I hoped to gain understanding on how to design a perfect mobility solution for long-term wheelchair users. This solution must be affordable, accessible, and reliable.

Sample Size

For my qualitative research, I interviewed seven long-term wheelchair users. The sample consisted of two women and five men. In my quantitative research 19 wheelchair users from The Rehabilitation Center in Detroit, people from a wheelchair basketball team, people who I met randomly on the streets, in the grocery shops, museums and friends of friends were involved in the survey process.

Methodologies

For my qualitative research, I conducted verbal interviews. For my quantitative research, I used verbal and pictorial methods in order to find out their needs and complaints. For the validation part, I used mostly the pictorial methods in order to explain my design proposals and my vision so that they have the same image of the concept as I do.

Specific needs

To travel independently
The desire to travel to work quickly, without any public transportation issues
Have an accessible and a very personal space
Be supported in special needs
To make the modification of private vehicles easier
To save time and have less stress
To be able to consider jobs far away from home
To fit into the car if they have a special size of a wheelchair
Support but not from people
Acceptance from people
Better public / private transportation enabling a very personal space
Flexibility in traveling
Safety

Mental and physical needs from people in wheelchairs:
They wish to have more support but not from people. They do not like asking people for help because they fear to lose their friends.

They wish to have support from the technology: AI, automation (automatic opening doors, autonomous cars).

They wish to have easy and usable technology (smartphones are complex to operate). They also wish to have more flexibility and to get anywhere, anytime.

Key Findings

I found out that the people have some basic needs on accessibility, availability, convenience and affordability of transportation modes. There is a big area for improvement on the product design and the service design level. Users will use public transportation as an option but many prefer private transportation, however private transportation is more costly. Many long-term wheelchair users have low incomes.
I also found out that people like to have their private space and a personal vehicle. **Personalization (modifications of personal vehicles) and access** are the most important aspects that were always mentioned by participants during the research phase. That will be the area I specifically will be working on.

Concept Development

I went through a few phases of my development process. My ideation and progress on a concept was supported through the research insights. The secondary research helped me to understand the general problem statement. I also gained new knowledge about Universal Design and its principles.
Through the interviews with seven people in the beginning and even more during the ideation phase, I was able to understand the specific difficulties that people in wheelchairs are facing in their daily lives. To understand how many people have the same struggles with the mobility I created a first survey. I got great results and knew which common problems people experience with transportation.

I started with a product creation and after an insight I created a service and an environmental solution.

This insight helped me to make the next very important step on the concept development.
My final design concept will offer a user a platform to create his own experience room on wheels. The user's desire is to have his personal vehicle with a personal space that he could decorate as his own living room or office.
My concept is "I design My Individual Experience Room (MIER)". I will create a digital package of a vehicle interior. The user will be able to "walk" through a virtual shop (IKEA like), grab and put virtual furniture pieces together. He would create his own special interior. The digital model will be saved and sent out to the 3D Print production. The car will be ready to be picked up the same day.

Validation Results

Through the validation and feedback from some participants, it was clear that the concept sounds promising but still need some additional research and compromises.
I consider that further research and ideation may be necessary to fully satisfy the user wants and needs.

Conclusions

The key concept of the co-creation is an innovative design approach. The user would virtually build his own car without any effort and without unnecessary walking through crowded shops. However, the solution needs some additional refinements and research.

Appendix

3. Qualitative Research

Qualitative Research

1.   **Introduction**

1.1. The Goal of the Research

The general goal is to improve wheelchair users' ability to navigate their daily lives ease, to enable them to do something they weren't able to do before. Through research I hope to understand not only the problems users face with their wheelchair, but also how I might be able to design a better solution to promote positive transportation experiences, and what that might entail. This could mean designing an autonomous vehicle, a more efficient/better designed wheelchair, or any other method of transportation I find that would improve their quality of life and experience.

1.2. The Big Question
Can I design the perfect mobility solution for long-term wheelchair users?

2. Qualitative research

2. 1. Objectives

It was a unique experience to talk to people with disabilities. I realized that we hardly interact or encounter people with disabilities in our everyday life. Thus, we don't include them while designing new products. It became clearer when we couldn't answer Donald's question "Is there is a law in Europe to design any kind of products in a more accessible way (like design of doors, elevators, public transportation)?" Donald explained, "In the United States there is a law, that emphasize the necessity of universal design." In fact, I never had to do anything with disabled people before and was not interested in this topic. I couldn't even remember if I had ever seen any people in

wheelchairs in Europe. I am sure that there are a lot of disabled people that are isolated from the world, but I think we usually don't pay attention to something or somebody we are not really interested in.
It is the question of the perception. Our perception is very selective. Two people would look at the same thing and see it differently.

As I asked myself a question what the autonomous cars are good for, I realized the need of the people with disabilities in the advanced and self-driving mobility.
The people with disabilities are restricted in their opportunities. Even the simple activities are very difficult to them to perform. They have to call their parents, children or siblings to bring them to grocery stores, to their appointments to see a doctor and so on. They always depend on somebody's help. Other people even if they are relatives don't like to be permanently called and asked for help. It costs them their precious time they could spend differently. It restricts the helper's lives as well. No one likes to be restricted.
For people with disabilities, the fact of the dependency and mercy from other people leads to frustration, depression and isolation.

Following questions are interesting to look at closer:
How people with disability think about autonomous technology?
How would they spend time in autonomous cars?
What troubles do they have with the mobility?
What would they like to improve?
What are their big desires?

I formulated a major question: Can we design the perfect mobility solution for long-term wheelchair users in order to improve their lives and give them a chance to explore the world?

Qualitative Research

2.2 Findings

After some interviews, I could recognize some patterns, needs and desires expressed by people with disabilities. I summarized some of them.

A desire to be a part of the society and from non-disabled people.
As I asked Eric, Donald, and Brent if people treat them differently, Brent said that the men don't but the women do. If he goes to a casino and tries to talk to a woman, she refuses him right away because she doesn't see him as a person but as a person in a wheelchair. She doesn't see him as a potential partner and doesn't even give him a chance to get to know him better. Donald added that the people think that they will need to help him all the time. But he is doing everything on his own, he claims. He cooks, does his own laundry, and goes grocery shopping by himself. But of course, he is not flexible to go anywhere without a special equipped car and he can't take his date on an elegant cruise.

A desire of improvement on personal mobility
I asked them: "How do you access your car or a transportation you use?"
Donald explained: "He accesses his car from a passenger seat. He breaks down his wheelchair, removes the wheels, the bolster. Then he slides to the driver seat and controls his car with the hand controls on his steering wheel. It is pretty complicated but works for him. He uses his car every day and is happy that he can do it on his own. He only said that it would be cool if his wheelchair would break down on his own!
Eric has a completely different way to get into his car. Eric has an electric wheelchair and enters his VAN from the ramp from the side of his car. His car has three rows of the seats. His son removed the seats in the middle of the car to enable Eric to enter his car. The driver seat is able to turn around, so that Eric can slide from his wheelchair into it.
A desire to have a better accessibility to public transportation
Brent doesn't have his own car anymore. He had a surgery and will need to recover for two more years. But after that he wants to buy one, he said. Currently he uses paratransit / mobility service from the Rehabilitation Center. He doesn't like to use the bus if it is overcrowded. He never uses Uber, as he doesn't understand how it works. His son, brother, and father live in the same town as him. They visit him every or every second week. He can ask them for a favor to do something for him, but he doesn't like to bother them a lot.

Jacob is very independent. He has a job in the downtown area of Detroit. He moved just recently to the downtown area to avoid the public transportation issues. His work is less than a mile away from his home. Sometimes he travels to his working place by his wheelchair. On the way back home he always uses the people mover. If he wants to go out on weekend, he rides by the Q-Line.

 Donald never traveled by train in Detroit. He likes to travel by plane for a long distance. He had good and bad experiences by traveling by bus. But unfortunately, more bad than good ones. He used Uber three times. He said that he had to call and order a special car for people with disabilities. It worked out well for him.

Change of the residence to avoid the bad public transportation experiences.
From the Interview with Jacob I figured out that some people move extra close to their working place in order to have a better accessibility and be able to be at work on time.

But not everyone has the privilege to move to the downtown area. It is quite expensive.
Also, people from the rural areas experience not the same as the people in the urban areas. In the rural areas, the public transportation is even worse or non-existent.
Jacob expressed his need in an enhanced public transportation.

Winter is the worst season for wheelchair users.
Eric and Brent are both electric chair users. They tell me that they always get stuck in the snow and have to ask people to push them. It is very cold outside and while waiting for a bus which not always can be accessed it gets easily to a time of torture. Donald says that even though he uses his car every day instead of public transportation he needs about twenty minutes to get into the car and get ready for the drive. At first, he slides into the passenger seat, then he breaks down his wheelchair, he puts it into the back row and slides to the driver seat. In the winter the time, if it is cold outside, Donald prefer to stay at home as to spend a lot of time outside preparing his drive.

A need of better car controls. They are not designed well.
The controls of the cars have to be modified extra for people with disabled legs. The modified controls aren't the best. It is sometimes difficult to operate them especially the break. "It is not user friendly at all!"
No trust in autonomous technology.
None of the interviewees expressed a definite wish to be driven by an autonomous car. They said it is not safe and they don't trust the new technology. Donald is
very good in technology, and knows that a little mistake of the software can cost his life. If the innovative technology is so advanced it has to prove that it really is. He doesn't want to play with his life. Joan said that she is scared as well but she would try it within Detroit. She wouldn't go too far. What if it will break and she will be too far away from her home. She wouldn't know how to get back.

Using the space and time in the autonomous cars.
Donald sees the autonomous vehicles as a chance to work during the ride. He would convert the interior if the car to his music mix office. He is a DJ and has an exact plan of how he would spend time in a self-driving time.
Jacob likes to play video games. He says that it would be fun to play during the ride.
Brent said he wouldn't do some stuff he already does at home. He wouldn't want to watch movies, read books or sleep. He rather would like to look out of the window and to observe people, nature, and buildings.
Eric said that he would like to relax in the self-driving car if he could really trust it.

A wheelchair that breaks down on its own.
Since Donald needs a long time to get ready for a ride, he imagines how great it would be if his wheelchair would break down on its own.

Qualitative Research

2.3. Hypotheses for qualitative research

From the quantitative research, I hope to gain more knowledge about general and broader difficulties like facility and vehicle barriers. I would like to get an overview of daily challenges including public transportation, personal comfort and discomfort in the wheelchair and some future predictions for the improved mobility for the wheelchair users.

My hypothesis is that every wheelchair user wishes to have a better access to a public transportation. Better usability is as important as better accessibility. A product can be accessible but have the worse user experience.

A further hypothesis is that the life of disabled people can be improved with the autonomous car technology. Even though the user doesn't trust the artificial intelligence it can make them independent and is more safe than driving in their own.

The autonomous technology will make people happier, will give them a chance to travel the world and get out of the isolation.

3.1 Interview preparation

Tools for the interview.
Required: Paper/Pen.
Optional: Camera, questions or Mac/PC
Starting the conversation.
How did you get to this place? Did you have any troubles to get here?
Thank you for your time.
Before we start we would like to mention that I am not testing you but the situations you have to deal with. There is no right or wrong. You absolutely cannot fail. If you do not feel comfortable to answer a question, just say "I would like to skip" or "next one".

Interview questions.
How did you get your disability?
What is your big desire?
Have you ever traveled on your own?
How often do you travel on your own?
What are your difficulties if you travel by bus, train, or car?
Do other people treat you differently?
What difficulties do you have going to the public restrooms?
Do you feel comfortable to leave your wheelchair if you have to travel by plane?
Where would you like to go if you would be able to travel on your own? (Far away or just around here)
Do you usually communicate with people like you, who are also in the chair and know how you feel?

Do you have any further contacts for me from people in the wheelchairs?
Would you like to have more conversations with people without disabilities with disabilities?
Do you feel discriminated? In which way?
Can you send me a message? (to see how He / She will interact with the smartphone if further disabilities).
Do you work? If no, why not? (Bad accessibility?) If yes, how do you travel to your work?
Are you flexible in meeting friends?
Have you ever had depressions?
Can you describe your disability?
Do you always go the way you already know or do you like to explore and have some challenges?
Do you feel that your wheelchair is the part of your body? The part of your life since you are dependent on it to move?
Test: Do you reach the buttons? Have you ever used voice control before? Do you like it?
What do you do in your free time? Do you like to move around? Exercise?
 What do you think the autonomous cars could offer you?
a)   Would you like it?
b)   Would you travel a lot?
c)   Would you want to buy or lease a car?
(Leasing would be easier since I couldn't wash and maintain it on my own. I wouldn't need a garage to store it. I would just talk to it through my smartphone to pick me up any time I need it. But if I would buy it, I could just send it to a bakery or to pick up my laundry, while I am at work.)
24.   Are you a visual person? What do you like to do if you sit in a car as a passenger?
25.   Do you like to observe people, cars, and surroundings or just talk to a driver?
26.   What are your hobbies? Even if it is just watching movies
27.   Would you like to travel alone or with somebody else?
28.   Is it expensive to have a wheelchair and maintain it?
29.   Would you be able to buy or lease a car?
30.   What kind of transportation do you use? Bus, Cab, Train? How is the accessibility?
31.   Have you ever missed your (doctor) appointments because of the bad accessibility?
32.   Do you want your wheelchair to have an interface design?
Showing the speed,
The battery status
Indicate/blink
Turn on your lights
Measuring your blood pressure
Activating the massage function
The weather outside
The navigation
Info about accessibility to some places?
33.   What does your chair do? Does it have some features? A cup holder? A convertible table?
34.   What would be the features you would like to have on your wheelchair?

Qualitative Research

35.   Which of those are the most important ones?
36.   How do you move at home?
37.   How do you wash your car?
38.   Do you have to maintain your wheelchair a lot?
39.   Do you get stuck in the snow in the winter?
40.   Do you fall over sometimes?
41.   Do you like to be a driver or passenger?

Stimuli:
"Please feel free to message me if you think you would like to add something. Here is my phone number."
During the person is typing the number, we observe how the user operate the smartphone/ the interactive tool. Does he or she has any difficulties?
Question: "Do you like the modern technology?". "If no, why not?". "How often do you use you smartphone?" "Do you use it for navigation or to order an Uber?"

Qualitative Research

3.2 Interviewees introduction

Eric

Length of the interview: 50 minutes
Age: 55
Occupation: Retired
Hobbies/Interests: Usual stuff. TV, working out every day at the Rehabilitation center
Status: Middle
Degree of disability/disabilities: He suffered C6 and C7 spinal injuries, in addition to not being able to walk he cannot use his right hand properly.
Mobility:
·   Wheelchair,
·   Special modified Van: He bought a ramp, took away some seats in the middle of his van. His driver seat swivels around. He has a special equipment to drive on his own.
·   Q-Line: Detroit streetcar that travels from New Center to Downtown Detroit

The reason of his disability: He was shot during a bank robbery. The robbers shot and killed 4 people, including his wife. He had to learn how to deal with his new life and had to learn how to open doors without any help. He is mentally very strong. He says he never dealt with depression.

The Most Interesting Responses

Do you trust autonomous cars? "No, I don't. What if a drunk person would bump into my car? It wouldn't even react."
What would you do in your autonomous car? "Sleep, look out of the window."
What would you like AI do for you? "I need a better footrest, I have big feet."
Could you imagine leasing a car? "No, it is so expensive!"
Have you ever had depression? "There are a lot of people in wheelchairs who have deep depression. I don't have any. You should be grateful for that, for what you have. Blind people will never see the world. I have the ability to see, to move, to make my own food. I am pretty independent and don't need anybody's help."

Donald

Length of the interview: 1 hour
Age: 36
Occupation: Retired, partial DJ, volunteer for the Rehabilitation Center
Hobbies/Interests: Listening to music, mixing music, billiards, bowling, cruising, traveling, seeing friends, doing some activities with the people from Rehabilitation Center (basketball, skydiving, bowling, billiards)
Status: Middle
Degree of disability/disabilities: Can't walk. He can stand for a few minutes.
Mobility:
·   Wheelchair
·   Special modified Chevrolet

The Most Interesting Responses

Do you trust autonomous cars? "No, I don't. I know a lot about technology. I know that a small error of a computer can cost me my life."
What would you do in your autonomous car? "I would use it as my office. I would mix music, download, organize, play around. I also would watch movies, sleep, check emails, go to social media. I would cruise around on the Belle Isle, date somebody, pick up my partner. I would enjoy people, music, other cars. Sit by the water."
What would you like AI do for you? "It would be cool if my wheelchair would break down on its own."
What can you say about innovative technology? "The features shouldn't take away the beauty of the Pictionary. You shouldn't look through the smartphone at the world but through your eyes. When you go to a concert you go there to enjoy and not to post on Facebook later that you went there. But most of the people do. Technology made us disconnected to each other! I have on social media 8000 friends but don't know anything about them. And in real life I have nobody I can meet with."

Qualitative Research

3.2 Interviewees introduction

Brent

Length of the interview: 45 minutes
Age: 56
Occupation: Retired
Hobbies/Interests: Cooking, spending time with family. "My life is boring", he said.
Status: Middle
Degree of disability/disabilities: Cannot walk and his right hand doesn't function appropriately.
Mobility: Electric wheelchair

The Most Interesting Responses
Do you trust autonomous cars? "No, I don't. I am scared of that."
What would you do in your autonomous car? "I would look around. I don't like reading. I wouldn't sleep in the car as well."
What would you like AI do for you? "I would like to go faster than 8 miles / hour. 15 would be way better."
What do you hate about going by any kind of transportation? "In the winter traveling by the wheelchair even traveling by a car is not a nice experience at all! I freeze. And it takes too long to get into a car. Every minute seems to be a torture."
What can you say about innovative technology? "I am not a big modern technology fan."
Could you imagine leasing a car? "No, it is so expensive!"

Jacob
Length of the interview: 36 minutes
Age: 29
Occupation: has a job.
Hobbies/Interests: Comic book fan, video games, find people to hang out with, board and card games, movies
Status: middle
Degree of disability/disabilities: Can't walk.

Mobility:
· Electric wheelchair
· People mover
· Q-Line

The Most Interesting Responses
Do you trust autonomous cars? "Not really. But in the future, it must be improved. It is interesting and might be very helpful if it can buy groceries for me."
What would you do in your autonomous car? "I prefer to have windows. I like to do sightseeing. I like to look out of the window and see what actually happens outside. But watching movies or gaming would be cool though."

Joan
Length of the interview: 50 minutes
Gender: Female
Age: 72
Occupation: Retired, self-employed - distribution of EMA skin products.
Hobbies/Interests: Crochet, Representative of AVA organization
Status: Low
Degree of disability/disabilities: Can't walk.
Mobility:
· Electric wheelchair
· Paratransit

The Most Interesting Responses
Do you trust autonomous cars? "I am very scared of them. I don't think they are safe."

What would you do in your autonomous car? "I can't even imagine. I need to test it at first. But it would be interesting to feel independent and be able to travel again without asking anybody for help."

What difficulties do you have? "I am 72 and still have to work to pay my bills. This work keeps me very busy. I deal with bills, ordering and receiving products and bringing products to my customers."

Qualitative Research

Do you have anybody who can help you? "I have three daughters but they live outside of Detroit. They don't come very often. I didn't want to move to suburbs. I know the downtown area pretty well and can reach the grocery stores on my own."

What would you like to change on your wheelchair? "I would like to have an umbrella holder. I'm getting wet when it rains. And an integrated backpack on the back of my wheelchair would be great."

How would you like to interact with an advanced technology? "Via voice control."

Santa

Length of the interview: 25 minutes
Gender: Female
Age: 67
Occupation: Retired.
Hobbies/Interests: Reading
Status: High
Degree of disability/disabilities: Can't walk.
Mobility:
· Wheelchair. She is pushed from her husband.
· Car. She only travels with her husband.

The Most Interesting Responses
What would you like to change on your wheelchair? Her husband said: It would be great if the wheels would be bigger and wider. It is difficult to move through the stones. An integrated backpack on the back of the wheelchair would be useful. The breaks to fix the wheelchair at one position are difficult to access. I think it would be nice if there would be one break in the middle on the back of the wheelchair.

Have you ever traveled alone? No, I only travel with my husband.

Do you travel by public transportation? If no, then how do you travel then? I don't use public transportation. And I can't travel without my husband anyways. He always has to push me. We have a car. He puts me in the passenger seat, breaks down the wheelchair and puts it into the trunk. It works out well.

3.3. Survey answers

1. How did you get your disability?
1. Eric: As I was 30 I was injured through a gunshot by bank robbers.
2. Brent: Gunshot in his nick. It met his back-spine nerves. (27 years ago)
3. Donald: Nerve disease.
4. Jacob: I was born with a disease called Spinal muscular atrophy.
5. Joan: 7 years ago, an accident at work happened. A table fell on my back and took away my ability to walk.

2. What is your big desire?
1. Eric: Nothing special. "I had a great life" he said. I had 2 wives, children and grandchildren.
2. Brent: To own my own restaurant. I like cooking. I am a chef. Also, to own a sports bar, because it brings money.
3. Joan: My big desire is being able to walk again! That's my desire! Then I wouldn't need anybody's help! I hate asking for help!

3. Have you ever traveled on your own?
1. Eric: I always travel in my own. I like being independent. I don't let people help me and they get angry. He laughs.
2. Brent: I was married to a woman in a wheelchair. We used to travel together.
3. Donald: I traveled on my own many times by plane, car, bus, cruise boat. But I like to travel with somebody else.
4. Jacob: I travel on my own every day to work. I live 0.7 miles away from my office. I get there by using my wheelchair. And back using the people mover.
5. Joan: I have to travel either by my wheelchair or by paratransit every day. I am a busy woman.

4. How often do you travel on your own?
1. Eric: Almost every day. My life is balanced. I enjoy staying at home but also like to go out and explore. I know Detroit very well and here is a lot going on: events, festivals.
2. Brent: I travel by paratransit.
3. Donald: Every day.
4. Jacob: I don't have a car. It is very expensive to modify it, to get the training and to buy a car. I travel every day to work on my own by the wheelchair and a people mover.
5. Joan: Every day.

Qualitative Research

5. What are the difficulties if you travel by bus, by train, by car?
1. Eric: It is difficult to travel by bus. They often don't have the equipment/ramp.
2. Brent: I try to avoid public transportation. I travel by paratransit, by my wheelchair or with my relatives.
3. Donald: I had good and bad experiences. If it is overcrowded then it is no fun.
4. Jacob: There are a lot of different ones. Sometimes if I go to some house parties then I have to ask somebody to bring me there. The bus transportation sucks. Bus is not reliable. I often have to go much earlier to some places. He had plenty of negative experiences. But I try to find right places.
5. Joan: I don't travel by bus. I don't like it. It is always overcrowded and difficult to get in. I couldn't move by "People mover". It is not accessible for wheelchairs (that's not right but she doesn't know that). I only tried Q-Line once. I even don't like the paratransit. Too many people want to get in. I travel by my wheelchair. But it could be faster though. It is the cheapest way for me.

5. What could be improved in the future?
1. Jacob: Subway (New York), Chicago (Trains) - it would be better if we could travel in Detroit not only within the Midtown and Downtown areas in Detroit but also to the suburbs. A better public transportation would be good.

6. Do other people treat you differently?
1. Eric: There are a lot of weird people around.
2. Brent: Not the guys, but the women. They avoid me.
3. Donald: I have my friends. They like me.
4. Jacob: I have my friends, colleagues and also a community of people in wheelchairs.

9. Where would you like to go if you would be able to travel on your own? (Far away or just around here).
1. Eric: He already traveled each city of the US. He was also talking a lot about the time before his disability.
2. Brent: I already traveled so much.
3. Donald: I already traveled so much.
4. Joan: At first, I would just travel in Detroit and then maybe Chicago. I don't want to go too far away. What if it breaks? I could get back home.

10. Do you usually communicate with people like you, who are also in the chair and know how you feel?
1. Eric: Yes, he goes every day to rehabilitation Center. There are many disabled people like him.
2. Brent: Rehab friends in wheelchairs and family. Otherwise I don't have any further friends.
3. Donald: Not necessarily. I often go to bars and meet my friends there or go to some house parties. I go to rehab to support people in wheelchairs. I organize a lot of different activities.
4. Jacob: Yes, I do.
5. Joan: No. I don't have lots of friends.

11. Do you have any further contacts for me from people in the wheelchairs?
1. All of them: Yes, just call the rehabilitation center in Detroit.

12. Do you feel discriminated? In which way?
2. Eric: It depends. He built his own comfort zone at home - lower kitchen, he lives in the first floor. He seems to be very positive.
3. Joan: The Designers don't think about us when they design products.
4. 13. Can you send me a message? (to see how he/she will interact with the smartphone if further disabilities).
5. Eric: He only has one functional hand. So it takes longer for him to type.
6. Brent: He had some troubles to write his name of the piece of paper with his right hand.
7. Donald: He has no problems.
8. Joan: No problem.

14. Do you work? If no, why not? (Bad accessibility?) If yes, how do you travel to your work?
1. Eric: Right after the accident he tried to stay at the same company. They gave him another job. He got bored he says. That's why he retired.
2. Brent: No, I don't work. I am retired.
3. Donald: Currently I don't work. I am retired. But sometimes I play DJ and am also a volunteer in the Rehab.
4. Jacob: Yes, I have a job. I experienced sometimes some difficulties to get to my office because of some transportation issues.
5. Joan: Yes. I am self-employed and distribute EMA Skin care. I have to deal with bills, brochures a lot.

15. Are you flexible in meeting friends?
1. Eric: Yes. He meets his friends from college.
2. Brent: I don't have friends.
3. Donald: Yes, I meet a lot of friends.
4. Jacob: Yes, I meet my friends. I always look for new contacts.
5. Joan: I don't do that. I am too busy.

16. Have you ever had depression?
1. Eric: No. He is mentally very strong he says... Some people have worse life situations. Some are blind and can't see the world. I'm happy that I survived.

2. Brent: Yes. Especially in the beginning. Two years long right after the accident I had deep depressions.
3. Donald: Yes.
4. Joan: Yes.

17. Can you describe your disability?
1. Eric: Legs, arm, back (spinal C6, C7) still swollen (for already 25 years)
2. Brent: Disabled legs and an arm.
3. Donald: Disabled legs.
4. Jacob: Disabled legs.
5. Joan: Disabled legs.

Qualitative Research

18. Do you always go the way you already know or do you like to explore and have some challenges?
1. Eric: He knows Detroit very well.
2. Brent: I don't like exploring and don't know how to use GPS. I know Detroit pretty well and move around only here.
3. Donald: I like exploring. I'm flexible in my car.
4. Joan: Always the same way

19. Do you feel that your wheelchair is the part of your body? The part of your life since you are dependent on it to move?
· Eric: It is the "extension of my body" he says.
· Brent: I don't want to think so. I am not happy to be in a wheelchair.
· Donald: No
· Joan: Do you think I like to be in the wheelchair? I don't like to be disabled.

20. Test: Do you reach the buttons? Have you ever used voice control before? Do you like it?
1. Eric: He figured out how to reach buttons. He was trained to adjust to his new life at the Rehab center.
2. Joan: Yes, I usually do. But I don't like it if there are no buttons for automatic opening doors. I would like to use voice control. But I have never used it before.

21. What do you do in your free time? Do you like to move around? Exercise?
1. Eric: He likes reading, watching TV, going to cinemas and the usual stuff you also like to do, he says.
2. Brent: Cooking, Watching TV
3. Donald: Mixing music (DJ), cruising around, meeting friends, watching TV, Going to Rehab.
4. Joan: I do crochet.

22. What do you think the autonomous cars could offer you?
1. Eric: I don't like them.
2. Brent: It could be a place for me to relax and look around.
3. Donald: It could be my office.
4. Jacob: It could be an opportunity to travel on my own. But I don't trust them now.

5. Joan: I would love to travel in Detroit and to my customers.

a. Would you like it?
1. Eric, Brent, Donald: No, because I don't trust them. What if a drunk guy will hit my car?
2. Jacob: I've heard there is a lot of distrust and suspicion towards them. But I think I would like them. It is interesting. It could buy some grocery for me. But I also do buy some grocery stuff on amazon and it just ships it to me. I think that the advanced technology would make our lives easier.
3. Joan: Yes.

b. Would you want to buy or lease a car?
1. Eric, Brent, Donald: Leasing is expensive

A philosophical question.
How to build up the trust into the new autonomous technology?
To be able to see what the car sees.
To visualize the emergency opportunities in the car. (The interviewee always said that they wouldn't like to travel for a long distance, because they wouldn't know what to do if the car will break somewhere in nowhere)

4. Additional Research with a reduces number of questions

older. I'm getting wet when it rains. And an integrated backpack on the back of my wheelchair would be great."
How would you like to interact with an advanced technology? "Via voice control."

Robin
Length of the interview: 25 minutes
Location: Maryland
Gender: Male
Age: 57
Occupation: Employed. 1 day/week at the office and 4 days/week home office.
Hobbies/Interests: Reading
Status: High
Family: wife, 3 children
Degree of disability/disabilities: Right side of his body is paralyzed. Spinal cord damage.
Mobility:
· A modified vehicle, Scion 2006
· Scooter

Emma
Length of the interview: 35 minutes
Location: Maryland
Gender: Female
Age: 22
Occupation: Student
Hobbies/Interests: Reading
Family: not married, but has a boyfriend
Degree of disability/disabilities: Too short. 1 meter. She has troubles walking on long distances.
Mobility:
· A modified vehicle with expanders on pedals and pillows to be higher and see better.
· A battery-operated scooter to travel within a campus.

Qualitative Research

1.What transportation do you use for traveling?
Robin: Only my car
Emma: My modified car and an electric scooter.
2.How is the overall experience, accessibility and interaction in your car?
Robin: In the past, I accessed the car through sliding in there. Now it is getting more difficult because I am getting older. I have to lift my right foot. If it is rainy or snowy if is getting more difficult. Sometimes I have to cancel my appointments at the office and stay at home. I am thinking about getting a wheelchair soon. I am trying to walk as long as I can walk. Now I am using a crutch and sometimes a scooter.
Emma: It is hard to drive any kind of car for me. But it makes me flexible. I don't have to wait and walk to reach bus or train stations. It's hard to reach buttons. The buttons on the steering wheel are more helpful.
3. How often do you travel?
Robin: On Sundays, I have to bring my daughter to the basketball training. I have to drive. But I don't travel so much anymore. It is always a problem for me to lift my foot if I have to walk stairs.
Emma: I live on campus and travel with my scooter to class rooms and for grocery shopping.
4.Do you travel by public transportation?
Robin: Not very often. It is a problem of lifting my foot or walking stairs. "Light rail" is a train in my city. It is very wheelchair friendly. But I don't like public transportation. Some busses bringing themselves lower. It is nice. Also traveling to Disneyland there was a bus which had a special lift in the bus.
Emma: No. In Ohio, I don't live in the city. So, there is not much public transportation. As I lived in Austria for 4 months I had the opportunity to travel with public transportation a lot but the trans and metros are not all accessible for people in wheelchairs. Sometimes there are only stairs.
5.What would you like to improve in your car?
Robin: I want to have a van because it would have enough space for my wheelchair. I need a ramp, a door which would open from bottom up (so called suicide doors), all controls on the steering wheel - they would be easier to reach. Since my right side of the body is not functional, it is difficult for me to operate the windshield wiper.

Emma: The controls on the steering wheel. There should be more place for people in wheelchairs.
6.Can you reach all controls in your car?
Robin: No, I can't it is difficult especially the controls on the right side.
Emma: No.
7.How do you get to places? Google maps, navigation system?
Robin: I am old fashioned. I have an old phone. The new one I would drop. I look up directions at home or use the navigation that is built into my instrument panel.
Emma: Google maps
8.What do you think autonomous cars could offer you?
Robin: It would be so great to have one! I would be independent. I could travel to my work without any problems. I would love to try it out.
Emma: I wouldn't have to drive, which is so difficult for me. But I have a trust issue. If it would become a big trend and everyone would be doing it, then I would like to try it out.

9. What would you do in an autonomous car?
Robin: The usual stuff like in a train. Reading, Looking out of the window.
Emma: Sleep, table would be good to eat, play cards, draw.
10.What cool features could you imagine in your car?
Robin: I have Alexa at home. It would be cool to control my car via voice recognition. Joystick would be easier to steer my car, driver seat adjustment, gas, break, easier access.
11. Have you heard about Mobility as a Service? Would you like it? What does your car mean for you?
Robin: It would be great to rent out different cars depending on the occasion.
Emma: It is a nice idea. I would do that. In an autonomous car, I wouldn't have to drive. That would be so much easier to move around if my car would just pick me up and bring to places. I like to own a car but not because I love it but because it makes me flexible. It is mine, it is easier than public transportation because I don't have to find and go to the bus/train stations. I can't walk for a long distance.
11. How would you like to communicate to your car?
Robin: Via Voice
Emma: Via voice and touchscreen. Voice is nice because you can be anywhere and don't have to reach to the screen.
12. Do you have a big dream?
Robin: Rom is on my bucket list.
Emma: To go to Ireland.
15. What organizations are helpful for my research?
Robin: MTI - Administration Mobility
Physical therapy, (Institute of Bela mere)
Emma: No, I don't go to any since I grow up with my sister with the same disability

Findings Robin:
Bad accessibility of the cars. They need to be modified.
Difficult to reach all buttons and controls in the car.
Robin doesn't travel so much. It is difficult to operate the car. But he wishes he could.

Struggling with public transportation. Some people can't lift their foot. Some people can't walk for a long distance to the stations and the metros are not always accessible for people in wheelchairs.
Despite trust issues they would like to try out the autonomous technology if it would become a trend.
They would **communicate to the car** via voice. In this way, you can be anywhere in the car. It gives you a flexibility to move in there.

Objectives:
How the controls can be redesigned to operate the car?
How to design a better accessibility to the transportation?
(Busses, cars, special cars, mobility as a service)
How to combine the flexibility that you have traveling by car and the autonomy (not driving) that you experience by public transportation?
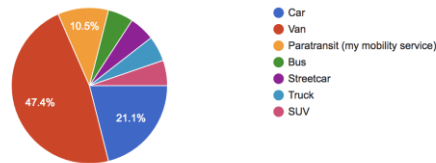
Appendix

4. Quantitative research

Quantitative Research
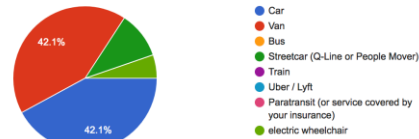
6.3 Quantitative Research - Survey

Q1. What is your usual transportation mode?
19 responses

- Car
- Van
- Paratransit (my mobility service)
- Bus
- Streetcar
- Truck
- SUV

47.4% — 21.1% — 10.5%

Q2. What mode of transportation do you like best?
19 responses

- Car
- Van
- Bus
- Streetcar (Q-Line or People Mover)
- Train
- Uber / Lyft
- Paratransit (or service covered by your insurance)
- electric wheelchair

42.1% — 42.1%

Q3. Why is that mode favorable to you? (You can select more than one)
19 responses

Ease of access	12 (63.2%)
Convenience	7 (36.8%)
Travel route	3 (15.8%)
Proximity	3 (15.8%)
Security / Safety	9 (47.4%)
No waiting time	7 (36.8%)
Flexibility	8 (42.1%)
Affordability	4 (21.1%)
I am dependent…	1 (5.3%)
I can't afford any…	1 (5.3%)

0.0 — 2.5 — 5.0 — 7.5 — 10.0 — 12.5 — 15.0

Q4. Do you usually need help to access your mobility?
19 responses

- Yes
- No

68.4% — 31.6%

Q2. Please describe how exactly do you access your mobility? The exact sequence is important (for example: slide into the driver's seat, break down the wheelchair, take off the wheels, lean over the B-pillar from the driver's seat in order to put the wheelchair into the back... Another example: request a ramp, roll up into the car (does it require a lot of power?), place myself in a special spot, fasten my seatbelt, ...)
18 responses

I drive a Dodge Grand Caravan with a 10 inch lowered floor Braun conversion I am in a power chair. I pull right under the steering wheel in my wheelchair and lock into an EZ-Lock, To get the door closed and the ramp to come up I push one button on my dash and it puts that in motion ramp comes up door follows behind. (2)

Roll in passenger side, have passengers side seat out, from my manual wheelchair, I transfer to drivers seat. Drive with hand controls.

Well I transfer to the drivers seat then balance myself enough I hold the steering wheel with the right hand and to fold the manual wheelchair with left hand then top the wheels off 1 at a time put them on the floor of the passenger side then I pick up the frame of the chair and put it on the passenger seat....

I place myself in a special spot & fasten my seatbelt.

Lift And Slide onto seat and fasten seatbelt.

I put my right leg in to distribute my weight and then transfer onto the drivers seat. Then I put my right leg back out grab my wheelchair (the whole thing) and pull it into the spot where I have taken out two seats directly behind the drivers seat and pull it into the van. Then I use the button and close the van door and off I go.

I roll up the ramp of the van that's transporting me. I don't have a vehicle of my own yet.

Lock chair, put right leg inside floorboard, pull myself to edge of chair, grab steering wheel, pull myself up to roof handle, pull myself into seat. Pull left leg in. Unlock chair, put chair up on front casters leaning against rocker panel of truck, pull left wheel off, put in truck behind me, pull right wheel off put behind me, pull entire chair in and over me placing gently in passanger seat.

Enter through ramp inside side door and strapped down with q-straint straps.

I dont require a wheelchair

I have a 2016 Dodge Grand Caravan wheelchair conversion van made by Braun. I roll up the ramp , transfer to a 6 way power seat, secure my wheelchair with straps .

Roll into van and strapped in

I don't drive so I use a slide board to transfer into the passenger seat and whoever I'm with helps with my wheelchair.

roll up into the car

Take an elevator to the people mover. Get in. There is enough space

van kneels. ramp deploys, power wheelchair rolls up ramp, steer chair into "easy lock" on passenger side front seat area, make sure chest belt and lap belt attached to wheelchair are buckled, then staff buckles van shoulder belt around me.
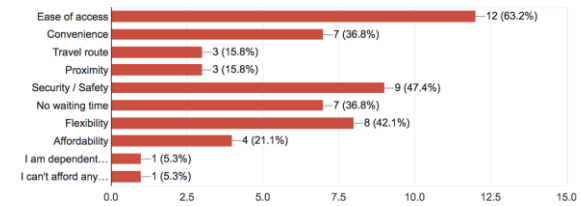
Q3. How would you like to improve the mobility access to make it easier?
17 responses

Lots of improvements can be made the industry has been doing very well keeping up with times in technology if you would like to further this conversation my phone number is 248-515-6563. I am a C-5,6 quadriplegic and have been injured for 28 years I have a degree in CAD & mechanical engineering. I've worked for several van companies would love to give some more input (2)

More space.

Maybe some kind of hook or something like that can be inside the roof of the car to help with the lifting of the wc....because now I suffer from shoulder injuries from all the years of in and out of the car and put the wheelchair together.

Less steep ramps

Have more Reliable Transportation and make it more easier to access the Resources out Here and create more closer places to go too.

I would like to have something load my chair for me that doesn't take up a bunch of space in the vehicle.

Well it depends on what you're driving. I know some of them ramps needs to be wider on them transportation vans.

Haha.

Not sure.

An extra bar to help pull myself in a higher vehicle. Rising & lowering running boards.

yes

No improvements to be made

A extended piece off the seat of the car to eliminate the slide board need.

Place myself into a special spot

Modification is very expensive and the driver training as well. Usual van costs 20.000. A modified vehicle costs around 40.000 - 60.000$. Make it cheaper.
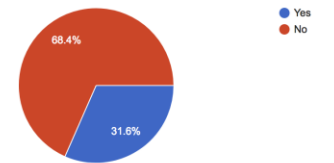
Have a chair that breaks down and folds

Q5. What do you usually do during the ride / drive (if you travel alone or with someone)? Please describe in detail.
19 responses

I am the driver 98% of the time. I just drove 18 hours straight four months ago. It was tough have somebody with me pumped all the gas help me with my food (2)

Drive alone, mostly for work. Have other wheelchairs including power chairs that I move around metro Detroit.

Listening to the radio touch screen is a beautiful thing or talk via Bluetooth best invention ever. Left hand used to drive with hand controls (gas/brake) right hand to steer, I also use a steering knob. It kinda become the free hand in a way to changes stations, volume, eat a sandwish, smoke if you're a smoker ijs...

I travel with a driver. I'm in the passenger seat. I change the radio, my window, heat, air.

Just get in and Go

I have a hand control and drive independently. I tend to use the cruise control once I am out on the open road so that I can give my arm a break from pushing it up and down in and out.

I'm usually in the back of the van with my wheelchair strapped down.

Concentrate on driving?

Travel with a driver and listen to the radio or read.

Listebn to music & relax.

Sit in the car and talk with who I'm with and listen to music

kill time on my smart phone

With someone

Talk, Radio

often the motion puts me to sleep

I use portable hand controls

Q6. How would you like to spend time in a self-driving car?
18 responses

I feel it is truly the future - we will not be driving soon - I educated on driving and I Bring this up often - soon we will not be driving we will be the passenger . I have no problem with that (2)

Doing computer work or watching technology

First question I have is what is an autonomous car? Once I know what it is maybe then I can answer the question accordingly. I will try anything once if that helps any....

The sky's the limit. Exercising. Returning calls. Making needed calls. Networking.

Just enjoy it and my independence.

I would like to catch up on emails, make important calls and watch my live feed on Instagram.

I'd give anything a try that'll make things easier for us disabled people.

Self driving cars are a horrible idea. Would never get in one

Listening to the radio.

Be safe & try to relax.

watch a movie , play cards if I wasn't alone , read a book or sleep

Not interested

Comfortably.

listening to music

Don't know

reading if motion is smooth

Would love it

Quantitative Research

Q7. How would you like the technology and artificial intelligence support and assist you during the ride? (Please describe even if it sounds unrealistic)
18 responses

- feel it is truly the future - we will not be driving soon - I educated on driving and I Bring this up often - soon we will not be driving we will be the passenger . I have no problem with that (2)
- I would love some kinda robot that is in the trunk of the car that push of a button and voice recognition would top of out and come round the drivers side and take the chair and put it in the trunk and climb back into the trunk and close the door
- Exercising. Mobility.
- Make it more affordable and easy to use.
- I mean if I need to use the bathroom to urinate during a ride I might use it to help make my vehicle more discrete or make privacy.
- Well tell us if it's safe to switch over to another lane while on the expressway.
- Would not
- Not sure.
- I think it would be fabulous.
- I don't think I would like it

- Really don't know
- Easy to use hand controls, maybe a removable seat and a lift to just put me in the car without having to get out of my wheelchair.
- Would love it if it was accessible for my wheelchair Power and manual
- Unsure
- Play music, play games. Robotic arm, that can pick up something.
- I could go where I wanted when I wanted if seatbelts were self locking—like you would drive into shoulder belt, it would follow a track around and fasten...then I would tell the van where to go
- I would like for the chair to be put in and taken out on its own

Q9. Would you prefer to stay in your wheelchair while traveling or would you rather prefer to switch to a seat? And why?
11 responses

- Car seat. I'm in my wheelchair enough. And my chair isn't made for comfort, it's made for mobility and efficiency, a car/truck/ van seat is made for comfort with bolsters and padding.
- Stay in my wheelchair - convenience
- A seat with a seat warmer.
- transfer to a seat
- A seat because it's more comfortable
- Depends on the vehicle and the day really. Some days it's hard to get in and out of my chair but the car seat seems to be more comfortable to me.
- Either. is ok
- Switch to a seat it's more comfortable
- Stay in my power chair, because it is designed for me. It is comfortable. It is difficult for me to change from my wheelchair to a seat. I only leave it if I I go to bed.
- wheelchair—as a quad my chair is formed to my posture, support for my trunk muscles. my chair can recline or tilt back as needed.
- Switch to a seat car seats are more comfortable than the wheelchair

Q8. If you could talk to your car (comparable technology: Alexa, Google home) during the ride, what would you like it to do for you or show / give to you?
18 responses

- I would like access to be able to work Why traveling down the road - driving takes a lot of time out of my day if I could work while I was traveling I could double the things I do in a day (2)
- Let me know how it's going. Will we be on time for our next stop?
- I use alot of Bluetooth for making phone calls but sometimes I hate it because when you ask it to do something it does the wrong things drives me crazy I would love a built in GPS navigation system I wouldn't care if it was black or white screen...
- I'm not sure
- Give Directions like a GPS
- I mean I like to use it for shopping and to - do lists now so maybe I would have it keep a record of vehicle maintenance and other financial decision, food choices where to eat and anything I already use google for... maps.
- The driving conditions of where I'm heading to if it's out of town and on my way to work and what would be a better route or wait another day to take the trip.
- Wouldn't use
- Control the radio.
- Change radio channels, Assist navigation.
- not sure
- Dont know
- Navigation, traffic, music.
- Let me know when it gets close to my destination
- Google
- arrival times, upcoming traffic jams, deploy window shades as needed when sun comes in the window too hot
- Put chair in take chair out

Q10. Would you like to travel with others / to share your mobility and costs or is the privacy very important to you?
10 responses

Shared mobility and costs
Private mobility for private use only
Both

60% / 30% / 10%
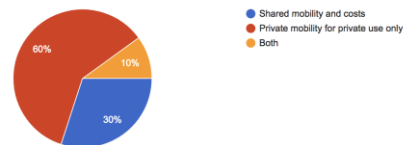
Q11. Is there anything you would like to share, to suggest, new features you would like to implement into a car? Please feel free to leave any kind of note.
2 responses

- radio controls on the passenger side.
- I would like for there to be a wheelchair user discount on the price as opposed to a higher cost for equipment

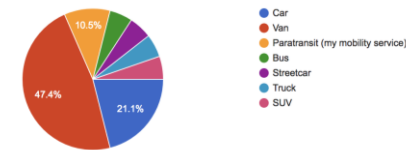**Additional Survey for deeper understanding:**

Q5. What do you usually do during the ride / drive (if you travel alone or with someone)? Please describe in detail.
19 responses

- I am the driver 98% of the time. I just drove 18 hours straight four months ago. It was tough have somebody with me pumped all the gas help me with my food (2)
- Drive alone, mostly for work. Have other wheelchairs including power chairs that I move around metro Detroit.
- Listening to the radio touch screen is a beautiful thing or talk via Bluetooth best invention ever. Left hand used to drive with hand controls (gas/brake) right hand to steer, I also use a steering knob. It kinda become the free hand in a way to changes stations, volume, eat a sandwish, smoke if you're a smoker ijs...
- I travel with a driver. I'm in the passenger seat. I change the radio, my window, heat, air.
- Just get in and Go
- I have a hand control and drive independently. I tend to use the cruise control once I am out on the open road so that I can give my arm a break from pushing it up and down in and out.
- I'm usually in the back of the van with my wheelchair strapped down.
- Concentrate on driving?
- Travel with a driver and listen to the radio or read.
- Listebn to music & relax.

Q1. What is your usual transportation mode?
19 responses

Car
Van
Paratransit (my mobility service)
Bus
Streetcar
Truck
SUV

47.4% / 21.1% / 10.5%

Q2. Please describe how exactly do you access your mobility? The exact sequence is important (for example: slide into the driver's seat, break down the wheelchair, take off the wheels, lean over the B-pillar from the driver's seat in order to put the wheelchair into the back... Another example: request a ramp, roll up into the car (does it require a lot of power?), place myself in a special spot, fasten my seatbelt, ...)
18 responses

- I drive a Dodge Grand Caravan with a 10 inch lowered floor Braun conversion I am in a power chair. I pull right under the steering wheel in my wheelchair and lock into an EZ-Lock, To get the door closed and the ramp to come up I push one button on my dash and it puts that in motion ramp comes up door follows behind. (2)
- Roll in passenger side, have passengers side seat out, from my manual wheelchair, I transfer into drivers seat. Drive with hand controls.
- Well I transfer to the drivers seat then balance myself enough I hold the steering wheel with the right hand and to fold the manual wheelchair with left hand then top the wheels off 1 at a time put them on the floor of the passenger side then I pick up the frame of the chair and put it on the passenger seat....
- I place myself in a special spot & fasten my seatbelt.
- Lift And Slide onto seat and fasten seatbelt.
- I put my right leg in to distribute my weight and then transfer onto the drivers seat. Then I put my right leg back out grab my wheelchair (the whole thing) and pull it into the spot where I have taken out two seats directly behind the drivers seat and pull it into the van. Then I use the button and close the van door and off I go.
- I roll up the ramp of the van that's transporting me. I don't have a vehicle of my own yet.
- I drive 99% of the time . maybe listen to the radio
- Listen to music
- Sit in the car and talk with who I'm with and listen to music
- kill time on my smart phone
- With someone
- Talk, Radio
- often the motion puts me to sleep
- I use portable hand controls
- Lock chair, put right leg inside floorboard, pull myself to edge of chair, grab steering wheel, pull myself up to roof handle, pull myself into seat. Pull left leg in. Unlock chair, pull chair up on front casters leaning against rocker panel of truck, pull left wheel off, put in truck behind me, pull right wheel off put behind me, pull entire chair in and over me placing gently in passaanger seat.
- Enter through ramp inside side door and strapped down with q-straint straps.
- I dont require a wheelchair
- I have a 2016 Dodge Grand Caravan wheelchair conversion van made by Braun. I roll up the ramp , transfer to a 6 way power seat, secure my wheelchair with straps .
- Rolll into van and strapped in
- I don't drive so I use a slide board to transfer into the passenger seat and whoever I'm with helps with my wheelchair.
- roll up into the car
- Take an elevator to the people mover. Get in. There is enough space
- van kneels. ramp deploys. power wheelchair rolls up ramp, steer chair into "easy lock" on passenger side front seat area, make sure chest belt and lap belt attached to wheelchair are buckled, then staff buckles van shoulder belt around me.
- Lift up into veh break down chair lift frame and place in passenger seat

Quantitative Research

Q3. How would you like to improve the mobility access to make it easier?
17 responses

Lots of improvements can be made the industry has been doing very well keeping up with times in technology if you would like to further this conversation my phone number is 248-515-6563. I am a C-5,6 quadriplegic and have been injured for 28 years I have a degree in CAD & mechanical engineering. I've worked for several van companies would love to give some more input (2)

More space.

Maybe some kind of hook or something like that can be inside the roof of the car to help with the lifting of the wc....because now I suffer from shoulder injuries from all the years of in and out of the car and put the wheelchair together.

Less steep ramps

Have more Reliable Transportation and make it more easier to access the Resources out Here and create more closer places to go too.

I would like to have something load my chair for me that doesn't take up a bunch of space in the vehicle.

Well it depends on what you're driving. I know some of them ramps needs to be wider on them transportation vans.

Haha.

Not sure.

An extra bar to help pull myself in a higher vehicle. Rising & lowering running boards.

yes

No improvements to be made

A extended piece off the seat of the car to eliminate the slide board need.

Place myself into a special spot

Modification is very expensive and the driver training as well. Usual van costs 20.000. A modified vehicle costs around 40.000 - 60.000$. Make it cheaper.

Have a chair that breaks down and folds

Not interested

Comfortably.

listening to music

Don't know

reading if motion is smooth

Would love it

Q4. Do you usually need help to access your mobility?
19 responses

68.4% No
31.6% Yes

Q5. What do you usually do during the ride / drive (if you travel alone or with someone)? Please describe in detail.
19 responses

I am the driver 98% of the time. I just drove 18 hours straight four months ago. It was tough have somebody with me pumped all the gas help me with my food (2)

Drive alone, mostly for work. Have other wheelchairs including power chairs that I move around metro Detroit.

Listening to the radio touch screen is a beautiful thing or talk via Bluetooth best invention ever. Left hand used to drive with hand controls (gas/brake) right hand to steer, I also use a steering knob. It kinda become the free hand in a way to changes stations, volume, eat a sandwich, smoke if you're a smoker ijs...

I travel with a driver. I'm in the passenger seat. I change the radio, my window, heat, air.

Just get in and Go

I have a hand control and drive independently. I tend to use the cruise control once I am out on the open road so that I can give my arm a break from pushing it up and down in and out.

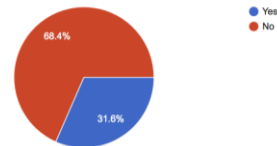I'm usually in the back of the van with my wheelchair strapped down.

Concentrate on driving?

Travel with a driver and listen to the radio or read.

Listebn to music & relax.

Not interested

Comfortably.

listening to music

Don't know

reading if motion is smooth

Would love it

Appendix

5. Further interviews

Interview with Kirk Steudle

Interview with Kirk Steudle,
Director of Department of Transportation
State of Michigan

Intro

Based on discussions about autonomous mobility and accessibility issues in New York last week (beginning of February) I decided to interview Kirk Steudle, who is the Director of Department of Transportation in State of Michigan.
According to Conrad Albrecht-Buehler (Lead of Interaction Design at BMW Designworks in California) Kirk Steudle considers it of **vital importance that AV manufacturers spend time defining how users of AVs that have different handicaps will interact with them**.

Questions

What do you expect automotive companies to implement in AV for a better accessibility?
How do you want to push the automotive companies to work on accessibility topics? What are the methods, what is the approach? What are the actions to be taken or sanctions?
How will companies react to your message?
How did you realize the need in accessibility in Av's?
Are we talking about physical elements, user interfaces or navigation tools the car makers will have to think about working on the accessibility issues?
What do you think is the most crucial aspect of the AV accessibility? Is it the get in and out process or the interaction inside the vehicle?
Contact information from a person from advisory board for persons with disabilities.
What is your prediction about autonomous cars? When will we see them on our roads?
Are we talking about different concepts or unique universal design for all vehicles?
Did you have some conversations with them? Will they provide MaaS with different car platforms.
What do you think the environment for AV will look like? Will the structure of cities change, in which way?
Will the city have huge parking lots only for AV?

Interview

Sofia: You were saying that you consider it of vital importance that AV manufacturers spend time defining how users of AVs that have different handicaps will interact with them. Is it an official statement?
Kirk: We have interjected (eingeworfen) this conversation into nothing officially but in conversations with suppliers and OEMs how the conversations between humans and human machine interface will look like to support different people with different disabilities. We have no authority to push the automotive companies to work on the topic other than to suggest that they take it into account.

Sofia: What was the outcome of this conversation?
Kirk: We were talking about creating a challenge program for students or people like you who are coming up with an idea. This conversation is days old and we have to think about how will the challenge look like. Maybe there will be a cash price. Think about what is the industrial design look like for people who have mobility challenges.

Sofia: How would you push the automotive companies to work on accessibility topics?
Kirk: We have no authority to push them. We only can suggest what to do. They will look if there is a business market to do this and make their decisions. But what we can do is to push the conversation so that it becomes something to think about. We intend to do a public voice that was interjected into the conversation: What does the future design look like for people with limited mobility or special needs?
There was friend of mine who suddenly lost her vision in age of 48. She was talking about colors and shapes on dashboards that she can't see, she can't distinguish.

Sofia: Do you think about accessibility as physical or conversational elements?
Kirk: It is both. We have the paratransit program for people in wheelchairs. **They call the paratransit driver. The bus driver gets out of his vehicle. Helps the user to get on the bus. Locks the wheelchair so that the user feels comfortable. How will this process look like with autonomous cars?**

Whatever challenges the people might have. If they don't have a hand how will they lock themselves? Think about the people with a joystick and they cannot use their hands how do they interact with that? Is it the voice control, is it a button? So what are the challenges from the point of their residence to the place where the vehicle is. How do they get in and out? What are all challenges along the way.

Interview with Kirk Steudle

Interview with David Bulkowski

Sofia: When will we see autonomous vehicles on the roads?
Kirk: They are already there. Waymo already offers driverless ride sharing in Phoenix area:
https://www.azcentral.com/story/money/business/tech/2018/01/30/waymo-start-driverless-ride-sharing-phoenix-area-year/1078466001/
In approximately 5 years we will see more and more autonomous cars on roads.
At first, they will be for commercial sales. That's what Ford and GM promised. That will be the first step of major acceptance. But they will be very expensive. Here we are talking about Level 4 of autonomy including ride sharing. In 2030-2035 the Level 5 will be available for anybody and the streets will be full of autonomous cars.

Sofia: What challenges with commercial vehicles are we facing now?
Kirk: If a person with mobility challenge will call an Uber. Uber will usually refuse, because their cars aren't accessible.

Sofia: Is the connectivity and mapping from Cities be a requirement for autonomous cars?
Kirk: The cities will provide data based on scanning the environments of cities. For better prediction and orientation for autonomous cars. But the updates won't happen immediately. The data provided by cities won't be able to show constructions and accidents. (They will be able to update data maybe once a week or even less). The autonomous cars will have to decide completely on their own. They will have to rely on their own decisions.

Sofia: Will the structure of the cities have to change? I can imagine that if we are talking about Mobility as a Service concepts (MaaS) then the huge parking spots will have to be created for the autonomous cars where they will wait while being out of use.
Kirk: Exactly, it is a topic of the future. Where will these cars stay overnight? Outside of the cities? That's what we will have to think about. They have to be charged, they have to be washed. They won't drive around whole day long. From midnight until 6am only 5% of streets will be used. Where these cars will go? Will they sit on the side of the road?

Sofia: What are your thoughts about private mobility versus mobility as a service? Do you think we will be able to afford the private autonomous cars?
Kirk: First of all, the question is if I will want to buy a car for 100.000$. What will the parking spaces cost for me 50$ a day? Will I still want to pay as much?
The use of my electric car saves 3$ per trip. Maybe I will tell the car to go home because it will cost me 6$ for parking in the city, then it will have to come back. There are a lot of public policy pieces. The public acceptance is a big piece of it.
You will see the Mobility as a Service models. Mobility owned by large companies that take on the liability to start with.
Also, if you will own a car and share it while you are at work it can happen that the car will have an accident and I will be responsible for that. Do you want to deal with that?
My insurance company might not let me do it either.
Think of New York city where the apartments doesn't provide parking spots. They start using MaaS. But where do the car go after?

Executive Director at Disability Advocates of Kent County (contact through Kirk Steudle)

Interview questions:

Sofia: What are the biggest unsolved challenges for disabled people?
David: Vertical access, mobility, added costs.

Sofia: What are their pain points?
David: Costs, poverty, planning, not spontaneous. 20 % of disabled people have jobs. It is based on earlier lack of education. For them it takes longer to get to work. Catch 22 – no win situation.

Sofia: What does your department do to help solve these problems? What is your approach?
David: Educate for community changes. Public transportation for everybody.

Interview with people with mobility challenges

Intro

In order to find out how the exact scenario of traveling with Transportation Service (sometimes called: paratransit) works some people in wheelchairs who use paratransit service were interviewed.

Questions

Is it?...
Calling a transit ahead two days before your journey to reserve the spot?
What are the possible destinations? Are this only for the Rehab and your doctor appointments? What if you have to go for a grocery shopping?
Once the paratransit is there, are you the only one in the bus? Is there place for others?
Can you get inside on your own? Or does the driver get out, open the door, pushes you in, close the door?
Does he lock your wheelchair?
Do you feel comfortable?
What is around you? Is it a nice environment or do you feel like a cargo or do you feel like a sick person? Describe your feelings inside.

How do you get out? Does the driver get out, unlock your wheelchair, helps you get out backwards? Close the door? How do you feel?

Where do you wait for paratransit? Is it in front of your door?
Is it always on time?
Is the driver polite?
Do you talk to him during the ride?
Is he telling you where you are?
Do you need this conversation with him?
Is the communication with the driver necessary?
What conversations are necessary in general to take the paratransit?
What do you usually ask him? (When will we arrive? How was your day?) – Is it an opportunity for you to communicate?

How do you get from the Paratransit to your destinations? Do you have any challenges? (Open the house door, is there an elevator? Do I have to wait outside because the building I want to enter is not accessible?) If the building is not accessible what do you do then?

Once you are done with your appointment. How will your paratransit driver know that you are done? Or do you just wait? How do you know he is there? Does he give you a call or do you just go outside and wait or do you have an app where you can see where he is?

Interview with Alonzo

Sofia: Calling a transit ahead two days before your journey to reserve the spot?
Alonzo: Yes, 2 days before. Insurance Progressive covers the Service

Sofia: What are the possible destinations?
Alonzo: Doctor appointments and Rehab.

Sofia: What if you have to go for a grocery shopping?
Alonzo: I would ask my relatives. These are usually my siblings.

Sofia: Once the paratransit is there, are you the only one in the bus? Is there place for others?
Alonzo: There should only be one disabled person a vehicle. My relatives can come with me. There are always different sizes of vehicles. I prefer to be only one disabled person in the vehicle.

Sofia: How do you know the driver is there?
Alonzo: He knocks on the door. He is parked in the driveway.

Sofia: How do you get inside of paratransit?
Alonzo: The driver has to get out, open the door, push me in on the ramp, lock my wheelchair, close the door. The locks are on the floor.

Sofia: Do you feel comfortable in the Paratransit?
Alonzo: It depends. The vans are all different. But I feel more comfortable in my car.

Sofia: How do you get out?
Alonzo: The driver gets out, unlocks your wheelchair, helps you get out backwards. He closes the door.

Sofia: Where do you wait for paratransit? Is it in front of your door?
Alonzo: I wait inside of the building. The driver comes in. Sometimes I just wait outside because I feel warm inside of buildings.

Sofia: How long do you usually wait for the driver?
Alonzo: Sometimes I wait for hours! Between 2 to 6pm these are rush hours. It can take for a driver forever to get back. I would prefer that the driver waits for me. Some of my appointments don't take long but then I have to wait for too long for the drivers. Of course, I can understand that they have to drive other people as well. Sometimes I just call my relatives to pick me up and bring me back home.

Interview with people with mobility challenges

Sofia: Is it always on time if you go to the doctor's appointment?
Alonzo: It depends. Usually on time to bring me to an appointment.

Sofia: Is the driver polite?
Alonzo: It depends. I get along with most drivers. But some are not very friendly.

Sofia: Do you talk to the driver during the ride?
Alonzo: Sometimes. I don't have to. I listen to the music. I always know where I am going.

Sofia: Is the driver polite?
Alonzo: It depends. I get along with most drivers. But some are not very friendly.

Sofia: Do you talk to the driver during the ride?
Alonzo: Sometimes. I don't have to. I listen to the music. I always know where I am going.

Sofia: Is he telling you where you are?
Alonzo: No, I always know where I am going. These are the same places.

Sofia: Is the communication with the driver necessary?
Alonzo: No, It's just for fun.

Sofia: What do you usually ask him?
Alonzo: I ask him how he is doing or we just listen to music.

Sofia: How do you get from the Paratransit to your destinations? Do you have any challenges? (Open the house door, is there an elevator? Do I have to wait outside because the building I want to enter is not accessible?) If the building is not accessible what do you do then?
Alonzo: I don't have any troubles. Mostly, the driver knows that they transport people in wheelchairs. The buildings will be accessible. The transportation service would tell the driver.

Sofia: Once you are done with your appointment. How will your paratransit driver know that you are done? Or will you just wait?
Alonzo: I would call the service. I would wait inside or outside. He would get in and let me know.

Sofia: What is the name of your insurance company?
Alonzo: Progressive

Sofia: Can I have a number from the transportation service (not from the insurance)?
Alonzo: Sure, it is Give-A-Lift Transportation and Rudy is their dispatcher that tells where to go. His number: 248 569 5010

Sofia: Are they working on weekends?
Alonzo: Rehab doesn't work on weekends. But they probably would drive. I don't know.

Interview with Brent

Sofia: How do you order your transportation Service (Paratransit)?
Brent: Calling a transportation service 2 or 3 days before your journey to reserve a spot.

Sofia: What are the possible destinations?
Brent: Different insurance companies do different services. My insurance only covers Rehabilitation Center and my doctor appointments.

Sofia: What if you have to go for a grocery shopping?
Brent: I ask my son. I never consider busses. The last time I took a bus was 20 years ago. It means for me inconvenience, in other words too much trouble: Dealing with bus drivers, some aren't friendly, some wheelchair lifts might be broke, too many people inside or no free spot for wheelchairs.

Sofia: Once the paratransit is there, are you the only one in the bus? Is there place for others?
Brent: The trans service takes maximum two people in wheelchair. Depends on the Van. Mostly I am alone but sometimes we are two. Relatives also can join.

Sofia: Can you get inside on your own? Or does the driver get out, open the door, pushes you in, closes the door?
Brent: I have different wheelchairs. In my electric wheelchair, I usually don't need any help.
If I am in my non-electric wheelchair I need help. The driver needs to push the button. He would open the doors, the lift would come down automatically, I would roll in and get inside. The driver will lock my wheels down (these are hooks) and I would fasten my seatbelt. If I need help or not he should help anyways. It is his job.

Sofia: How long does it usually take to get ready?
Brent: 4-5 min.

Sofia: Do you feel comfortable inside?
Brent: It doesn't matter to me.

Sofia: How do you get out? Does the driver get out, unlock your wheelchair, helps you get out backwards? Close the door?
Brent: The driver unlocks the wheels. I drive backup. The lift comes down. I need or don't need help depending on the wheelchair I pick. If I am in my electric wheelchair I usually don't need help. The driver closes the doors.

Sofia: Would you be able to get in without a driver?

Interview with people with mobility challenges

Brent: People with their own specially modified vans have automatically opening doors and automatic lifts. They wouldn't need help.

Sofia: Can you turn around in the van?
Brent: It depends what vehicle they send to pick me up.

Sofia: Where do you wait for paratransit? Is it in front of your door?
Brent: They would call me. He would wait in the drive way.

Sofia: Is it always on time?
Brent: No! I have been late before.

Sofia: Is the driver polite?
Brent: Yeah. Their job is to be polite.

Sofia: Do you talk to him during the ride?
Brent: Sometimes.

Sofia: Is the communication with the driver necessary?
Brent: No. And we actually usually don't talk.

Sofia: What conversations are necessary in general inside of the Van?
Brent: No. The destinations are usually always the same ones.

Sofia: What do you usually ask the driver? Is it an opportunity for you to communicate?
Brent: We talk about different stuff like Basketball.

Sofia: How do you get from the transportation service to your destination? Do you have any challenges? (How to open a door? Is there an elevator? Do I have to wait outside because the building I want to enter is not accessible?) If the building is not accessible what do you do then?
Brent: The buildings are accessible and I have to troubles.

Sofia: Once you are done with your appointment how will your paratransit driver know that you are done? Or do you just wait?
Brent: I give a call. I wait about 45 min to an hour.

Sofia: How do you know he is there?
Brent: The service would call me. And let me know the driver is there.

Sofia: What is the name of your insurance?
Brent: Medical transportation Service. Medicay or Medicare.

Appendix

6. Persona creation

meet
Brent

VITALS

Mobility challenge

Age:
58
Occupation:
Early retirement
Income:
$20,000 – $25,000
Marital status:
Divorced
Children:
Philipp, 36
Vehicle:
None
City & population:
Detroit, 700,000

PROFILE

Personality:
Brent is an introverted person. He experienced a lot of mental pain caused by his disability.

Hobbies:
Brent likes cooking, watching TV and movies and reading books and newspapers.

Social:
Brent often stays at home because he has no opportunity to travel. His paratransit brings him only to his doctor appointments. His son is not always available. He doesn't want to trouble other people. He never uses buses because it is inconvenient.

Responsibilities:
He needs to go to his doctor appointments.

Technology:
Brent does not understand a lot about technology. He has difficulties to type because his hand is paralyzed. He is able to use his joystick on the wheelchair and the remote control at home for TV.

MOBILITY HABITS

- He used to have a car before his disability but now he depends on paratransit service or on his son.
- He uses paratransit service as a possibility to socialize.

- To modify a car is complicated. He needs to look for a bigger car, special modification parts and take an expensive driver's training.

- Brent is afraid of future autonomous cars. He thinks that the technology can fail and cause his death.

PAIN POINTS

- If he wants to go to Rehab or to his doctor, he calls paratransit service two days ahead. He can't be spontaneous. He always needs to plan ahead of the time.
- He is annoyed of being dependent on paratransit service and wait for it for hours after his appointments. He doesn't like wasting time.
- He is very impatient and that's why he often gets angry at the whole world.
- Brent does not like the driver helping him getting inside of paratransit but he couldn't manage it to get inside and lock down the wheels on his own.
- Brent doesn't feel comfortable in paratransit. It feels like being cargo.
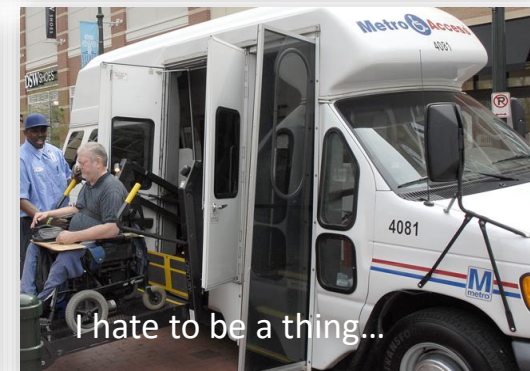
I hate to be a thing…

meet Brigit

VITALS

Mobility challenge

Age:
71
Occupation:
Make-up distribution
Income:
$18,000 - $21,000
Marital status:
Widow
Children:
Monica, 45 & Ann, 56
Vehicle:
None
City & population:
Detroit, 700,000

PROFILE

Personality:
Monica is 71 but she is very fit. She knows that in order to survive she needs to have a job and earn money. She has her clients she takes care of. She distributes Mary Kay make-up. She manages a lot of orders, calls and paperwork.

Hobbies:
She tries to find some time to knit. It calms her down. She also likes drinking coffee.

Social:
She has her best friend taking care of her. She doesn't like wasting much time talking to people. Time is money.

Responsibilities:
She needs to get around the city to visit clients.

Technology:
Brigit is elderly but she knows how to send emails and make phone calls from her smartphone. She had to learn it.

MOBILITY HABITS

• Brigit tries to get around with her electric wheelchair in order to avoid troubles with public transportation and save money.

• She would like to have the ability to drive on her own and be more independent.

• If someone gives her a ride, she likes to stay in her wheelchair. She hates it to switch to a seat. Her wheelchair is comfortable enough and it takes too much time for her to switch the position.

PAIN POINTS

• She wishes nothing but the ability to walk again, in order to be able to get a car, move **faster** and be on time for her appointments with clients.
• Brigit never takes busses because it means too much trouble. The driver doesn't like to get out to get her ready for the ride. It means putting down the rail, waiting until she gets in and locking her wheelchair down.
• Busses are overcrowded and would have to wait for too long in the cold.
• She needs a bigger basket for the items she cares with her.
• She needs an integrated umbrella and cup holder.

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

meet
Victor

VITALS

Mobility challenge

Age:
48
Occupation:
Commissioner for people with
disabilities
Income:
$70,000 – $80,000
Marital status:
Married
Children:
Sophia, 13 & Lola, 10
Vehicle:
None
City & population:
New York, 8.5 Mio

PROFILE

Personality:
- Victor is a busy person. He received his Bachelor's degree in sports administration and studied urban studies for his Master's later on.
- After his spinal cord injury 23 years ago he developed himself and achieved a great career in his life.
- Victor's motto is: get out of your comfort zone, challenge yourself.

Hobbies:
Victor likes to play sled hockey. He works out every morning in Central Park or in the gym. He likes playing golf with his friends. He is a big fan of musicals on Broadway. He coaches his daughter's soccer team. He goes to the farmer's market with his wife every Sunday to get ingredients for his traditional Italian sauce.

Social:
Victor has his great apartment in Brooklyn. But Victor worked hard on his dream. He likes to invite friends to his place and have some drinks with a wonderful view of the mega city.

Responsibilities:
As a commissioner he has a lot of responsibilities and needs to move around a lot for meetings. Every Sunday on his way to the soccer field, he is making sure that the curb cuts are in good order, the gates are open, the bathrooms are accessible and that there's the right signage.

Technology:
He uses technology he needs for work every day.

MOBILITY HABITS

- He personally as a Commissioner for people with disabilities tries to make the public transportation in New York more accessible.

- He doesn't have a car. It is not the smartest option in a big city like New York. It would mean permanently looking for accessible parking spots. He tries to get around with public transportation.

- He thinks autonomous cars – "personal taxis" will solve a lot of mobility challenges but they need to be designed accessible from the beginning.

PAIN POINTS

- He was afraid starting to work as a disabled person, because in the USA you lose your disability benefits and Medicare once you start working. He is still afraid.

- A lot of subways in New York don't work well because some stations don't have elevators. He always has to figure out which station to take. If the subway station he needs is not accessible, he would get off at the one before and take a bus to the place he needs to go.

- Victor would like to spend time working rather than look for opportunities how to get home.
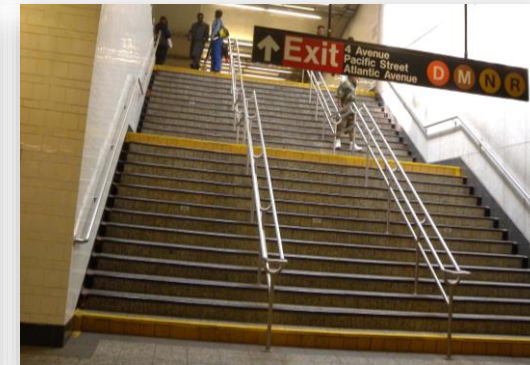
meet
Robin

VITALS

Partially paralyzed
Uses wheelchair when driving

Age:
57
Occupation:
Business administration. 1 day a week in the office, 4 days from home
Income:
$36,000 – $40,000
Marital status:
Married
Children:
Luke, 23 b& Katy, 16 & Lola, 5
Vehicle:
Modified Van
City & population:
Baltimore, Marry land, 620.000

PROFILE

Personality:
Robin's disability made him a quiet and not very active person.

Hobbies:
His main hobby is reading.
He wants to travel to Rome one day.

Social:
He does not go out a lot. He has his home office and family. It is not easy for him to move around or drive especially if it's snowy or rainy. His disability increases with age. It is difficult for him to walk.

Responsibilities:
On Sundays, he has to bring his daughter to the basketball practice. He has to drive.

Technology:
He is an old fashioned guy. For navigation he looks up directions at home or uses the navigation that is built into his instrument panel. He uses his smartphone only for phone calls.
He has Alexa at home. It is easier to communicate with technologies via voice.

MOBILITY HABITS

- He drives a specially modified car, because he has no other choice. He would never take public transportation: long walking distance, not accessible, long waiting times, crowds.
- He would appreciate Mobility as a Service in the future. It would be great to rent out different cars depending on the occasion.
- He would communicate to the car via voice. In this way, he could be anywhere in the car. It would give him a flexibility to move in there.

- He listens to music while driving.

- He uses navigation in the car.

PAIN POINTS

He doesn't travel so much anymore. It is always a problem for him to lift his foot using stairs or to get around in a wheelchair.

Since his right side of the body is not functional, it is difficult for him to operate the windshield wiper. **He can't reach all controls on the right side.** His car needs further modification.

It is actually pretty dangerous for him to drive with only one functional part of his body. He knows it.

meet
Raul

VITALS

Little person

Age:
26
Occupation:
Student
Income:
$0
Marital status:
Single
Children:
None
Vehicle:
2016 Scion Sedan
City & population:
Pforzheim, Germany, 500,000

124

PROFILE

Personality:
- Raul is a person who likes developing himself. He gives talks about self development and self confidence. He has learned how to deal with discrimination by facing many troubles and exclusion.
- He has troubles walking long distances. His wheelchair is an "extension" of his body. It makes him taller and mobile.

Hobbies:
He likes listening to music, drawing and talking to his sister. He would like to go to Ireland one day.

Social:
He likes visiting his grandparents and talking to his sister and parents.

Responsibilities:
He need to go grocery shopping for himself.

Technology:
He is average in using different technologies.

MOBILITY HABITS

- He has a modified vehicle with expanders on pedals and pillows to be higher and see better.
- But he prefers to use his wheelchair mostly to get around the campus.

- It is hard to drive any kind of car for him. It's hard to reach buttons. But it makes him flexible. He doesn't have to wait and walk to reach bus or train stations.
- Autonomous cars would be great to move him around. He wouldn't have to drive, which is so difficult for him. But he has a trust issue. If it would become a big trend and everyone would be doing it, then he would like to try it out.
- In an autonomous car he would sleep, play cards and draw. A table would be good for eating.

PAIN POINTS

- He can't reach buttons. The controls on the steering wheel would be helpful.

- He wishes he could take his wheelchair with him. There should be more place in cars for people in wheelchairs.

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

meet Mandy

VITALS

Blind person

Age:
29
Occupation:
Singer
Income:
$200,000 – $300,000
Marital status:
Single
Children:
None
Vehicle:
Sedan
City & population:
Denver, 680,000

PROFILE

Personality:
- After losing her hearing to a connective tissue disorder, Harvey had to re-learn how to sing and soon learned to sense the vibrations of the music through her bare feet on a stage floor while watching for visual cues from her live accompaniment.
- She is passionate about what she is doing and inspires other people.

Hobbies:
Her hobbies are playing the ukulele, biking and fishing.

Social:
She loves her family and friends. Her best friend always supports her and travel with her as much as he can.

Responsibilities:
She has to travel around for concerts and communicate with people. Communication to people who don't know her is the biggest challenge.

Technology:
She says that technology definitely supports her disability. She has a vibrating alarm clock that she feels in the morning.

Since she can not hear, visual and haptic cues help her to understands the world that does not speak the sign language. She reacts to curtain lights that give her cues.

MOBILITY HABITS

- She does not like driving cars and being in traffic jams.
- But she likes to be a passenger and look around.
- She also likes spending time alone in the car while traveling to the airport and practicing singing. But at least a driver is in the same car with her.

PAIN POINTS

- Her challenges are the communication with people in general. She can speak but can not hear and understand them.
- She also can not react to a car hopping behind her. That's why her reaction time is much slower than of a non-disabled person.
- As a deaf person she needs cues and feedback – the vibration of the floor or some visual cues like lights.

meet
Amanda

VITALS

Cognitive, Vision

Age:
75
Occupation:
Retired
Income:
$12,000 – $15,000
Marital status:
Divorced
Children:
Ann, 58 & Leo, 55 & Kim, 45
Vehicle:
None
City & population:
Stuttgart, 700,000

PROFILE

Personality:
- Amanda's personality changed with her age. She always used to be hard working and very independent person. She moved out from Slovenia to Austria with her children. Now she lives in Austria for 20 years but still didn't adapt to the new culture. She totally depends on her children who do for her paperwork, bring her to doctor appointments and buy groceries. She got comfortable. But feels quite lonely.

Hobbies:
She likes doing some favors to her children to attract their attentions. She makes dumplings and tells them to come over and pick them up or to have dinner with her. She reads books, but not very often.

Social:
She is pretty isolated from the society and only wants to spend time with her children and grandchildren, but they have their own lives and are very busy. She calls them and her cousins every day. Her daughter lives 2 minutes away from her place. Her son lives 50 minutes away from her. Sometimes he picks her up for a few weeks to visit. She loves visiting her children. In this way she does not feel lonely.

Responsibilities:
To go for grocery shopping

Technology:
Amanda doesn't know at all how to deal with technology. She only can pick up her phone if her daughter calls her.

MOBILITY HABITS

- As she was young she used to ride motorcycle. She never had a driving license. She was dependent on her husband. After they got divorced she took a bus to get to places.

- Since she moved to Austria she used to live with her daughter's family. They brought her everywhere. Her daughter's new husband didn't want to live together his wife's mother. She moved out. She aged, has cognitive issues and does not really speak the language. She never goes somewhere on her own. She is afraid that she might get lost.

PAIN POINTS

- Amanda is dependent on other people's help. She does not want and probably can't change anymore. She would live the house if someone would pick her up.

- Her children wouldn't let her go somewhere on her own. They know that she might get lost . They would be happy if they wouldn't have to always spend time driving and someone else could bring her safely to them.

Amanda

VITALS

Mother with child

Age:
29
Occupation:
None
Income:
$30,000 – $35,000
Marital status:
Married
Children:
Brian, 2 & Bea, 4
Vehicle:
Semi autonomous SUV
City & population:
Stuttgart, 700,000

PROFILE

Personality:
Liliane is a happy person. She is comfortable and doesn't look for challenges but if she faces some she manages them very well.

Hobbies:
She likes cooking, watching TV, reading, playing piano, playing with her kids.

Social:
Liliane is always very busy with her children and family duties, but she tries to join her colleagues occasionally for some events. She also loves to have some family celebrations at her place. She invites her parents, siblings and close friends.
She likes to go to restaurants on her birthday. In this way she doesn't have to cook and have lots of stress. She can relax and enjoy.

Responsibilities:
He needs to go to work every day. Her husband brings children to the kinder garden in the morning. She picks them up in the evening.

Technology:
Liliane loves voice control function. It this way she doesn't have to press any buttons while she is busy with her child

MOBILITY HABITS

- Liliane has a big SUV so that the baby stroller can fit into the trunk.
- She loves semi autonomous cars where she can turn around to her child to take care of it for a moment.
- She uses cameras in the back to see how her baby is doing.
- Without having her car Liliane couldn't imagine her busy life. She goes to work, picks up her children, go for grocery shopping and visits her parents weekly.
- If the car could take over the control, she would be very happy about that.

PAIN POINTS

- Liliane and her husband both have to have children's seats in their cars. She can't ask spontaneously her sister to pick up her kids, because her sister's car has no special equipment.
- It is annoying to fold the stroller every time and put it in the trunk.
- She is afraid that the autonomous mobility would steal her only time where she is alone and doesn't have any responsibilities. Driving makes her busy with driving and disconnected.
- She thinks that the "office on wheels" idea with wifi and wheel free hands would raise employer's expectation of getting work done while traveling to the office.
- On the other hand in a non autonomous car she can't take care of her child if starts to cry.

meet
Tim

VITALS

School student

Age:
13
Occupation:
None
Income:
$0
Marital status:
Single
Children:
None
Vehicle:
None
City & population:
Chicago, 700,000

PROFILE

Personality:
- Tim prefers to meet people online rather than in person. He chats a lot with his friends. He is always online and always connected.

Hobbies:

He loves playing basketball. He also likes playing video games, watching Youtube videos, and using social media like Facebook, Instagram and Snapchat.

Social:
He likes spending time at home in front of his MacBook or playing games with his friends. He meets his friends in real if he goes to school or to basketball practice.

Responsibilities:
Tim needs to go to school every day. After school he would like to go to a basketball practice.

If his mum has to leave for a moment he will have to look for his younger sisters.

Technology:
Even though Tim is only 13 he is a digital nomad like a lot of teenagers. He grew up with the technology: computer games, smartphones, IoTs and smart sensors.

MOBILITY HABITS

- Tim does not have a driving license yet.
- Tim does not care about the car exterior. He cares how comfortable he feels inside while playing video games. But his sister usually bothers him.
- The car is for him the room that brings him from point A to point B.
- He also does not really care about the happenings outside of the vehicle. He likes to be in his own world and sees the mobility as an opportunity to change the location.

PAIN POINTS

- After his school he would like to go for a basketball game. But his mother has no time to bring him there.
- He doesn't like the public transportation option.

- He also would like to visit his grandparents more often on his own.

- He would like to play without his younger sisters bothering him.
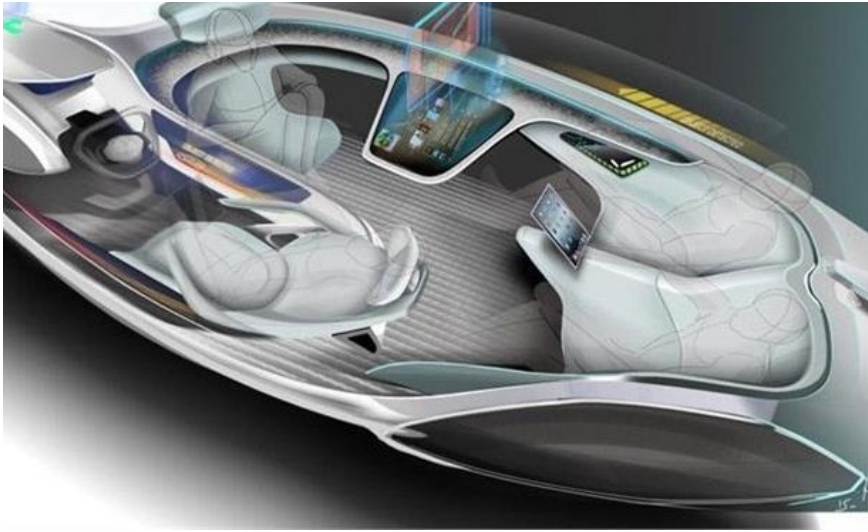
Appendix

7. Existing AV concepts

Benchmark: AV concepts
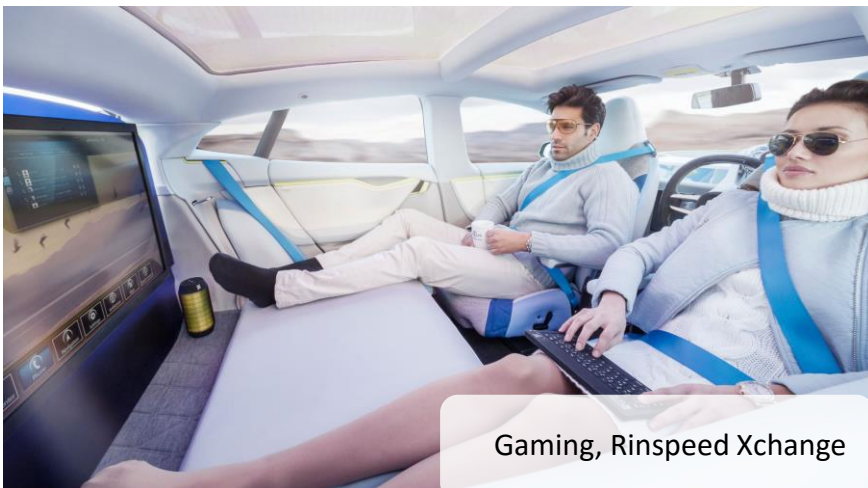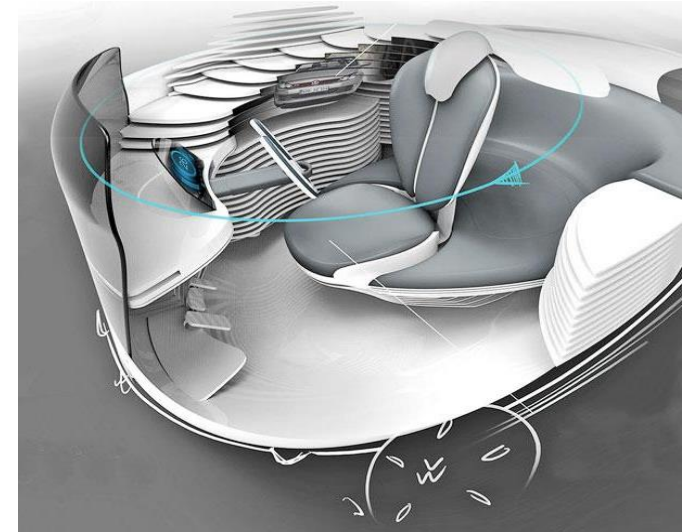
Gaming, Rinspeed Xchange

Communication, F015 MB

Office, Rinspeed Budii

Sofia Lewandowski | MFA Interaction Design | College for Creative Studies | Detroit

Benchmark: AV concepts

An hour for relaxing

Local businesses

Freedom to explore
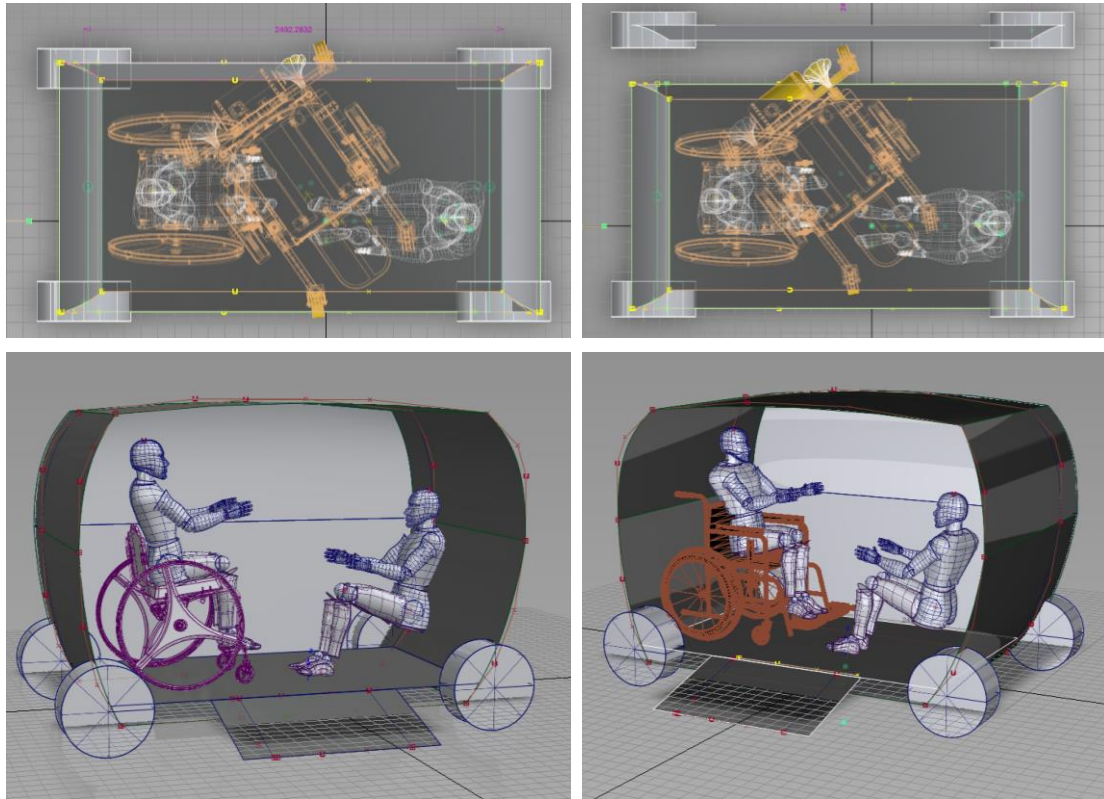
Explore and have fun

Office spaces
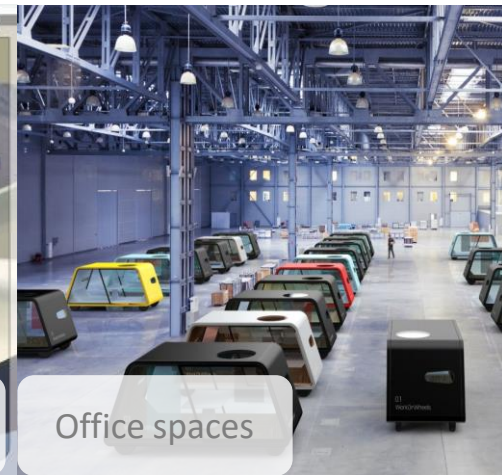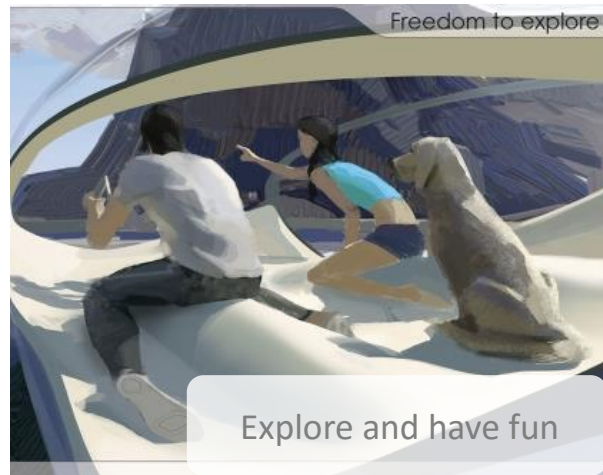
Appendix

7. Package development

Package size

The first package dimensions for the project were developed in Autodesk Alias. Different sizes of wheelchairs were positioned inside of the vehicle interior.

On the later development stage a 3D model from Volkswagen Cedric was purchased. It had the right size and interior architecture for the project. A few adjustments of the interior were made in Autodesk Maya.

The modified model was exported into Unity Engine. Other 3D objects were found on Grab CAD and Google Poly and placed inside of the vehicle.