OSLO MET

SMART CITY SIMULATOR | "PHASE TWO" – THE WHEELCHAIR CHALLENGE

European Project Semester

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ABSTRACT

Many Smart City infrastructures are physical models or Lego models that are static and difficult to scale. Other existing Smart City concepts have not taken wheelchair users and their needs into account. Oslo Metropolitan University (OsloMet), in cooperation with Oracle, assigned a project which sought to address these issues to a group from the European Project Semester. We are five international students trying to create a 3D- Simulation of a Smart City with Unity software to solve space and mobility problems. The main part of this task was to create a wheelchair accessible Smart City, which can be presented and visualized by a simulation. Right at the beginning of the project, we decided to focus not only on wheelchair users but on all kinds of physical limitations: blindness, deafness, mobility difficulties, old, young, and pregnant women.

We analyzed existing concepts, asked why it is more important than ever to develop Smart City models, and make existing cities smarter. We also looked at what needs to be improved in cities in general, especially to make life easier for people with disabilities. We exchanged ideas with organizations that helped us to learn more about the everyday life of people with disabilities, we also exchanged ideas with companies that are already actively working on making cities smarter and last but not least we looked at the innovations in Oslo that are trying to make this city smarter. Based on our results and with the help of Proxima Lego City, a Lego model built by Oracle, we made a questionnaire to ask the participants what belongs in a smart city and what challenges specifically the participants with disabilities have in their everyday life in cities.

After the research, the questionnaire, and the exchange with organizations and companies, we decided to create a Smart City in Universal Design, which is accessible for everyone and can be presented and experienced through a simulation. We implemented an electric autonomous public transport system, a smart trash system, a smart parking system and a smart lighting system.

We also developed an app, especially adapted to our simulation, that makes the simulation appear even more real. With the help of real-time data, the app shows the advantages of a Smart City, and it also shows the advantage of having an app specifically adapted for the Smart City.
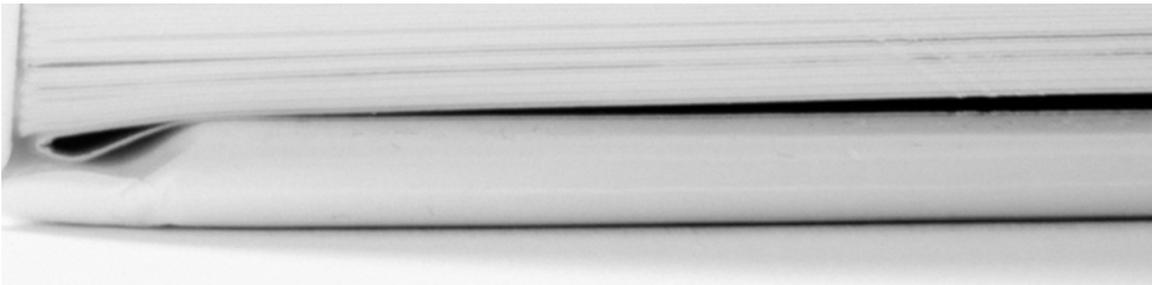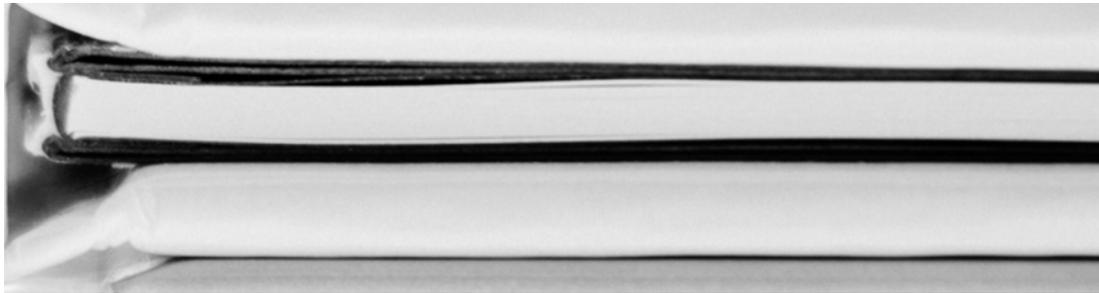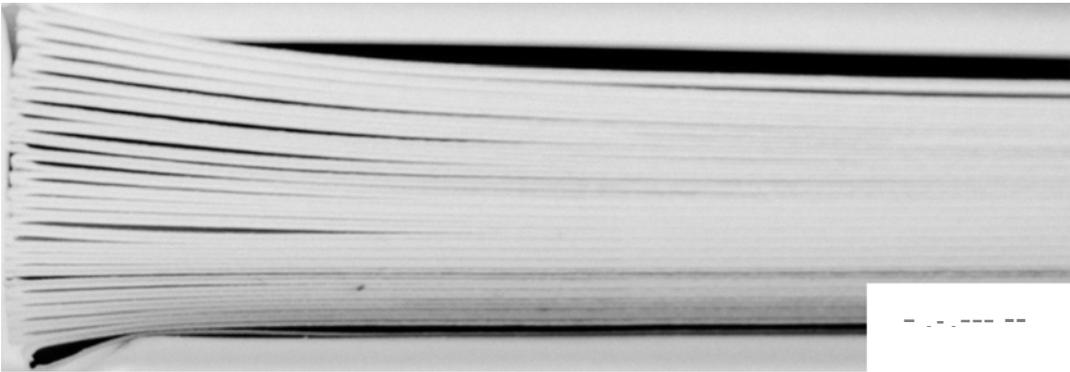
"project work is not necessarily about following a plan, but mostly about navigating the present and handling the unpredictable"

Abstract

Many Smart City infrastructures are physical models or Lego models that are static and difficult to scale. Other existing Smart City concepts have not taken wheelchair users and their needs into account. Oslo Metropolitan University (OsloMet), in cooperation with Oracle, assigned a project which sought to address these issues to a group from the European Project Semester. We are five international students trying to create a 3D- Simulation of a Smart City with Unity software to solve space and mobility problems.

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Based on our results and with the help of Proxima Lego City, a Lego model built by Oracle, we made a questionnaire to ask the participants what belongs in a Smart City and what challenges specifically the participants with disabilities have in their everyday life in cities.

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THANKS

Thanks

First of all, we would like to thank our supervisors, Berthe and Petter, for their support, expertise, feedback and the enthusiasm they have put into this project and also into our group in each step we took.

We would like to thank our teachers, Kristin from the English and Academic Writing course and Sinan from Working in Projects.

We also want to thank Oracle and In-Virtualis and especially Naci for his expertise, honest feedback, professional help, and great cooperation.

Also, thanks to the Disabled Community Organization (FFO) who helped us a lot with their advice and knowledge about Universal Design, as well as with the distribution of our questionnaire to people with disabilities. We are very grateful to the Oslo Kommune for their expertise and provision of various materials on Smart City.

Moreover, we would like to thank OsloMet, who made it possible for us to continue our studies despite the crisis situation we had this semester.

And finally, we want to thank the participants in our questionnaire.

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Team

Our team consists of five members from five different nationalities. This diversity made working in a team much more interesting because different backgrounds and attitudes also lead to different approaches.

Through the diversity we had in our group, we quickly understood how important it is to agree on a cooperative working relationship to achieve good results. We are a group that complements each other not only in terms of cultural background, but also in our professional fields. We are all engineers with different specializations. In order to unite these different specialist skills and to be able to achieve the best possible result, it was important to us from the very beginning that everyone should bring in an idea or problem-solving concepts. Because it is only possible to achieve an optimal result if everyone passes on their specialist knowledge.

For example, we were able to develop 3D models that not only satisfied Maxime as a mechanical engineer, but with the help of our programmers John and Karol we were able to optimize these models so that they now work perfectly in our city.

Andrea

Andrea studies Industrial Electronic Engineering and Automatic Control Systems at the University of Cantabria - Spain. She is doing the EPS program at OsloMet as her bachelor's thesis, in order to improve her English and working together with international people. The knowledge she has because of her Electronic Engineering study was not that much needed for our project, but Andrea learned fast and was very hardworking. She is giving her best everywhere regardless of the subject. Through her drawing skills, she created all our sketches and put everyone's ideas on paper, which was a massive advantage for the imagination of each scenario. Andrea also devoted a lot of time to her work as a Universal Design expert. She is the sunshine in the group. She is always optimistic, positive and energetic and brought the group back on track during discussions.

John

John studies Computer Science Engineer at OsloMet – Norway. He is doing the EPS at OsloMet as his bachelor's thesis in order to challenge himself to work in an international environment. As a Computer Science Engineer with professional experience, his computer skills were a huge advantage for our project. His programming skills and the fact that John was able to quickly familiarize himself with new material for example the Oracle database enabled us to achieve so much more in our simulation than we initially thought. John is a good team worker, a great problem-solver and a hardworking person. He also was opened to remarks and accepted to change his initial ideas if needed.

Karol

Karol studies Telecommunication & Computer Science at Lodz University of Technology – Poland. He is doing the EPS, because he prefers to work in groups rather than attend normal courses. He likes to learn from others and share his own knowledge. With his knowledge as a Computer Science Engineer, it was easier for him to get familiar with Unity and to design scenarios and the whole city. Karol know how to work in a group and this knowledge has been useful in each step of the project. He was our problem solver in the group and always tried to mediate between the team members when misunderstandings arose. He always finding the best compromise possible for the project.
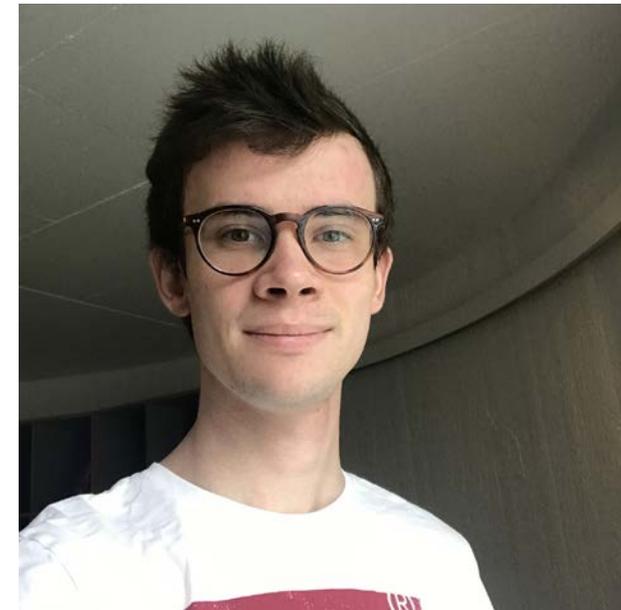
Maxime

Maxime studies Mechanical Engineering at Ecole Nationale d'Ingénieurs de Tarbes (ENIT) - France. After his internship last Spring, he wanted to do another project based and not a classic exchange semester, this is why he takes part of the EPS. As the only mechanical engineer he was able to contribute his knowledge in mechanical matters and in 3D Design. Because of his very good competences in 3D Design we were able to create several models which where necessary for the project. Maxime is hard-working, engaged, imaginative person, who always get his job done. He is an excellent worker and have an eye for the details.

Verena

Verena studies International Sales and Purchasing in Engineering at Kiel University of Applied Sciences - Germany. She takes part of the EPS at OsloMet for finishing her bachelor's degree and improving her skills to working in an international team. As the only industrial engineer she was able to contribute her knowledge in project management as well as in technical areas. Her overview and organizational skills were advantageous for the project. Verena pushes the team and makes the decisions that need to be made, in time and with consideration. She is leading the team and bringing up timelines and deadlines to be sure that everyone was doing the best job possible. During the time of Corona Crises, she was able to keep the group as a team.

Personality test

Whilst getting to know each other, we decided to do several personality tests to get to know our similarities and differences and where our strengths and weaknesses are. We also wanted to find out how and whether we could use a personality test to better distribute the tasks in the team and which personalities would work best together.

Belbin test

One of the tests was the Belbin test, which we did in class. Our results were completely different, and we determined the strengths of each of us in different areas. These strengths came to the fore again and again during the whole process. Karol, for example, always acted as a good team worker, mediating between two parties that did not agree. Maxime tried to finish everything perfectly and unconsciously acted according to his test result. Also, Andrea constantly provided the whole group with good articles, information, and resources.

We can explain that the results were not complete but still largely in line with our personalities. Nevertheless, these results were not decisive in how we divided the tasks in our group. We found out right after the test that although the different personality types could work well together, they were so different in their field of work that sooner or later there would have been considerable misunderstandings. That is why we divided our expert groups not according to their personality, but according to their expertise. With this division, we were able to work together as a group in the best possible way.
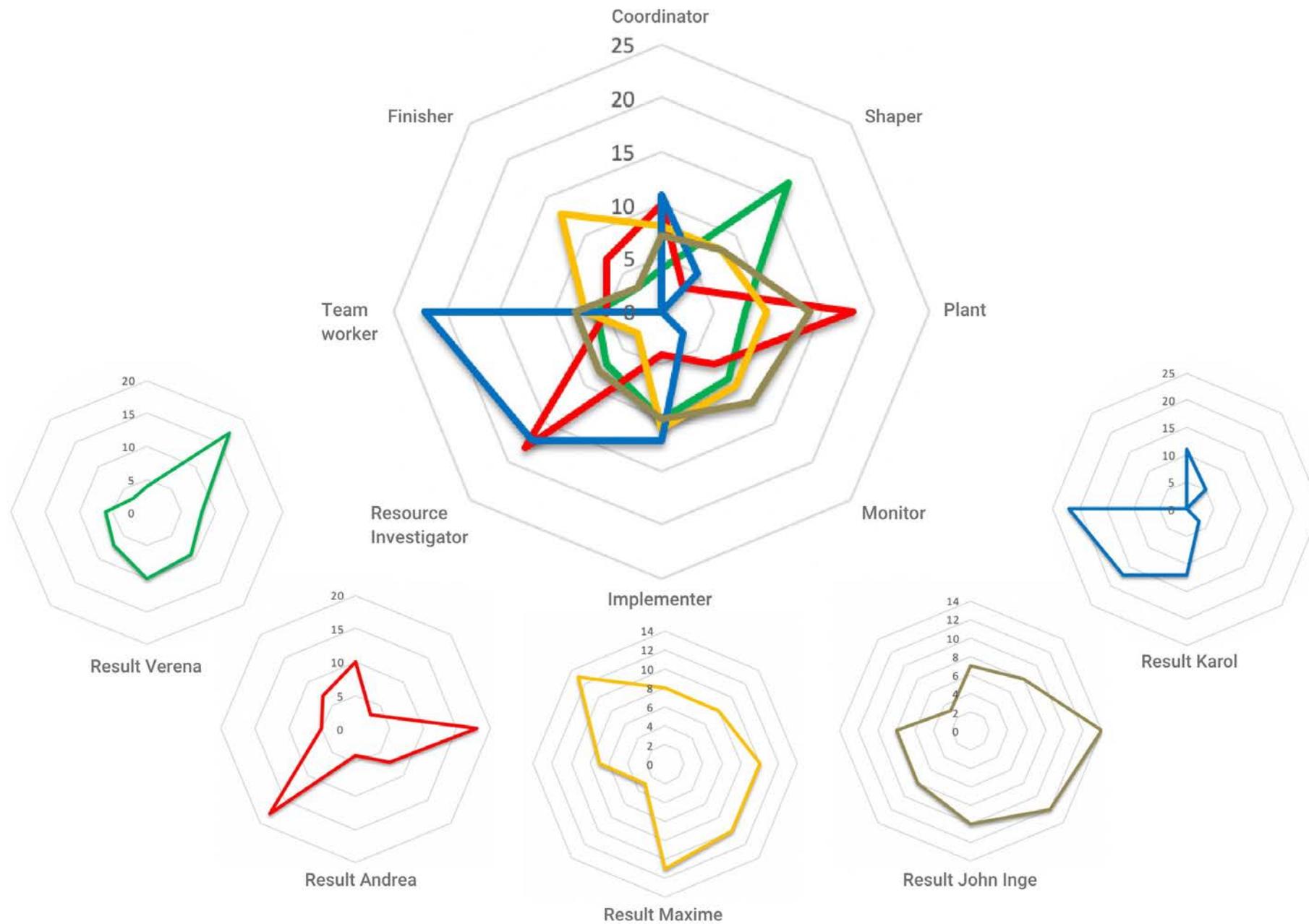
Figure 1. Belbin test results

The Smart City Challenge

Today, 55% of the world population live in urban areas a proportion that is expected to reach 68% by 2050 (United Nations, 2018). In Europe, for example, 78% of the population already live in cities, which is why 85% of the EU's gross domestic product is generated there (SINTEF Smart cities, n.d.). Jobs and improved living standards are one of the reasons why more and more people are moving to cities. If we compare urban growth with the overall growth of the world's population, it can be assumed that by 2050 the relocation of residence could bring another 2.5 billion people into urban areas.

This increasing urbanization brings with its great risks and threats. Poor air and water quality, waste disposal problems and high energy consumption are just a few of the problems exacerbated by increasing population density and the urban environment. Other challenges that need to be addressed are the solution of inefficient mobility, environmental problems, for example high levels of pollution in cities due to exhaust fume and large amounts of non-collected trash pose a variety of health risks. Also, the increasing number of older people living in cities is a challenge we have to face in the future. Smart urban planning will be crucial to address these, and other difficulties associated with the growth of urban areas. Planning intelligent cities is therefore essential and indispensable. A Smart City is based on the needs of all citizens and at the same time on the environment. New technologies are used to make the city a better place to live and work

(National Geographic, n.d.).

While existing Smart City concepts have taken us far in many aspects, most of them have failed to take into account people with disabilities and their needs. Nevertheless, accessibility is widely recognized as a feature of physical urban infrastructure that needs to be taken into account. In conjunction with Universal Design, Smart Cities can fundamentally change the experience that people with disabilities have in urban spaces and provide tools that enable people to reach independence and autonomy. If a Smart City project is designed and implemented with the needs of people with disabilities in mind, it will most likely also meet the expectations of ordinary people. Consequently, people with disabilities can take advantage of the combination of mainstream technologies to reach greater autonomy and independence in the city.

For this reason, our project focuses on the creation of a Smart City in Universal Design. This aims to ensure that cities can be a good place to live and work for everyone (Stavanger Kommune, 2016).

Introduction

When building Smart Cities or Smart City models, the focus is not only on new future technologies and the well-being of people but also on making cities more sustainable.

In September 2015, 193 countries agreed on the sustainable development goals (SDG) at the United Nations. Due to rapid urbanization, environmental, social, and economic sustainability is a must in order to keep pace with this rapid increase, which is straining the resources of our cities.

Cities and metropolitan areas are the powerhouses of economic growth. But they also contribute to around 70% of global carbon emissions and over 60% of global resource consumption. Furthermore, pollution and energy consumption in cities is very high, even though cities cover only 3% of the earth's surface. Due to the high concentration of people, which will continue to increase in the coming years, cities are more vulnerable to climate change and natural disasters. Building urban resilience is, therefore, crucial to avoid human, social and economic losses (United Nations, n.d).

Furthermore, many cities are unsuitable for people with disabilities. Therefore, a single day in the city can be a great challenge. No possibility to use public transport without the help of others, parking lots that are usually built too narrow, far away bus stations and the lack of contrast on pavements are just a few examples. 15% of the world's population has a disability, so it is all the more important to integrate these people into everyday urban life and make life easier for them (Handicap International, 2015).

For these reasons, the development of Smart Cities is indispensable, and the creation of new Smart City models and concepts is essential. Few of the existing Smart City models have been built virtually, the majority are physical models that are difficult to scale and modify.

How can we design a 3D simulation that represents a sustainable Smart City accessible to all people, using smart technologies to make life in cities easier? This question became the main topic of our project. By analyzing existing concepts, talking to people with disabilities, and exchanging ideas with companies specializing in smart urban design, we were able to get a better picture of the technologies and concepts currently being worked on and the obstacles that need to be overcome.

Our project goal was to create a 3D simulation of a Smart City that shows a sustainable city with smart technologies and their functions, which is accessible for everyone and can be used by Oracle for presentation at conferences.

Measures taken to achieve the SDG

UN goals problems and progress

The UN SDG call for global economic, ecological and social progress. According to the United Nations, the proportion of urban dwellers with comfortable access to public transport was 53% in 2018. Also, two billion people do not have access to trash collection services and three billion do not have access to controlled trash disposal facilities (United Nations, n.a.).

The United Nation`s goals

SDG 11 in particular calls for strengthening the resilience, security, inclusiveness and sustainability of cities, which is why this goal is most closely linked to our project. To make a city technology, especially information and communication technology (ICT) is deployed to enhance efficiencies and connectivity. However, being smart is not enough. Sustainability is necessary to enhance the longevity of economic and social progress. Today, sustainability covers a wide range of challenges, including urban growth, transport and even the reconciliation of people's professional and private lives. As population growth is expected, this issue has become a focal point for future-oriented cities.

In the context of this project, we have specifically addressed sub-goals 11.2 and 11.6. The former defines the goal of creating a city accessible to all. Therefore, our city was designed in Universal Design, which was implemented in all our transport facilities. Our city also includes universal

pavements and a universal designed underground train station.

We have also sought solutions to limit air pollution 11.6. because a significant part of the population lives in cities where the air quality index exceeds the limits for air pollutants. For this reason, we have removed all cars from cities and replaced them with electrically autonomous public transport. This will reduce air pollution and increase the number of people using public transport.

We have also introduced a smart trash system to avoid overfilled trash bins in cities. This system will reduce the use of refuse trash cars and improve route planning, thus saving fuel and time.

In addition to our main goal 11, we have also implemented aspects of goal 7, affordable and clean energy. This objective focuses on improving access to electricity, increasing energy efficiency and the use of renewable energy. The corresponding sub-goal 7.B explains that a Smart City simulation aims to maintain an infrastructure and technology that will allow energy to be saved, improve the ecology or boost the economy. To achieve part of this goal, we have implemented pavement lighting with motion sensors that are switched on during the night only when a person is nearby. Another important solution is the use of solar panels we implemented throughout the city.

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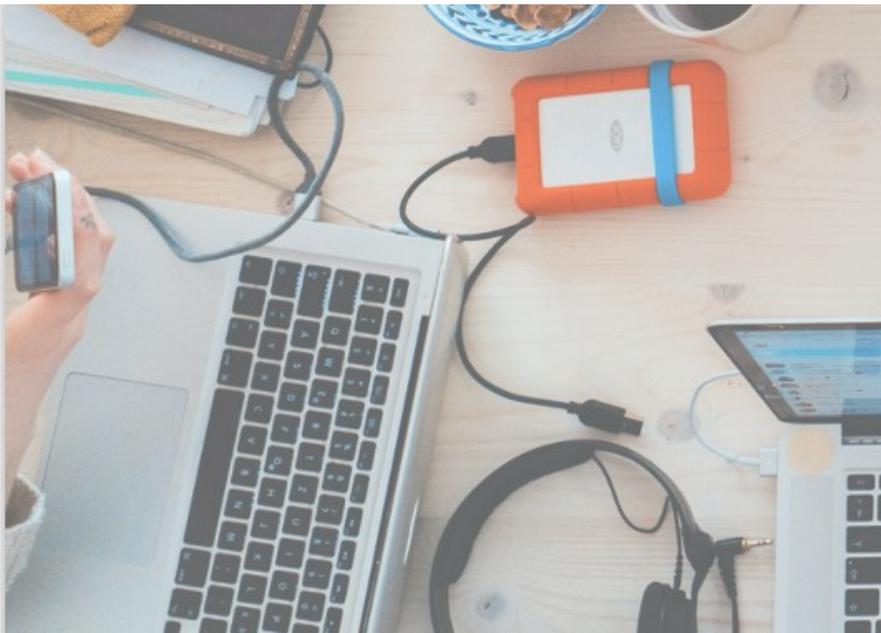
1 | PROJECT MANAGEMENT

Methods

Work organization

For the constructive operation of the group, we created a contract with rules to define the members rights and duties. These rules refer for example to language matters, deadlines, keeping in contact, agreeing on decisions and punctuality.

To ensure that we met our own, our superiors' and those of Oracle's expectations, we implemented a team organization of workflow and timelines. From the beginning we worked five times a week from Monday to Friday, knowing that our project was one of the most challenging this year. At the beginning we could not estimate the exact time required for our project. To avoid having to work under pressure towards the end of the project, we met every day Monday to Friday from 10 am to 2 pm.

We had booked a group room for each day, this allowed us to work properly in a suitable environment with most of the time the equipment we needed. Also, it was important to have a place where we as a group can work effectively.

Right before the mid-term presentation, we were so well in time that we only met four times a week, until we had to continue working through COVID-19 at home. During this time, we had team meetings once or twice a week via Zoom and once a week a meeting with our supervisors also with Zoom.

First steps

In order to gain insight into our topic from multiple perspectives, we used an eclectic range of research approaches. First, we identified and read relevant researched literature.

We visited Oracle's Norwegian headquarters, where we received an introduction to the Oracle database and discussed the ideas of Proxima Lego City and especially our tasks and Oracle's wishes.

Since we did not want to build the project exclusively on our research and the Proxima Lego City, we decided to get data from outside. For this reason, we created a questionnaire with which we interviewed people of different ages, nationalities, with and without disabilities. We wanted to know what a Smart City is for them, what they think of our ideas, what challenges they have in daily life in a city, what they would like for the future and whether they have any other ideas that we had not considered.

The final step of our research was to visit the FFO to learn more about people with disabilities. Here we were explained the difference between accessibility and Universal Design. This meeting was the foundation for why we started to focus more on Universal Design from that point on.

Furthermore, we visited the Oslo Kommune, which specializes in Smart Cities and contributes a significant part to why Oslo is one of the smartest cities in the world.

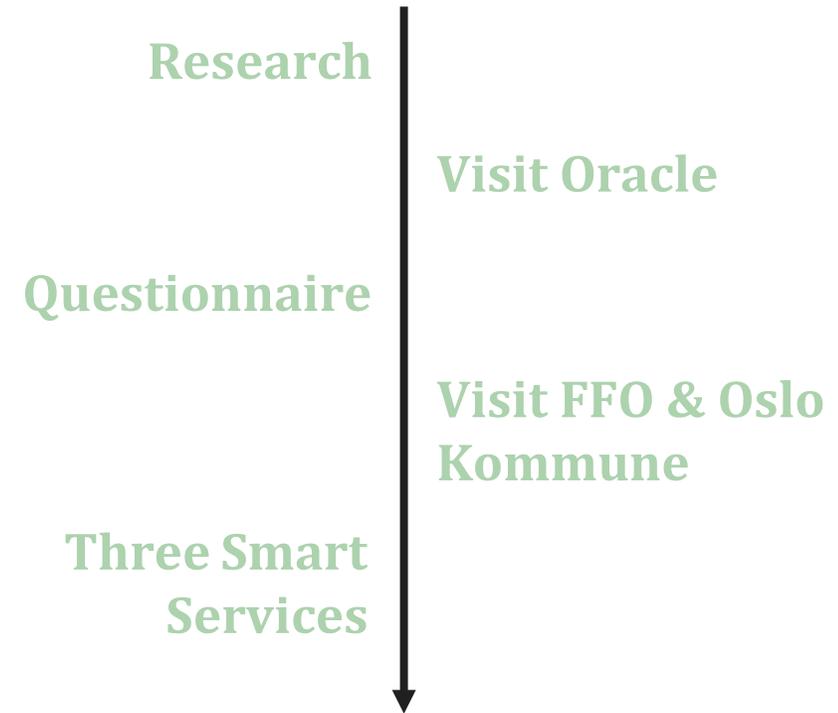Based on our findings, we decided on three smart sectors that we wanted to implement in our city.

Research

Visit Oracle

Questionnaire

Visit FFO & Oslo Kommune

Three Smart Services

Figure 2. First steps

Scope

The idea of a Smart City requires innovation and imagination. Since we were an international team, we had different ideas of what a Smart City should be. So we had to stick to the scope, work as efficiently as possible, and make the final product as synchronous as possible.

First, our City does not include a suburb. The main reason for this is that a 3D simulation is a complex process for computers, and we were faced with problems in testing the unit right from the start, such as low frame rate or overheated processors. We were also inspired by the Proxima Lego City, which also did not involve suburbs.

Furthermore, we limited ourselves to the entire city and not to individual buildings and their interiors. In our city, we also kept a simple layout, without tunnels or roundabouts. Since none of us were Unity experts and working on complex models would have been very time consuming and rather a waste of time than a relevant addition to the simulation.

Animations provide more realism and understanding in simulations. But they are also the final part of a simulation, so we decided to make this work depends on how much time we have left at the end and how the project is developing in general. Nevertheless, we managed to implement essential animations, such as taxi doors and parking barriers.

The most difficult part of our scope concerned our smart services. The important thing is that they enrich the daily life of everyone without differences. Therefore, we developed only unspecific smart services that should reach as many people as possible. This is why we have focused on the mobility, electricity and trash disposal of a city.

For our project, we developed 4 hypotheses based on research on the concept of the Smart City.

- The first hypothesis is the disappearance of every petrol car in cities.
- The second hypothesis is a completely autonomous transport policy within the city center.
- The third hypothesis is the city center, organized only around one-way streets.
- The fourth hypothesis is the lack of parking spaces in the city center.

# Stakeholders

Stakeholders are all the people with an interest and concern in our project. We categorize our stakeholders into three priorities regarding to the importance. First priority core stakeholders, the second priority primary stakeholders and the third priority secondary stakeholders.

STAKEHOLDERS

Citizens

Govern-
ments

Urban
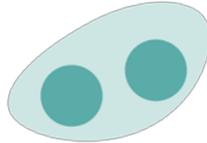planners

Admini-
strations

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Virtualis

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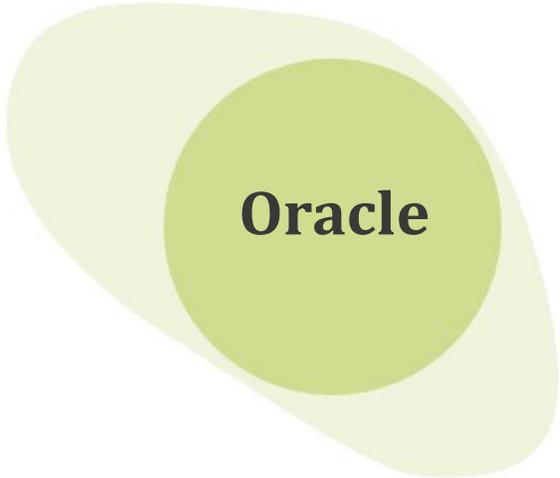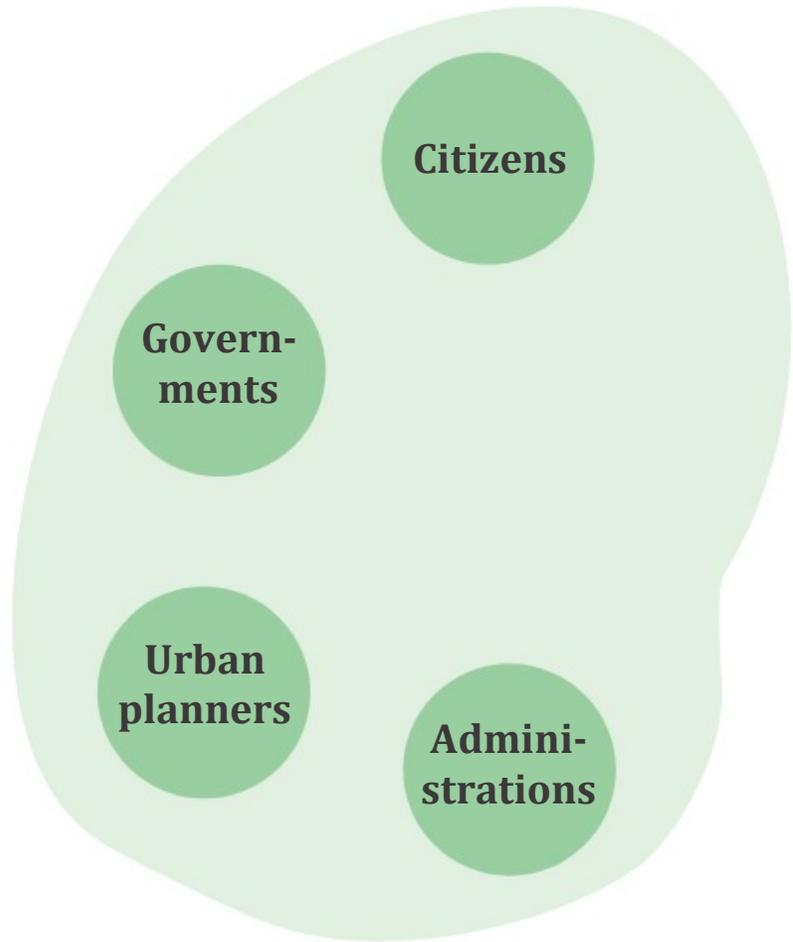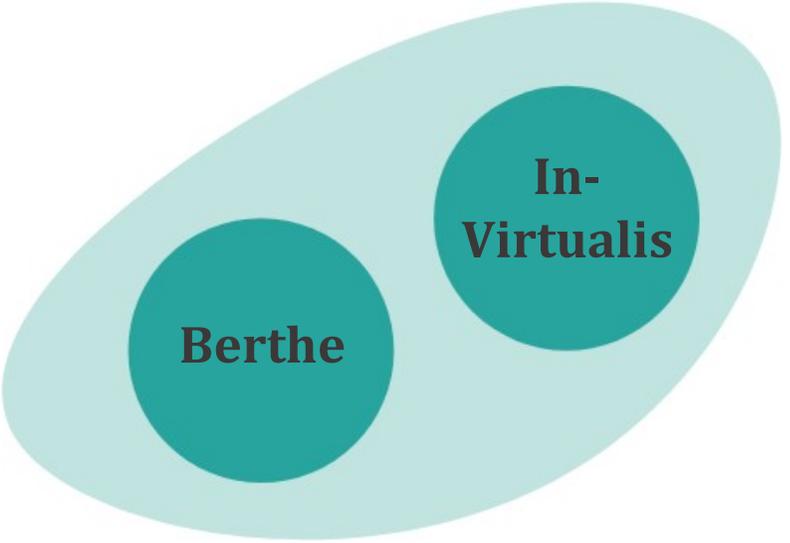
Core Stakeholder:
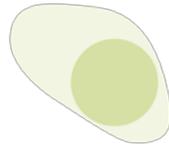
Oracle provides the technology for our project. The company would like to be able to use the simulation to attract people to the Oracle stand in the coming conferences and demonstrate Oracle's supporting technology for implementing Smart City services.

Primary stakeholders:

Berthe is our supervisor and directly involved in our project. She is a teacher at OsloMet in the field of "built environment" and is especially interested in a proof-of-concept for a digital twin as a means to achieving the goal of a more sustainable city/built environment.

In-Virtualis will use the simulation to further develop it to a 3D immersive virtual reality (VR) Smart City demonstrator.

Secondary stakeholders:
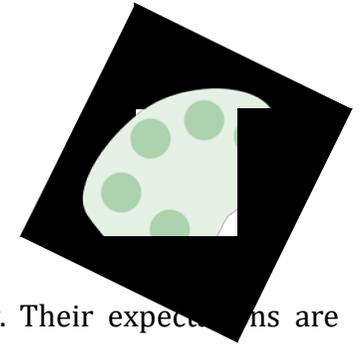
Citizens will be the future users of a Smart City. Their expectations are rising and the desire for digital innovations that offer quick help in everyday life is growing. Citizens want to feel safe and comfortable in a Smart City.

Smart Cities provide solutions for **governments** to address the challenges posed by rapid urbanization.

Virtual city models will become extremely important for future **urban planning**. With simulations and virtual 3D city models, projects can be presented in advance to all decision-makers and interest groups and can be experienced and explored together to support decision-making. In this way, it can be ensured that the projects are understood by all those involved.

Smart City projects require improved public services, e.g. public authorities offer numerous online services, therefore **local and regional administrations,** are interested in making cities smart.
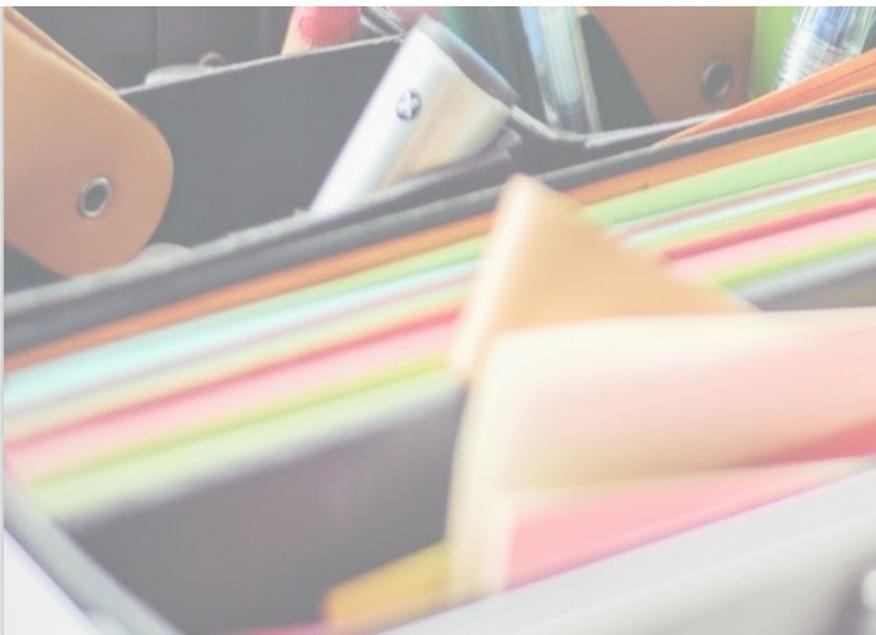
2 | PROJECT DEVELOPMENT

1. Exploration

Research

Reading

At the beginning of our research process, we needed a clear understanding about what a Smart City is, so we searched for as much information as possible to expand our knowledge about Smart City concepts and smart services.

While reading articles, get some inspiration from previous Smart City projects and also analyze the Proxima Lego City, we found some interesting ideas what a city of the future could have, but not more specific concepts or details.

With our advanced knowledge we specified our research focus. So, we clustered our ideas and all the information we got and put them in tasks which are important and also possible for us to implement and which were not. After that we established a classification of terms with which we made a mind map to summaries our information in order to provide us a clear overview. The next step was creating a timeline, because at this part we separated our group in three subgroups. So, the timeline showed us how much time we had for our tasks and which tasks are related.

Mind Map

With this mind map we got a first overview of our topic. We discussed some aspects that are of great importance for an intelligent city. In this report, all elaborated areas are presented in detail.
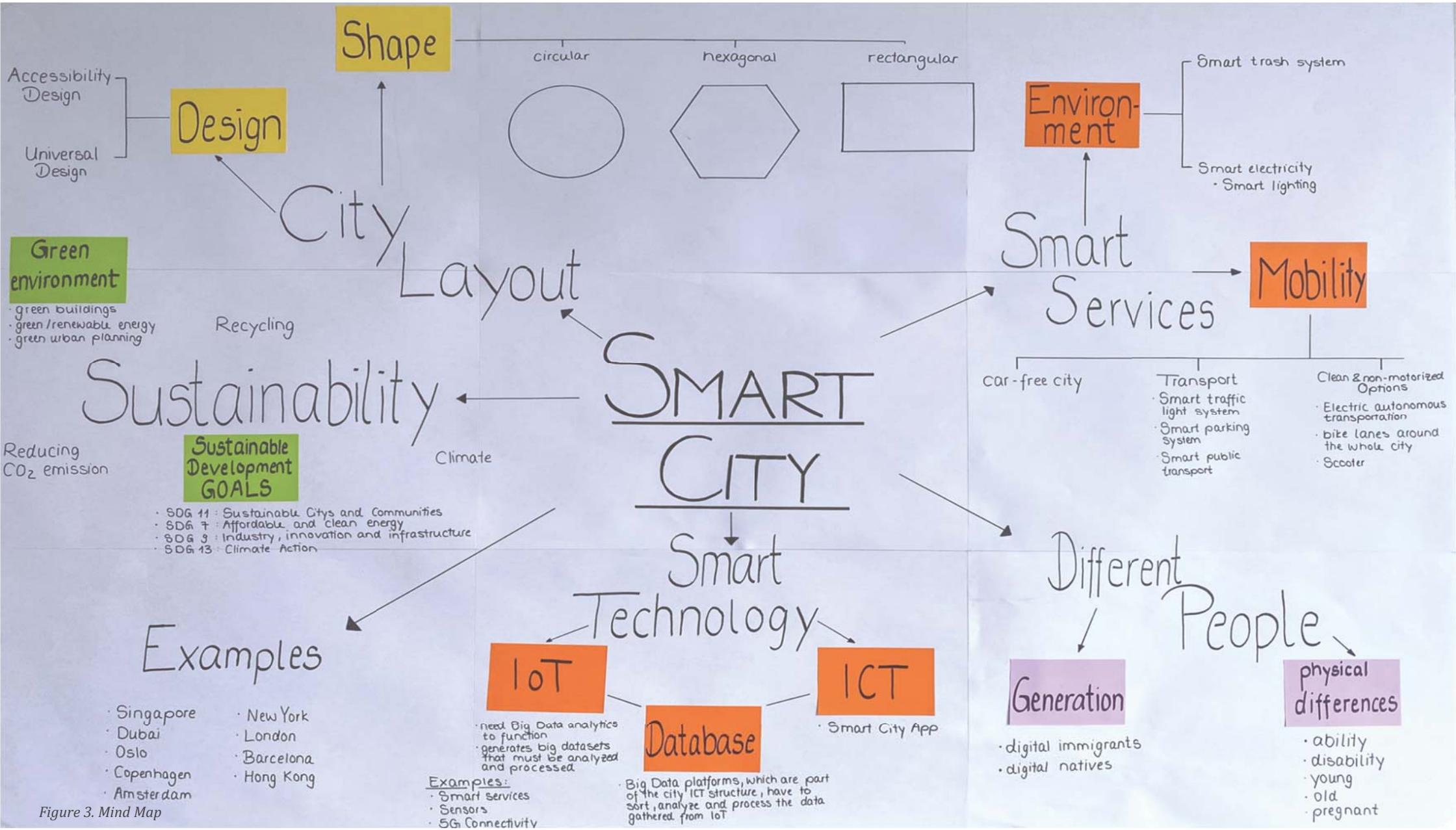
Figure 3. Mind Map

Proxima Lego City

Proxima City is a Lego model of a Smart City created by Oracle Rome and Oracle Stockholm. The goal of Proxima City is to demonstrate visually / physically, using gateway capabilities of Raspberry Pi, Arduino boards, sensors, and LEGO bricks, which services can be automated and made "smarter" using Oracle technologies. The YouTube video of Proxima City showing both the services and the underlying technology can be found here: https://www.youtube.com/watch?v=x2wMzMjsSGo

The challenge of a Lego model like the Proxima City is that it is not easily scalable and modifiable. It also turned out that such a Lego model is not easy to transport. For this reason, a project was set up to create a 3D software simulation, making the model scalable and modifiable, but above all transportable. This project was called Smart City Simulation (SMACS).

Right at the beginning of the project, we were introduced to this Proxima Lego City to give us an idea of what a city of the future could look like. We focused on three Smart Services: Smart Parking System, Smart Trash System, and Smart Lighting System. The model was a guide for us throughout the whole project, so as not to lose the thread of the goal of our project. (Oracle, n.d)
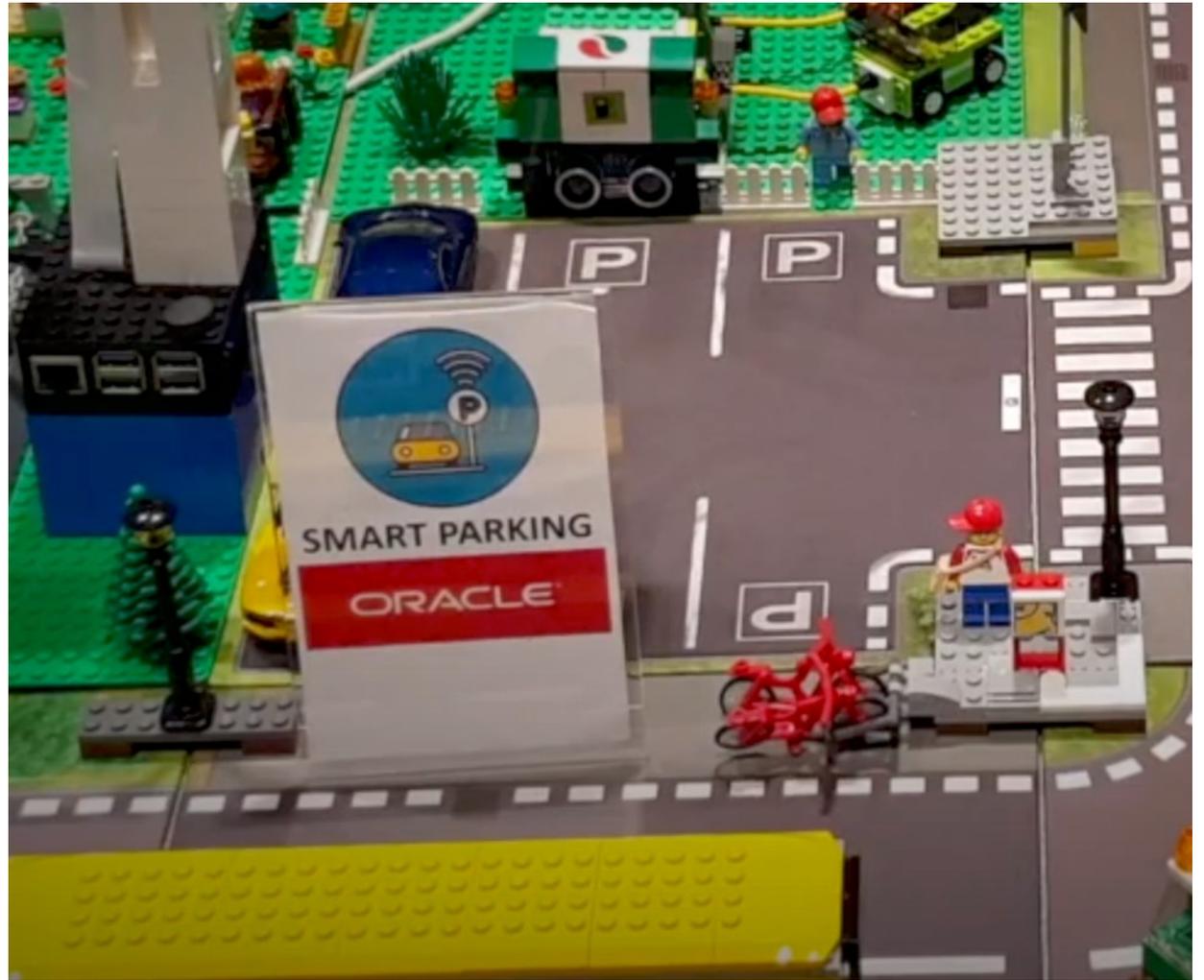

Figure 4. Proxima Lego City

Figure 5. Smart Parking - Proxima Lego City

Figure 6. Smart Trash and Lighting - Proxima Lego City

Data Compilation

Questionnaire

During the 4th and 5th week of the EPS we created a questionnaire to gather different opinions, ideas and suggestions on the concept of a Smart City. We asked people of different ages, different nationalities, with and without disabilities what they understand by a Smart City, what should not be missing in a Smart City under any circumstances, and whether they have challenges in today's cities that they wish they would not have in the future. It was also very important to us that our project was not only based on our opinions and ideas, but that we wanted to involve as many people as possible. The questionnaire consisted of 13 questions in total. For further information, please go to the appendix.

Evaluation Questionnaire

We distributed our questionnaire through social media, friends, family and through the FFO. A total of 282 people took part in our questionnaire. After analyzing the responses to the questionnaire, we found that opinions about what makes a Smart City vary according to age, personality, nationality, and whether the person was able-bodied or had a disability. With the questionnaire we wanted to find out how well our ideas were received by the people. We received positive feedback on many of them, but opinions differed widely on others.

Furthermore, the ideas of the participants were very helpful, as we did not even think about some of them, such as bike lanes throughout the city, expansion of the 5G network or car sharing possibilities.

Personality Questions

It was important to reach people of different age groups and nationalities with the questionnaire in order to achieve very meaningful results and to be able to make important decisions.

The participants are people of all ages from 22 different countries around the world. The gender ratio of 47% of women and 52% of men were quite balanced.
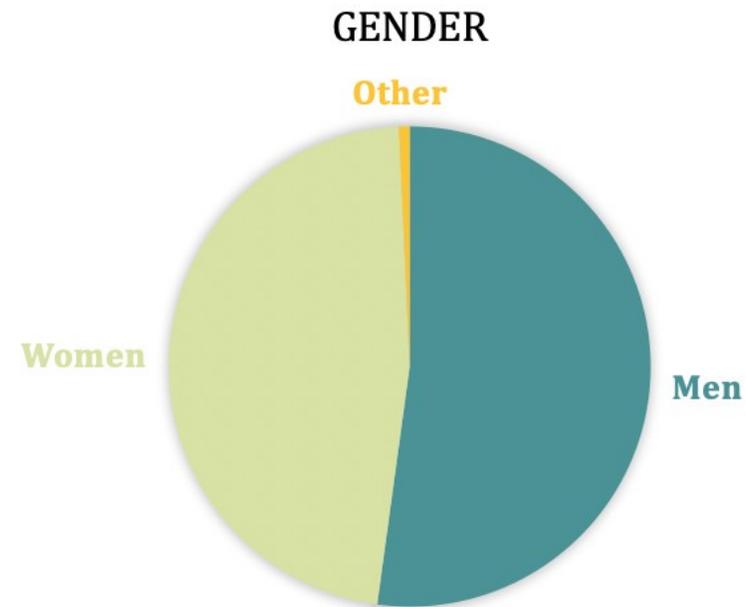
GENDER

Figure 7. Questionnaire - gender

AGE GROUPS

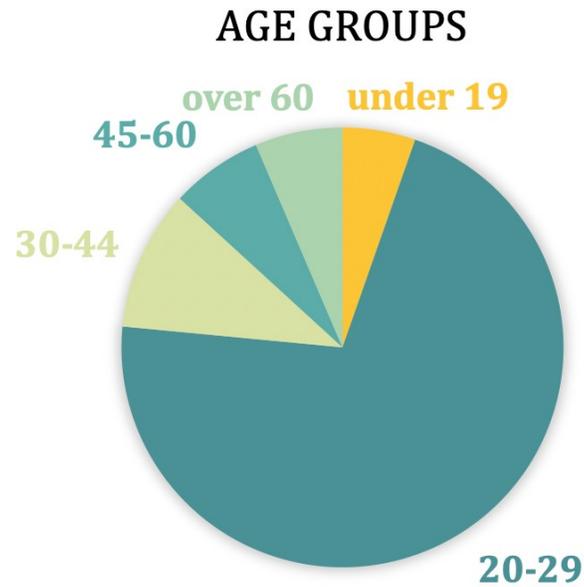*Figure 8. Questionnaire – age groups*

DISABILITY

Figure 9. Questionnaire – disability

In the age group 20-29, we were able to reach the most people with 71.92%. At first, we were unsure whether the questionnaire would be meaningful enough with such a high percentage of one age group, but then we noticed that the young people of today are the ones who will be allowed to grow old in a Smart City and will experience possible restrictions.

Since we wanted a diverse group of respondents, it was important for us to include people with disabilities and older people. Especially this target group should help us to uncover problems which seem to be self-evident to us, but which should definitely be considered in a Smart City.
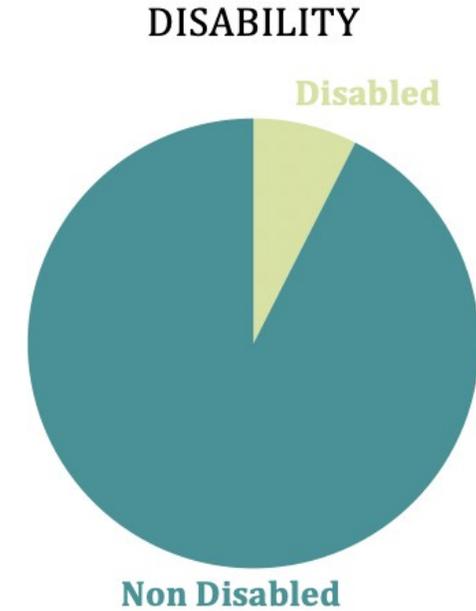
Only 6.38% of our respondents were over 60 years old, and only 7.45% of our respondents were people with disabilities. As mentioned before, we had distributed our questionnaire online, so we knew we could reach fewer older people. Therefore, we made the questionnaire by phone with some older people.

We also contacted organizations that work with people with disabilities. Unfortunately, even with the help of FFO, a Norwegian organization for people with disabilities, few people with disabilities agreed to participate.

Disabilities

As mentioned earlier, we could only reach fewer people with disabilities, but still, 21 people took the time to participate in our questionnaire. Of these 21 people, about 38% were wheelchair users.

Also, in the category "others" we wanted to know exactly what kind of disabilities they have. Six out of eight participants also stated that they had movement disabilities and were dependent on a walking aid.
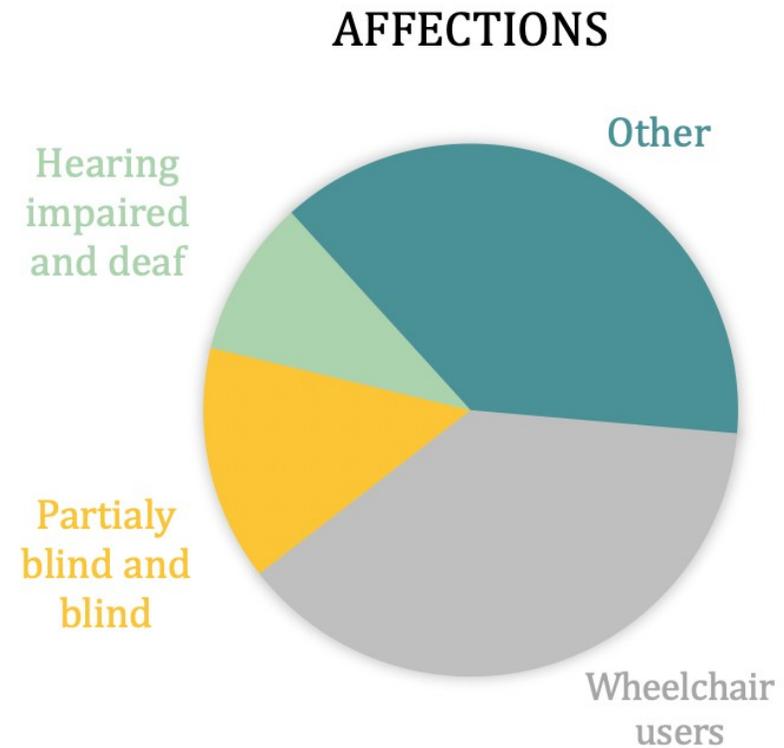
AFFECTIONS

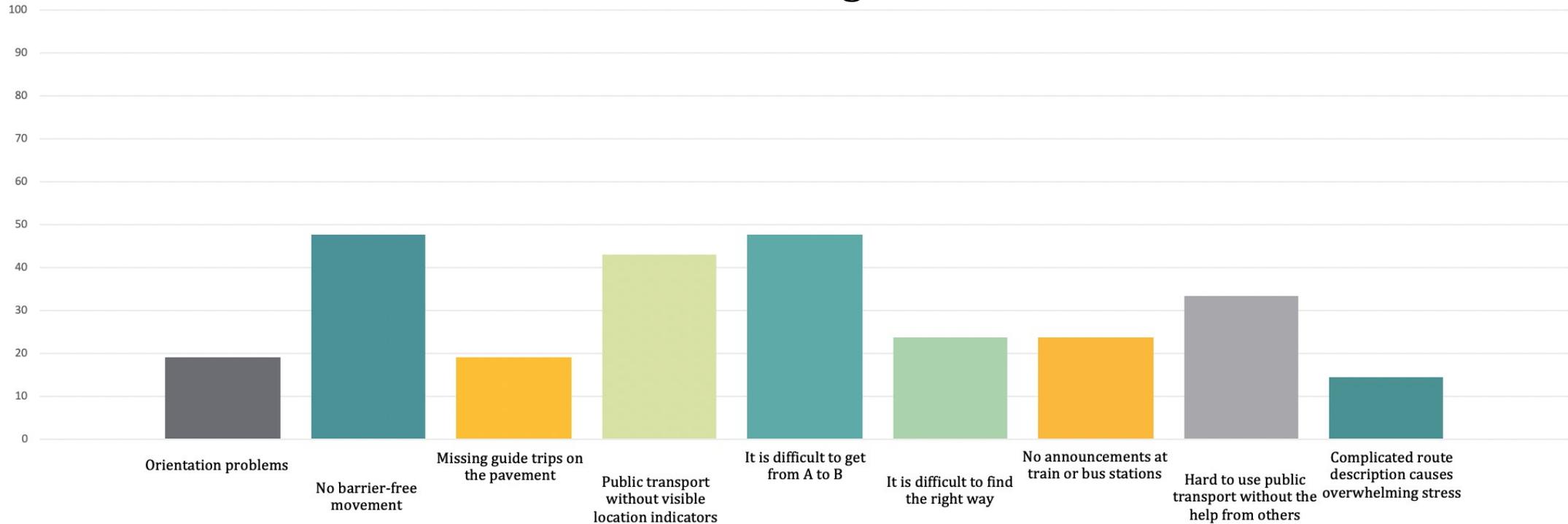*Figure 10. Questionnaire – affection*

Challenges

Figure 11. Questionnaire – challenges

It was particularly important to find out what challenges these people face in their everyday city life because it was precisely for these challenges and problems that we wanted to propose solutions with our simulation.

The challenges of the participants varied according to their disabilities, but there were four challenges that stood out clearly from the others. The most mentioned challenges were "No barrier-free movement within the city" and also that it is difficult to get from A to B. Furthermore, the use of public transport was often seen as a challenge. On the one hand, the participants stated that most public transport is equipped without visible location indicators and that it is almost impossible to use public transport without the help of others.

These answers allowed us to go further into the urban planning of a Smart City in Universal Design. They were extremely helpful for the progress of our project.

Smart Services

Smart services are one of the main components in a city of the future. With the help of these services, some issues will be solved more simply and intelligently through new technologies. As explained in the scope, we have limited ourselves to the mobility, electricity, and waste disposal of a city, so we asked questions explicitly about these smart services.

Around 80% were positively impressed by a Smart Trash System, Smart Parking System, and a Smart Lighting System.

A conspicuous and big question for discussion was the question of what the participants thought about autonomous public transport in the city center and removing private traffic from the city.

33.33% were against a self-driving idea, citing arguments such as "it is more flexible using one's own car and that this idea would take away many jobs." The most common argument against it was the safety of people. The participants gave good reasons why self-driving transportation might not be good enough. So they said "it would be too dangerous with all the people walking around in a city", others said "self-driving cars probably don't make the same decisions as a human being" or "Machines would try to save the life of the stronger person, even if the weaker person is a child."

Opinions also differed on what participants thought of a Smart Traffic System. A total of 89% said that a Smart Traffic System would be necessary for the future and a good idea, but 33.33% of them were against a system
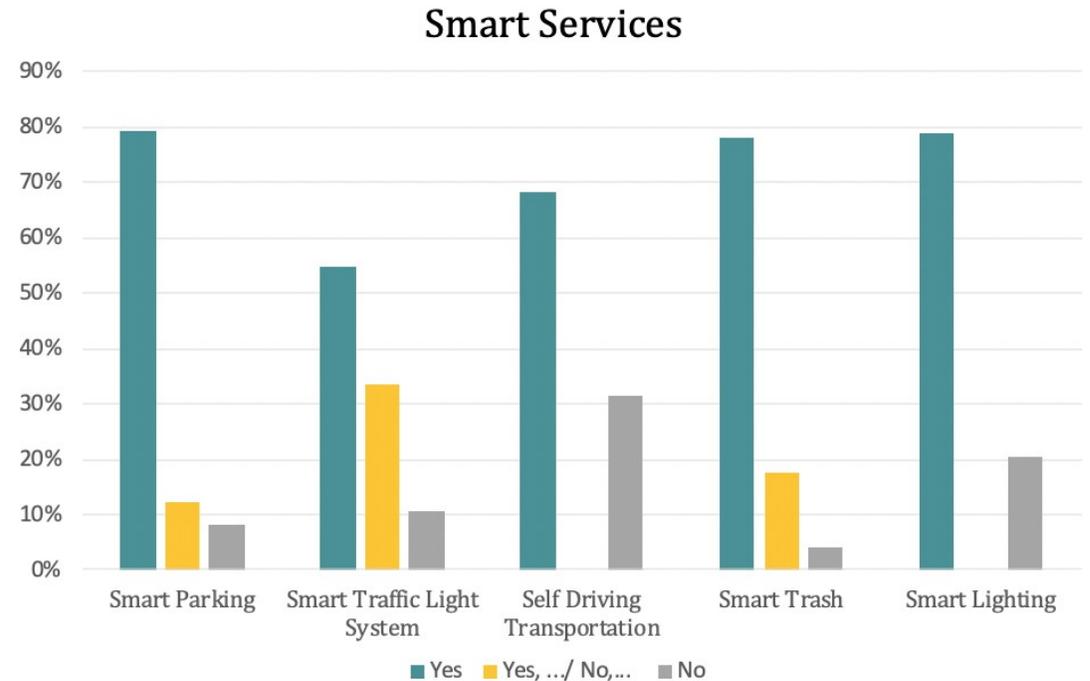

Figure 12. Questionnaire – smart services

with cameras. While all of our eastern participants had no problems at all with a camera surveillance system, it would be an invasion of privacy for many of our western participants.

In conclusion, the questionnaire has given us a clearer understanding of what is needed in cities and what must not be missing in the future. We also received helpful feedback for our ideas, which strengthened our ideas and was helpful for improvements.
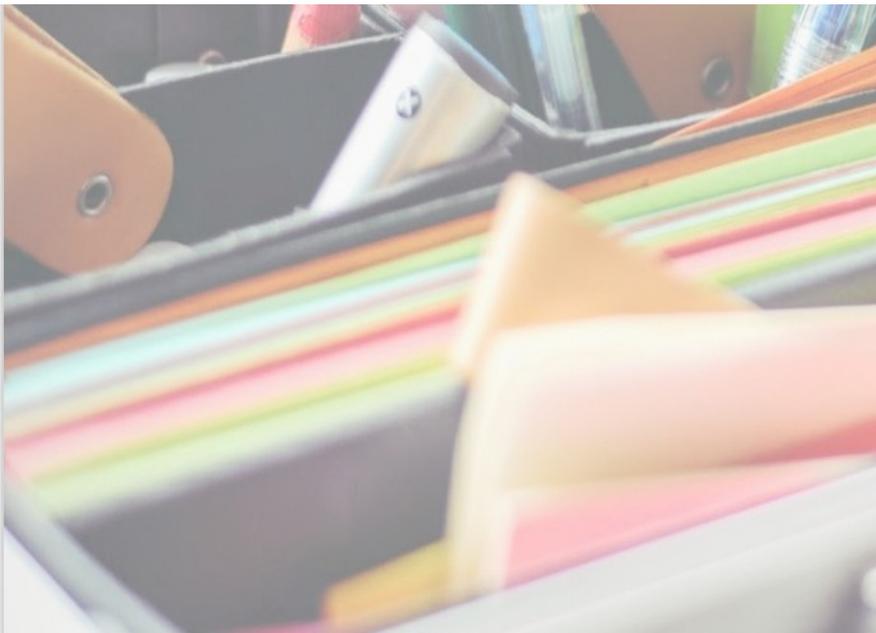
2 | PROJECT DEVELOPMENT

2. Conceptual Design

Explanations

The City

Our city called Proxmania, derived from the name of Proxima City, is an invented city that we built from scratch. Proxmania does not represent an image of an area of an existing city and thus cannot be directly transferred to an existing city. Our city serves only as an inspiration and can be considered as a model.

Figure 13. City by day

Figure 14. City by night
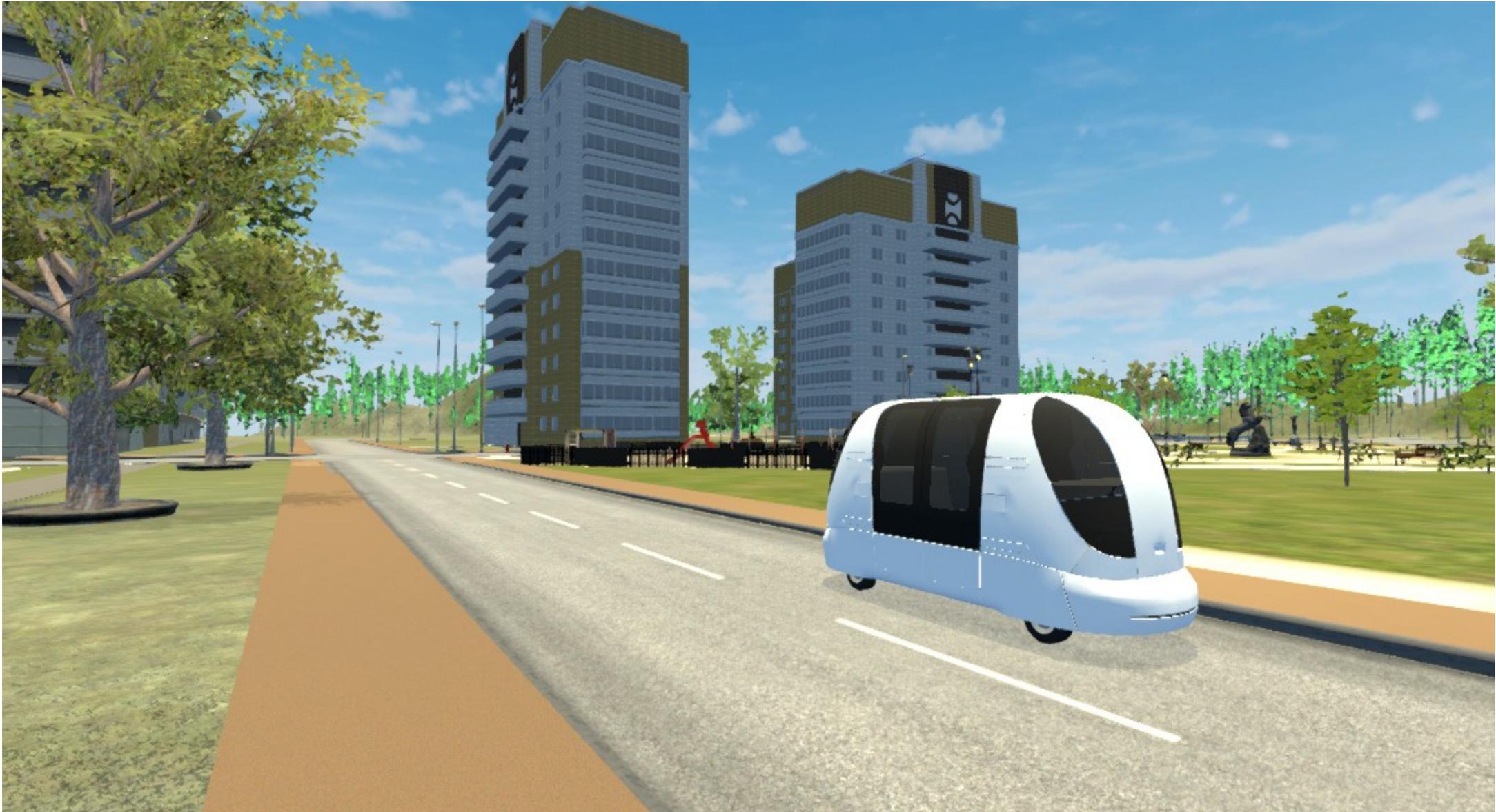
Figure 15. Autonomous taxi

Figure 16. Autonomous bus

Figure 17. City park

Figure 18. City park and fountain

Smart Services

Smart service is a concept that aims to improve actual services by using technology. The objective is to enhance the efficiency of those services fo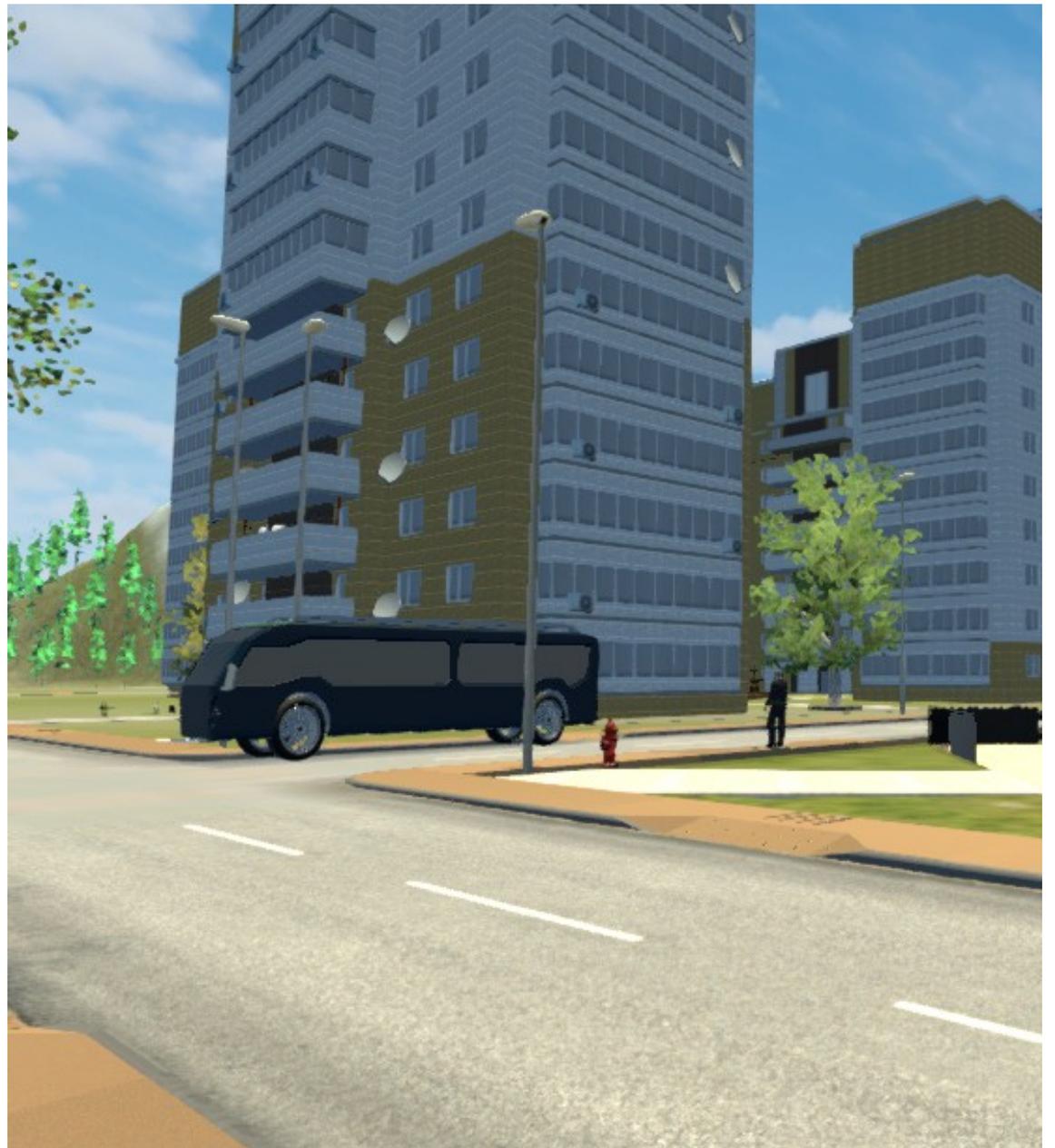r everyone, preserving the environment and resources. It is also well known that the urban population will continue to increase for the coming decades, challenging cities on access to those services. The concept is based on the analysis of data collected by interconnected sensors and devices such as ultrasonic sensors detecting objects or a digital car plate device allowing automatic payment at parking areas. Different smart services will be included in our Smart City project as following: a Smart Parking System, a Smart Trash System, and a Smart Lighting System.

Smart Parking

Previously, drivers did not have a system to help them locate available parking spaces. In recent years, some parking areas have been equipped with displays giving this information to drivers, but they first needed to enter the parking area.

The main objective of smart services is to improve efficiency. That means, allowing people to have access to reliable information as soon as possible. When it comes to find a place in a parking area, our smart parking system will analyze historic and real-time data and tell people through the Smart City App in which parking area they have the best chance to find a place, before they leave their house.

Arriving at the parking, drivers will have two choices. The first one is an underground parking area, built to gain space and reduce visual pollution of cars standing on the ground. The second one will be a classic parking area. Both provide sensors and an inductive charger for each parking place and an automatic payment system through detectors reading the "digital car plate number" device placed behind each windshield. Those detectors will be placed at the unique entry / exit point of the parking area, calculating how long a car stayed in the parking.

To comply with the concept of Universal Design, all the parking places, by being larger than the standard dimensions, will be usable by people with disabilities.

Properly speaking about the "on ground" parking area, each parking place will be equipped with an ultrasonic sensor detecting if a car is standing on the place or not, thus sending information to the system and updating the number of available parking spaces both on the Smart City App but also on panels placed at the beginning of each row.
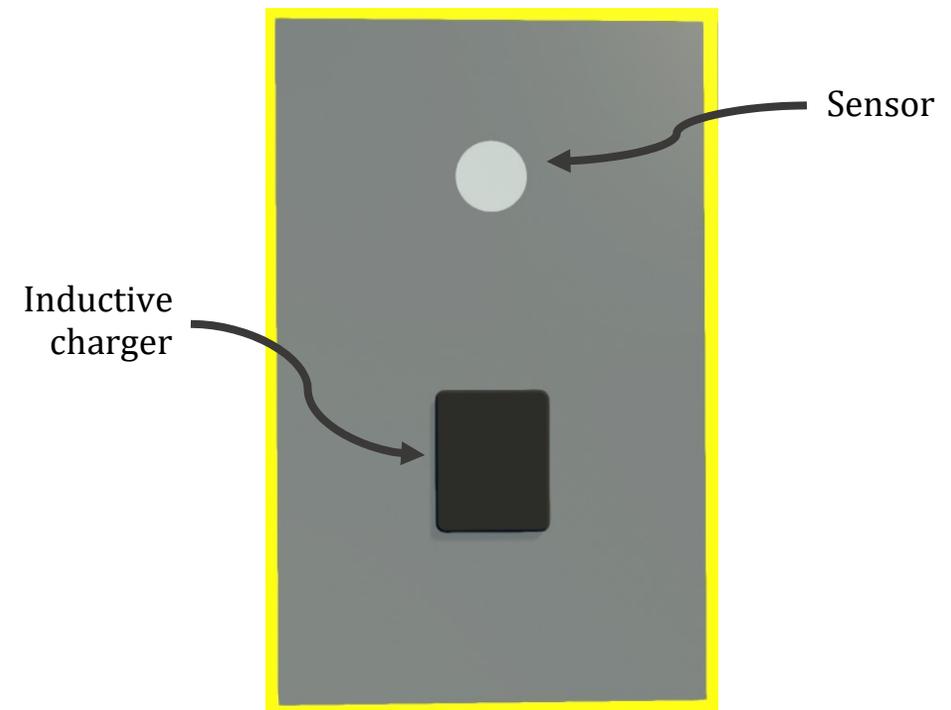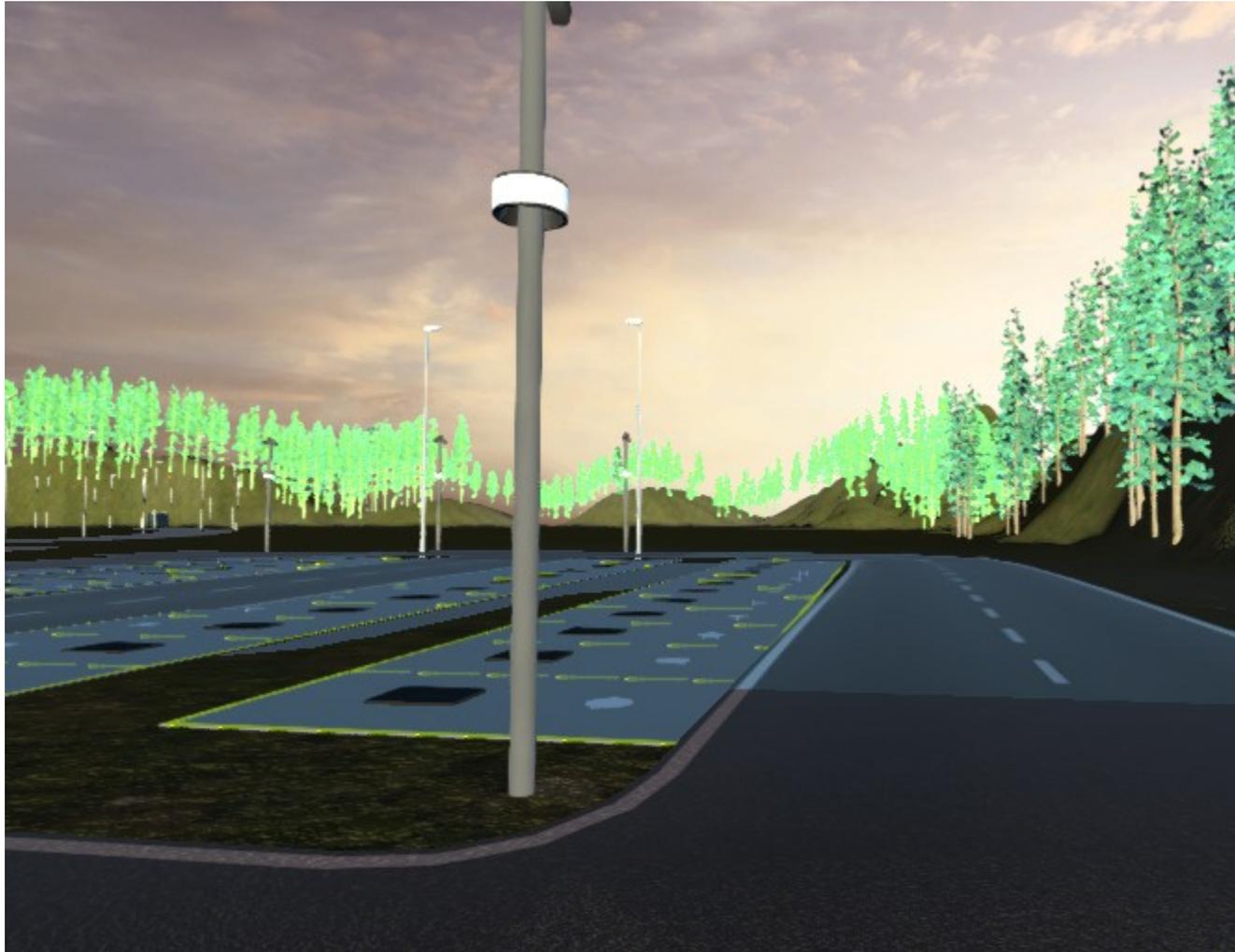

Figure 19. Parking place

Figure 20. Carpark

Figure 21. 360° sign in carpark

Figure 22. Example 360° sign

Figure 23. Park sign and automatic payment system

Smart Trash

Today, trash management systems are based on a cycle. Trash trucks take our bin on specific days. Sometimes bins are full for one or two days already, compelling people to leave their bags nearby the bin, on the street. But sometimes, the truck comes even if the bin is not full, therefore polluting the environment because of an unnecessary trip.

Our smart trash system will use connected, battery-powered, ultrasonic sensors to send data about the filling status of each bin in the city. Once some of them reach a certain filling level an optimized path will be calculated by the system itself and sent to an autonomous truck. By proceeding like this, we optimize the use of the truck and reduce pollution. Because the truck will be fully autonomous, bins will have specific places on the street where the truck will stop to empty them using an automatic arm system.

To give people the information that a bin is full, a red light will start blinking once the filling status reaches the threshold. Moreover, for professional purposes such as restaurants or manufacturers, it will be possible to have access to the filling status in real-time on a monitor. Finally, in living quarters, the filling status of specific bins will be accessible through the Smart City App.

Figure 24. Smart trash car

Figure 25. Smart trash bin "empty"

Smart Lighting

It is generally agreed that light brings security, but fully illuminated cities is a recent situation for humans. However, the waste of energy is significant for a very low utility. The idea behind this concept of a smart pavement lighting system is to reconnect people with nights, removing any visual pollution. It is also beneficial for some animals, disturbed by this brightness.

The system is based on movement sensors turning on the light when someone is approaching, as the light travels with the pedestrian through the city. To ensure safety, the light will remain on for a certain amount of time after the pedestrian left the detection zone. At a pedestrian crossing section, the system will turn on the light on both side of the street, giving more visibility to the pedestrian.

Figure 26. Pavement lights off

Figure 27. Pavement lights on

Figure 28. Park lights off

Figure 29. Park lights on

Universal Design

*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. An environment (or any building, product, or service in that environment) should be designed to meet the needs of all people who wish to use it.*

(NDA, National Disability Authority, 2007)

To talk about Universal Design, first, we need to know what accessibility is. This idea introduces the principle of making everything accessible to everybody. Universal Design goes one step further than accessibility. It proposes one design for everybody, not different adaptations for different disabilities (Fundacion ONCE, 2011).

As both concepts can be blended, we can use the next example to understand the differences. If there are stairs and a lift in a building, everybody will not use the stairs, as wheelchair users. However, Universal Design uses just a ramp to reduce inequality, which is accessible to the entire population without making distinctions.

The places where we can find the use of Universal Design in our project are in public transportation systems as autonomous buses and taxis, where the buses have ramps for wheelchairs. Moreover, along the city there are wide sidewalks with ramps, touch tiles and big contrast in the color of the floor, which is helpful and important especially for blind people. To improve the security, there are different paths for bikes than for pedestrians. In our parking, there is enough space in the parking places, and autonomous payment. Finally, in the train station we can find entry/exit systems for everybody as mechanical ramps or lifts. Sufficient space in the roofs and contrast signals, voice signals and a simple access to the train.

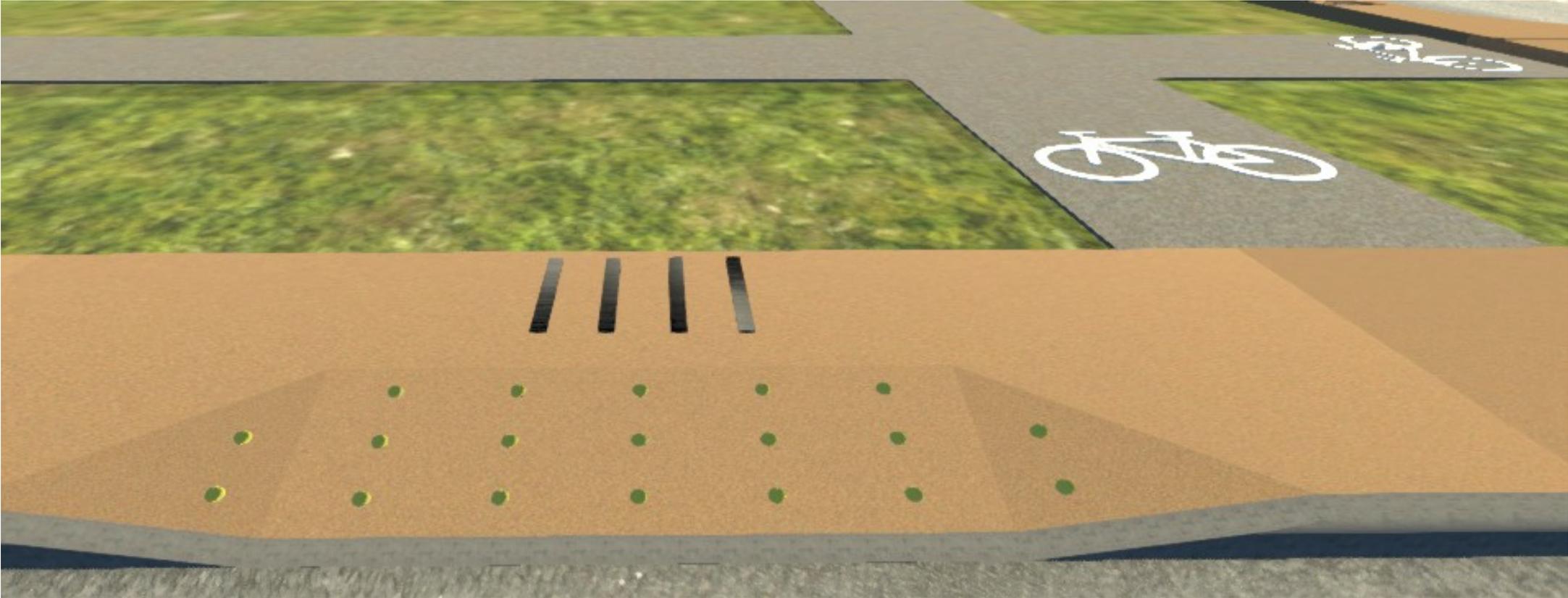*Figure 30. Example for accessibility*

Figure 31. Example for Universal Design
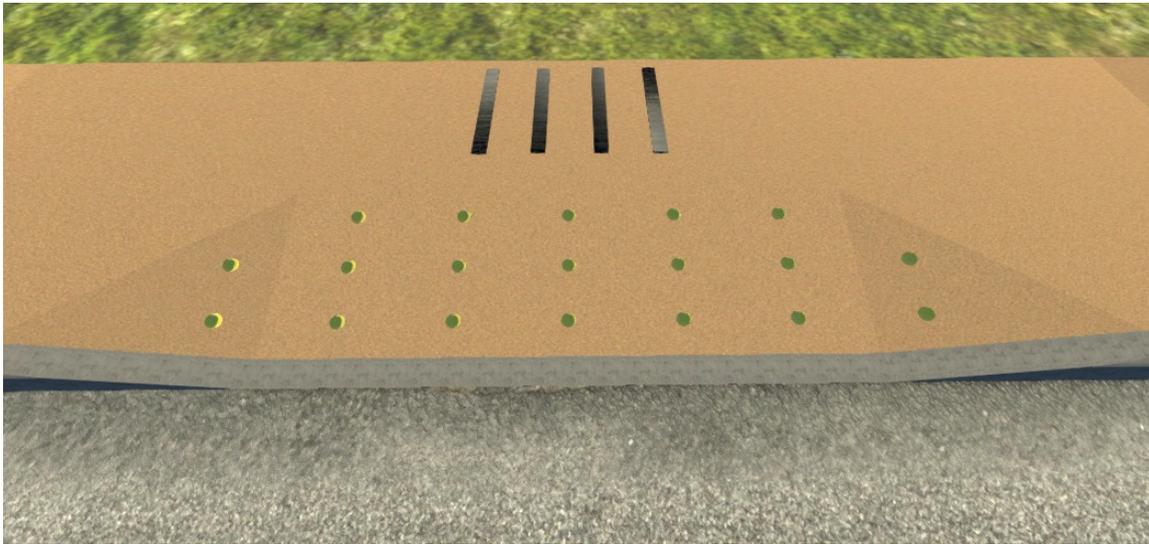
Figure 32. Pavement ramp and touch tiles

Figure 33. Color contrast pavement

Figure 34. Pavement ramp, touch tiles, and bike lane

Sketches and Models

First Sketches

During the questionnaire, we assembled as a team to create a suitable city layout, as this is the basis for the entire simulation and further planning of the city. It was therefore important to us to choose a layout that saves space, but at the same time allows some for an efficient expansion of other districts. We examined and evaluated many city layouts and finally decided on a simple rectangular shape. The inspiration for this was Manhattan, the district in New York, which uses the limited space efficiently thank to its rectangular layout.

After understanding how the smart services work and developing them theoretically, we had to make them concrete through sketches. Since each of us had different ideas about the concepts, we had to try to work out a concept that everyone agreed with. We deliberately opted for handwritten sketches, because it was easier for us to understand the concept behind the smart service system when it was drawn by hand, as a line drawing. Even for the imagination, we found that sketches are the easiest way to share ideas with others instead of showing photographs.
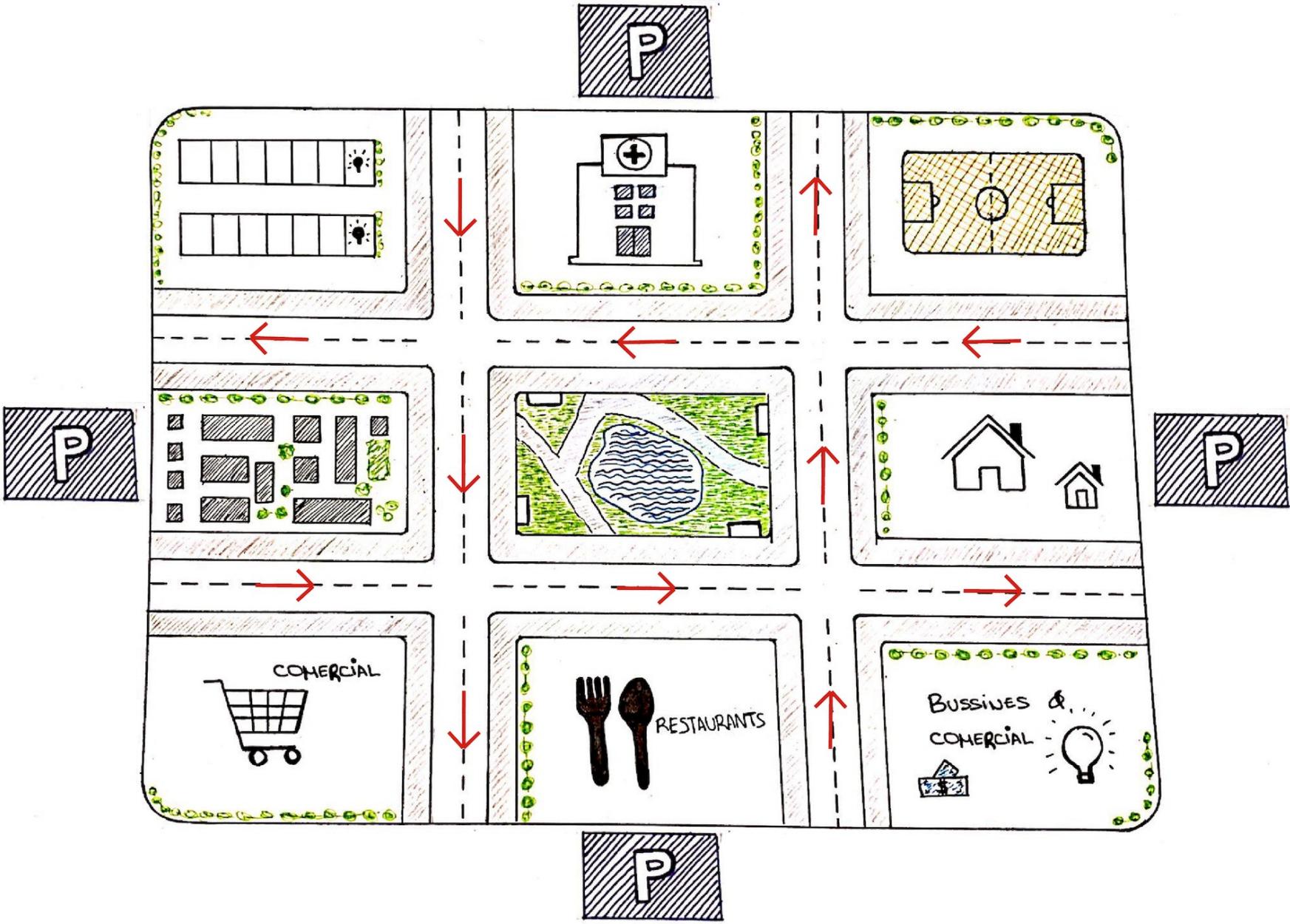
City Layout

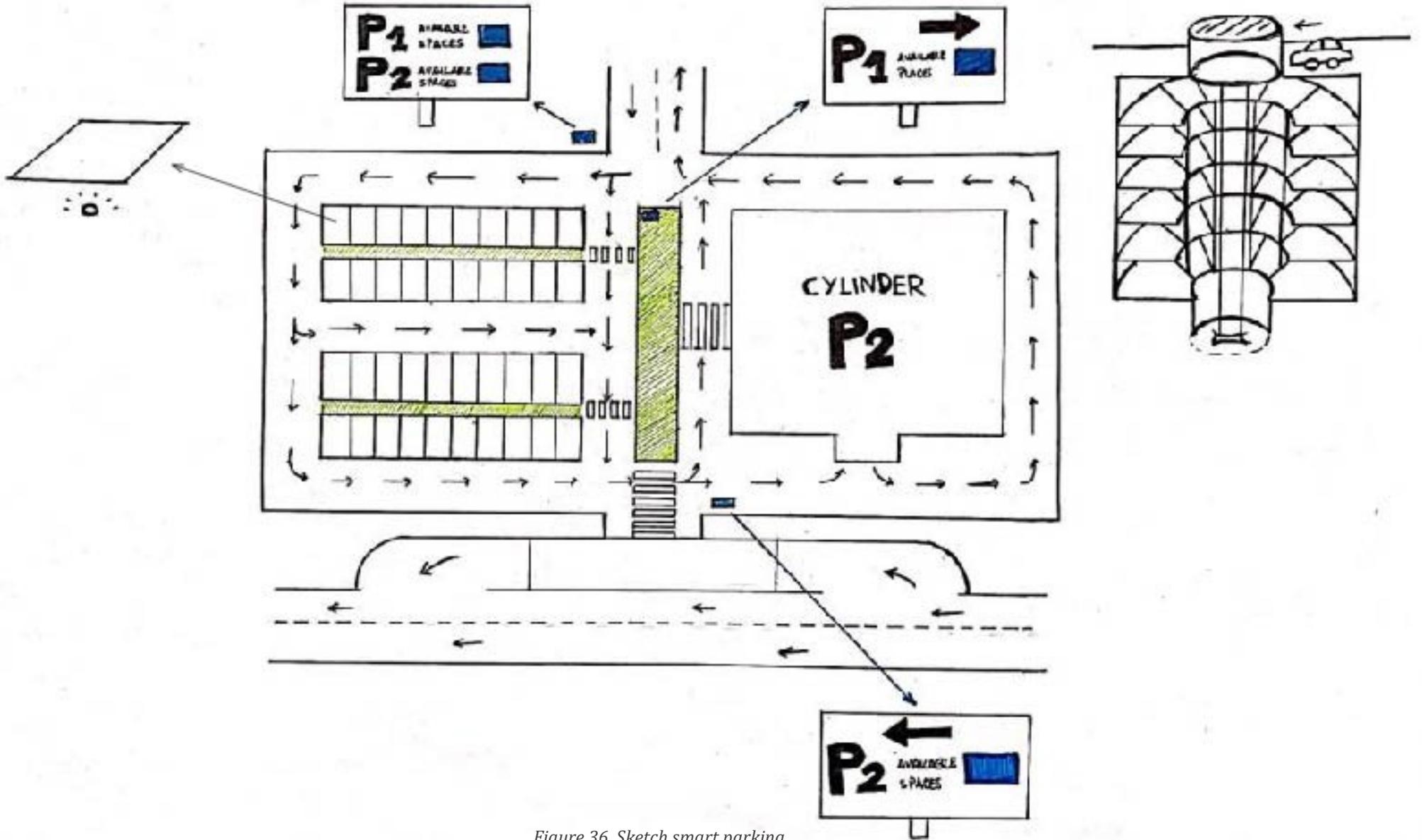*Figure 35. Sketch city layout*

Smart Parking

Figure 36. Sketch smart parking

Smart Trash
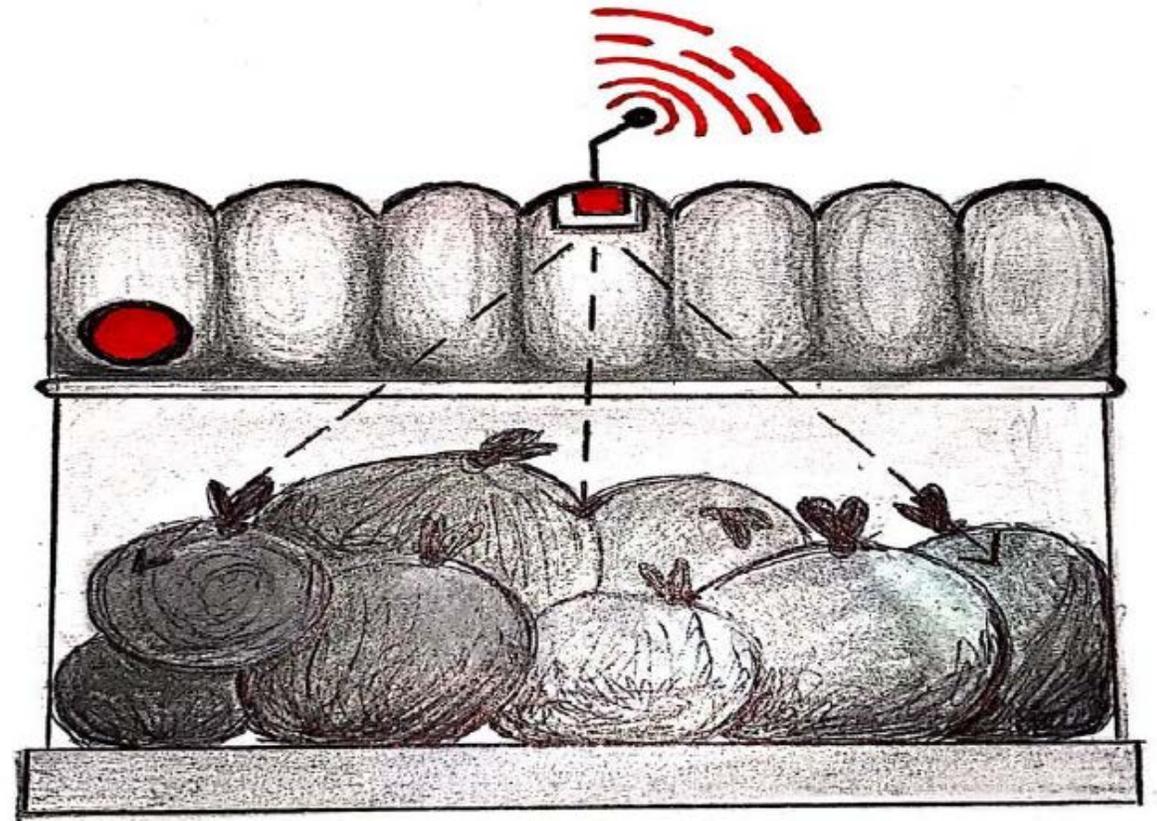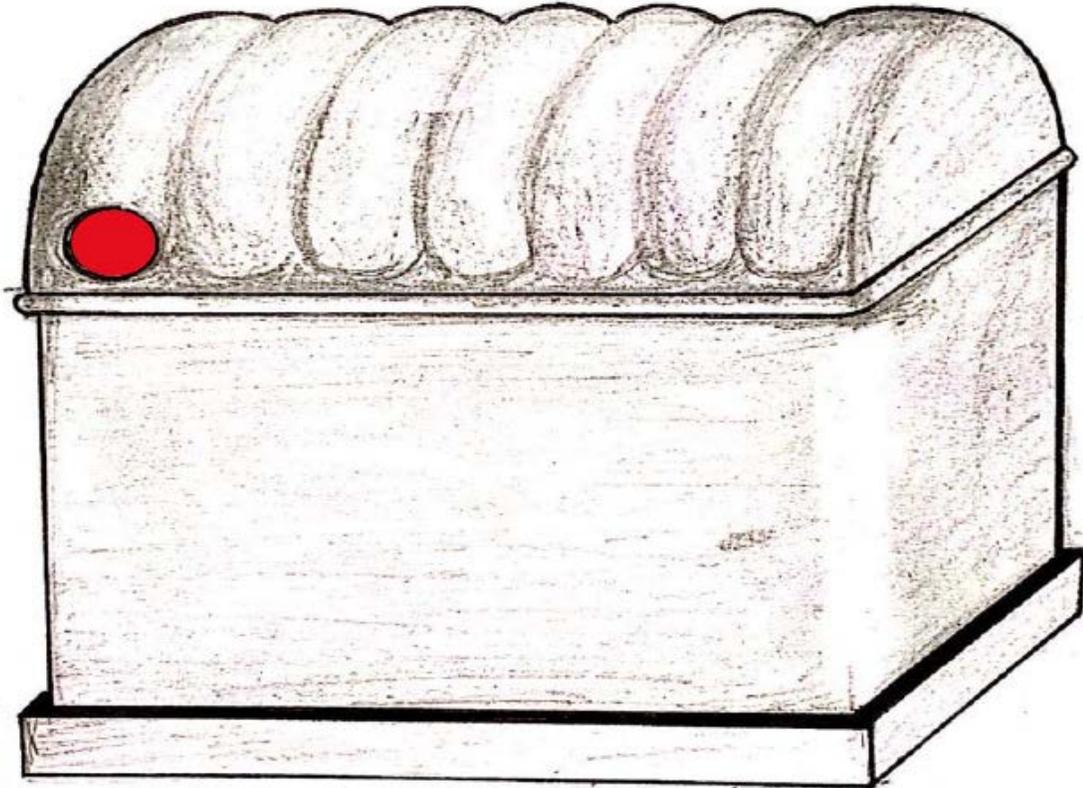
Figure 37. Sketch smart trash

Smart Lighting

Figure 38. Sketch smart lighting

3D Models

Since we decided to create a car-free city but still believing there will be individual transportation system in the future, we have created a smart parking system that will take place around our city center as entry points for people coming from outside the city center. We created these parking systems using Catia V5 from Dassault Systems as 3D models.

Every city should have a train station, even in the future but we found that surface train stations take away a significant space. Thus, we designed a 3D model of an underground train station using Catia V5.

Train Station

The main objective we had regarding the train station was to integrate the notion of Universal Design from the docks to the surface. Next pictures will show some features of our train station:

We implemented the train station right at the center of the simulation. Therefore we have four entry end exit points.
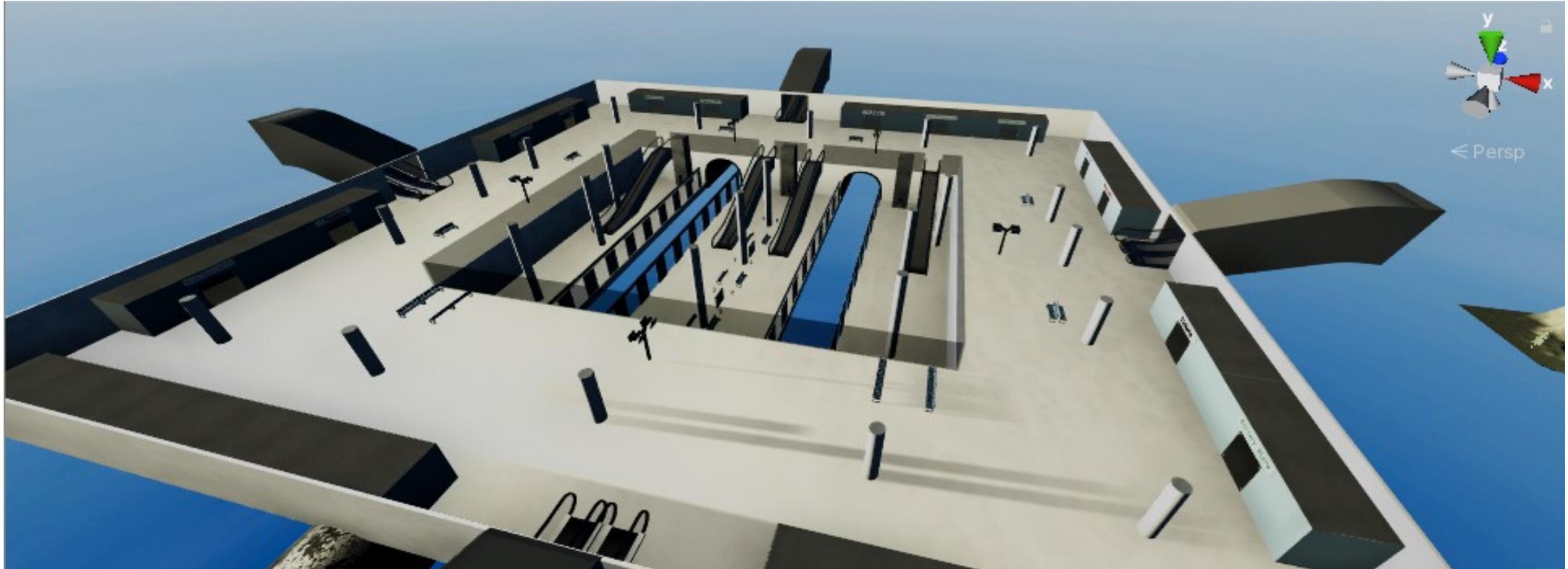
Figure 39. Train station
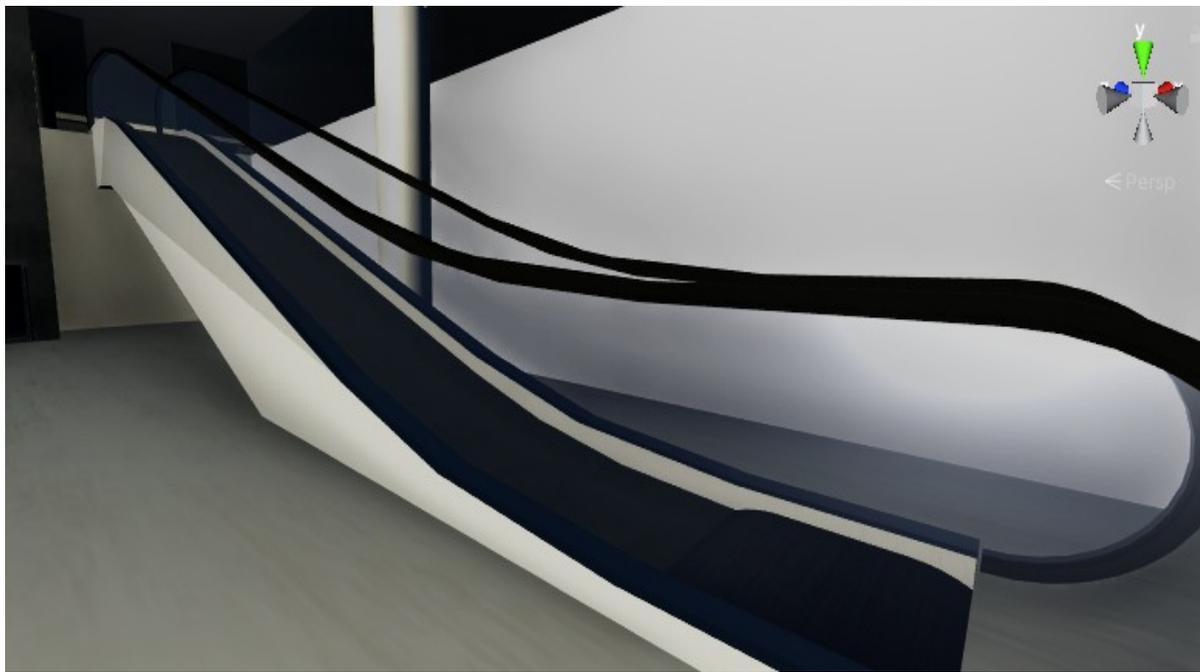
We avoided classic escalators by choosing moving walks (a moving carpet). They can be used by everyone and are still usable in case of a blackout.

Figure 40. Moving carpet

To prevent accidents and because our trains are fully autonomous, we implemented automatic doors so the flow is optimized because people can wait on the right spots before entering the train.
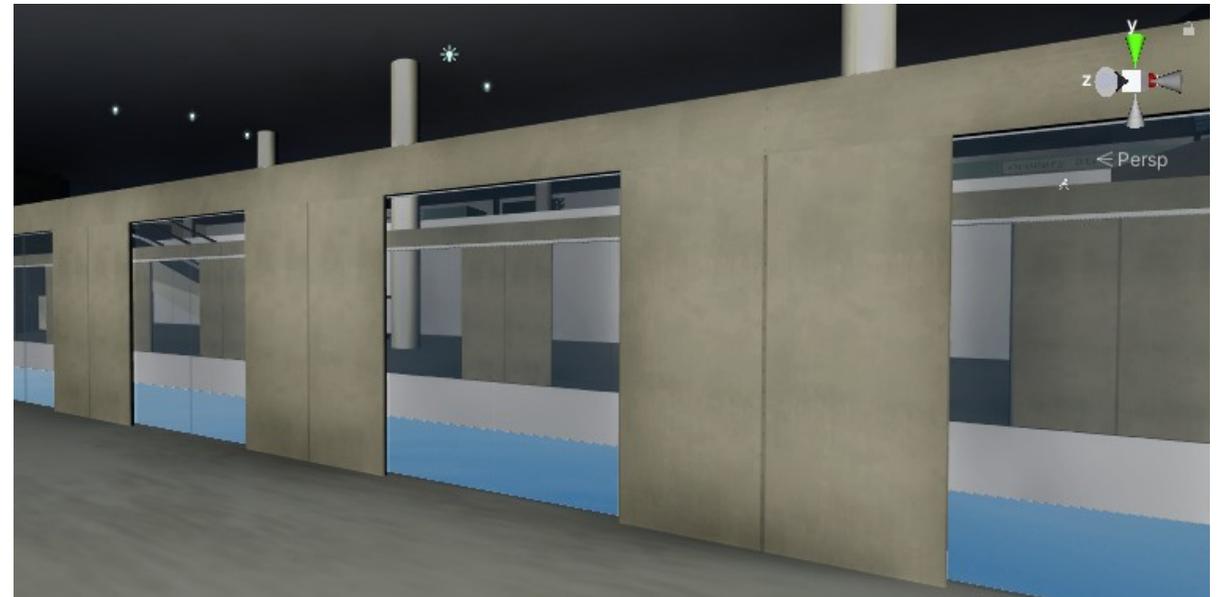
Figure 41. Automatic doors
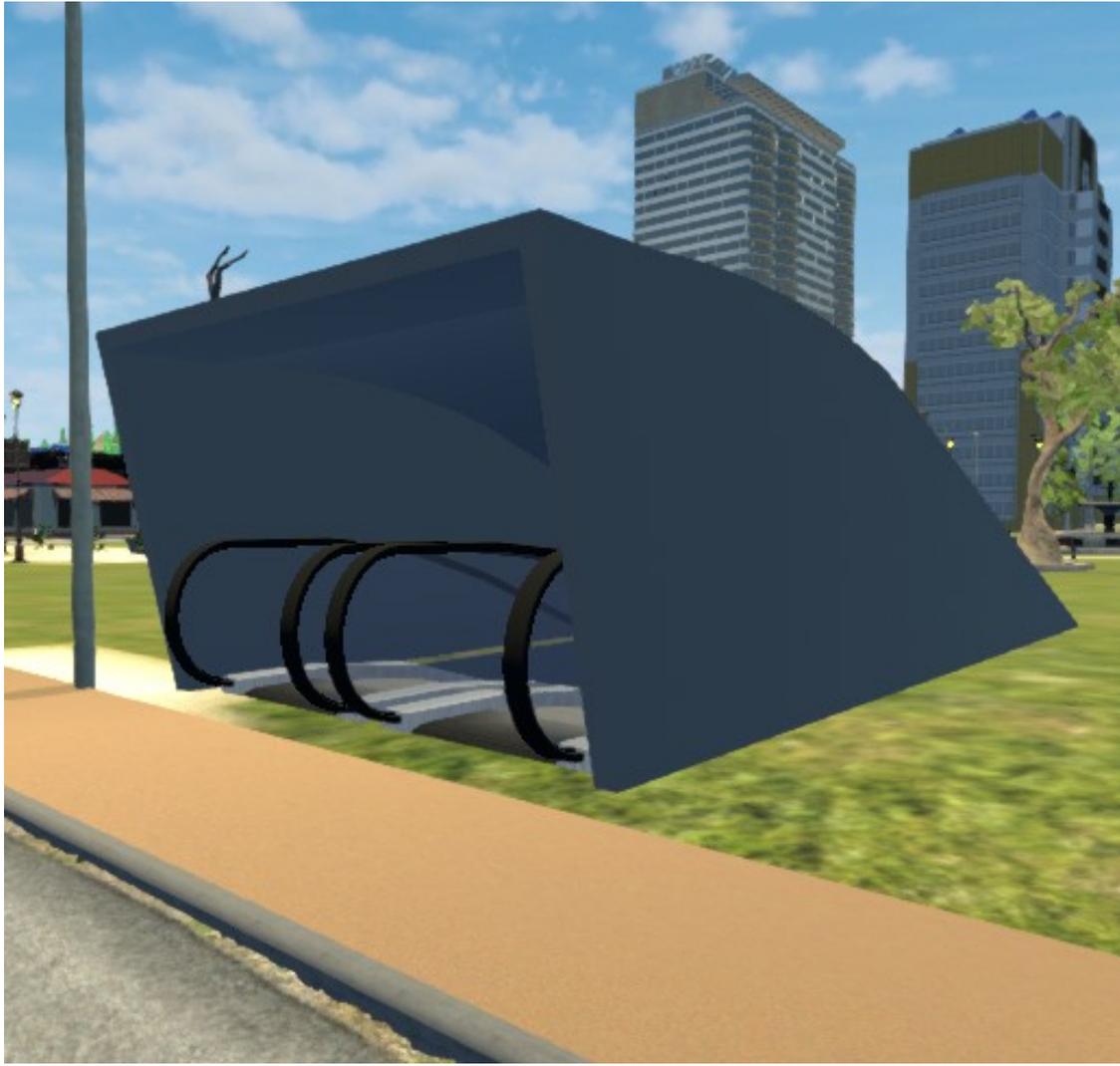
Figure 42. Entrance city park
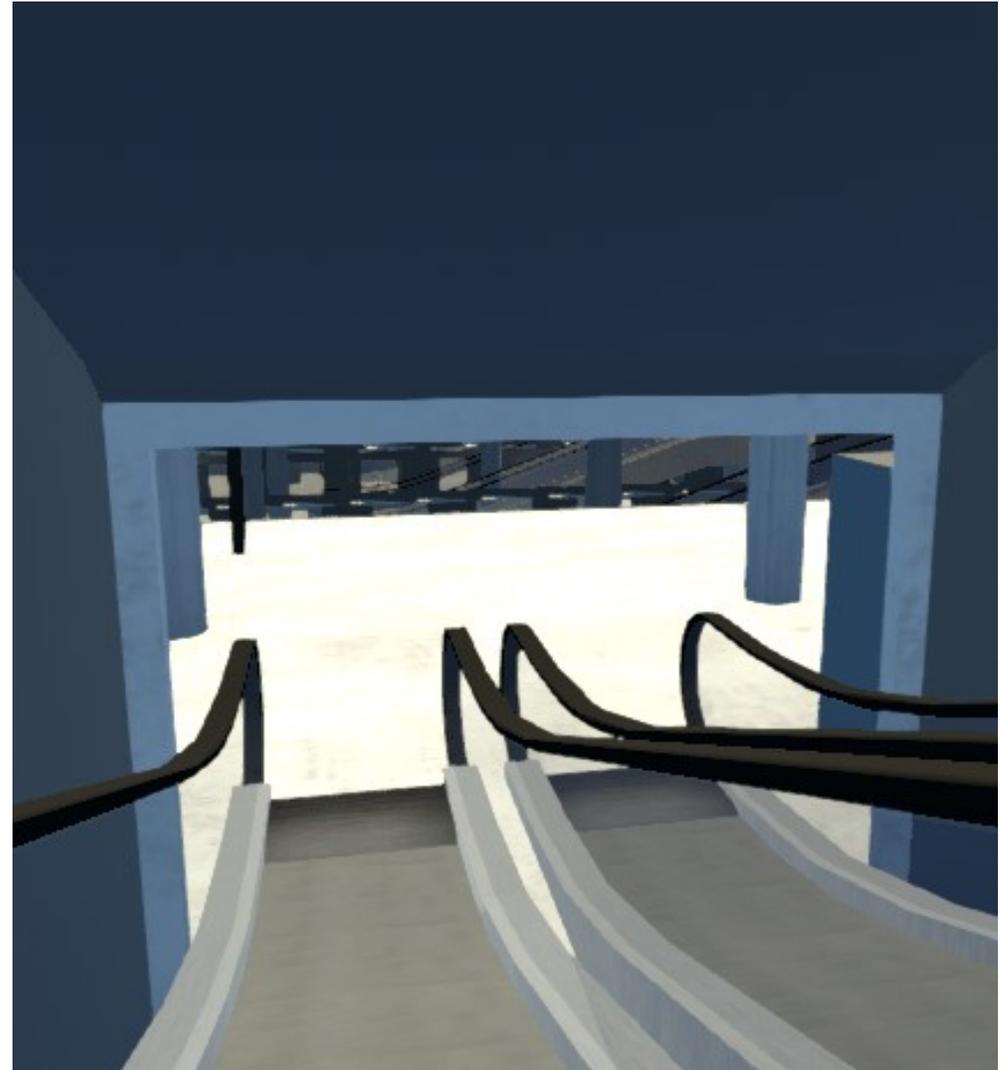
Figure 43. Entrance train station
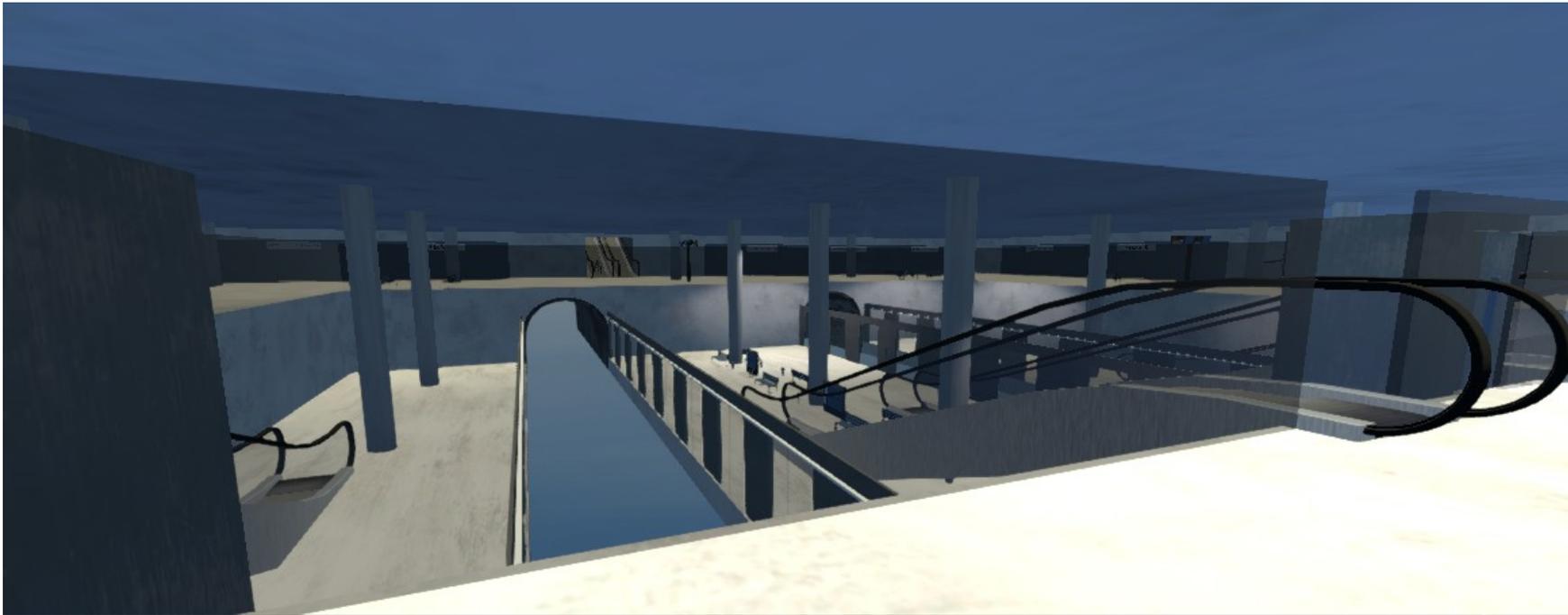
Figure 44. Train station platform

Underground Carpark

In the simulation only the surface of the parking area is visible, the underground view is shown on the next page.

Figure 45. Underground carpark
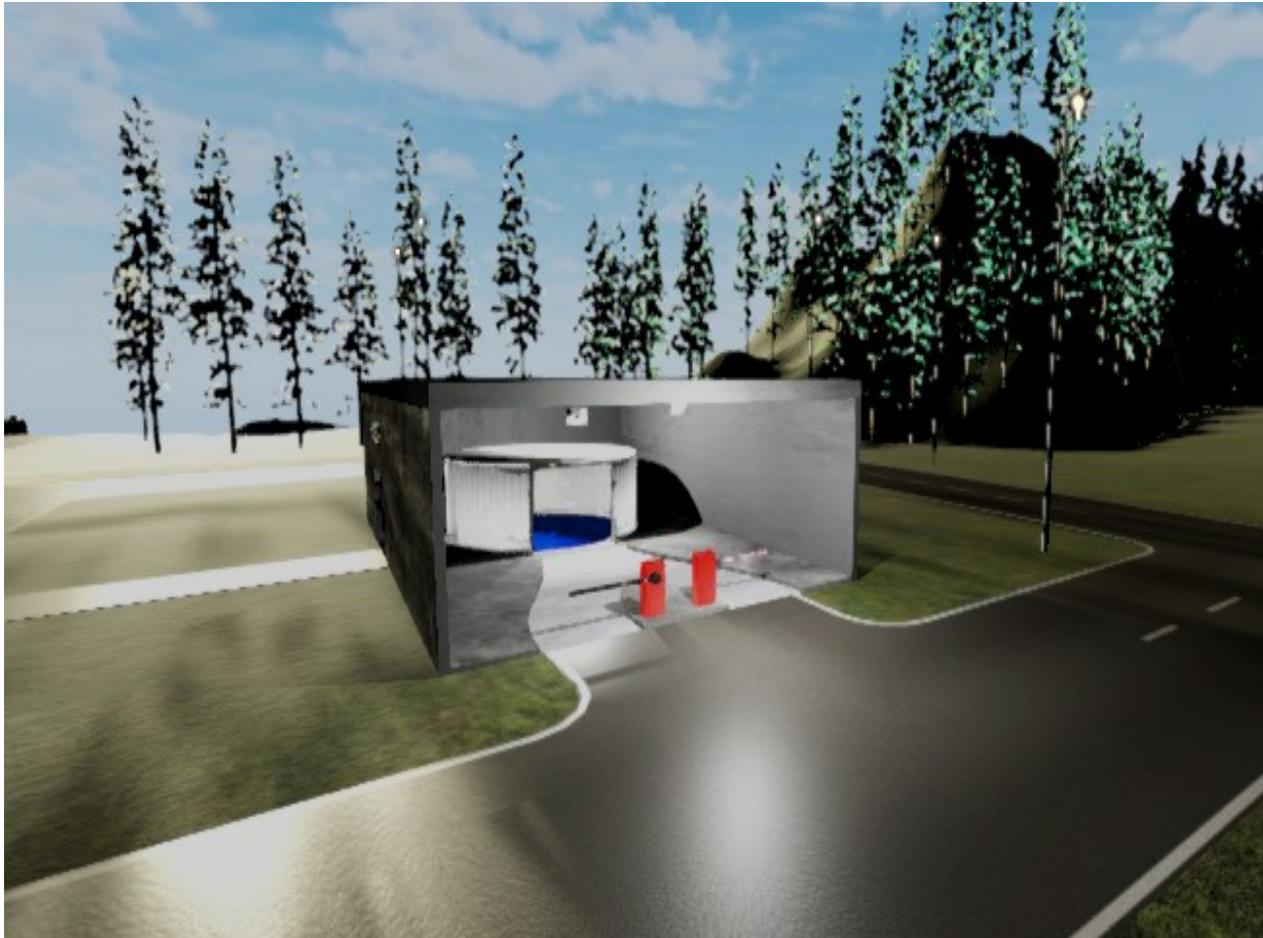
Figure 46. Underground carpark
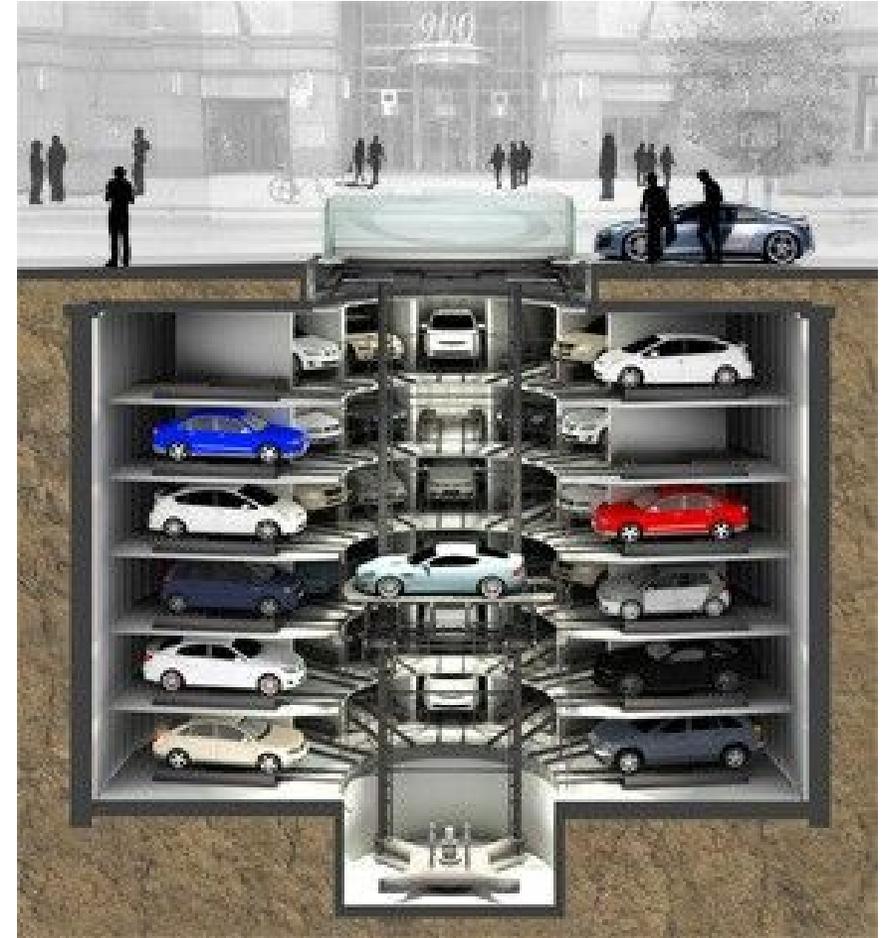
Figure 47. Underground carpark example
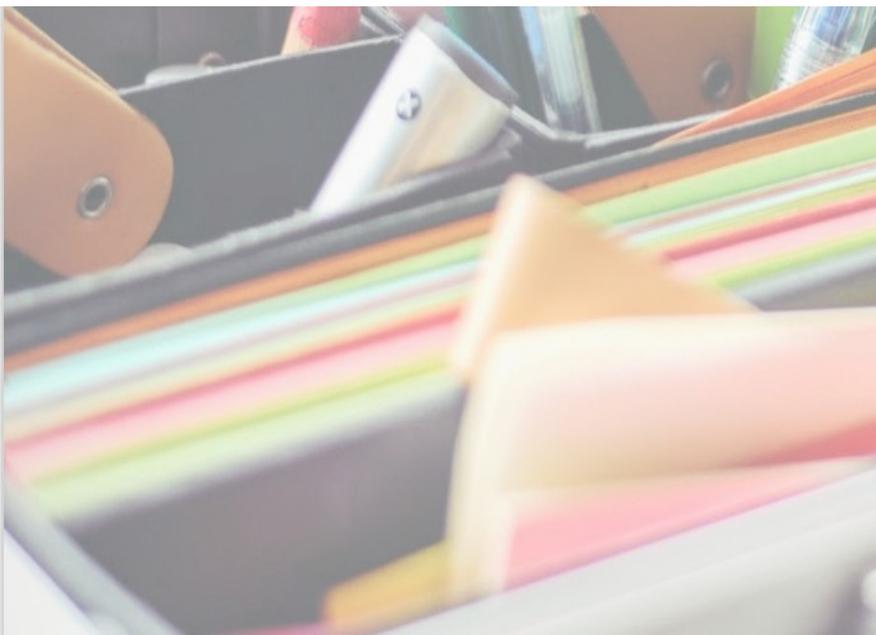
2 | PROJECT DEVELOPMENT

3. Coding

Database

In the making of the Smart City simulator, we needed a way to store the information about the different objects. A model of a trash car in the digital world does not contain any information other than how the different pixels correlate to each other in order to make its general shape. To store information about the amount of trash, where it is and other information, we need a database. This, of course, applies to all units in our city. We also need to store information about the content of trash bins, location of vehicles and the parking spaces. By logging all the actions performed, it might be possible in the future to implement machine learning to find optimal routes for trash collection, for example.

What is a database?

> *"A database is an organized collection of structured information, or data, typically stored electronically in a computer system"*
>
> (Oracle, 2020)

A database and specifically relational databases, as we are using in our project, is a collection of data structured in an affiliated manner. We call this relational database structures, and by this we propose that every object in the collection has some sort of link to the other entities. By following the links, we can access all the objects with simple references (normally an ID number), rather than having to know anything about the underlying data structure. SQL, Structured Query Language, is the language we use to access the data, whereas the actual data storage is hidden from us under layers of abstraction and managed by the DBMS, Database Management System. By storing data in this way, no data is repeated (ideally), and we get a minimal collection with good search performance.

Oracle APEX

The dashboard for the overview of the objects in the city was made using Oracles application express framework. This framework lets us easily make graphs, and manipulate data based on the underlying database. The APEX framework is made so that we can create graphical user interfaces using low code approach. An approach that also Microsoft (Microsoft, 2020) now promotes so that people without a strong background in computer science can create applications (Oracle, 2020).

REST

For communicating with the database through the internet from the simulation we utilized the Oracle database built in REST framework. A restful state API built into the database, helps us define triggers to update and get the data for use in the Smart City. As shown in the appendix "Restful state services". We can call a http trigger and send data to and from the database as strings of text structured as Java Script Object Notation.

Logic

The underlying logic is constructed in C#. A programming language closely related to Java and featured in the Unity development platform that we used to construct the simulation. This makes us able to create complex logic in a structured manner. We have tried to make the code readable, and reusable. Most of the logic is built around triggers that fire an event if you get close. Some events like blinking lights on the trash bin happens when the database amount reaches a certain point. A simple example of the trigger system can be seen in Figure 48.

The code in the example checks when an object enters a certain area if the object is a player. It also restricts the code for continuing if the object is a car, or another vehicle. The getDayTime() part is connected to the sun and responds with true or false according to if it is daytime, and the lights should not turn on. When you go out of the area of effect, the light turns off. Simple yet effective.

For a detailed overview of the code, and the use of the different scripts, please go to the appendix (Erlandsen & Antoszewski, 2020). For the navigation system we utilized the built-in navigation AI in Unity. This allowed us more freedom in how we wanted to present the city as opposed to if we had to use a lot of time hardcoding all the navigation. After configuring the built-in system, it was a matter of creating waypoints and telling objects where to move.

Figure 48. Trigger system

Simulation

Since this is a simulation, we wanted the city to feel as real as possible. With moving clouds, sunrise and sunset, parks, fountains and autonomous vehicles driving around.

From the dashboard it is possible to fill up a trash bin, and the trash car will then come and empty the bin, if it is more than 85% full. These features allowed us a fair amount of freedom in capturing of the movie clips for the final presentation. Since nothing is hard coded, it feels more like a simulation, and less like a rigged movie set when you are moving around. This was done to allow for the possibility of Virtual Reality which should be possible to implement in the future.

For the navigation system, we utilized the built-in navigation AI in Unity. Approaching the challenge of navigation in this way allowed us more freedom in how we wanted to present the city. We did not have to specify any behavior related to the movement of objects and could define waypoints for where we want entities to move. The first-person character is also fully controllable in the simulation. All in all, this project should serve as a good base for further studies of behavior in a city.
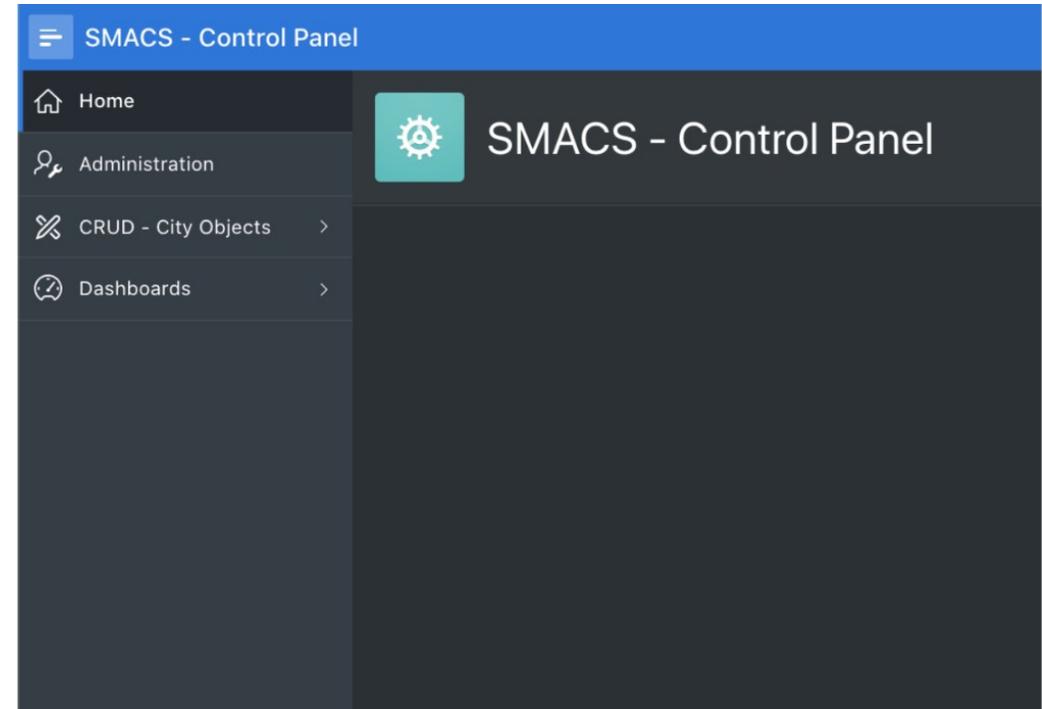
Figure 49. Overview and menu
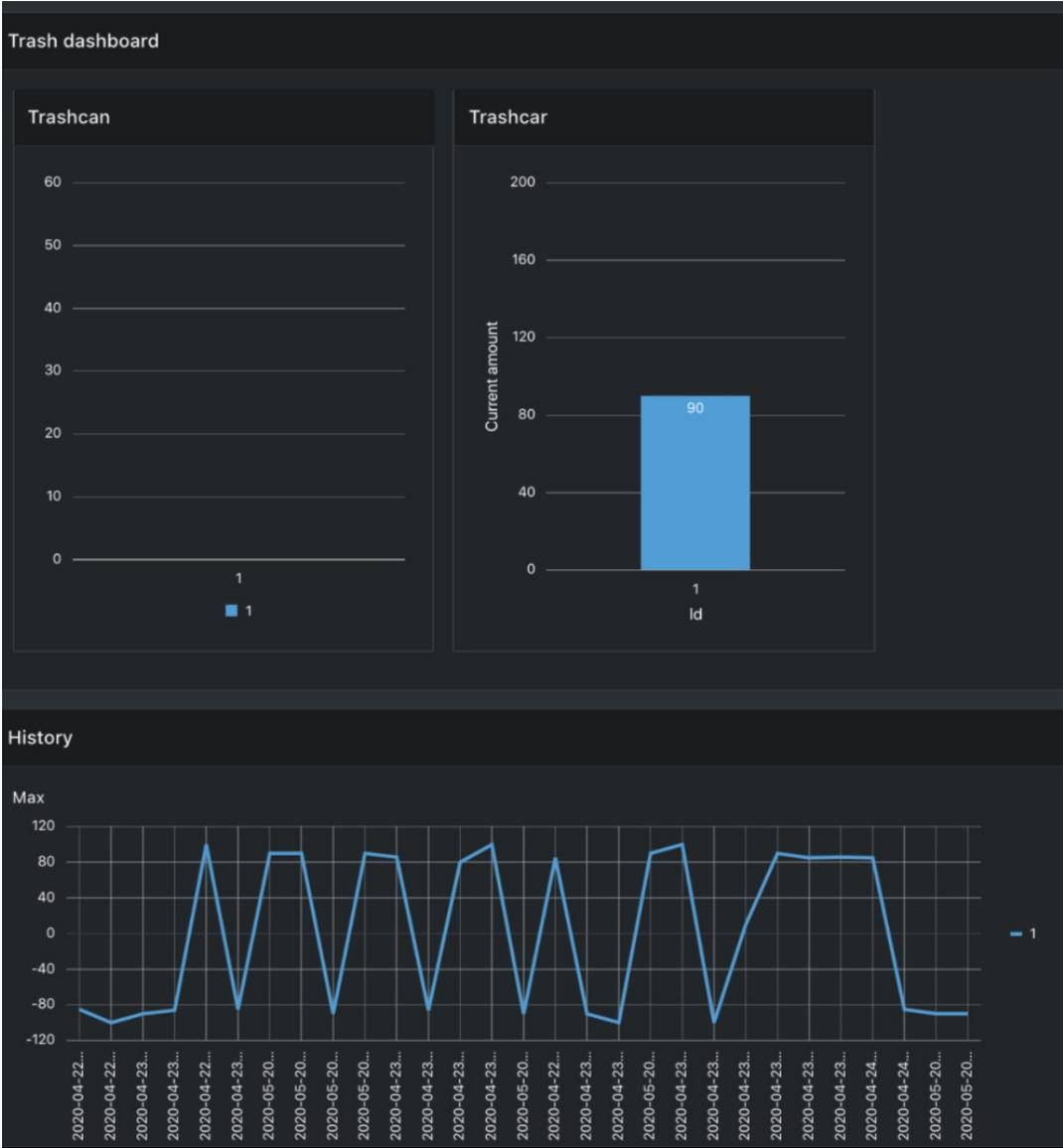
Figure 50. Overview of the current amount in car and can. In addition to historic data. (Fill and empty history)
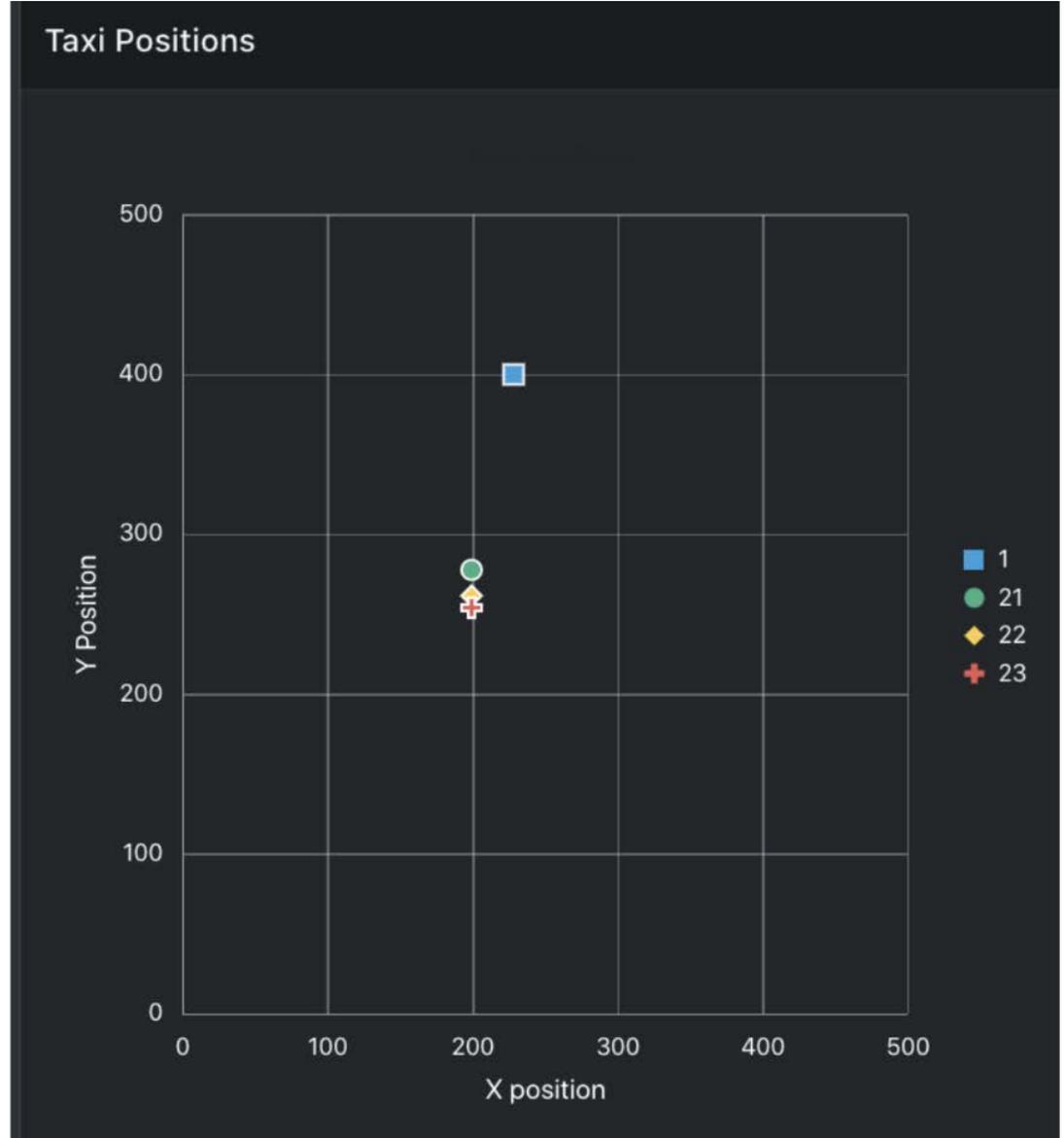
Figure 51. The taxi dashboard consists of a positional overview of where the taxis are on the map

Figure 52. The parking overview contains information about how many % availability is in each spot as well as historical data with regard to time and how full the space has been.

Figure 53. Several objects in the city has its own entry in the database, which can be manipulated from the dashboard. This includes Create / Read / Update / Delete operations.

Implementation

Fitting the database, apex, REST, and the simulation together had somewhat of a learning curve. Especially the trigger system of the database which automatically updates a log reference when a change occurs, was a challenge to figure out. As seen in the appendix "Database triggers", we update a changelog whenever the trash changes in some way. Also, asynchronous programming against the REST API was challenging. The data we get from the database is collected in asynchronous calls, which means that the connected function does not necessarily have the requested value before processing it, as long as you do not clearly state that it should wait for the requested value to be present before continuing. To make matters worse, it is not possible to store any of the values that we receive in intermittent variables. This again, means that we must pass values from function to function, nesting bits of code together to process the data. An example of this can be seen in the appendix (Erlandsen & Antoszewski, 2020) in the method called getFullCans(). Programming such as this is challenging when one does not understand why null pointer exceptions keep popping up everywhere. Null pointers being undefined variables with names, and no initialized value. After a bit of trial, error, research and debugging the communication between database and simulation works fine.

Scenarios

From the beginning we decided to present our simulation with the help of storytelling, for this we needed little stories, which could be cut together to a movie at the end.

For this reason, we have implemented various scenarios in our city that not only present our smart services, but also depict everyday situations in the city. These can be viewed in the appendix in detail. The story of the movie is told with the help of two protagonists Lucy and Emma. The two girls will meet in the city and explore the city together. The girls have never been in the city before and will, therefore, look at everything very closely. Emma will explore the city in her wheelchair and will arrive alone by train. Lucy will visit the city by car and meet Emma in the city. During the film we will be Lucy and look at the city from her perspective.

Figure 54. Lucy

Figure 55. Emma
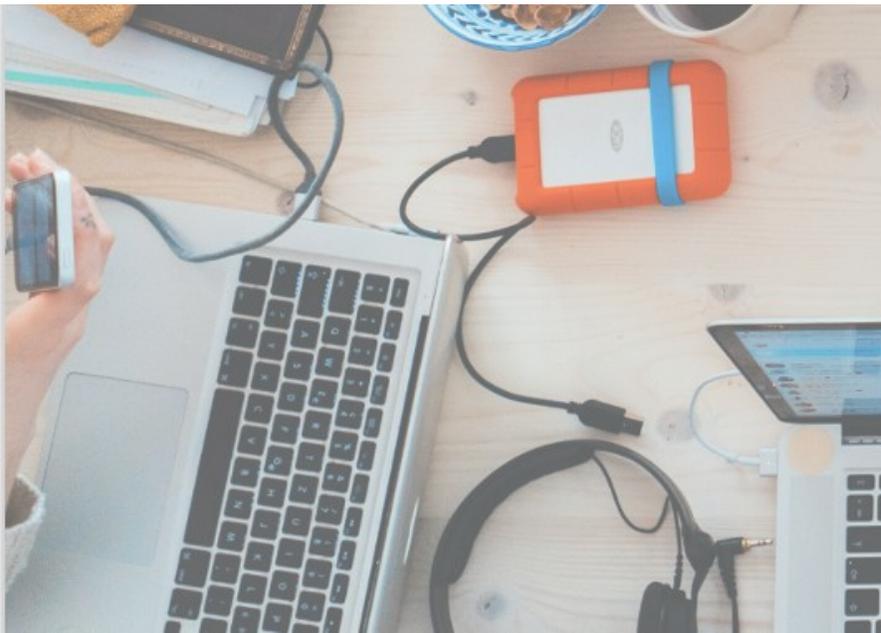
3 | CLOSING AND EXTRA CONTENT

Discussion

Throughout the project, we repeated our concept of a Smart City simulation: to create a Smart City model that contains new future technologies and that is accessible to all people, regardless of their physical condition.

To achieve this, we created a solution that encompasses a city center with a rectangular layout, developed in Universal Design, and thus enables a city life in which everyone can experience the city without restrictions. The concept enables them to use all means of transport in the city, whether taxi, bus or train, without the help of others. Furthermore, parking facilities have been created that offer enough space for wheelchairs and are close to public transport. The sidewalks also contain contrasts and dots that can be felt at crossroads, allowing blind citizens to move around the city more freely and safely. Besides, three different smart services have been implemented in our Smart City model that will make life easier. Firstly, we have removed all cars from the city center, creating a car-free city, and secondly, we have developed a smart parking system outside the city, a smart trash system, a smart lighting system and an electric autonomous public transport system.

Our solutions showcase ideas that can be implemented in cities in the future to improve the well-being, safety and sustainability of all urban citizens.

As we have chosen a car-free city model, citizens will be forced to use public transport or to move around the city by bike or electric scooter. This solution can reduce air pollution and CO_2 emissions in the city. Moreover, all the buildings in our city are equipped with solar panels to generate electricity from renewable energy sources. We have also addressed the issue of green urban planning by creating several green squares in the city and a large city park in the heart of the city center. Which was especially important to many of the participants in our questionnaire.

We also think it is necessary to explain that our model is an example of what a city could look like in the future and which smart services could be implemented. The project is also flexible, i.e. it gives food for thought and shows a variety of future ideas using smart technologies to serve as inspiration. It should be emphasized that we created our Smart City model not physically but virtually with the help of a simulation. This allows stakeholders such as city planners to move around the city virtually to better view and understand our ideas. This strengthens the imagination and prevents misunderstandings and feels much more real through the visual effects.

Big decision

The actual goal of our project was to create a Smart City, which was to be presented with the help of a VR simulation. Due to COVID-19 and the uncertainty of when we will be allowed to enter the campus again, we had to make an important decision as a team.

From the beginning, we wanted to get the best out of this project and do our best to create a project that not only we as a group, but also our supervisor and especially Oracle would be satisfied with. Since we had never worked on a VR simulation ourselves, we knew that it would take us longer, so we gave ourselves seven weeks. Due to the lockdown of the university and the unclear statements if and when we can enter the campus again, we decided not to present the city in the form of a VR simulation. This allowed us to focus more on optimizing the various scenarios in the city.

For us as a team, this was an extremely difficult decision, because from the very beginning we worked towards designing a Smart City that people could enter themselves with the help of VR. Nevertheless, we did not want to present a mediocre VR simulation, but only one that we were satisfied with.

Spin-off

The popularity of mobile applications (apps) is steadily increasing with the ubiquitous penetration of smartphones across the globe. Currently, 3.5 billion people own a smartphone and this number will increase more and more, over the coming years (Statista, 2019).

The smartphone has also become an integral part of our everyday life. We have become too accustomed to the many helpful tools that a smartphone offers and makes all our lives easier.

That's why creating a Smart City without the Smart City App was unimaginable for us right from the start. During our visit to the Oslo Kommune, we were presented with ideas that could be integrated into such an app. Unfortunately, apart from these concrete ideas, there is nothing tangible yet.

In Oslo alone, we investigated the number of apps that would make life easier. We found countless apps for one and the same thing. There were three different parking apps one of them "Bil i Oslo", four different apps showing car charging stations, one of them "Chargemap". To rent a bike in Oslo there are two different apps. To use the scooter closest to you, you need four different apps "Voi, Lime, Circ, Bird". We have also looked into our smartphones to see which apps we need in our daily city life here in Oslo. Four apps we all need every day were "Ruter Billett, Ruter Reise, Studentbevis, and GoogleMaps. It is hard to imagine that we first had to

download four apps to get from A to B in Oslo.

Downloading all the apps and still discovering new apps that might be needed can quickly be overwhelming and the multitude of apps does not really make life in a city any easier.
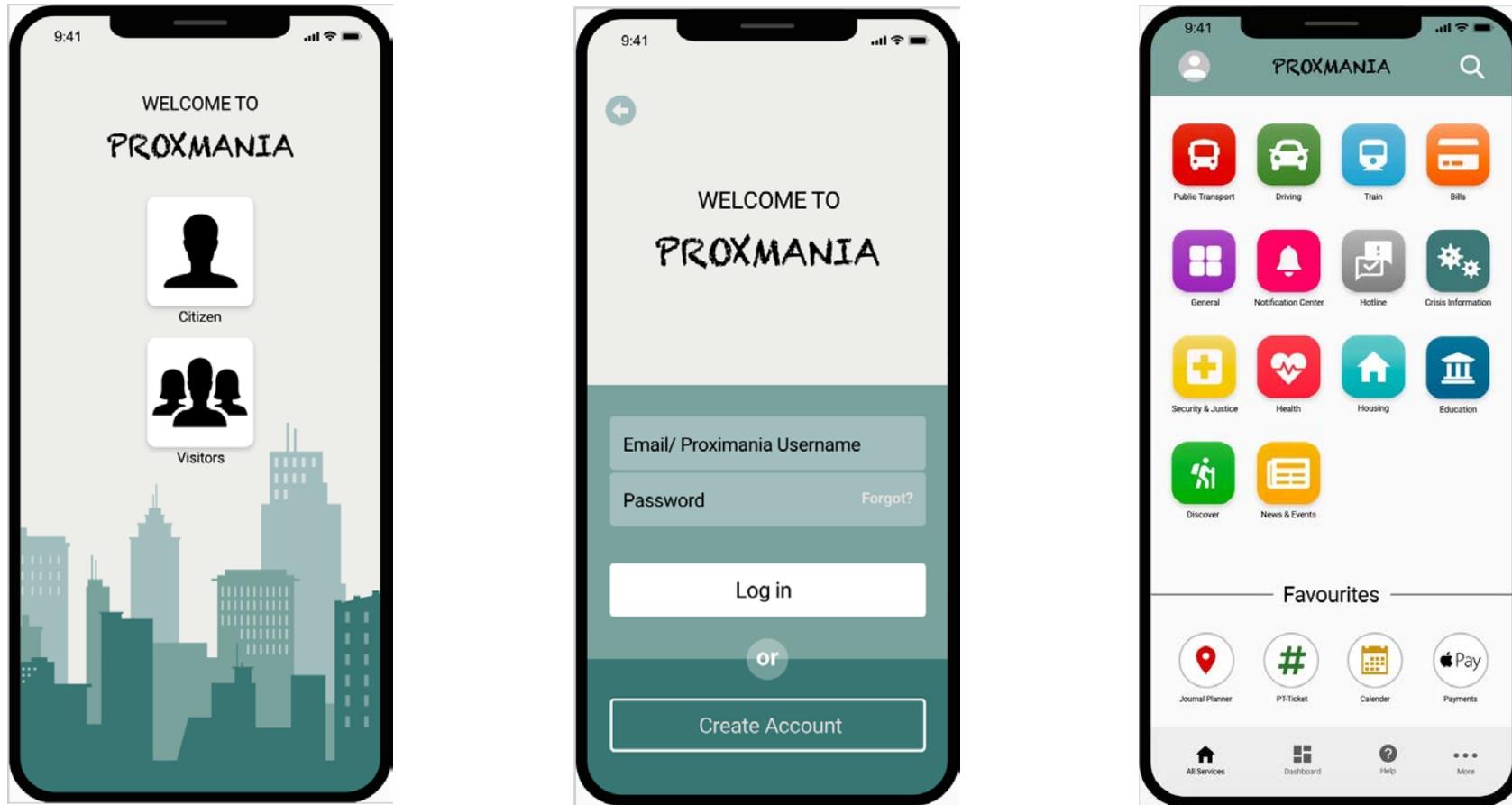
Figure 56. Smart City App - Log in and main area

Therefore, we decided to develop a Smart City App for our Smart City. The idea behind is that every city has only one app with different areas of application to make different functions more clearly arranged. Our Proxmania City App has two login areas, one for residents and another for visitors or tourists. The login area for residents contains all tools about parking, payment, home, health, mobility, news, events, education, and so on. The visitor or tourist area contains only functions such as parking, payment, mobility, news, events, and discover. The individual application areas of the Smart City App are described in more detail in the appendix.

Future Ideas

Due to the limited time of about 17 weeks we were not able to realize all ideas. Nevertheless, some ideas seem important to us, so they should be developed in the future. That is why we wanted to pass them on to the next SMACS group, in order to gradually perfect the city.

Like any city, Proxmania should have emergency services. We also had to consider how to supply a fully autonomous city.

The issue of sustainability should also become more important in the future, possibly through even more smart services or even greener buildings. We are still convinced of our Universal Design and we wish that it will be expanded even more in the city. And especially for the current situation, it would be exciting to consider what a lock down situation in a Smart City could look like. The future ideas described in detail can be found in the appendix.

Conclusion

Through analyzing individual concepts and researching information in various areas, we were able to create a 3D simulation of a Smart City. Ultimately, this project is not only ideal for Oracle, for presentation at conferences, but also for urban planners, governments, citizens, and other stakeholders who can be inspired by such a 3D model.

We believe that our project is an example of a working development that the world needs in its constant change. We also believe that our project can be used to give critics of Smart Cities new food for thought. Our 3D simulation provides stakeholders with necessary ideas on how smart technologies can be implemented in cities to make a city more sustainable and facilitate people's everyday lives.

With our model, we clearly emphasize the needs of all people regardless of their ability or disability and do not just focus on majorities. This will help to critically question current concepts when presenting our model at large conferences.

We believe that our project is the basis for future Smart City concepts and can be used as a template for Virtual Reality (VR) city models. Smart Cities are still in strong development, where there is still much to investigate and adapt.

Reflection

The European project semester was a great experience for all of us. We learned how to work in an intercultural team, because for most of us it was the first time to work together on a larger project with several people involved. We were motivated from the beginning to bring this project to a successful end.

During these months we were able to learn things from each other and from our supervisors that will be useful for the future. We have gained experience both professionally and personally. To give an example: In this multicultural teamwork we have learned to deal with different nationalities. How to treat each other with respect, but also how to talk to each other honestly and sincerely. We tried to find compromises so that all group members felt comfortable and supported the final result.

At the beginning of the semester we did the Belbin test to find out our own team roles. Andrea, John and Maxime largely took the roles that corresponded to their results. The only difference was that Karol, in addition to his results as a team worker, also developed into an implementer. Verena, on the other hand, did poorly in the coordinator area during the test, but she was the one who automatically and unconsciously took on this role.

It was not always easy to follow the visions of the others in relation to the project. As English is not our mother tongue, we had to struggle with some communication problems. Especially during the home office time, it was easy to misunderstand each other through digital media. In order to avoid huge discussions, we included in our group contract that the discussions should be solved like in a democracy. We are happy that we worked so well together as a group that we had our disagreements here and there, but they were always resolved within minutes. In this way, we have learned how to meet each other on an equal footing during a discussion and how to be fair to each other. We also learned to improve our ability to solve team problems. All the disagreements and small discussions were not for nothing, because they resulted in all team members getting equally involved and sharing their knowledge.

A challenge we faced at the beginning of the project was that the work of the previous group could not be reused due to lack of information and disagreement with certain aspects of the project, for this reason we lost several weeks building something completely new instead of improving an existing project.

We started work right in the first week. Because so many different tasks come together in our project, we divided the tasks up. So, Verena was responsible for the organization and always kept the overview of the project. Karol and John worked from the very beginning on creating a simulation of a Smart City and working through the lost weeks. Maxime was the link between the programmers and the work outside the simulation and Andrea

was heavily involved with Universal Design and was responsible for the sketches that had to be made for the entire city. With this approach and our timelines, we were always able to meet our deadlines and never had to work under great time pressure.

One of the biggest challenges of the whole semester was probably the Covid-19 pandemic. Admittedly we all fell into a hole for a short time and were very unmotivated. But together as a group we pulled ourselves together and tried to help each other. Karol, who had particular problems during this time, we gave him the chance to take a little time out to be able to work fully motivated again afterwards. Which worked very well.

It was nice to see how our cooperation improved more and more during the project. We understood each other's working methods and tics better, supported each other continuously and talked about problems or difficulties openly and honestly in the group.

We are glad that we were able to have such a wonderful experience as a group and to share it with each other.

Introduction of the supervisors

Supervisors

Main internal

Dr. Eng. Berthe Dongmo-Engeland, Associate professor, Faculty of Technology, Art and Design, Department of Civil Engineering and Energy Technology

Supporting internal

Prof. Petter Øyan, Faculty of Technology, Art and Design, Department of Art, Design and Drama

Main external

Dr. M. Naci Akkøk, Co-founder & CEO, In-Virtualis AS, Adj. Assoc. Prof., Institute of Informatics, University of Oslo, Chief Architect, Oracle Nordics

References

Chamberlin, D. D. (2001). *An Interview with Donald D. Chamberlin.* Minneapolis: Charles Babbage Institute.

Fundacion ONCE. (2011). *Fundacion ONCE.* Retrieved from Fundacion ONCE: https://www.fundaciononce.es/sites/default/files/docs/Accesibilidad%2520universal%2520y%2520dise%C3%B1o%2520para%2520todos_1.pdf

Handicap International. (2015). *Handicap International.* Retrieved from Handicap International website: https://handicap-international.de/sites/de/files/pdf/zahlen_und_behinderung_2015.pdf

International Electrotechnical Commission. (2019, 7 26). *International Electrotechnical Commission: Electrotechnical aspects of Smart Cities.* Retrieved from International Electrotechnical Commission website: https://www.iec.ch/public/miscfiles/sbp/SYCSMARTCITIES.pdf

National Geographic. (n.d.). *National Geographic.* Retrieved from National Geographic website: https://www.nationalgeographic.com/environment/habitats/urban-threats/

NDA National Disability Authority. (2017). *NDA National Disability Authority.* Retrieved from NDA National Disability Authority website: http://universaldesign.ie/What-is-Universal-Design/

Oracle. (2020). *Oracle.* Retrieved from Oracle website: https://apex.oracle.com/en/

Oracle. (2020). *Oracle.* Retrieved from Oracle website: https://www.oracle.com/database/what-is-database.html

Oracle. (n.d). *Oracle.* Retrieved from Oracle webpage: https://www.oracle.com/a/ocom/docs/proxima-city-brochure.pdf

SINTEF Smart cities. (n.d.). *SINTEF Smart cities.* Retrieved from SINTEF Smart cities webpage: https://www.sintef.no/en/smartcities/#/

Stavanger Kommune. (2016, December 12). *Stavanger Kommune.* Retrieved from Stavanger Kommune website: https://www.stavanger.kommune.no/en/samfunnsutvikling/stavanger-smart-city/what-is-a-smart-city/

United Nations. (2018, May 16). *United Nations.* Retrieved from United Nations website: https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

United Nations. (n.d). *United Nations.* Retrieved from United Nations Webpage: https://www.un.org/sustainabledevelopment/wp-content/uploads/2016/08/11.pdf

United Nations. (n.d). *United Nations sustainable development goals.* Retrieved from United Nations sustainable development goals website: https://www.un.org/sustainabledevelopment/cities/

Appendix

Questionnaire

In addition to the questions about the person, we also wanted to know if the person has disabilities. This point was very important to us, because we want to create a Smart City that is accessible to everyone and where people with disabilities have no more restrictions. We also wanted to know whether the participants had ever heard of a Smart City, if not, we enclosed a short explanation, because our goal was to get all the respondents on board and not to lose them in this question.

Afterwards we presented our smart service ideas. These include Smart Parking, Smart Trash System, Smart Traffic System, Smart Pavement Light System and a self-driving transportation in the city center.

Personal Questions

Gender *

○ female

○ male

○ other

What is your nationality? *

Auswählen ▼

How old are you? *

○ Under 19 years

○ 20-29 years

○ 30-44 years

○ 45-60 years

○ over 60 years

Personal Questions

Do you have any disabilities? *

○ Yes

○ No

What kind of disability you have? *

○ Wheelchair user

○ Partially blind and blind

○ Hearing impaired, residual hearing and deaf

○ ADHD (Attention Deficit Hyperactivity Disorder)

○ others

Which challenges do you encounter in your daily life in the city? *

☐ No barrier-free movement within the city

☐ It is difficult to get from A to B

☐ It is almost impossible to use public transport without help from others

☐ It is difficult to find the right way

☐ Orientation problems

☐ Missing guide strips on pavements, road crossings, railway stations, etc

☐ No announcements at train or bus stations make it almost impossible to get on the right bus or train

☐ Complicated route descriptions causes overwhelming stress

☐ Public transport without visible location indicators

Smart City

Have you ever heard about Smart City? *

○ Yes

○ No

A smart city is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services such as energy, transportation, and utilities to reduce resource consumption, wastage and overall costs. - Based on this definition what should a smart city have?

Would you like to have a connected parking system through a smartphone app giving you real time information about available parking places and reservation possibilities? *

○ Yes, it's a good idea

○ Yes, maybe in the future

○ No, it's not necessary

Would you like to have a traffic light system able to regulate traffic on real time to ease the flow of traffic even if it uses cameras on every street? *

○ Yes, it's a good idea

○ Yes, but without cameras

○ No, the actual system is quiet enough

What do you think about having only self driving transportation possibilities (taxis, busses, trams...) in the city center? *

○ Yes, it's a good idea

○ No, it's not a good idea

Would you like to have smart waste systems, making waste collection more efficient that means the waste collection is notified by a sensor when the waste bin is full to avoid overfilled bins in cities? *

○ Yes, it provides a clean city

○ No, it doesn't encourage to consume less

○ No, other reasons

Would you like to have autonomous and connected pavement lights activated by pedestrian movements at night time to reduce energy consumption? *

○ Yes, it's a good idea

○ No, lights should be on the whole night

Do you have more ideas of what a smart city should have?

Meine Antwort

Restful state services

```sql
SELECT CURRENT_AMOUNT
from TrashCan
WHERE ID=:id

SELECT PASSENGERS_CURRENT
FROM taxi
WHERE id=:id;

SELECT xpos, zpos, current_amount
FROM trashcan
WHERE ID = :id

SELECT CURRENT_AMOUNT
from TrashCan
WHERE ID=:id

SELECT xpos, ypos
FROM trashcan
WHERE ID=:id
SELECT count(occupied) count
FROM parkingspace WHERE occupied='0' AND parkingspace.parkinglot_id = :id
```

Restful state services

```
UPDATE trashcar
SET current_amount = :amount, trashcan_id = :trashid
WHERE id = :id

UPDATE taxi
SET xpos = :x,
    zpos = :z
WHERE id = :id

UPDATE parkingspace
SET occupied = :status
WHERE id = :id

UPDATE taxi
SET passengers_current = passengers_current + :amount
WHERE id = :id AND passengers_current + :amount <= passengers_max AND passengers_current + :amount >= 0;
SELECT passengers_current FROM taxi;

UPDATE taxi
SET xpos = :x,
    zpos = :z
WHERE id = :id

UPDATE trashcan
SET current_amount = current_amount + :amount
WHERE id = :id
```

```
UPDATE trashcan
SET xpos = :x,
    zpos = :z
WHERE id = :id

UPDATE parkingspace
SET occupied = :status
WHERE id = :id
```

Database triggers

```
PARKINGSPACE_CHANGE
BEFORE UPDATE
    OF OCCUPIED ON PARKINGSPACE
    FOR EACH ROW
BEGIN
  INSERT INTO SMACSUSER.PARKINGSPACE_AUDIT_LOG VALUES(:old.ID, :old.OCCUPIED, CURRENT_TIMESTAMP);
END;

TRASHCAN_CHANGE
BEFORE UPDATE
    OF CURRENT_AMOUNT ON trashcan
    FOR EACH ROW
    BEGIN
  INSERT INTO trashcan_audit_log
  VALUES(
  (:new.CURRENT_AMOUNT - :old.CURRENT_AMOUNT),
  :new.TRASHCAR_ID,
  :old.ID,
  CURRENT_TIMESTAMp);
END;
```

```
TRASHCAR_CHANGE

BEFORE UPDATE OF
current_amount ON
trashcar
FOR EACH ROW
BEGIN
  INSERT INTO SMACSUSER.trashcan_audit_log
  VALUES(
  (:new.CURRENT_AMOUNT - :old.CURRENT_AMOUNT),
  :new.TRASHCAR_ID,
  :old.ID,
  CURRENT_TIMESTAMp);
END
```

*All the scripts from inside the simulation called "Erlandsen & Antoszewski, 2020" can be viewed in githup https://github.com/varleg/SmacsScripts

Scenarios

Scenario 1. Way to the carpark

Lucy is in her car on the way to the city. With the help of real-time data transmission, she gets information sent to her Smart City App, which shows her which carpark has the best chance of getting a free parking space.

Scenario 2. In the cylinder

In front of Lucy another car drives into the Carpark, this one is parked on parking space in the first row. Lucy continues towards the underground parking area, where she parks her car in the cylinder and then waits for her taxi towards the bus/taxi station.

Scenario 3. At the station

Frank and Gregor are also waiting at the station. Gregor is in a wheelchair and they both decide to take the bus to the city, because the bus ride in Proxmania is free.

Scenario 4. By taxi to the city

But Lucy decides to take a taxi anyway because she had heard from friends that they look so completely different from normal taxis. With one of these taxis Lucy drives to the train station where she will meet Emma shortly.

Scenario 5. At the train station

Emma, who arrives in Proxmania by train from her hometown, is so excited about this train station because it allows her to move around freely and does not require help from others, or even need to use other entrances and exits. At the platform Emma is picked up by Lucy. The two leave the train station together.

Scenario 6. Crossing with a blind man

The two decide to explore the city. Before them at the crossroads stands a blind man. With the help of the touch tiles on the floor where the people are standing, the taxis and buses are stopped. After that a signal sounds and the touch tiles start to vibrate, indicating that it is now safe to cross the street.

Scenario 7. Smart trash system

The three of them cross the street and Emma and Lucy walk towards the restaurant to see what there is to eat.

In the backyard of the restaurant they see a blinking trash bin. Not knowing why, the trash bin is blinking, they approach here to find out what it means. Here they see a sign saying "full". Only a few minutes later a trash car arrives, which has been informed by the smart trash system that this trash bin is full.

Scenario 8: Bike rider crosses the road

Lucy and Emma are on their way to the park. Just before the crossroads they see a cyclist crossing the road and the taxis and buses stopped automatically. Especially Lucy, who likes to ride her bike, thinks it's great that the bikes have their lanes all over town and that the vehicles stops automatically when the bikes cross.

Scenario 9. In the city park

When they arrive at the city park, they are quite taken with how big and how beautiful green it is. This makes the city much friendlier and above all more sustainable, says Emma. She also likes the fact that good paths have been built so that it is no problem to explore the park with a wheelchair.

Scenario 10: Smart lighting system

The two girls, who have lost track of time due to the many smart novelties in the city, notice that it is gradually getting dark and decide to make their way home.

On the way to the train station they notice that the park lights as well as the pavement lights only turn on when someone is underneath.
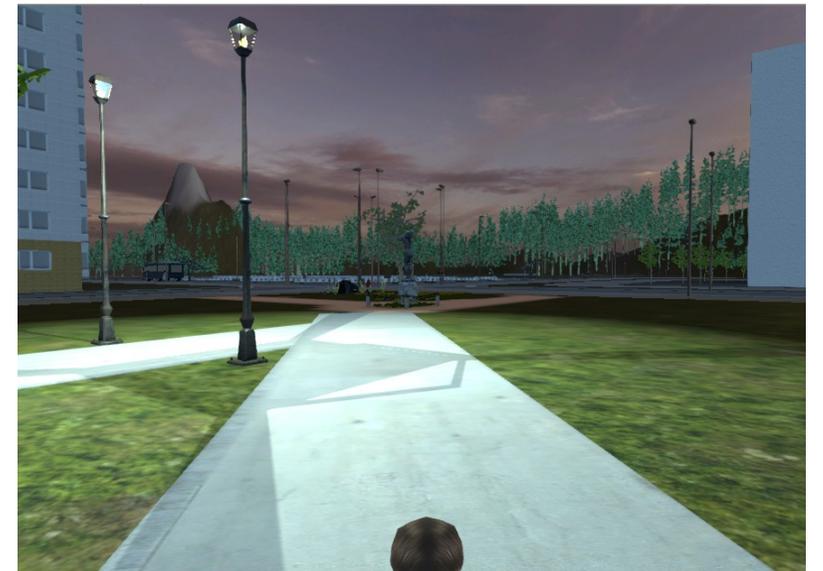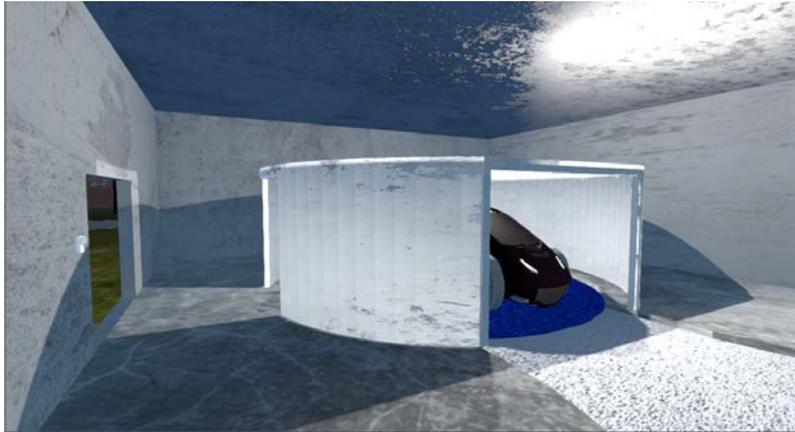
Scenario 11: Call a taxi and get your car back

After Lucy and Emma have said goodbye to each other, Lucy calls a taxi that will take her back to the carpark.

Once there, she opens her Smart City App to get her car back using the QR code that she received on her mobile phone at the beginning of the parking.

Lucy gets into her car and leaves the carpark.

The End

Spin-off

The main users of the Smart City App will be the residents of the City, this is why we introduce this area in detail in our App.

After logging in, you will get to the overview page, where all tools and areas of application are presented. We have especially worked out only those areas of application that are currently relevant in our city. This includes the areas Bills, Public Transport, Driving and General.

In the public transport area, you can find the map for trains and busses, you can rent bikes and scooters and call a taxi, or you can recharge your public transport ticket and buy a new one. We have also integrated a Journay Planner, which always shows the fastest way from A to B.
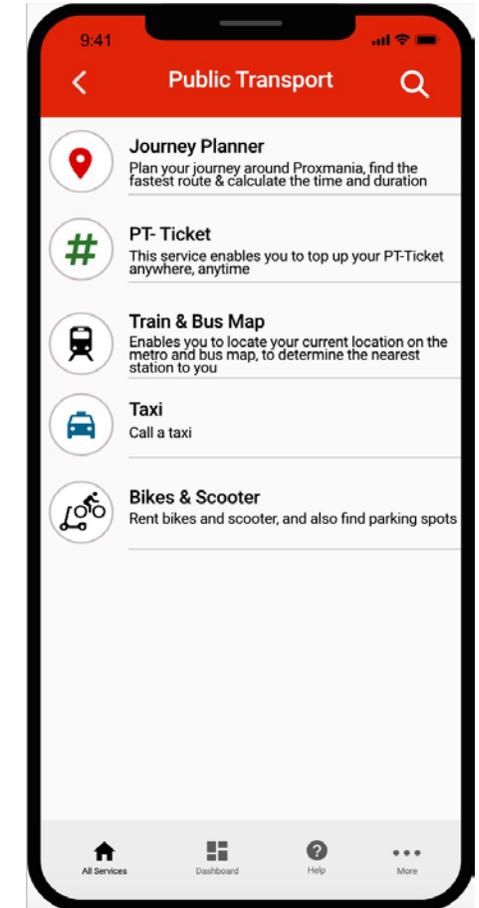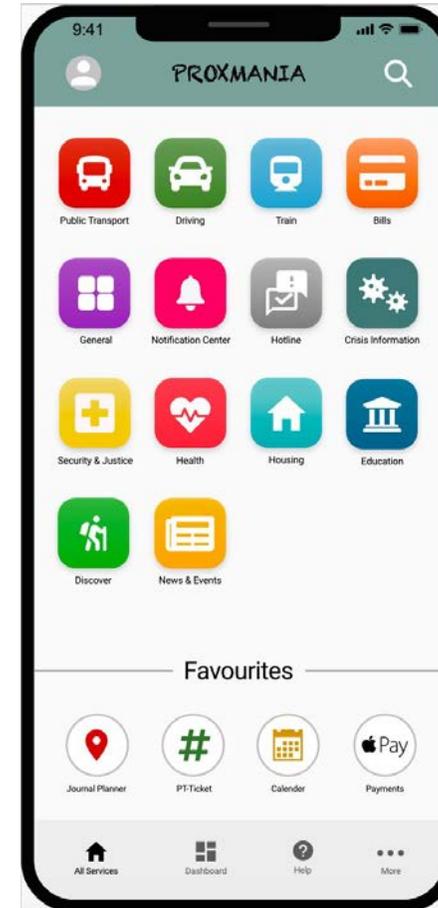
In the Bills area, all bills can either be paid immediately by clicking on "pay all" or by clicking on the individual bills, which will be settled. To go briefly into the "Roads" area. The cars in our city will have a digital car plate number in their windshield. You can either connect this number directly to your bank account and the outstanding amount will be deducted automatically or you do not connect it directly to your account and the bill will be settled via the app. The same applies to the parking area.

In the general area you can check the weather, order food and find out the password for the city's Wifi. Here you can also find the city map and all public toilets. For the cyclists there is a map with all bike lanes of the city, stations where they can have their tires repaired and charging stations for e-bikes.
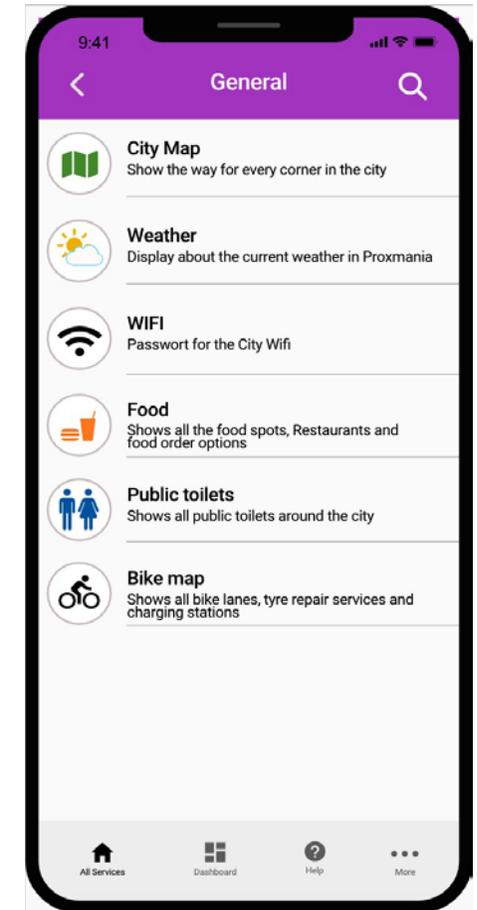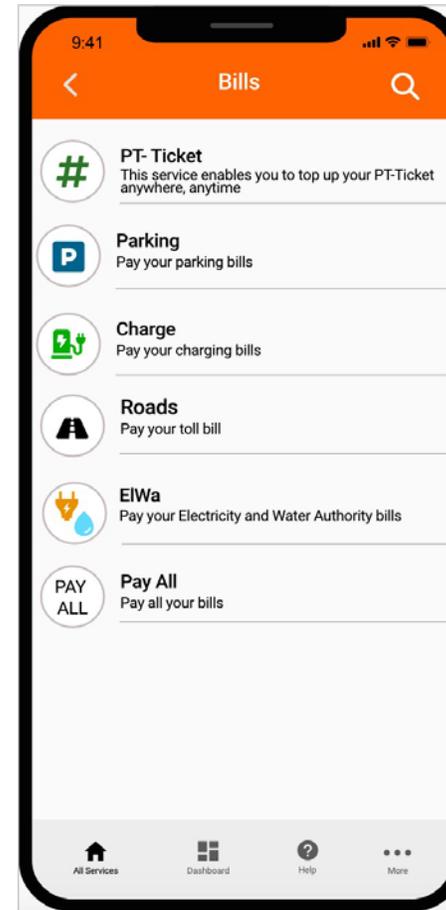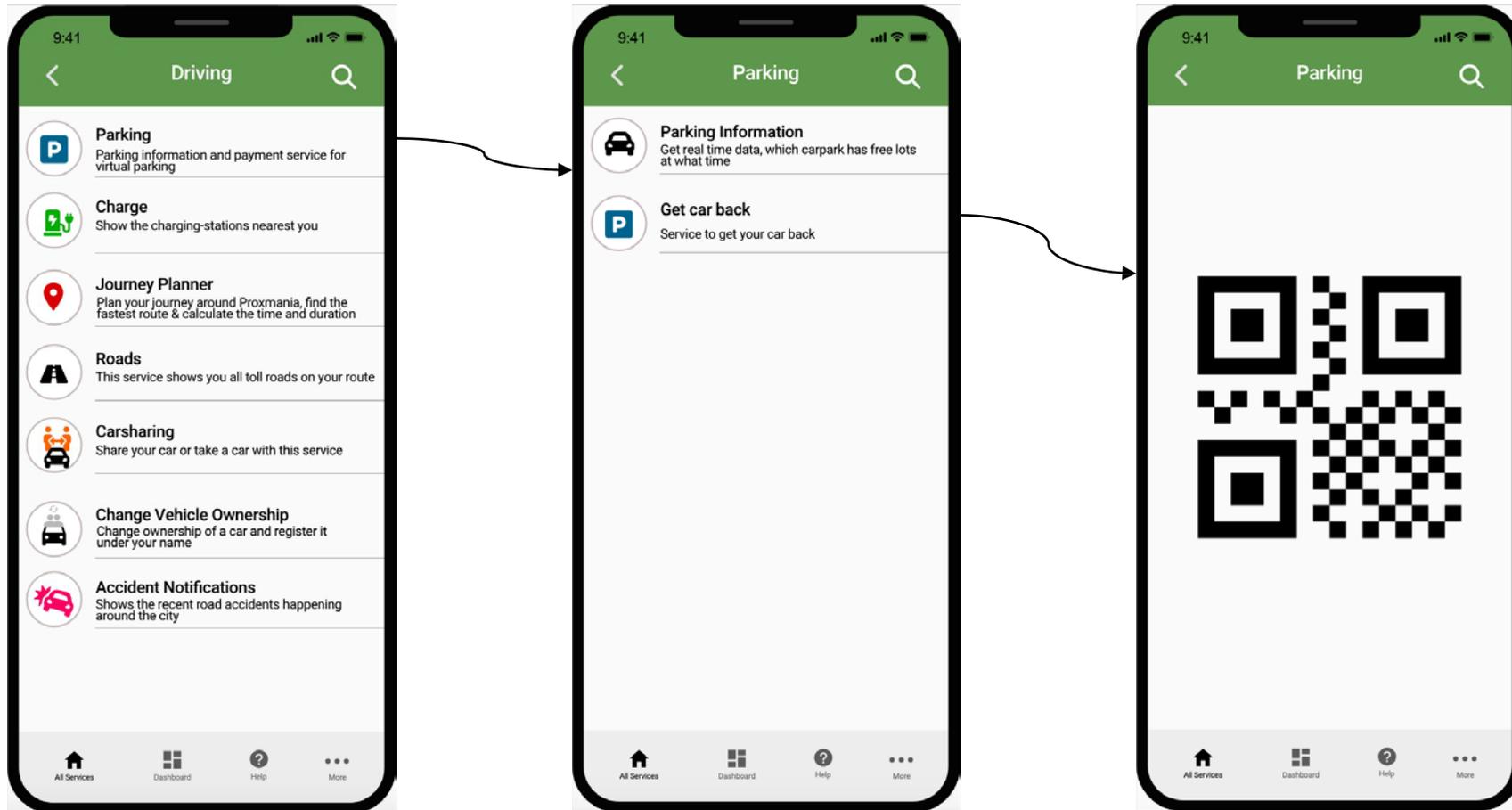
The Journay Planner from the Public Transport area can also be found in the Driving section. With "Parking", you get the evaluated historical and real-time data, displayed on the Smart City App to filter out the parking lot with the best chance to find a free parking space.

Outside the city you can drive with "normal cars" as usual, so we found the accident notification application important. We also integrated other areas like change ownership, car sharing and maps for charging stations.
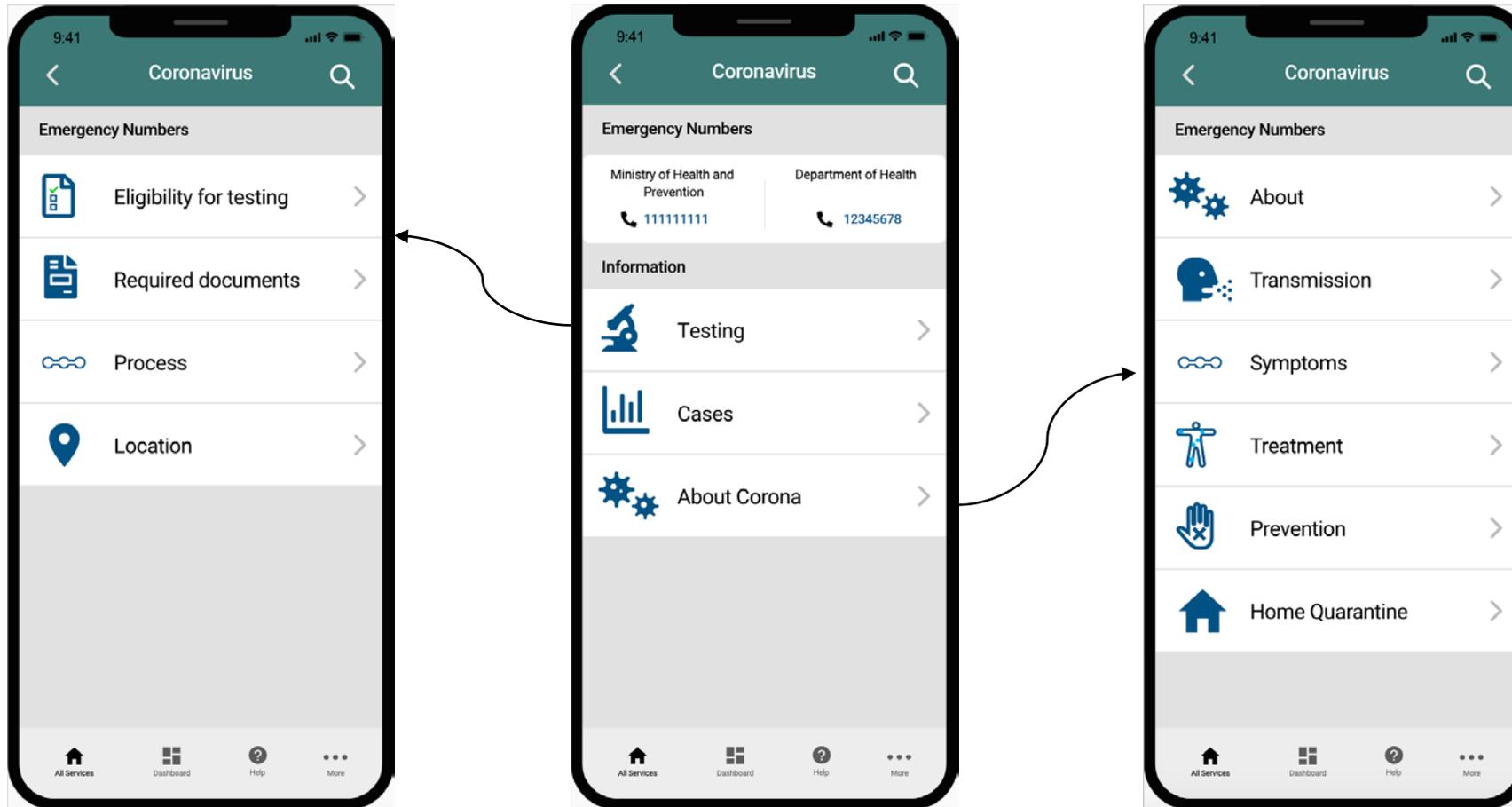
Due to the Corona crisis, we have seen that many people have become more and more anxious and the media has reinforced this with false reports. As we have already shown above in our future ideas, we have thought about how a Smart City should behave in a new crisis and what could possibly happen better during a Smart City lock down.

Since the topic of the Corona Pandemic is also a burden for us, and unfortunately, we couldn't think our thoughts further due to lack of time, we have nevertheless decided to include this point in our Smart City App. The idea is that people get real-time updates about the number of infected people, information about symptoms, behavioral instructions, and regulations directly sent to the Smart City App.

Future ideas

Emergency services:

Since we have chosen an autonomous transport system in the city center, we have to consider to what extent ambulance, fire and police vehicles should drive autonomously, or these should be the only vehicles in the city that will not drive autonomously. What are the risks of a concept with autonomous and non-autonomous vehicles in a city? Is there possibly another solution to how an emergency service could function in an autonomous city.

Service and delivery service in a city:

How will parcels and mail be delivered and delivered in an autonomous city center in the future. Does a large collection point make sense at all and how will the parcels be transported from outside the city to the city without having to have a truck drive into the city, because that would not be allowed in our autonomous city.

What we also dealt with was the supply of supermarkets, restaurants and other shops that regularly need food or goods.

It is incredibly important to think about how these can be supplied later on. Because without shops and restaurants a city is no city. In addition, services such as road and gardening work should not be forgotten. How should they do their work in a city in the future? Is an autonomous vehicle useful here or would it block the streets for too long?

Sustainability:

In our simulation, we did not deal much with buildings, but it is precisely these that must be built more sustainably in the future. Considerations like green buildings or solar walls are approaches that are already being tried out in some cities.

Universal design:

The integration of all people in the city was a concern for us and this concern must be respected in the ongoing projects. It would therefore be essential to orientate the city even more towards this concept in order to be able to really call it a universally designed city.

City in lock down:

In view of the situation we are currently in, one could see again and again how difficult it is for cities to lock themselves down completely. The contact between people could not be completely closed off. The question we asked ourselves was how a Smart City could operate in the future with a lock down, so that people no longer have to go outside and still have food and medicine available, in other words how the food supply could be maintained. For our part, we were thinking that maybe grocery stores and restaurants could combine their goods and thus supply the city for a longer period of time without having to import new food from outside on a regular basis.

Helpful information for the next group

How to create a 3D model?

It exists different software that can be used to create 3D objects, but you should pay attention to their compatibility with Unity.

- Google Sketchup

- Inventor

- Creo

- Catia

- SolidWorks

- Blender

- …

How to import a model in Unity?

- Unity accepts these formats:

- .FBX

- .OBJ

- .BLEND

- .MAX

https://docs.unity3d.com/560/Documentation/Manual/3D-formats.html

How convert a 3D model?

If the software you chose can not export your model in one of the formats mentioned above, you have few solutions but always associated with a trial time:

- Plugin Pixyz (7 days trial)

https://www.pixyz-software.com/download/

- CAD Exchanger (30 days trial)

https://cadexchanger.com/

General advices:

- If you want to color a model, make sure to have an assembly of different parts because a color can only be applied to a part.

- You can add color to your models but no textures (as far as we know -- 06/2020)

Helpful information for the next group

How to put textures on a model?

- We used Blender to add textures on our 3D models

- Convert your model as a Blender readable file (we used .FBX)

→ It must be an assembly of different parts if you want to put several textures

- Add textures on the model https://www.youtube.com/watch?v=fZSD7pVIUkY&t=278s

- Export it in Unity https://www.youtube.com/watch?v=xeZ918ppEDQ&t=609s

General advices:

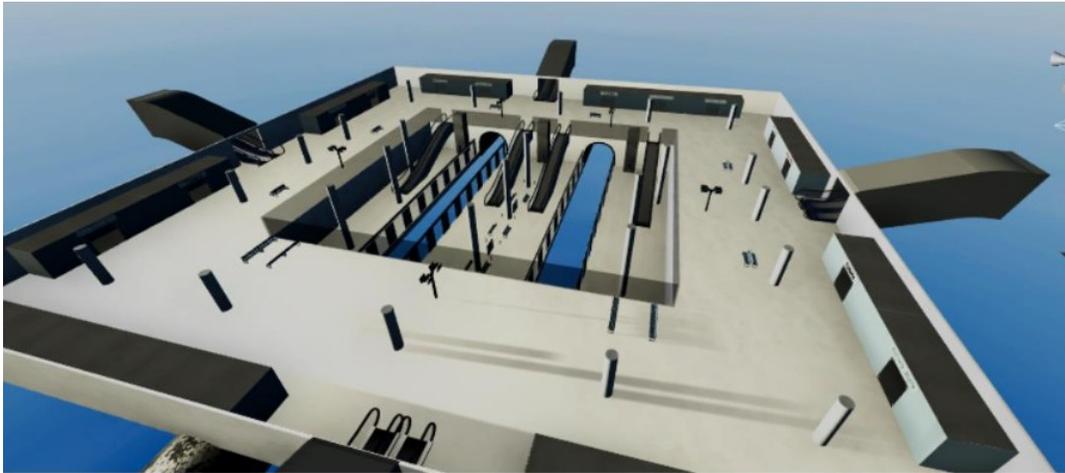- Rendered model in Blender looks different in Unity

Screenshot from Unity
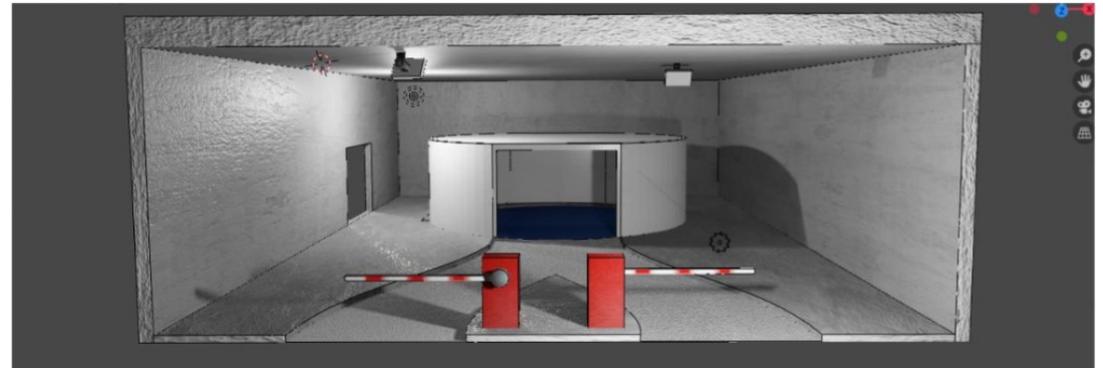
Screenshot from Blender

Helpful information for the next group

Screenshot from Unity

Screenshot from Blender

OSLOMET

Spring Semester 2020