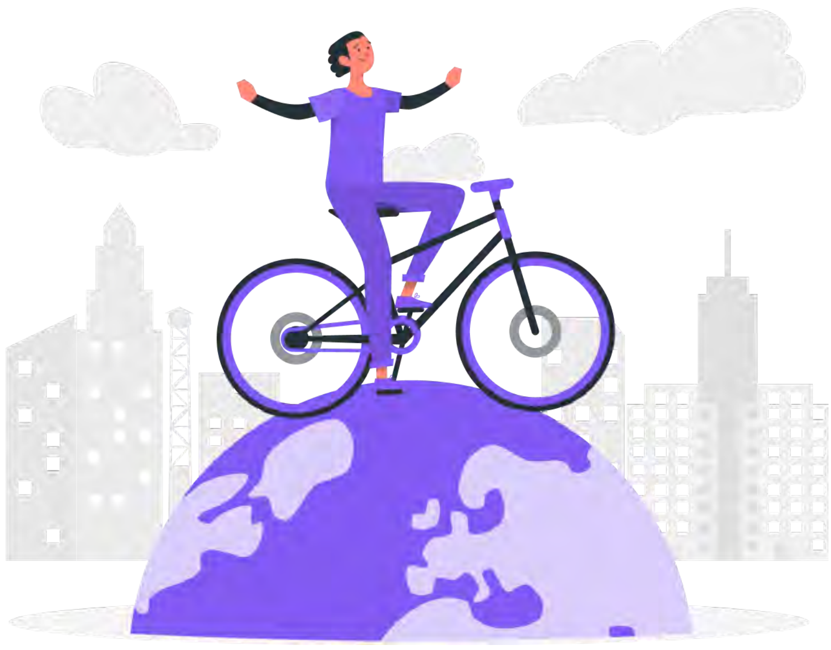

BEYEK

GPS bike monitor system

Figure 1: Logo of BEYEK

Course: IOB3-3 Data
Coach: Sander Mulder
Group: 11-04
Date: 01-11-2021

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Preface

This report was written by Sirian Maathuis, Yannick Renzen, Ian Tiemann, Mees van Boeckel and Joram de Haas, second-year students Industrial Design at TU Delft. The report was written for the subject *IOB3-3: Data* and is the accumulation of 8 modules where the societal challenge of bike-related problems in Amsterdam was analyzed and tackled. This report will showcase a bike tracking system that aims to solve this societal problem.

We want to thank our coaches Sander Mulder and Amine Allai for all the feedback they gave during the modules and for guiding us through the process of designing the tracking system and writing the report.

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Summary

This report aims to understand the bike parking problem in Amsterdam and introduces the product-service system (PSS) BEYEK to solve it. BEYEK wants to achieve this through redirecting bikes to park in less busy areas, through sharing parking information to users and the local government with the help of GPS and NFC monitoring. The local government can make dynamic regulations with this information to achieve this goal. These dynamic regulations can be enforced by BEYEK with the use of the app, dashboard, and GPS in the bikes.

Chapter two is all about the data use of BEYEK. This chapter will go into depth on what data ecology BEYEK lies in and how BEYEK fits within this data ecology. This will be done by describing BEYEK's data model, formulating a data collection strategy, and making a start on how this data will be visualized, which will later be expanded on in Chapter 3. The chapter will also describe other data-related challenges. These challenges include which values BEYEK strives for and how data can help us ensure or break these values, and which stakeholders have an interest in BEYEK, and how these stakeholders are connected through data use. This chapter also includes most of the work done in the modules, as was described in the report outline for this course.

In the third chapter we discuss how we made Beyek into a more tangible product by creating 2 prototypes, a mobile version and a desktop dashboard version. These prototypes are built upon a brand identity based around friendliness, calm but also modern and futuristic. The design of the prototypes is explained and its main functions are visualized. The designs keep current trends in app and web design in mind and provide a base for building out the rest of the UI and future features.

This proposal is made for the local government of Amsterdam, because of the perfect fit with their key values and its addition to the already existing infrastructure. In this way, BEYEK wants to expand on the already existing "Meerjarenplan Fiets" with the use of smart data monitoring of real-time activities of bikes throughout the city. The system of Beyek will require initial investments

but will be self-sufficient after implementation. Data will be shared between Beyek, the government, and parking organizations, but split so that the privacy of users is maintained while also supplying the government and parking organizations with enough data to make changes. The product-service system of BEYEK aims to include everyone and aims to have as few limitations as possible. Therefore, recommendations will be made to include everyone including the elderly, tourists, children, and handicapped people.

Introduction

Parking your bike in the busy places of Amsterdam seems to be impossible. In 2018 a record number of bikes were towed away (Claus, 2018). People not from Amsterdam get overwhelmed and parking your bike is a whole other challenge (Kevenides, 2019).

This report includes a product-service system (PSS) named BEYEK that can be used to monitor this problem by measuring the location of the bikes and the busyness of the busiest streets. This service can also solve the problem with the use of this data by making regulations in areas that include but are not limited to a small fee, a max parking time, or setting up mobile parking stations. The service can improve the current situation and make Amsterdam a more pleasant cycling city.

The report consists of 4 chapters. The first one introduces the product-service system and its components. The second chapter discusses the use and integration of data in our concept. The third chapter goes into depth about the interfaces, namely the app prototype. The fourth and last chapter goes into detail about the value that Beyek will have for the city of Amsterdam.

1. BEYEK - a GPS based parking service for bikes

1.1 The importance of BEYEK

BEYEK wants to solve the problem of the overly crowded bike parking spots in Amsterdam by redirecting bikes to park in less busy areas. BEYEK will lessen the problem by decreasing the number of bikes in the area. BEYEK will solve the problem that bikers have when trying to park a bike and the problems while trying to find the bikes. Protection against theft and damage comes into play here as well. The data necessary for BEYEK to work is not available at the time. This is why we make our own; to provide BEYEK and the government with the right data for the job. By solving these problems, we will make the streets more reachable for all people and solve the problem that bikers have when moving from point A to point B and back again.

1.2 BEYEK services

1.2.1 Busyness report

Firstly our concept starts with adding GPS systems to bikes. This data is used to make a busyness map of the whole city. This map is shared with both the city of Amsterdam and the citizens. The city will use this map to analyze hotspots where there are a lot of problems with parking. By pinpointing the problem they can take measurements against the problem.

The people of Amsterdam also can view this map through the BEYEK app. This is visualized inside the app with different layers stacked on a map. The layers include busyness, locations to park your bike, and regulations per area.

We use GPS because this will give us the most accurate data and is more future-proof than for example pressure plates or other methods of registration.

The use of a GPS also gives exact data on the whereabouts of bikes, which allows for integration with the bike depot of Amsterdam.

1.2.2 Dynamic regulations

With the busyness data, the local government can make regulations in certain areas. For example, in the city center, there could be a parking fee of one euro per hour. The fee does not have to be high. It is just a way to make people think twice about leaving their bike right there. Quiet areas a couple of streets further are free and hopefully, people get tempted to park their bikes there. This way the bikes are more dispersed and the problem lessens.

The regulations in combination with the app can support dynamic regulations. For example, during the busiest times of day, it is more expensive to park or people below the age of 25 can park free at cultural locations. Also, it is important that people can park for free at their work and home. This way the local government can include everyone and use it to stimulate culture and economy (this inclusion will be expanded upon in chapter 4).

1.2.3 Less costs for the bike depot

Our system will also monitor the movement of the bikes. Bikes in public spaces that have not been moved for a long period can be brought to the bike depot. This is more efficient than the way Amsterdam does it now. They mark bikes and go by two weeks later to see if they have been moved. With our concept, this can be done more efficiently. Each bike has an NFC tag ID to identify itself on location. This ID is the same ID used as the GPS identifier to easily find and monitor bikes. This ID is sort of like a license plate of a car. You link your bike to yourself. This data is not available to the government, only to BEYEK.

1.2.4 Always a safe place to park

Because every bike has a GPS system onboard the bike is protected from being stolen. The GPS is integrated into the frame and can not easily be removed. The bike’s location is visible in the app. This is also useful when you forget where your bike is parked.

1.2.5 Other BEYEK Initiatives

Another possible solution is the use of mobile parking stations. These stations can be put into use in busy areas or during events. These stations are decorated by artists and have more than one level to park bikes. This way the amount of bikes per square meter is increased.

BEYEK can also work together with cultural organizations like museums to make a custom parking station or maybe even integrate a privately owned parking station to do payments via BEYEK. We strive to integrate other companies. Partly to make one system for the end-user and to make sure a trusted organization monitors the sensitive data.

2. BEYEK Data Integration

This chapter will go into more depth about how BEYEK uses data as a design tool, which (types of) data were used in designing the system, which data shall be used, and how these different sets of data are connected.

2.1 Exploration (Module 1, 2 & 3)

2.1.1 Highlighting the Societal Problem

BEYEK wants to solve the problem by monitoring the traffic flow and busy parking locations to take appropriate measures. These areas contain a large number of bikes, in some cases to the point that it gets uncontrollable. People feel overwhelmed and It is a big problem as described before (Kevenides, 2019).

We want to discover how many people cycle to and from school/work, where and which roads are used. We want to analyze the busy biking areas and the number of deposits that are located there and needed. With this data, we can make sure everyone has the parking space they need.

Using BEYEK's bike tracking system we want to locate the spots where the biggest bike parking blockades are located and solve the problem at these locations. We'll do this with dynamic regulations and initiatives. As an example, the local government can enforce dynamic regulations like described in chapter 1 to disperse the bikes and lessen the problem.

We also want to generate this data for more accurate datasets which can be used to improve the regulations. The data can also be used to inform the citizens of Amsterdam in their cycling habits with busyness maps.

To conclude, the most important data we need and want to eventually generate ourselves is the traffic flow and parking location busyness. With this data, we can make dynamic regulations in different areas and maybe even different periods.

With these regulations, we want to improve the problems caused by the enormous number of bikes in Amsterdam.

2.1.2 Data Ecology

When starting this design project an exploration phase was needed. In this phase different aspects of the bicycle problem in Amsterdam were explored, these included a variety of different smaller problems that are caused by, or connected to the problem. This was done to get a proper view of the ecology in which the bicycle problem of Amsterdam lies. To visualize the problem, a Data Ecology Poster (Figure 2) was made highlighting the individual problems within the greater web of our societal problem.

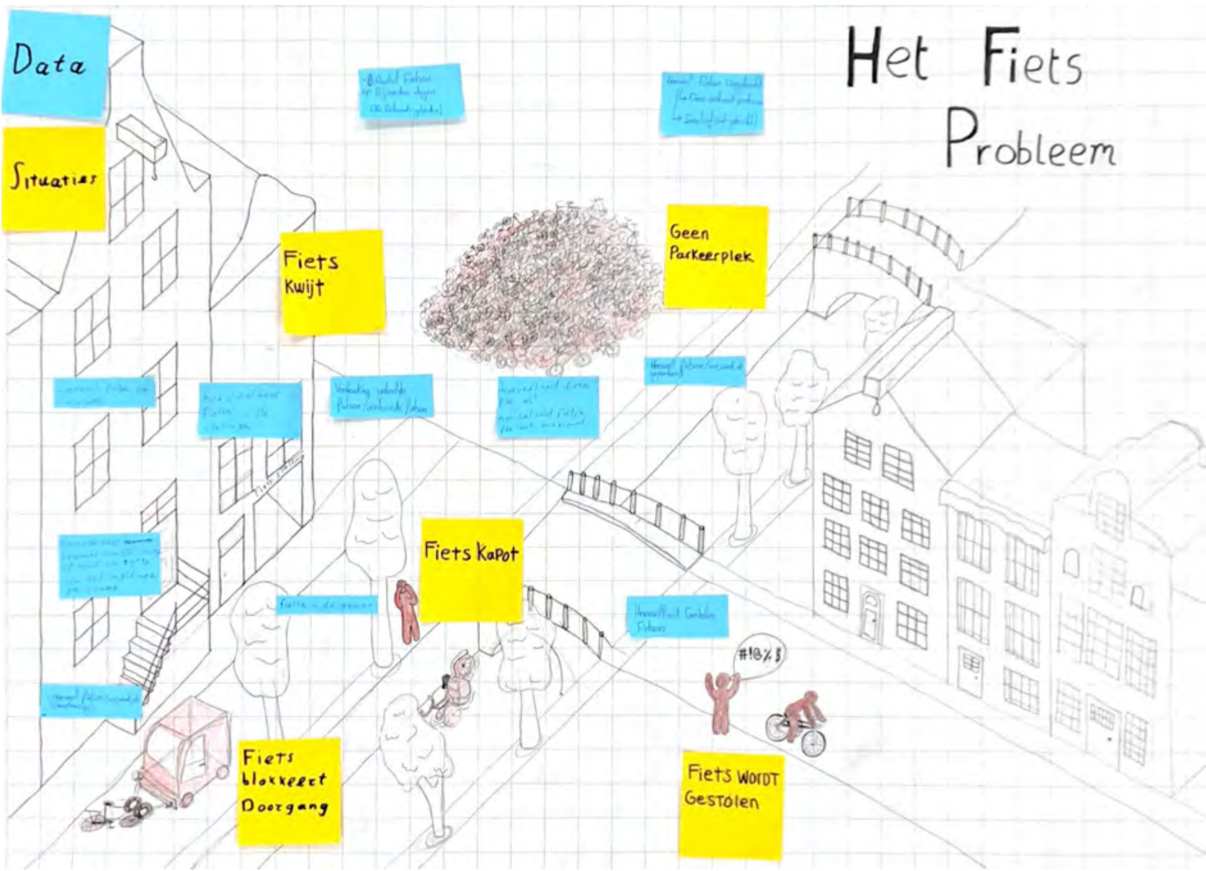

Figure 2: This is the total overview of the data ecology poster. Because it can be hard to read it will be zoomed in on different parts.

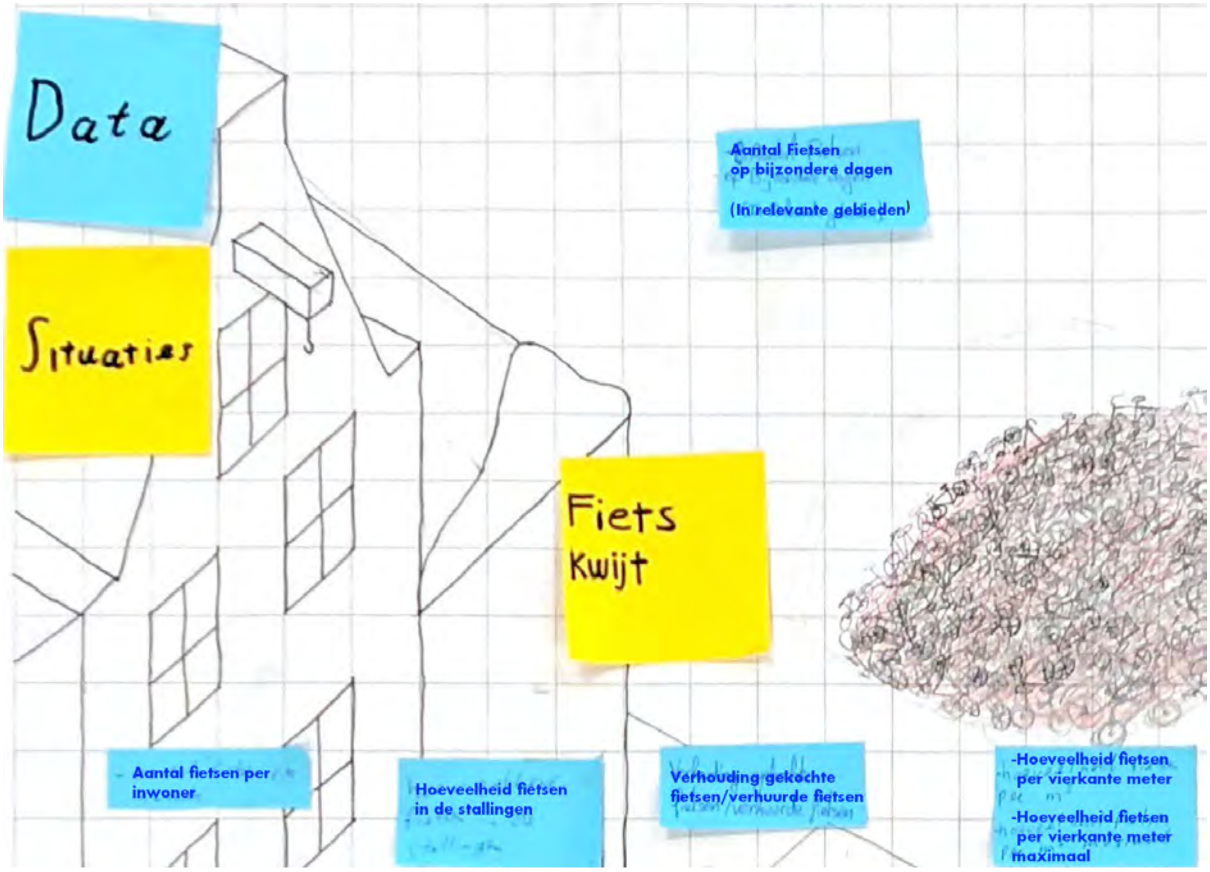

Figure 3: Top left part of the poster.

As is showcased above, the yellow post-its signal different situations and problems that happen within the societal problem, the blue ones signal types of data we can use and generate to gain an insight into these situations.

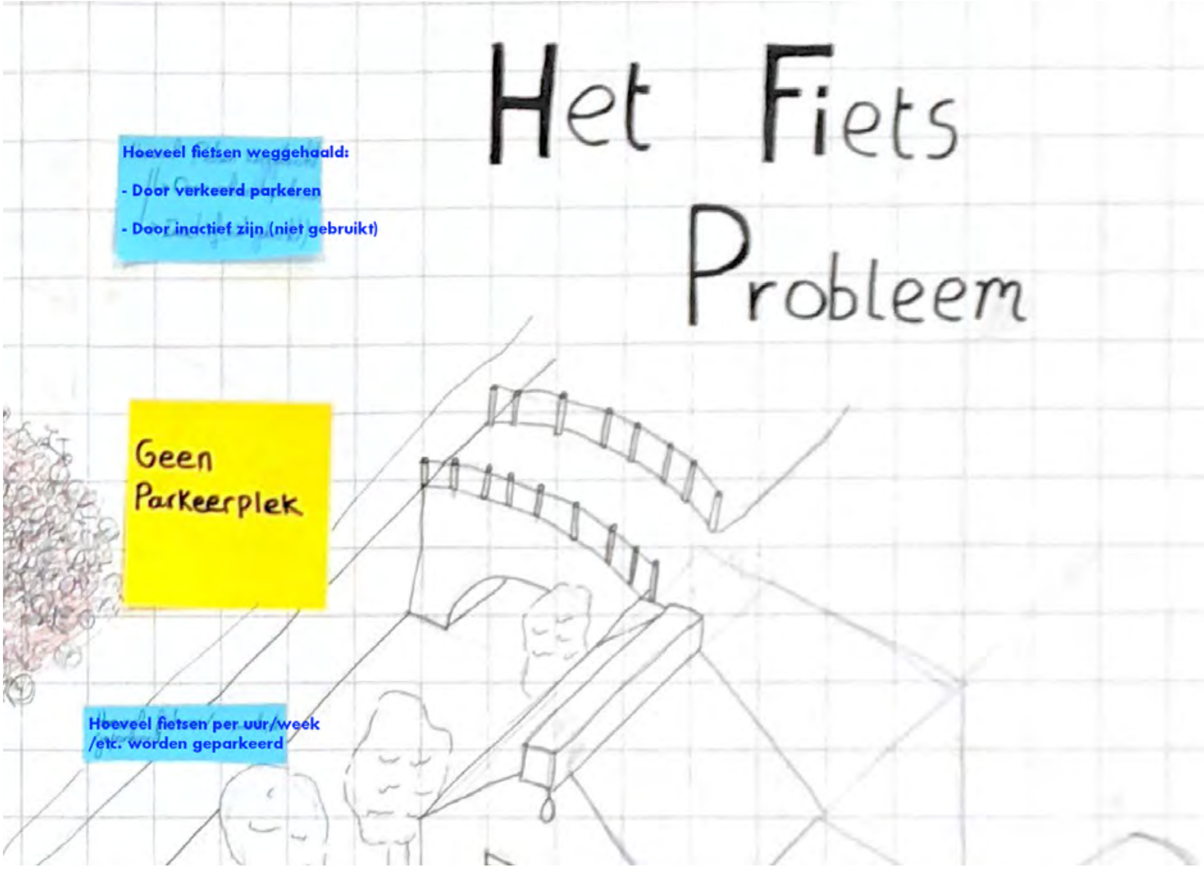

Figure 4: Bottom-left part of the data ecology poster.

As can be seen, we highlighted the smaller problems of people not being able to find a proper parking space for their bike as well as examined two types of datasets that are useful in analyzing and solving this problem within the societal challenge, in this case, these were the amount of towed away bikes due to them being parked wrong or abandoned and the amount bikes parked in that area per hour.

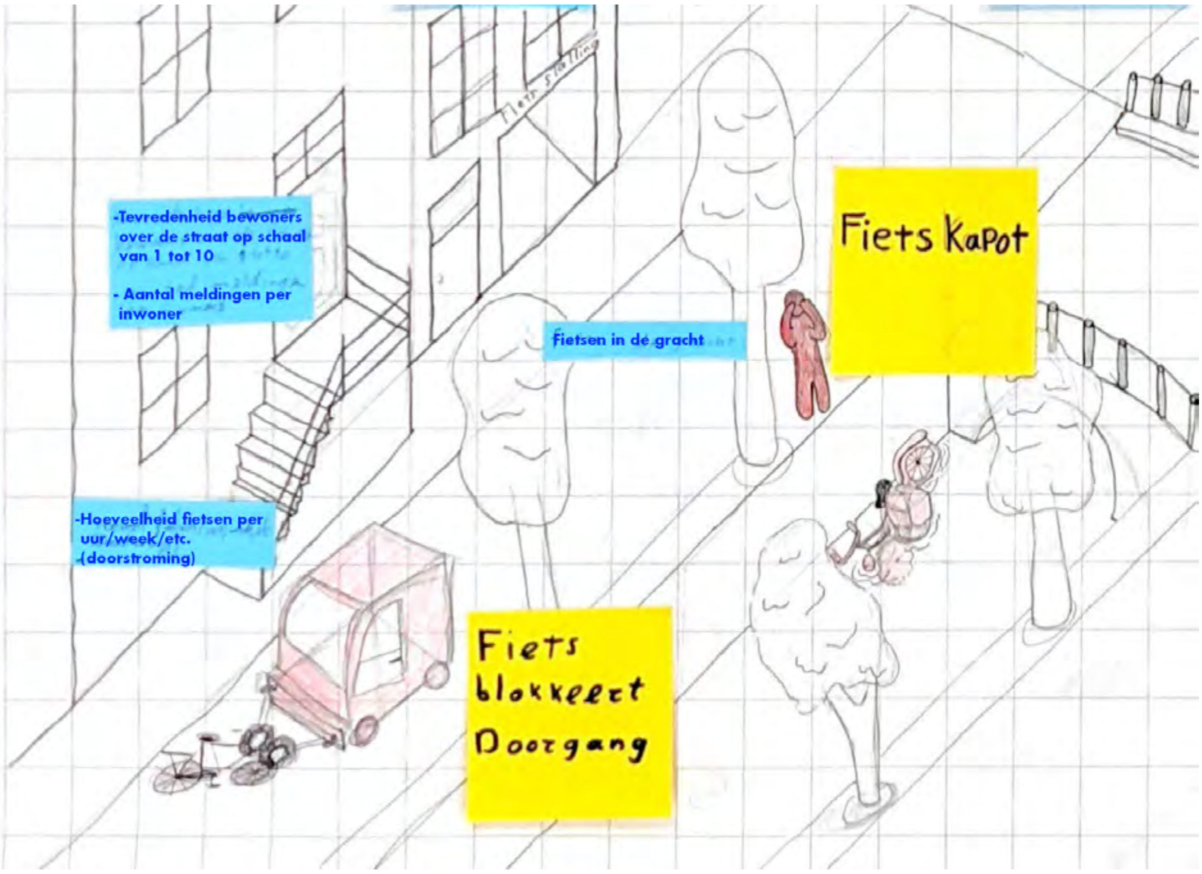

Figure 5: Bottom left part of the data ecology poster.

This part describes the problems of Bikes being damaged and blocking roads for all people in Amsterdam.

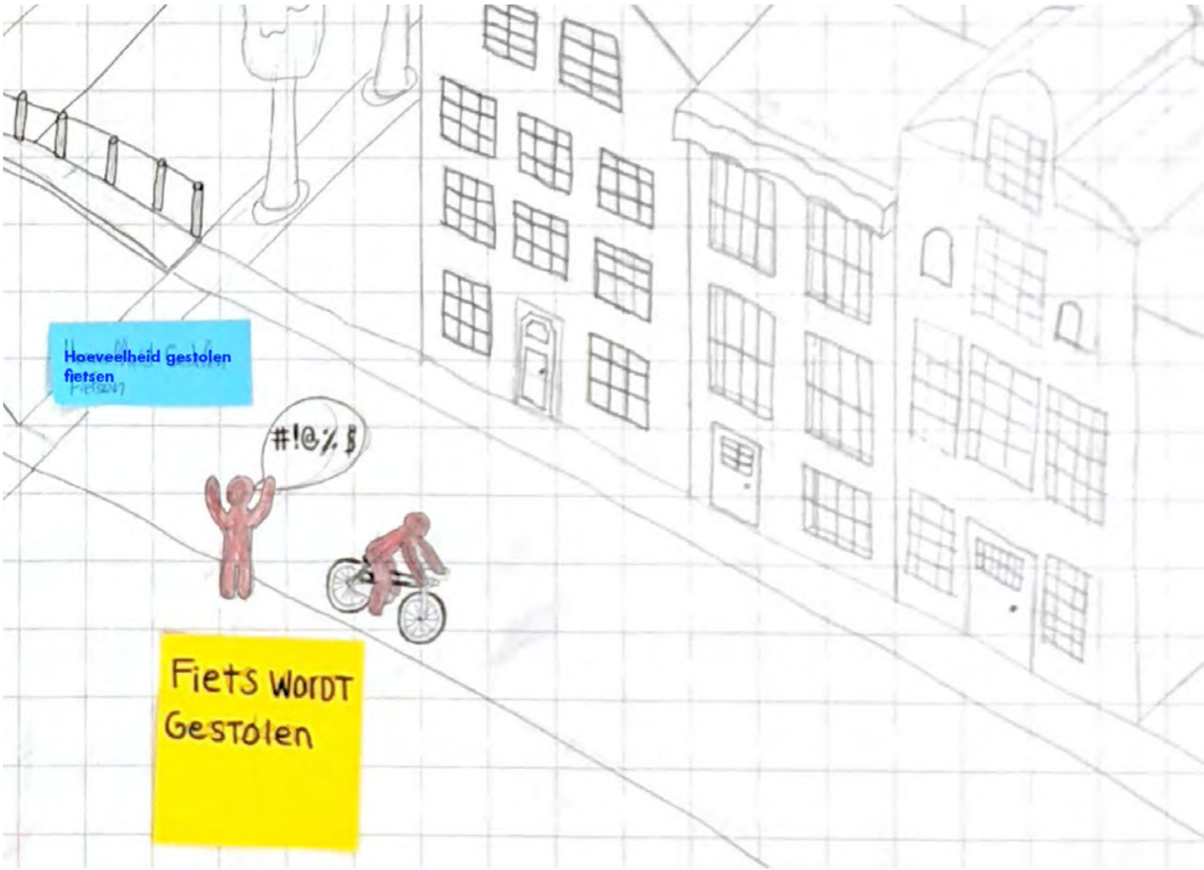

Figure 6: *Bottom right part of the data ecology poster.*

This part describes the problem of Bikes being stolen.

2.1.2 Data Modeling

After getting a greater view of the ecology surrounding the problem, a data model of BEYEK was created. In making this data model the main entities that describe the elements that make BEYEK work were identified. These entities were analyzed as to what attributes they have and their place in the system and put together in a large data model that describes BEYEK's data flow **(Figure 7)**. This data model will be very useful when developing the software BEYEK will run on.

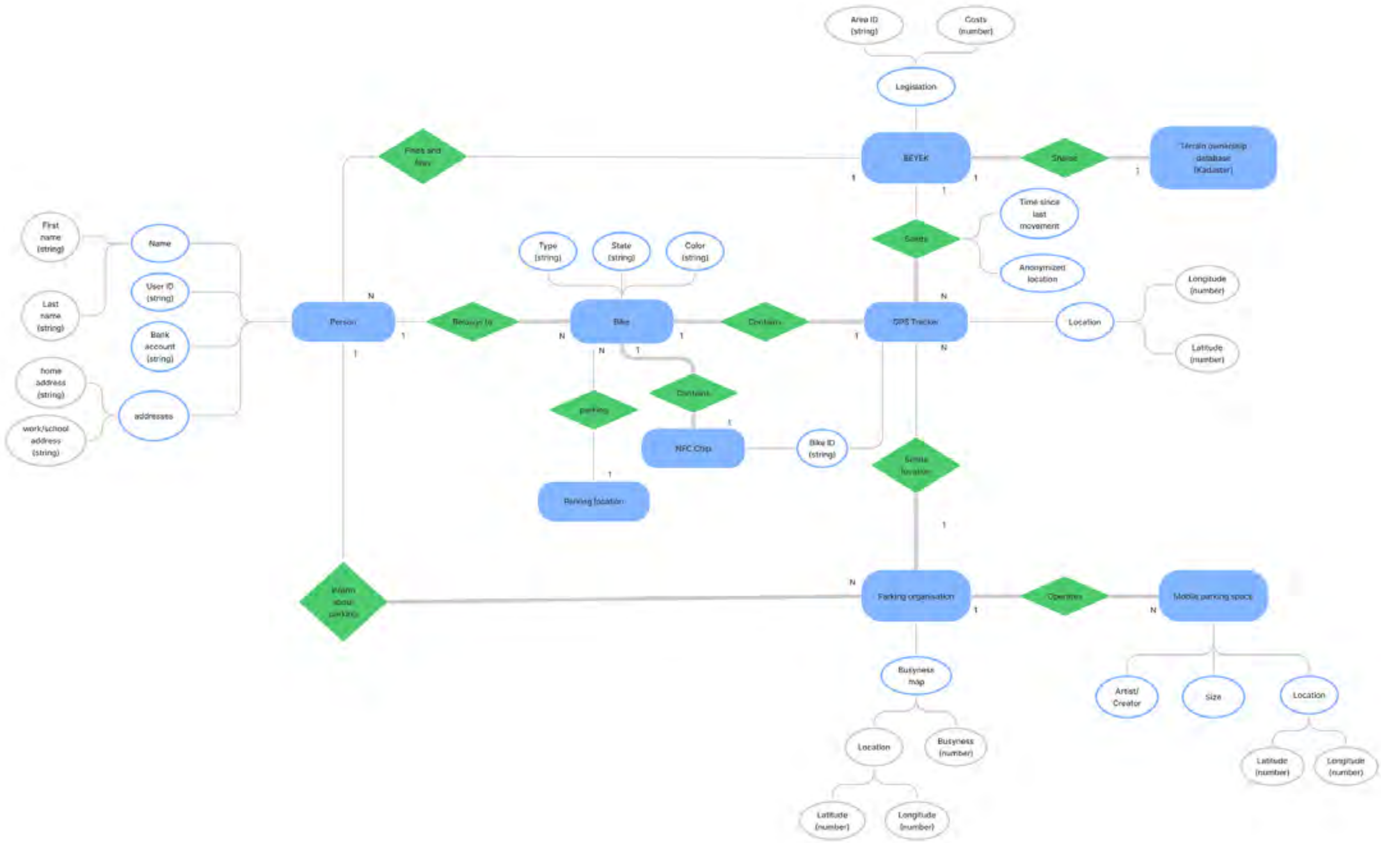

Figure 7: BEYEK Data Model

This data model was created by working with our team who each individually went through an iterative process to create a data model for BEYEK. After these iterations, everyone presented their final data model and there was a discussion on what elements of everyone's individual model worked well and what didn't. These individual models were then combined and optimized into the final data model as seen above. Although everyone's experience on the iterative process to create the model was different, most of us encountered the same problems during the same phases. In the first iterations our team tried to identify the main actors in BEYEK's system, label them as entities, give the proper attributes to these entities and identify the relations these entities have with other entities, the quality criteria of correctness was the main focus here. In BEYEK's data model an example of these entities are the bike itself as well as the tracking chip, these have a relationship where one contains and tracks the other. In later iterations, completeness was the most important aspect to focus on as everyone noticed that their first iteration was far from complete, so extra entities and relationships that were forgotten at first were added. This meant that in the last iterations minimality and readability were crucial as when finalizing the data models, we had to get rid of redundant entities and review some relationships and attributes that were made when trying to make the data model complete. Naturally, when finalizing our final data model, double-checking its correctness was again crucial.

2.2 Data Collection (Module 4)

2.2.1 Data Collection Strategy

BEYEK's data collection strategy is to insert NFC/GPS Chips in every bike in Amsterdam to collect their location data to real-time create busyness maps that showcase the cycling habits in Amsterdam. This data can then be used to locate the busy roads and know where bike deposits have to be placed, which bikes are abandoned, or in which areas a small fee for parking your bike should be introduced. However, this strategy can't be realized without some initial starting data to use as a substitute for the data BEYEK will be collecting during the development of the system, since when building the software BEYEK will run on this data will not be generated yet. The necessary substitute data consists of location data such as an overview of what is located where in the city, which locations are public and which are private property, where bike racks and other parking spaces are located. But also initial real-time data of busyness in certain locations so we can have an initial estimate of the cycling status in Amsterdam and tweak this estimate once there is more data on the exact biking roads people take at what times and where they park.

2.2.2 Necessary Data Sources

A multitude of open data sources was investigated to decide which ones would be the best fit for BEYEK. This paragraph will review the best fitting open data sources and how BEYEK plans to make use of them

OpenStreetMap (OSM)

OpenStreetMap is a completely open data source that consists of geographical data. It is a crowd-sourced mapping website and due to its blooming community, a lot of data is available about what is located where in the city, almost everything is mapped out in detail. It is located online and is easily found with a browser search as it is one of the most popular mapping applications available. It is also very accessible as the data you need can be accessed using a free online API named Overpass Turbo. Overpass Turbo is an online API that helps users find specific things in OSM. The API commands are very accessible using Wikipedia so there's no need to learn a specific language to use the API for collecting data from OpenStreetMap. The API converts the OSM data into data that is computer-readable and downloadable, after which it can be visualized or processed using different applications like Keppler, an online application where you can map out the OSM data downloaded using Kepler.
The data found in OpenStreetMap is mainly geographical data that links objects, organizations, areas, etc. to the geographical coordinates they're located in the real world. This type of data is very useful for BEYEK as it has a lot to do with locating objects (bikes, parking spaces, busy biking areas) in the real world in real-time. It's thus logical that a lot of the attributes in our data model can be matched with data found on OpenStreetMap, such as the 'business map', every 'location' attribute (which our data model has a lot of), and 'parking location'.
OSM has a lot of pros as an open data source, a lot of which I just listed. The main con of OSM is that it doesn't contain a lot of contextual data or metadata, it just lists objects, areas, etc., and gives their location, but it doesn't tell us anything about what these objects do, how people perceive these locations, etc. This

means that for our design concept we would have to get a lot of the real-time data, for example on the busyness of bike roads in certain locations, from a different source.

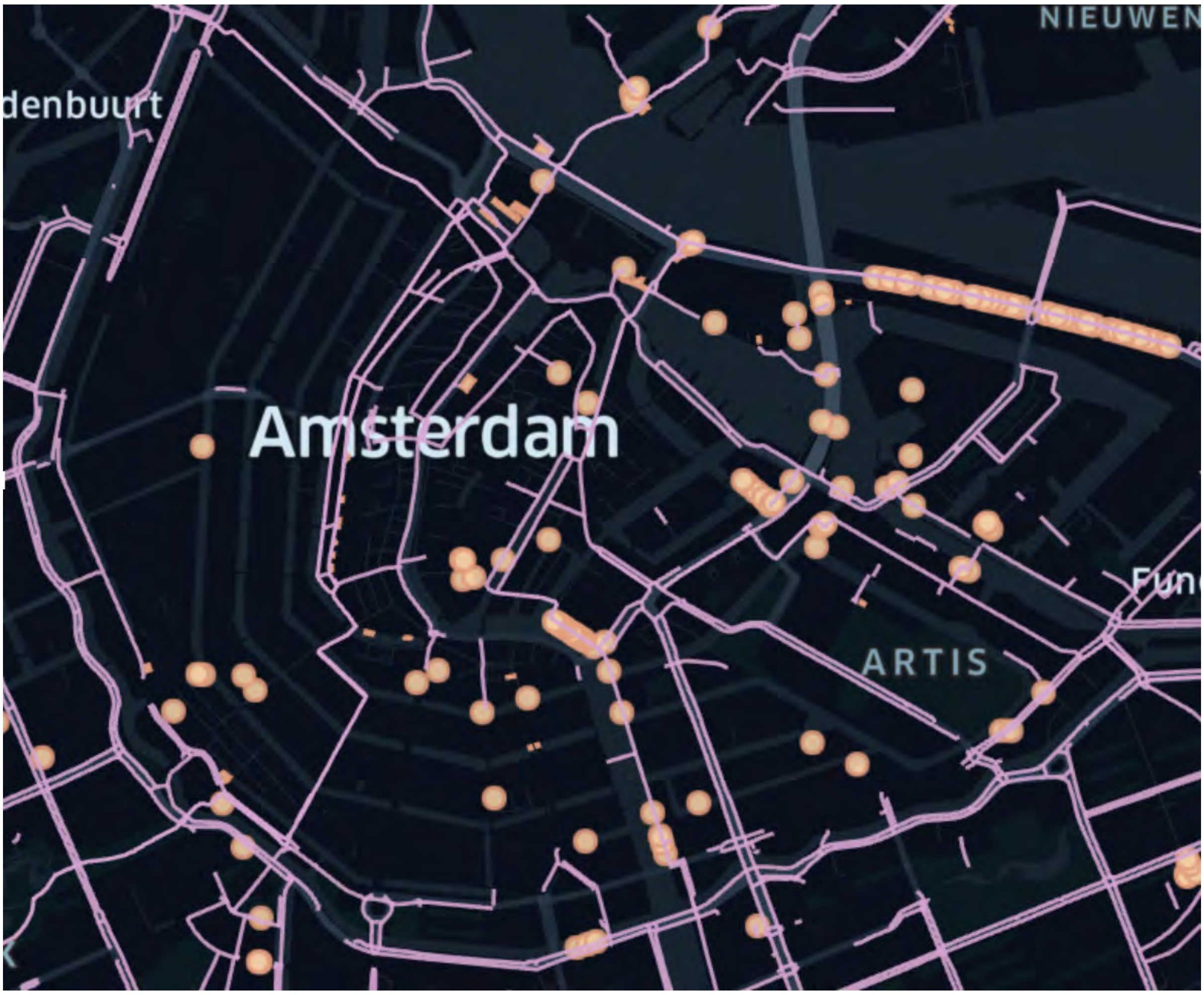

Figure 8: An OpenStreetMap dataset showing the location of bike racks in the center of Amsterdam, downloaded using Overpass Turbo and visualized using Kepler.

Data Amsterdam

Another good source to gather certain location data is Data Amsterdam. Data Amsterdam is a data source collected by the municipality of Amsterdam and thus is very reliable, they have a large amount of data on the city but the main one that stood out to us was the ownership map. The ownership map shows by who or which organization every location in Amsterdam is owned and thus is a great data source to discern private property from public roads, something that's crucial in our design model since we don't want to bill people for parking in their property. Using this dataset, we could set the areas in which bikes would be tracked and thus act more accordingly. This dataset is also a complete match with the entity of terrain ownership as seen in our data model. This entity is a necessity in our data model so our team is very pleased to have found a data source that matches perfectly with the database we needed.

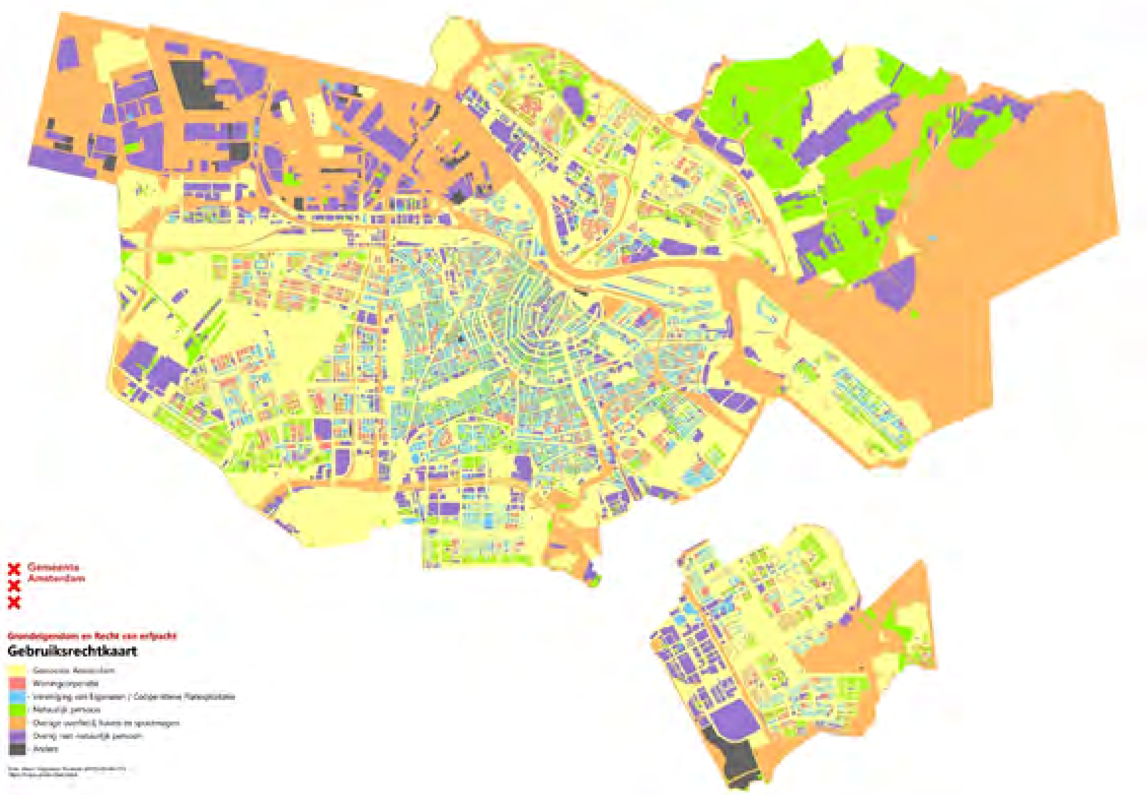

Figure 9: Data Amsterdam's Terrain Ownership Map

BestTime.App

The last open data source we decided was very useful is BestTime.App. BestTime.App is an open data source that uses Google Maps busyness data to create real-time heatmaps on busyness in certain locations. Since Google Maps is only a semi-open data source and the busyness data was all we needed from it, BestTime.App was the preferred option for us. These busyness maps naturally match with the attribute of ‘busyness map’ as seen in our data model. This attribute is necessary for the system to work as it is used to set dynamic regulations and manage mobile parking garages. At the moment the busyness data found in BestTime only consists of busyness in locations that are public buildings like businesses, museums, etc. This is different from the busyness data we need for our design model which is data on how busy the biking roads are at certain times. However, since we plan to collect this data ourselves, this busyness data is a great starting point since if there are more people in certain locations it generally means more people are parking their bikes in these locations too. We plan on using BestTime’s data as a starting point and switch to using our own collected data as BEYEK becomes more mainstream.

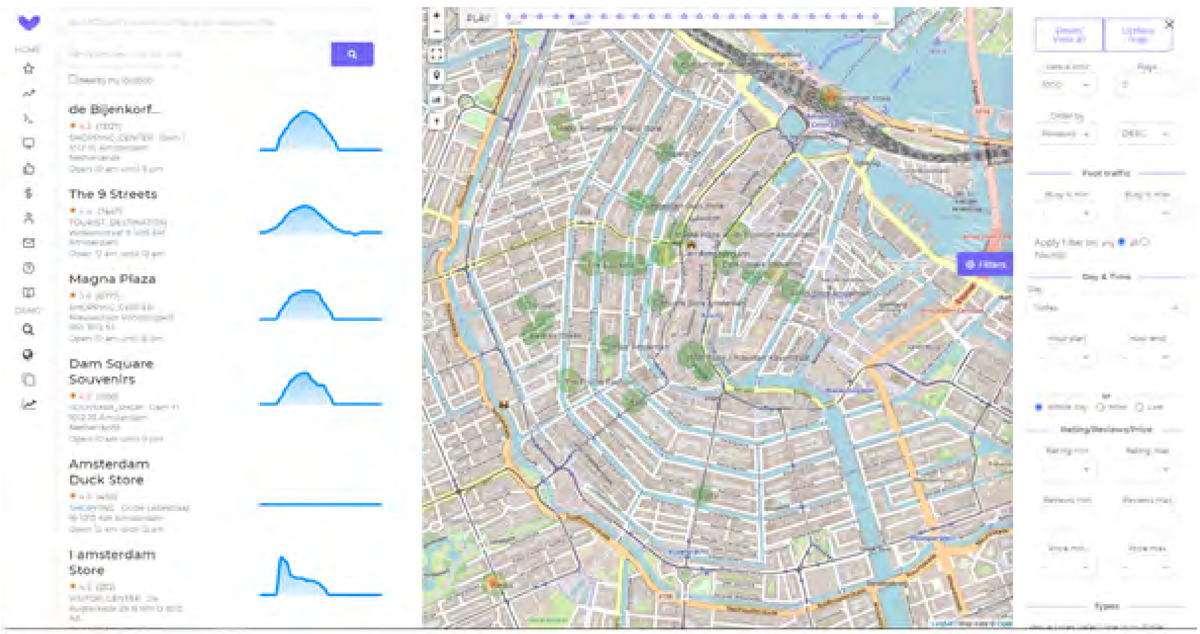

Figure 10: A BestTime.App heatmap showcasing busy hours at public locations in Amsterdam

I Amsterdam

Another usable open data source was found on the website of I Amsterdam. I Amsterdam is a tourism platform filled with facts and statistics about a large variety of subjects in Amsterdam, including its cycling habits, roads, and parking spots. It is located online and can easily be found with a quick browser search. The data is very easily accessible consisting of online tables of statistical data about the city of Amsterdam which are downloadable as a computer-readable pdf format, the tables are accompanied by articles containing lots of contextual information and metadata. The data on cycling has some data points that match with some of our data model attributes, such as the number of bikes matching with the entity 'bike' in our data model, and the amount of bicycle parking garages and bicycle racks matching with the entity 'parking spot' The data available is however very shallow. Because of the large number of topics on the site, I Amsterdam doesn't go into a lot of depth within one topic. The data on cycling in Amsterdam only consists of a table with some statistical facts about the cycling life in Amsterdam like the number of bikes in Amsterdam, the total length of the cycling roads, the amount of bike parking garages, and bike racks, etc. However, the data is very useful as a starting point to get a perspective on cycling life in Amsterdam.

Google Maps Platform

The final 'open' data source is Google Maps Platform. Google Maps Platform is a source offered by Google that allows you to use an API to retrieve data from Google Maps. It's an open data source in the sense that it is free up to 200$ a month, after which you will pay a fee that's linked to the number of requests you make with the API. Google Maps Platform is Located on the Google website or through an App. It's not that easily accessible as some of the previous data sources mentioned as you have to create an account and link a credit card to this account in case you exceed the 200$ limit. It's also less easy to use as the API isn't necessarily meant for general/personal use but rather for bigger businesses, therefore the API commands are more complicated than those of OSM for example. Where Google Maps Platform shines is its large amount of data and its large variety of data types. Since it is an API for Google Maps, the data types are a lot like the ones found on OSM and BestTime, geographical data which links objects to specific real-world coordinates, and real-time busyness data of certain locations. However, Google Maps also offers a lot of contextual data like photos, reviews, and ratings. A lot of attributes found in our data model can be matched to data found in Google Maps Platform. Examples of these are the 'busyness map' which you're able to create and visualize with the platform, geographical data like every 'location' attribute and the 'parking spots' entity but also data of 'legislations' in different 'areas' could be found in Google Maps Platform. A big pro of Google Maps Platform is that it's probably the most extensive data source out of the ones analyzed. However, it is hard to use and isn't free once you need it for bigger projects like BEYEK. For this reason, we'll use BestTime's busyness data to create the busyness maps, as BestTime uses the same busyness data as Google maps but is more accessible and open source. However, if BestTime's data isn't extensive enough or we need more contextual data of certain locations, Google Maps Platform is a very good backup data source to have.

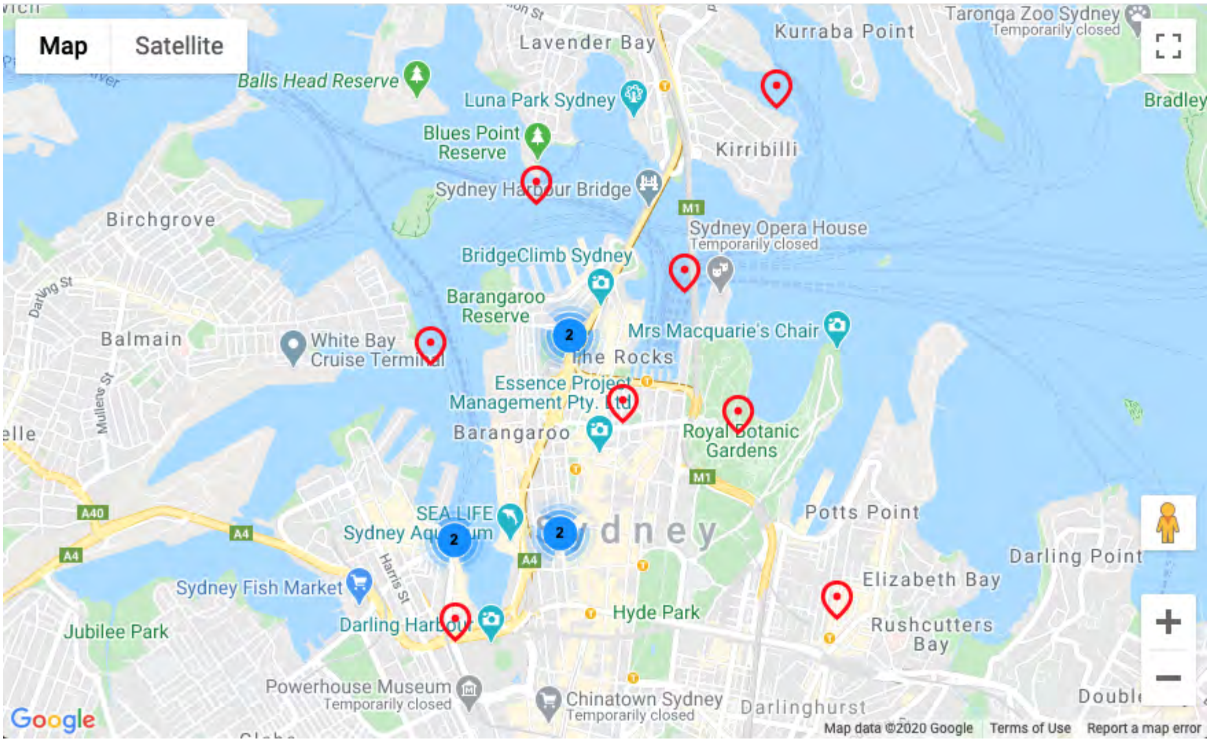

Figure 11: Custom Heatmap for Google Maps Platform

2.2.3 Feasibility

The effect that finding these data sources has had on BEYEK is pretty substantial. There was an assumption among our team that BEYEK wouldn't be that feasible considering the scale of the project. But after having completed this module it turned out that wasn't exactly the case as our plan on generating a lot of our visualization data means we will only need data to launch BEYEK because as it gets a grip there would slowly be a transition to collecting our own data. As seen after having researched lots of different data sources and coming up with our final data collection strategy, there are plenty of similar enough datasets available as the ones we'd be collecting ourselves to give us a proper starting point for launching BEYEK, which was our main concern since otherwise, we wouldn't be able to launch it properly. Starting off our project with open-source data instead of starting using only the data that was collected ourselves will give BEYEK a lot more functionality at the start and allow for a smoother introduction period, as with proper functionality BEYEK will hopefully gain traction sooner which allows us to become more detailed as more of our own data is collected and gain even more traction. This positive feedback loop allows for a smoother and shorter introduction period.

2.3 Data Visualization (Module 6)

2.3.1 Table of Variables

Now that we have the necessary data sources to start the developing process of BEYEK, we need means to visualize this data so it can be communicated clearly to customers and/or within the BEYEK organization itself. To properly visualize data we learned to work with concepts such as color use and the Gestalt principles and how to incorporate these principles to best showcase and communicate data in a visual form. Our team first had to decide which data was worth visualizing. A list of ten different variables that are used in our design concept was made, analyzed these variables, and organized in a table. After this, our team made different data visualizations that are useful to communicate data of our design concept (Beyek) to users, other organizations, or within Beyek itself. A couple of our favorite visualizations that best incorporated the learned principles, as well as the table of variables, are shown below.

VAR1	Persons living per area	How many persons live in the areas of amsterdam	categorical	1-200000	How can you visualize this combined with the paths they often take on their bike?
VAR2	Parking space locations	Where are there parking spaces	scale and location data	not applicable	
VAR3	Bikes per area per hour	How many bikes are present on average in this area at a given hour	ordered scale	1-200000	How can you visualize a traffic flow so it is logical and clear?
VAR4	Parking space type	Is this parking space inside and payed or outside in the public street	categorical	1-4	How can we combine this with VAR2
VAR5	Parking space capasity	How many places does this parking space have	scale	1-1000	How can we visualize how many places there are in a way you can see it in a blink if an eye?
VAR6	Looks bike	The bike are to be identified so there is a register which bike belongs to what person	image or description data	not applicable	How can we structure this in such a way it can me searched for easily?
VAR7	Terrain ownership	A map where is shown what is public area and what is privatly owned	location geofence data	not applicable	How can we accurate make this geofencing without problems while using GPS
VAR8	Busyness street per hour	How many people are walking, biking and driving through the streets per hour	location scale data	0-50000	How can we make a dynamic map out of this to make sure you can see the difference per hour
VAR9	Ownership of a bike	Which person is linked to which bike	pairing	0-4 (one person with more than one bike)	We can not visualize all people in one graph, but we can make graphs containing different areas and the average or different types of households and their bike ownership
VAR10	Impounded bikes per area	The amount of impounded bikes per area to see where there are the most problems	categorical	1-10000	it would be interesting to combine this data with mulitple years to see a rising or falling trend

Figure 12: Table of variables

2.3.1 Visualization Experiments

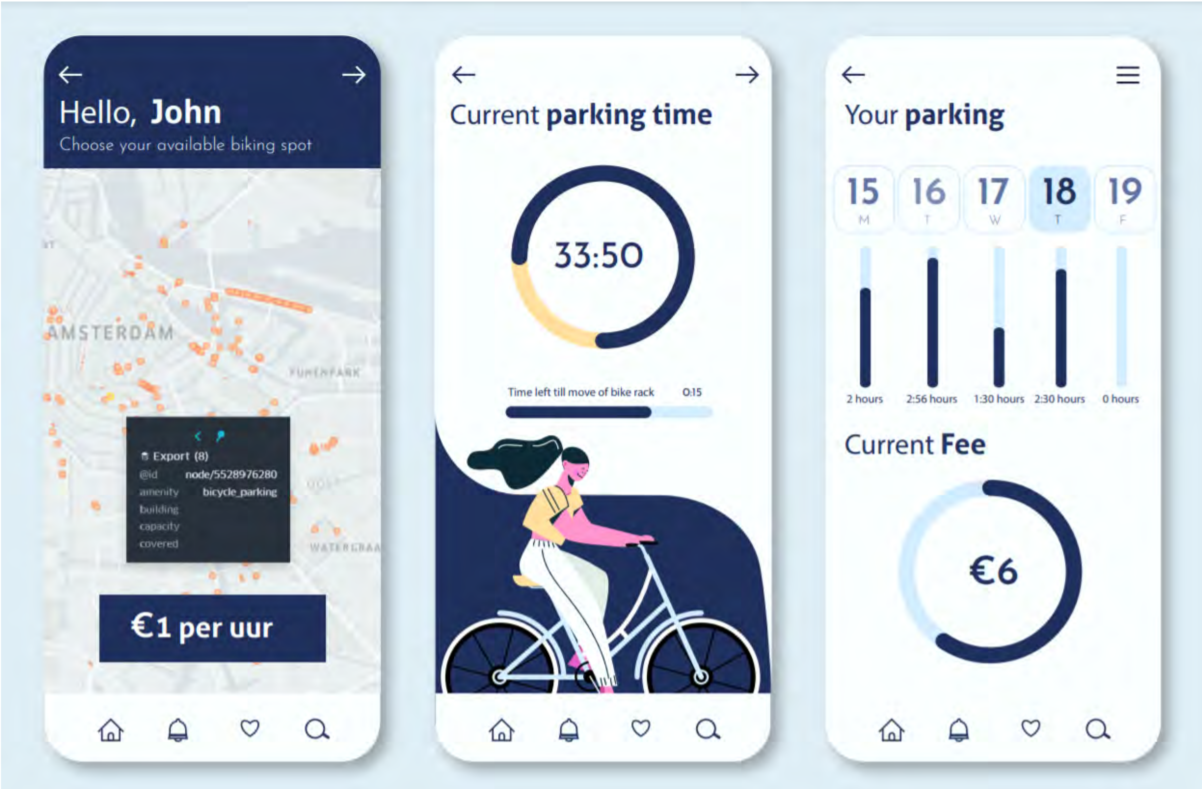

Figure 13: Home screen, park screen, fee- and history screen visualizations

These visualizations focus on user-product interaction. On the left, a search screen can be seen, which shows the available parking spots, what their capacity is, how many places are left, what type of parking space it is and what fee will be paid for parking the bike here for an hour. The left screen shows most of our data variables, but the other two screens should not be left out. The middle screen shows the current parking time and how much time there is left till the mobile parking station is going to be moved. The most right screen informs the user of their parking activity over the days and shows the current fee they have standing so that they can keep track.
These visualizations are very relevant, they showcase different data points to the users so that it becomes clear for them how to use the product.
The app is visually aesthetic pleasing to look at. It keeps information simple, not portraying too much detail and information at once.

Figure 14: Busyness screen visualization

This map represents the busyness of the streets in all locations close to the center. This area is the worst in terms of bikes and therefore this area is most interesting for us. Yellow means the least busy and dark red/purple are the busiest streets. While hovering over the streets you can see more information about the busyness types.

The visual numeration is strongly based on a map. A lot of our visualizations are maps because BEYEK makes use of lots of location data. Our most important data is all about locations and their properties.

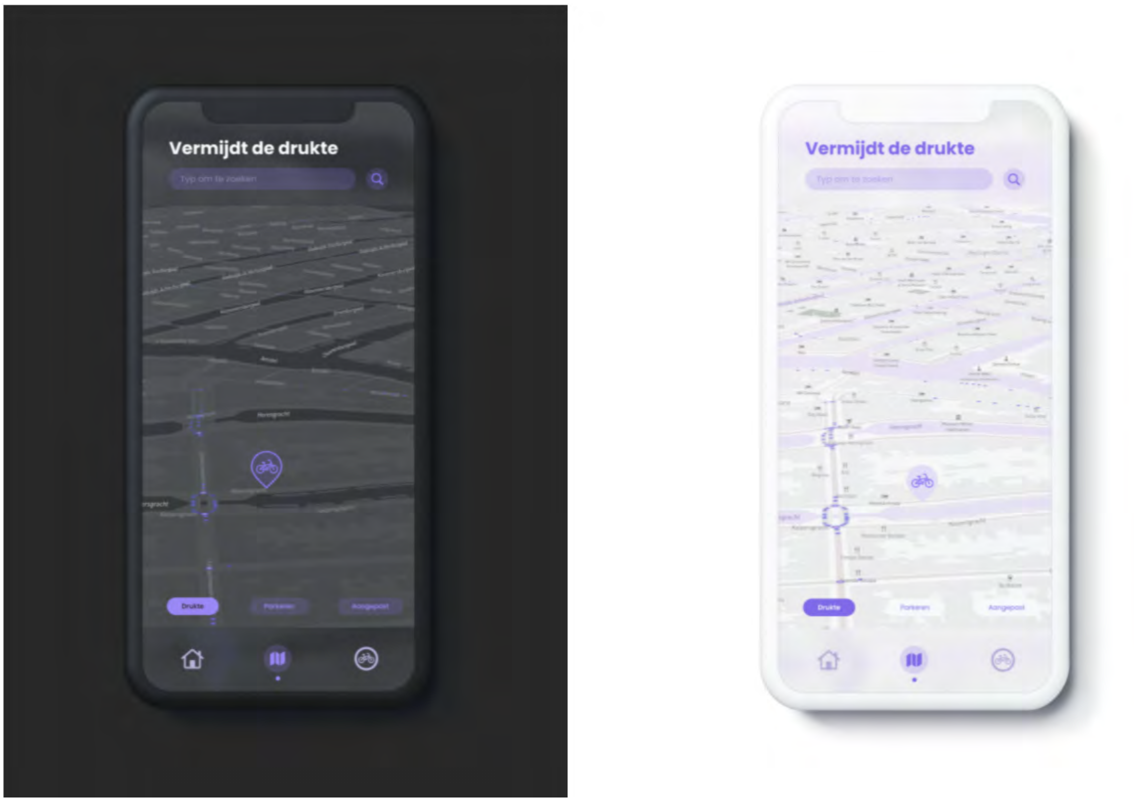

Figure 15: Busyness screen visualization

This visualization focuses on user interaction and showcases a map page of our app. This is a page where the user can filter and visualize multiple datasets to suit their needs. These filters are shown in the lower part and the first important one is the busyness layer. This overlays a heatmap of the current busyness in Amsterdam, so the user can avoid these areas. The page also shows the current location of the bike of the user.

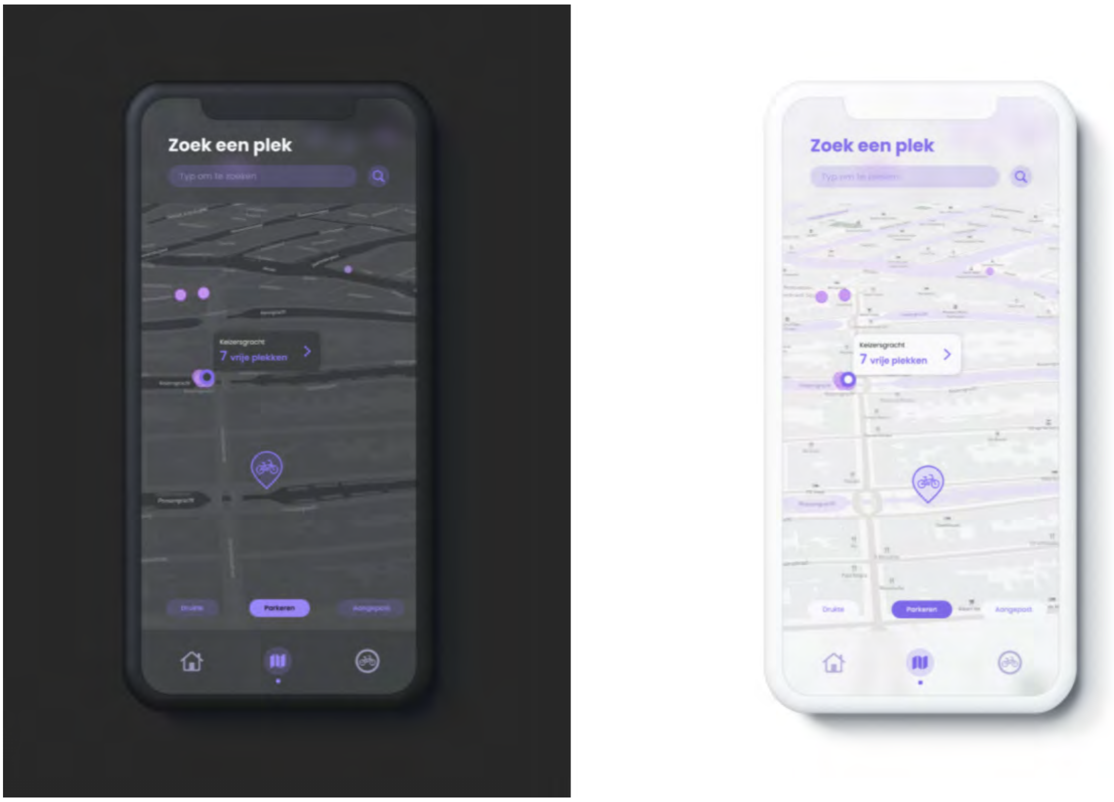

Figure 16: Parking screen visualization

This visualization is another layer for the map page. This layer shows all parking spots in Amsterdam. Clicking on a parking spot will show a small popup with some basic info, such as the number of free spots. This popup is clickable and would redirect the user to a page with more detailed information about the parking spot.

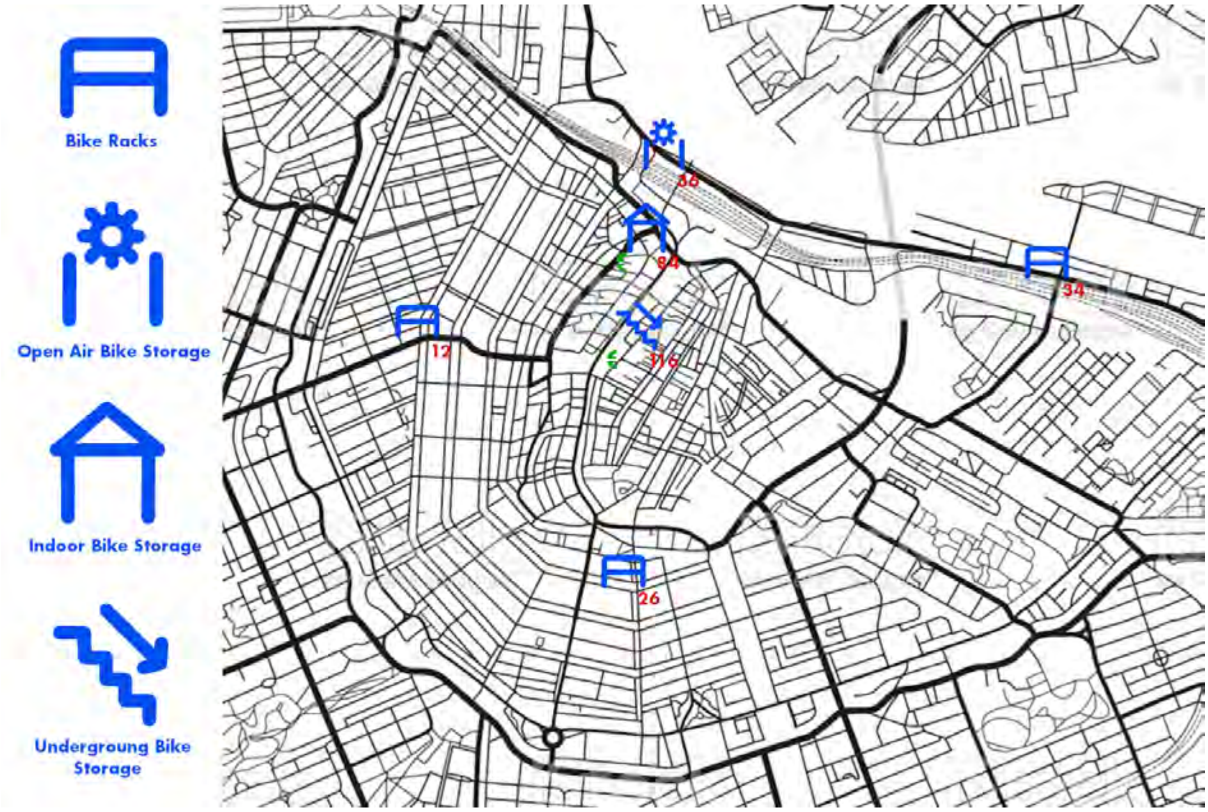

Figure 17: Parking types and locations visualization

In this visualization variables 2, 4, and 5 (Parking Space Locations, Parking Space Type, and Parking Space Capacity) were incorporated. In this simple map of Amsterdam icons showcasing the type of parking space were placed on the location they're located at. Under these icons, a red lowercase number shows the bike storage capacity of these locations. On the right, a green lowercase euro sign shows if the parking space requires a fee.

2.3.3 Final Visualizations

These visualizations were analyzed by our team and worked into final user interface designs for the BEYEK App. This app will combine the strong visual points of all the visualization experiments our team did to best communicate the necessary data to our users. The app and all its visualizations will be shown in Chapter Three of this report.

2.4 Data Analysis (Module 7)

To tackle Amsterdam's bicycle problem (see figure 18), we first need to know how big the problem is. We know that there are a lot of abandoned and wrongly parked bikes and we know that these bikes create a plethora of issues like, clogging up traffic, causing damages to other bikes, causing a shortage of bicycle parking space, etc. To investigate this phenomenon, we collected a couple of datasets on data.amsterdam.nl. The most important ones are the following: The first is the number of bikes being towed away in different districts of Amsterdam between the years 2010 and 2019 due to being wrongly parked. The second is the number of bikes being towed away in different districts of Amsterdam between the years 2010 and 2019 due to being abandoned. The third is the population in these same districts in the years 2016-2019.

We combined these data sets into one dataset in SPSS so that we could compare and analyze them together using Pearson's correlation test or crosstabs depending on the type of data. We did this to find useful information about the phenomena. For example, that the number of wrongly parked bikes increases/decreases every year or that in places with more abandoned bikes, more bikes are being parked wrongly. This data could help Beyek gain further insight into the trends of wrongly parked/abandoned bikes at different locations, which could help us in the development of our design.

Figure 18: The bicycle problem in Amsterdam

2.4.1 Most Important Variables

Abandoned Bikes

One of the five important data variables we analyzed is the of abandoned bikes delivered to the bike depot of Amsterdam per year per area of Amsterdam over the years 2010-2019. You can see in the histogram (see figure 19)below that most years about 1000-2000 bikes per area are delivered to the depot, though this number can be much higher, making the mean 2296. The distribution has a positive skewness and a negative kurtosis. as can be seen in the box plot (see figure 20) this particular variable only has two outliers. This could be due to the small size of the dataset.

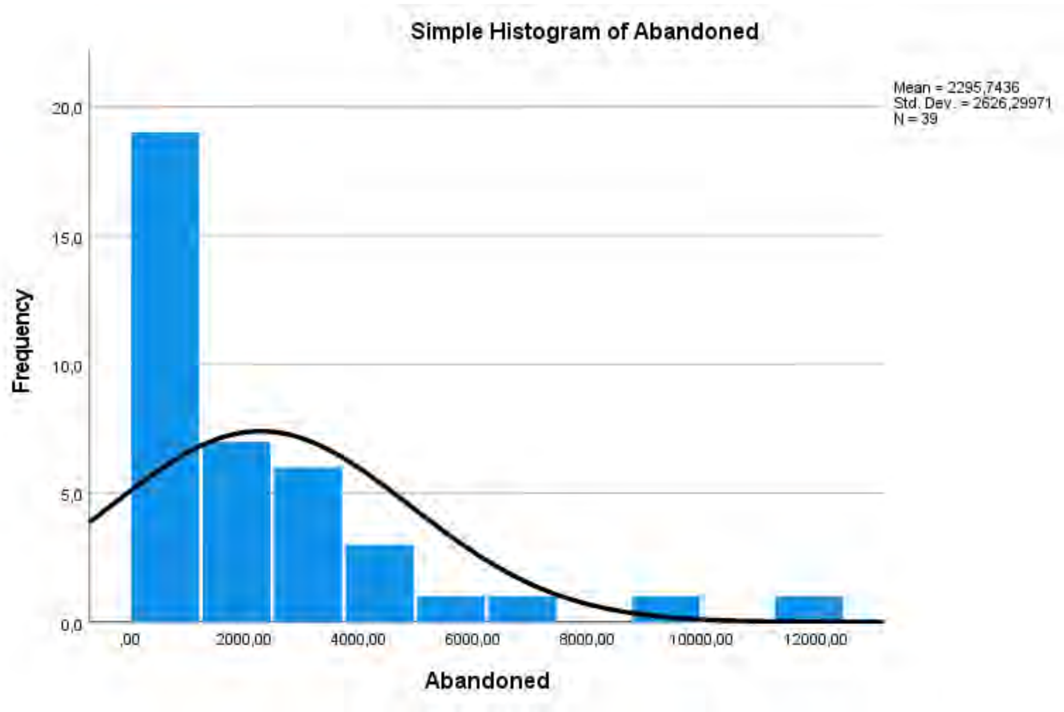

Figure 19: Simple Histogram of abandoned bikes

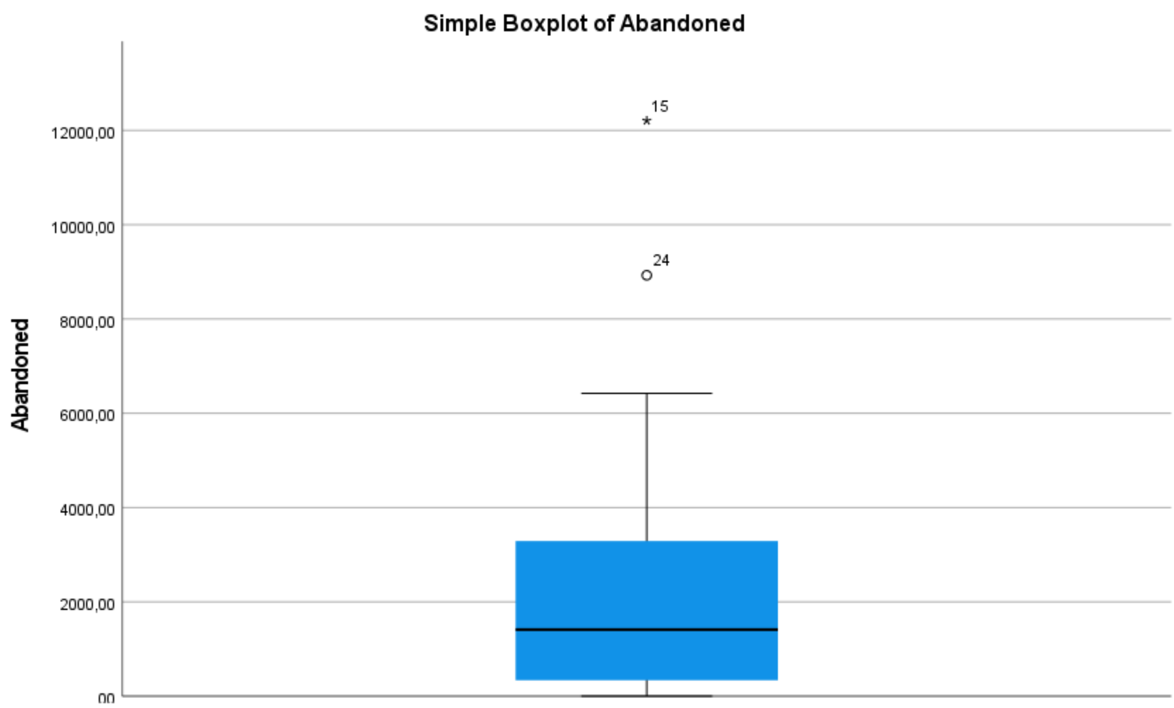

Figure 20: Simple boxplot of abandoned

Wrongly Parked Bikes

The variable of wrongly parked bikes is also important to us because wrongly parked bicycles block traffic. Below you can see a histogram and a boxplot of the amount of wrongly parked bikes delivered to the bike depot of Amsterdam per year per area of Amsterdam over the years 2010-2019. You can see that most years about 2000-3000 bikes per area are delivered to the depot (see figure 21), though just like with the number of abandoned bikes this number can be much higher, making the mean 6053. The normal distribution of this variable is also very similar to the normal distribution of the number of abandoned bikes, with positive skewness and negative kurtosis. The boxplot below (see figure 22) only has one outlier which is also probably due to the smaller size of this data set.

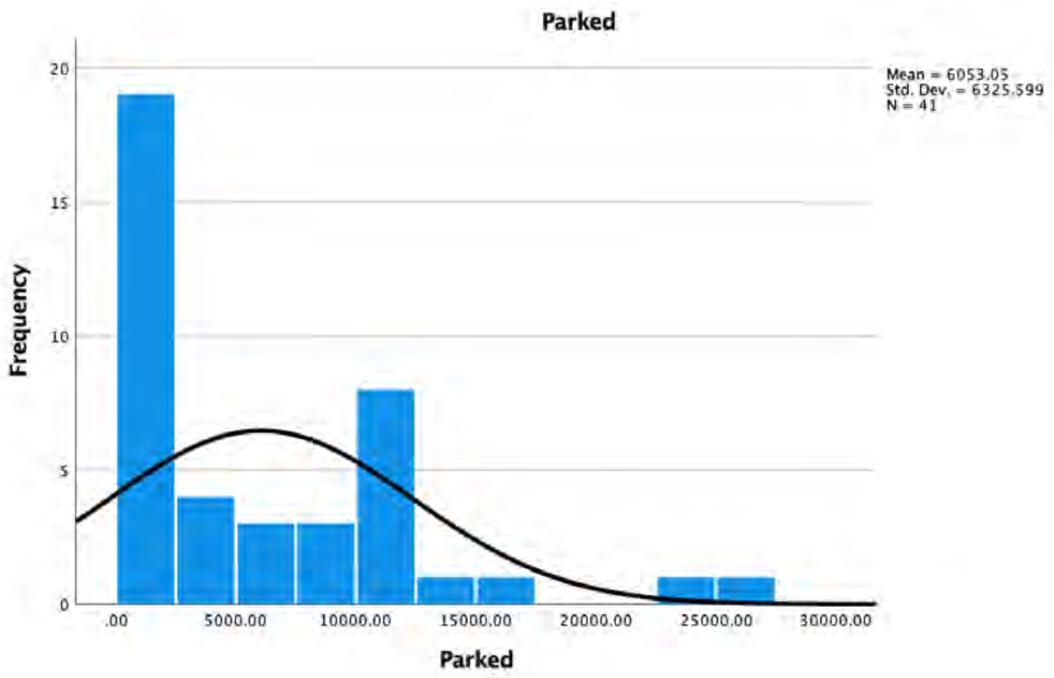

Figure 21: Histogram of parked bikes

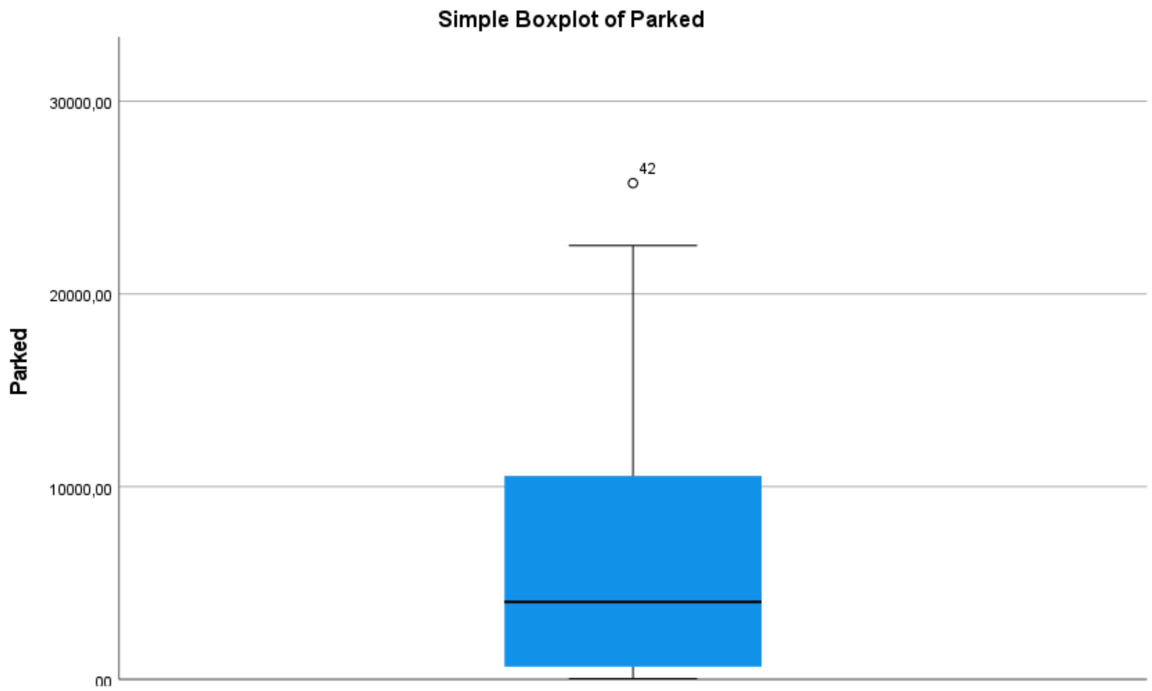

Figure 22: Simple boxplot of parked bikes

Population

We also decided to look into the populations in these areas of Amsterdam since we were interested to see whether there was a correlation between the amount of wrongly parked or abandoned bikes in an area and that area's population. The distribution of the population in Amsterdam could also possibly give insight into which areas might be more interesting to focus on to solve the bicycle problem efficiently. Beneath you can see a bar graph showcasing the average population of each area of Amsterdam from 2016 through 2019 (see figure 23). As you can see from the graph, Nieuw-West is the most populated area, and CSE (Central Station) is the least populated as no people live there.

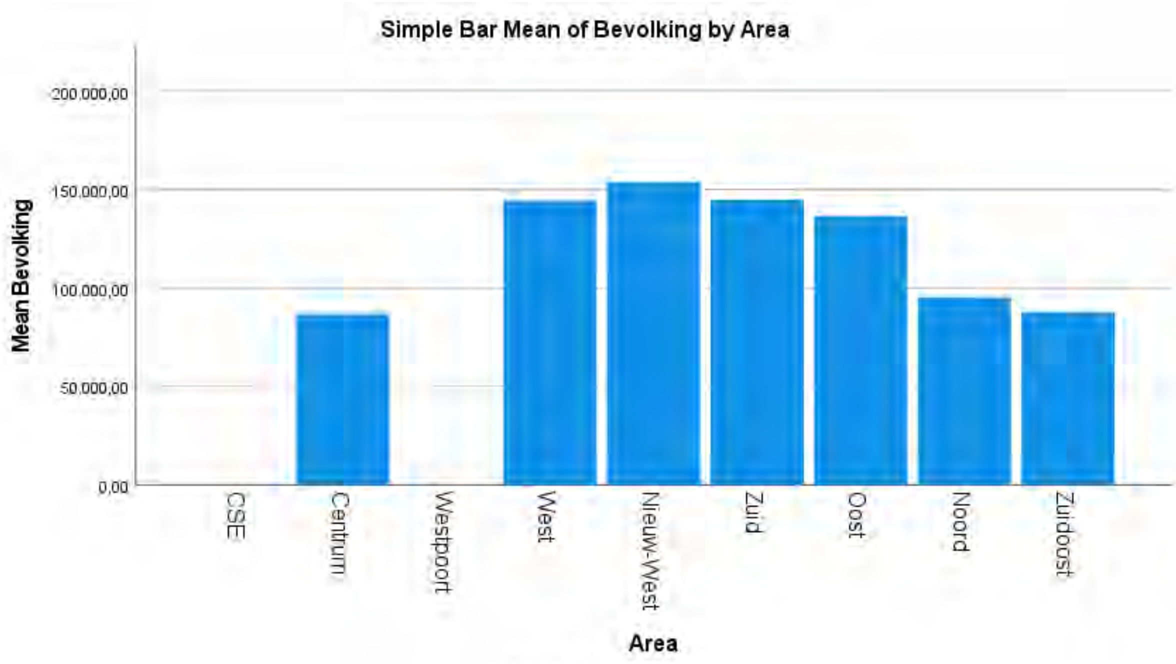

Figure 23: Simple bar chart of the mean of the population by area

Prevention

A later added variable that wasn't in our original dataset was the amount of bike theft prevention that was orchestrated by the municipality of Amsterdam. We found this dataset midway through our research and found it interesting as it would add another dimension to our analysis. With the addition of this variable, we wanted to see if we could conclude the success of bike theft prevention programs and if it helps with solving the bike problem in Amsterdam. A histogram of the number of bike preventions over the years 2010-2019 is shown below (see figure 24). This histogram shows that most years 2000-3000 preventions took place except for one year (2010) where over 8000 preventions took place, this isn't that weird since there is a five-year gap in data between 2010 and 2016 so our assumption is that bike theft preventions gradually went down in those five years.

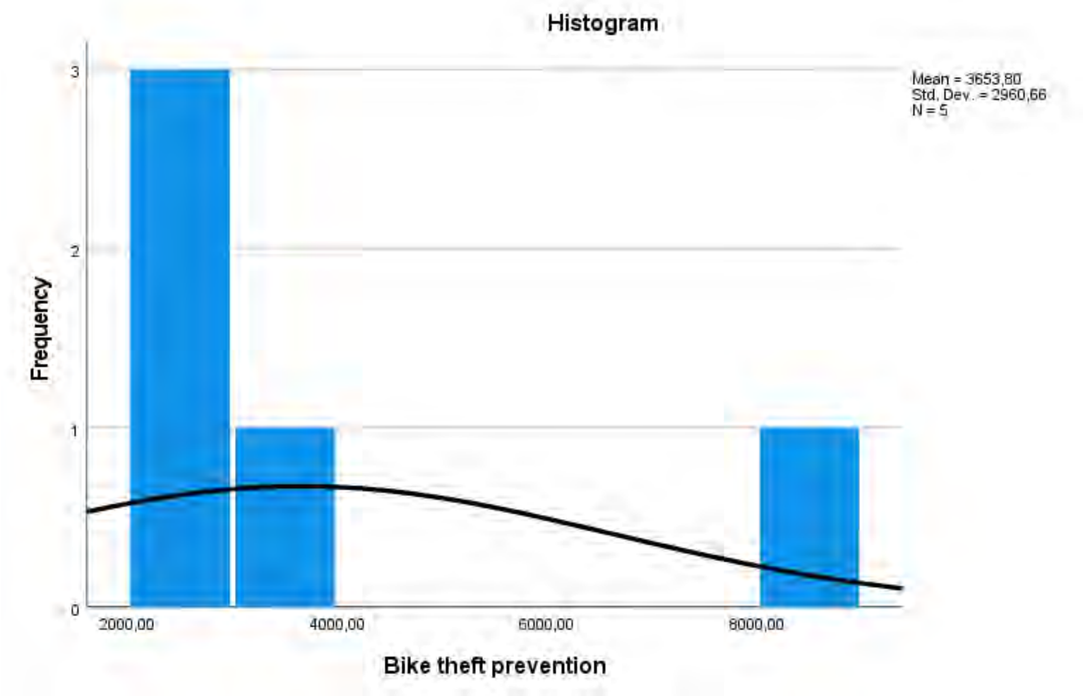

Figure 24: Histogram of bike theft prevention

Depot

Another variable that was interesting to look into was the total number of bikes in the bike depot of Amsterdam over the years 2010 and 2016-2019. Using this variable, a lot of different analyses about Amsterdam's problems involving bikes can be done. For example, analyzing whether or not big percentages of bikes in the bike depot come from abandoned or wrongly parked bikes or analyzing whether the number increases or decreases each year. In this histogram shown below (see figure 25) you can see that the number of bikes in the bike depot is usually around 15000, though there was one year (2010) where this number was way down at around 5000. This, like with the previous variable, isn't that weird if you consider the gap in data between the years 2010 and 2016. We assume that this increase in number happened gradually over these five years and that if we would analyze the number of bikes in the depot over the years we'd see an increasing trend.

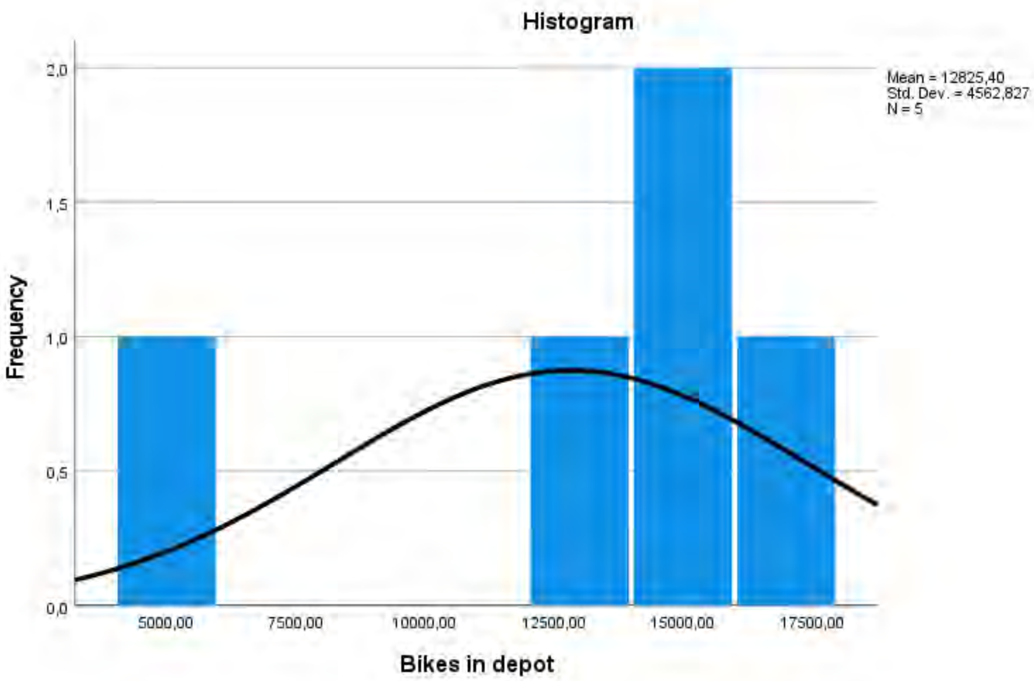

Figure 25: Histogram of bikes in the depots

2.4.2 Analysis results

Abandoned by parked

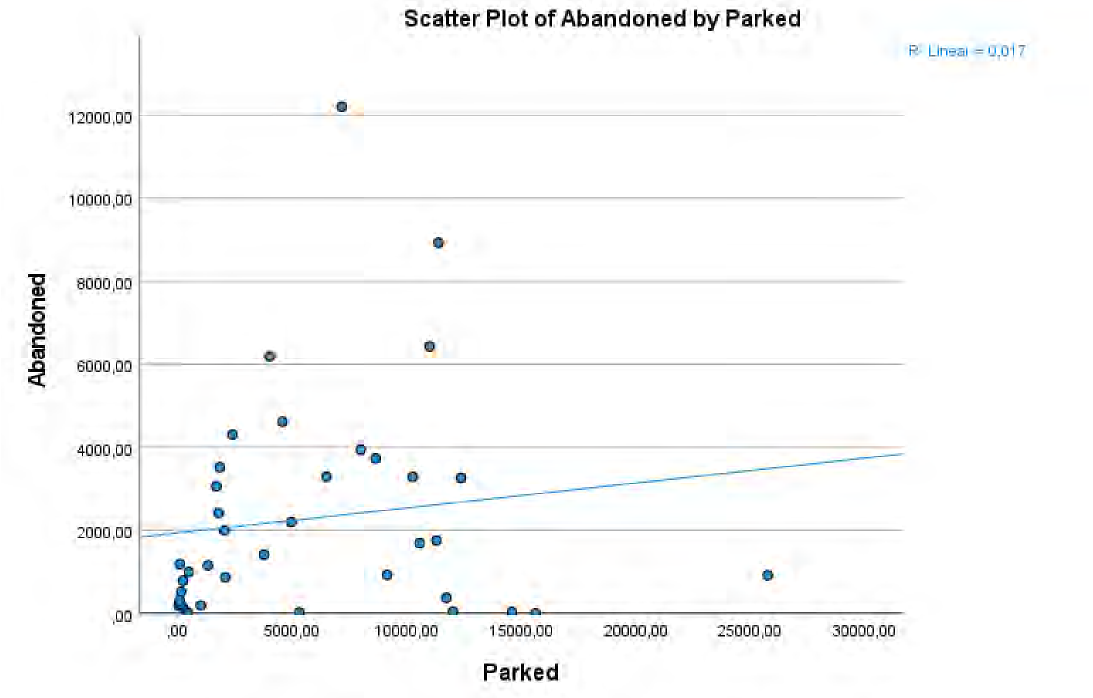

Figure 26: Scatter Plot of Abandoned bikes by parked bikes

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1406,000[a]	1369	,238
Likelihood Ratio	276,457	1369	1,000
Linear-by-Linear Association	,646	1	,422
N of Valid Cases	38		

a. 1444 cells (100,0%) have an expected count of less than 5. The minimum expected count is,03.

The chi-square test is not significant (X^2 (1369) = 1406,000, p >.05).

Spearman Correlations

			Abandoned	Parked
Spearman's rho	Abandoned	Correlation Coefficient	1,000	,208
		Sig. (2-tailed)	.	,211
		N	39	38
	Parked	Correlation Coefficient	,208	1,000
		Sig. (2-tailed)	,211	.
		N	38	41

Spearman's correlation suggests that there is no correlation (Spearman r = ,208, $p > 0.05$).

There seem to be no significant results thus we need to accept our null hypothesis. This means that there is no correlation between the number of abandoned and the number of wrongly parked bikes.

Abandoned bikes by population

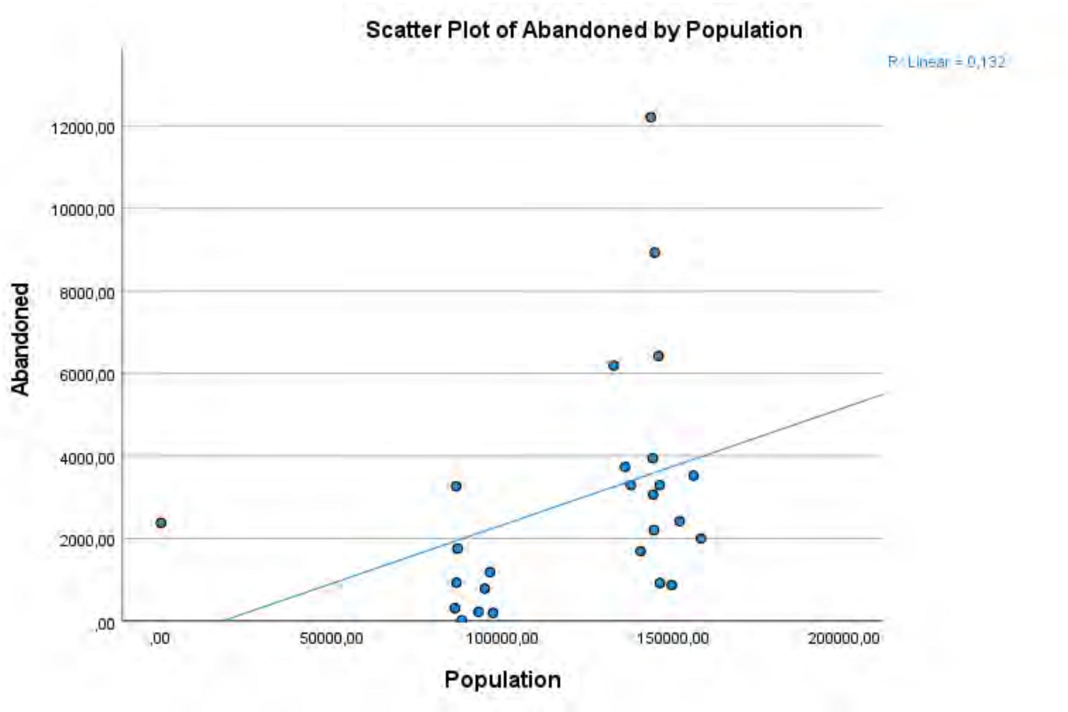

Figure 27: Scatter Plot of Abandoned bikes by population

Correlations

		Abandoned	Bevolking
Abandoned	Pearson Correlation	1	,363
	Sig. (2-tailed)		,068
	N	39	26
Bevolking	Pearson Correlation	,363	1
	Sig. (2-tailed)	,068	
	N	26	32

Pearson's r = 0.363 This means that there is a slightly larger correlation than between abandoned and rain, but it is still insignificant.

According to the data analyses I did, there is no correlation between the number of abandoned bikes and the population.
This means that a larger population does not mean that there will be more abandoned bikes.

Bikes in Depot by Bike theft prevention

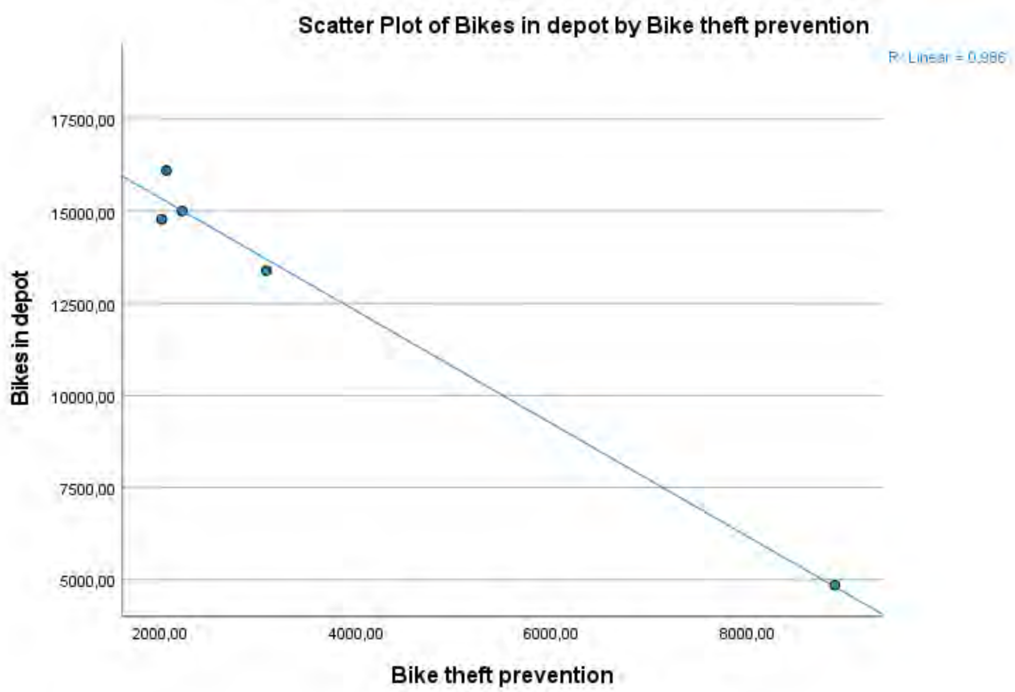

Figure 28: Scatter Plot of Bikes in the depot by Theft prevention

Correlations

		Bike theft prevention	Bikes in depot
Bike theft prevention	Pearson Correlation	1	-,993**
	Sig. (2-tailed)		,001
	N	5	5
Bikes in depot	Pearson Correlation	-,993**	1
	Sig. (2-tailed)	,001	
	N	5	5

**. Correlation is significant at the 0.01 level (2-tailed).

One of the correlation analysis we did was between the bikes collected in the depot and the amount of work done to prevent bike theft. Surprisingly this analysis showed a significant correlation, with a p-value of only 0,001. Even though 2010 had multiple outliers, it was in the margin of deviation to still be significant. Of course, this is not fully reliable, as the number of data points is limited to only 5 years. To prove the correlation more accurately, more data points would be needed.

Conclusion

Almost none of these variables have any correlation. This might be because the data we have is very minimal and not well documented. Most of the data we have comes from the bike depot of Amsterdam, but there is no guarantee that the bike depot regularly updates its data or collects it properly. We tried to find datasets that had more data points to draw significant conclusions from but we were unable to.

This is however not a total disaster for our concept, since it mainly relies on data that is generated by the concept itself. One of BEYEK's main goals is to make sure that in the future, there will be enough data about Amsterdam’s biking habits to analyze and draw significant conclusions from. For example, we suspect that there could be some correlations between wrongly parked bikes and the weather or other variables. But our data analysis results are not significant, thus we cannot make any claims. However, with the help of BEYEK, future analysts will be able to properly analyze what happens to bikes in Amsterdam

2.5 Privacy & Ethics (Module 5)

Amsterdam is a large city containing thousands of bikes, this abundance of bicycles has led to a multitude of issues, citizens and tourists alike have experienced more and more trouble with wrongly parked bikes, losing their bikes, not finding a good place to park their bikes, etc. It is our mission at BEYEK to solve these bike-related problems. We want to achieve this with a data-centered approach, primarily by collecting location-based data. The user's privacy is our top priority due to the sensitive nature of our data collection model. It is very important to us that the user feels safe when using our service, so naturally, we want to make sure that our data collection model meets our ethical standards.

2.5.1 BEYEK's values

Safety

Our most important value is safety, especially for our users. To ensure safety for our user base, the location data must be encrypted so that it cannot easily be intercepted and read by people with malicious intent, especially when dealing with important personal area data.

Integrity

Integrity is the practice of being honest and showing a consistent and uncompromising adherence to strong moral and ethical principles and values. Integrity can be seen as the truthfulness of one's actions and is thus highly intertwined with our other key principle Honesty. It means abiding by your own set moral principles and ethical standards and never diverging from them.

Privacy

Privacy in data mostly means that information about an individual is not shared with other people or organizations without permission or user knowledge. When users know this is happening and they are okay with this, it is not a bad thing. However, companies often do it in secret, or they force you to give up this data. When not handled properly, this data can be obtained by the wrong people. Good regulation is key to ensuring privacy for our users. The most important regulations include the accessibility of the data, who is allowed access, how to react to a breach, updating policies and how long the data is stored. Search for the AVG (Algemene Verordening Gegevensbescherming) for more information.

Honesty

Honesty is one of our company's main values. Especially with our company's goal; bringing mobility back to Amsterdam. We want not only to solve problems but to create better futures. This is quite a large goal that would be impossible to reach without clear and honest communication, not only within the company but also with our clients and users. Honesty is one of the building blocks of trust. Trust is necessary for a good relationship with our user base and clients.

Inclusion

Inclusion applies to many fields, and when this value is not maintained or strived for, it can quickly lead to a form of discrimination. In the case of BEYEK, this means that our service and system should at all times prevent the exclusion of anyone that uses or wants to use our service. In addition, inclusion also means that all risks and/or influences our service could have should be accounted for, especially for the people that do not use or cannot use our service

2.5.2 Ensuring our values

we want to ensure safety and privacy for our users by implementing the following strategies:
Data separation will ensure that no location data will be linked to the personal data of the users, this ensures that parties like the government or hackers cannot know from which user the data is coming. We will also be encrypting all sensitive data to protect the privacy and identity of our users.
To stay open to our users and stakeholders, we will have a detailed explanation of our data model and data flow on our website.

Lastly, we want to ensure that our services are available to everyone, so we designed the user interface to be easy to use. We did this to ensure that less tech-savvy users won't experience any trouble with using our service. However, this means that potential users that do not have access to a mobile device are unable to use our service. These users will mostly be children or elderly, so to solve this issue we want to implement the option to create a parent/guardian account, by creating a parent/guardian account you give consent that another user has access overall functions of your account. The guarded/child account will then be linked to the parent/guardian account and is now accessible through the guardian's mobile device.
We also want our service to be accessible to tourists, which is why we want to implement our system in shared bikes, this way tourists that may not be familiar with our system will still be able to use it without having to download an app. All parking-related costs could easily be included in the total costs of renting the shared bike.

2.6 Stakeholders (module 8)

In this chapter, we discuss the five main stakeholders of BEYEK. These stakeholders are the local government of Amsterdam, the user, the bicycle parking space owner, the owner of the bike depot of Amsterdam, and the data source (GPS + NFC). We explore the relations these stakeholders have via an interaction blueprint (figure 29) and by personifying some stakeholders in the form of persona's.

2.6.1 Stakeholder Map

To get a proper view of the different stakeholders that have a role in BEYEK, a stakeholder map was made. In this map, the different stakeholders and their connections to other stakeholders is showcased. The stakeholder map, as well as explanations about the connections between different stakeholders are shown below.

Stakeholder map

Legend

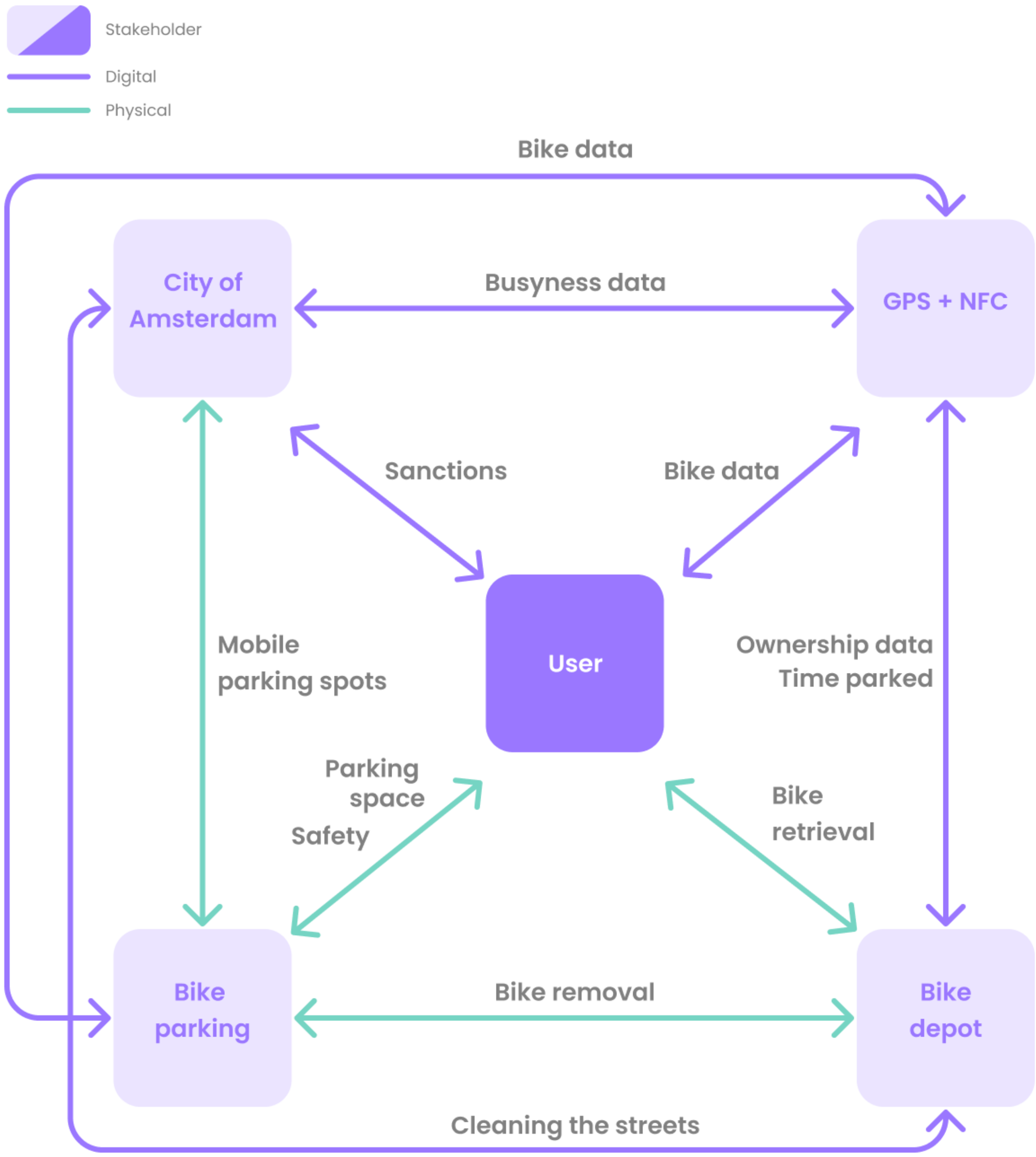

Figure 29: Interaction blueprint

User

The user is very central in the interaction blueprint. This is because users have certain needs, and therefore also exchange monetary, psychological, emotional material, and digital things. In the case of users, their needs are a quiet parking place where they can always stall their bikes, but also find them at all times. It is also important that their bikes are parked safely, to avoid damages and theft. Lastly, users should be able to find their bikes. Users should be able to see where their bike is parked, this way losing a bike should be impossible, even if the bike would get stolen. To fulfill these needs, users need to work or interact with other stakeholders. How this happens has already been shown in the interaction map. But will also be explained from the user's perspective.

User- Data Source

The user needs to know where their bikes are at all times, how long they are parked, and where there are available parking places, so they know that they can prevent any parking problems. The Dataset can supply all this information via GPS/NFC to the app and then to the users. In exchange, the dataset only needs to have a GPS/NFC on every bike.

User- Bike deposit company

The user needs to have parking spaces that are empty and clean. To obtain this, bike depots will remove the broken or unused bikes with the information of the dataset, so that these parking spaces will stay empty and will only be able to be used by bikes that need them. In exchange, bike depot companies are either supplied monetarily with payments when these unused bikes are claimed by their owner or can sell or repurpose the bikes that are not used.

User- Parking company/ Bicycle parking space

The user of course needs to stall bikes in spaces that are safe and empty. Parking company's or public parking places can provide this to the users. In exchange, parking companies get paid when users stall their bikes there or in public places, small fees will be charged.

User- government

The user itself wants this system as a whole, the government is the only one that will be able to supply the money and regulations needed, in exchange, they will put fees dynamically on certain busy areas. In this way, they get paid with money, data and as a result more fair and dynamic law enforcement.

2.6.2 Personas

To depict the stakeholders of BEYEK as real/humanly as possible, personas were made describing some of these stakeholders. These personas include municipality employees, bike deposit employees, and, because the user is so central to BEYEK, three different user personas. Mockups of the interfaces these different stakeholders will be using were also made to showcase the different functions these stakeholders will get using their versions of the BEYEK App

User: 67+

Figure 30: picture of Pieter

I am Pieter, a male of 75 years old. I worked in the harbor of Rotterdam, but now I am retired. I live in Amsterdam with my wife nowadays. I do some charity work and do a lot of sports with my friends. I don't have a car and I walk or bike everywhere. I have a problem with the number of bikes everywhere. Often I can't find my bike or I can't get to it because of all the other bikes. I am old and not as agile and flexible anymore. So I can't reach it. I want a solution and I heard about the Beyek program. I am curious because of the enormous amount of bikes everywhere. It is a real problem, it can be very annoying and sometimes even dangerous. Bikes are parked half on the street and fall against other bikes and cars. I have this problem with my charity work and where I play sports.

There needs to be a solution to this problem and when I heard that Beyek was working on it I became interested. I am scared of two things. The first one is that the GPS is always monitoring your location. Maybe it can be better when the location is not monitored by the government itself because they don't need to have my location at all times.

I am also concerned it is too technologically advanced. I am older already and not good with my phone. I hope it is easy to navigate the app or maybe there are other options? I just hope it doesn't make it harder for me to enjoy biking. I don't mind paying a small fee or walking just a bit to my destination, but I don't want to make it too hard.

Use situation 1
I want to park my bike without being overrun by other people at my charity work or sports location. I just hope the app isn't too hard to navigate.

Use situation 2
I want to find my bike back when I parked it without searching for 15 minutes. This happens often when I go to my sports because there are a lot of people with bikes.

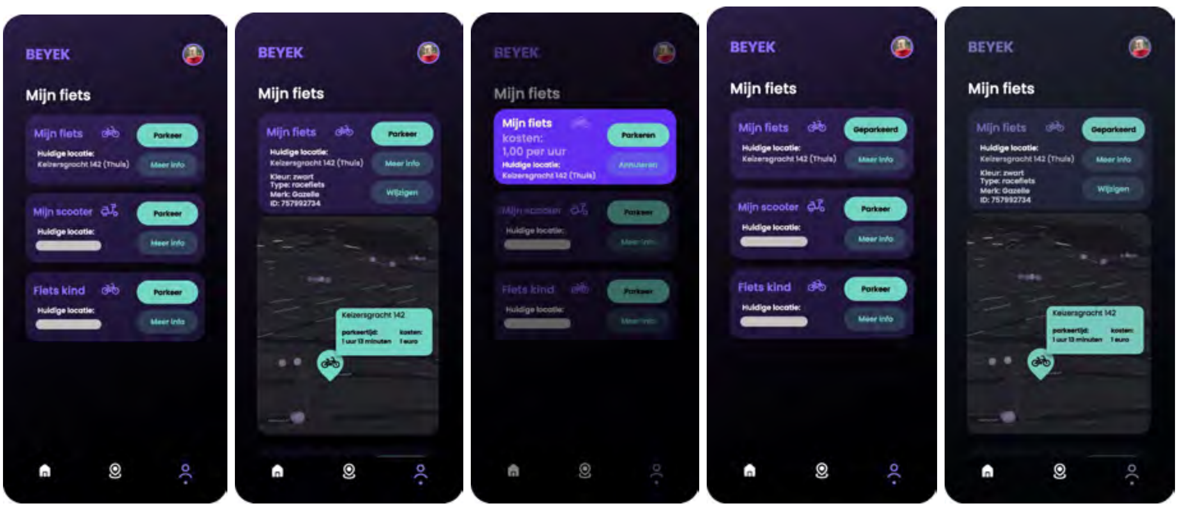

Figure 31: User interface BEYEK App

The user interface is a part of a whole app and is just the part where you can manage your bikes. The first UI is the one you are greeted with when you start managing your bikes. When you click on "meer info" you can see more information about the bike itself and its location. This is also where you submit your changes to your bike. You can park your bike via this page, just as the home screen for convenience.

The UI is made as an app. This is the most important UI for the consumer because they will use the app when outside of their home. The structure is based on the gestalt principles and mostly because the elements that belong together are placed close to each other. The most obvious example is the first and second pictures. The individual bikes are more apart and when you click more info the information linked to that bike is closer to each other. The screen to confirm that you want to park (picture 3) has a clear pop-up design to make sure that gets the attention. The interaction is a bit slower-paced. Mostly because this screen shows more information. It is not like the home page where you want to quickly park the bike when in a rush.

Because these are pictures, the interaction is harder to show but all buttons are connected to different frames. The manipulation is mostly based on touch. But We want to have an integration with Google Assistant and Siri. With this integration, you can use voice commands to park your bike for example.

Municipality

Figure 32: picture of Janine Derricks

Name: Janine Dercks

Age: 54

Hobbies:

- Cooking
- Walking
- Playing piano
- Going to museums

“Hello, my name is Janine Dercks and I am 54 years of age. I have been a citizen of Amsterdam for as long as I can remember. I was born in the city, and I’ve stayed here ever since. In my spare time I enjoy experimenting with cooking, taking walks, playing the piano, and visiting museums.

I work at the City of Amsterdam, the municipality, under the transportation department. I monitor where there are problems in the system and handle the communication with the bike depot.

A couple of months ago we got a new system called Beyek to monitor the bikes in Amsterdam. It's a lot different than what I first had. Personally, I still need time to adjust, whereas before I would communicate a lot more with different people to discuss what we had to do, right now it is just one system that displays most of the data I need. It's a bit weird sometimes, to see in real-time where people are. Luckily, I can only see blobs of the heatmap and not individuals, otherwise, I would get the feeling like I'm spying on people."

Use case 1:

"I look in the Beyek dashboard to see where bikes are wrongly parked. The ones that have parked there for too long I then send through to the bike depot, for them to pick those bikes up."

Use case 2:

"I look at the busyness map Beyek generates and filter it to show the average over last week. I then see where it is most busy and start planning to put a mobile parking station there."

For the design and explanation of the dashboard, see chapter 3.3.

User: Tourist

Figure 33: Picture of Frits Müller

Hello, I am Frits Müller, and I am 26 years old. I identify as a male, and I am a software developer. I like going to the gym, watching Netflix, and partying. Furthermore, I like exploring cultures all across the world, and I am very interested in history. Besides, I am going to Amsterdam for my holiday with my friends, and I like to explore the city. I have heard that biking is the best way to do this, so I have decided to hire a bike for the next week. Friends have informed me that using bikes in Amsterdam can be quite stressful. I have heard that biking itself can be hard in Amsterdam, but if personally think that finding, parking, and making sure that the bike is not stolen or damaged are things that are difficult in Amsterdam. I researched a bit and was told by the bike renting company that using the Beyek app can be very helpful. Furthermore, I am interested though in how this would work since I do not live in Amsterdam. How will payments then go? And will I be tracked all the time by the government? For me and other Germans, privacy is very important, I, therefore, like to find the same principles in Amsterdam. In the end, I do not mind paying a little more to be able to easily move around the city knowing where my bike is at all times and knowing that it will be safe and not stolen, I think that this concept could work if it is easy to understand and easy to use for all people. And maybe it could be useful if it had a partnership with TripAdvisor so that all could place and museums could be seen on the map.

Use situation 1

I want to understand quickly where I can park my bike in the locations that I need to be like museums or restaurants and cafés when I am planning an activity in the hotel.

Use situation 2

I want to be able to find my bike quickly after parking it when I am walking from an activity in the busy city.

Both of these uses are very common. For our design, these two uses are the most important to be able to work effectively and well. Therefore, understanding these uses and solving them is the most important.

As a solution, an example of a UI has been developed to solve the several needs of the users and to make the exchanges that happen between the user and the other stakeholders possible. Below the five different UI screens can be seen.

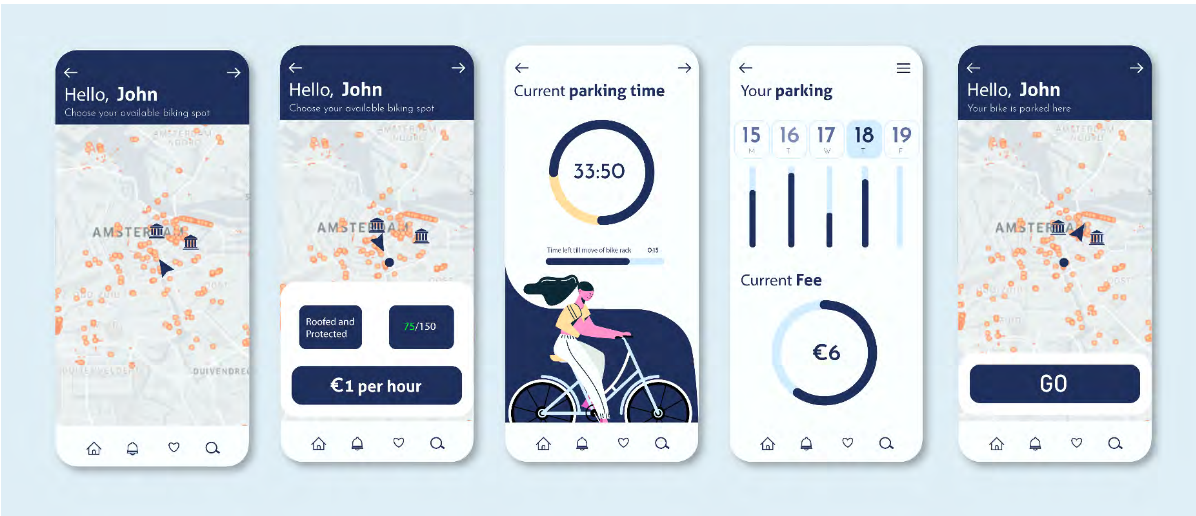

Figure 34: Different User interfaces of BEYEK

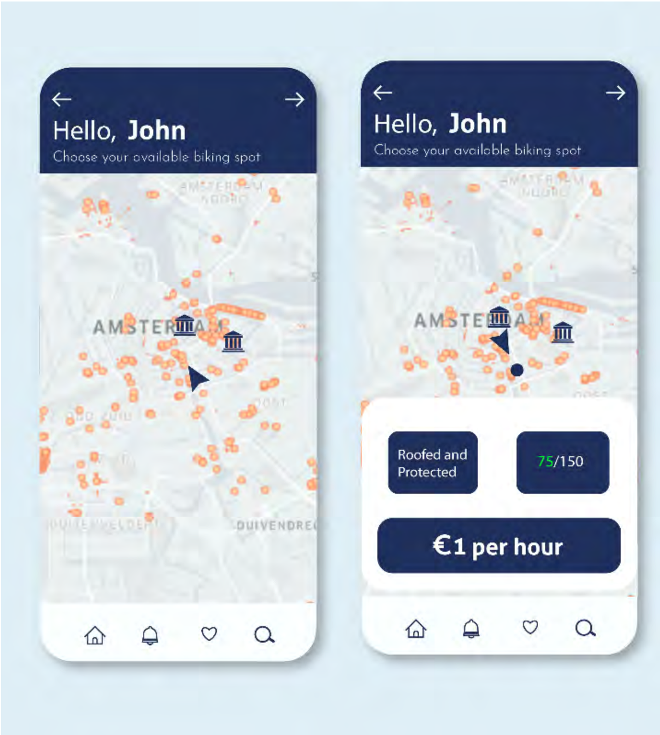

Figure 35: User interfaces homescreen

Content

The first two UI screens are the screens that give that purpose as a home screen, but also as the screen that shows the location of the user, location of several interesting locations that people would want to go to, locations of available parking spots. The right screen is then the screen that pops up when the person selects a certain parking place. It then shows the type of parking place as well as how many places are left and how much will be paid per hour. This solves the need for finding, locating, parking, protecting, and understanding what parking place is closest to what place is important to you.

Form

The form of the UI can be seen in the picture above. The UI used here is a smartphone app that makes use of visual, hearing, and touching senses.

Structure

The structure of the UI can be seen in the pictures above. The UI was chosen to be simple and clear to realize this layering and nesting was used.

Manipulation

The manipulation of the UI can be seen on the left. Important is that within two clicks a parking place can be reserved or either found. Moreover, users are supplied with information about the parking place as well as the number of parking places are left. What is important is that swiping can be performed when either going from home to other screens like, parking information or when selecting a parking place, and you want to leave that screen you swipe down. The app further can take an initiative, when for example finding the fastest route from a place to a parking place and of course only recommending parking places that have parking places left. The app is supposed to be used with one hand, but two-hand use is of course always allowed. It should primarily function as one uses Google Maps.

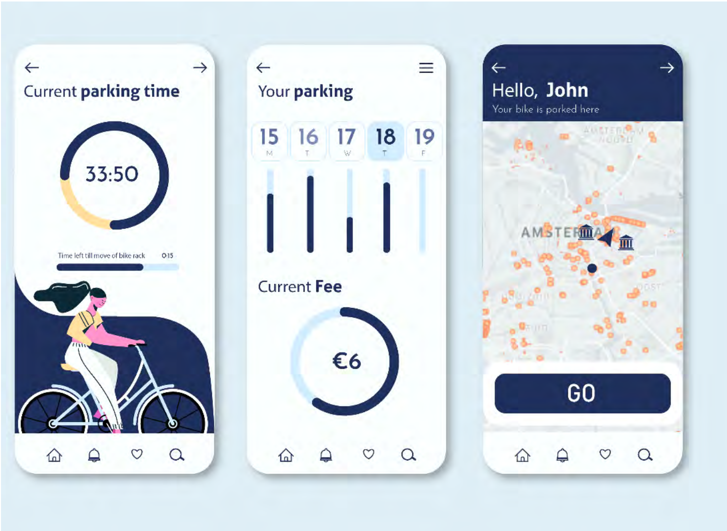

Figure 36: User interfaces timer and information

Content
The other three UI screens show parking information to the user. Showing time parked, time left for parking, the parking in the last week, the current fee, and a function where people can find back their bike. Finding back their bike is enabled when pressing GO an automatic fastest route is calculated and shown.

Form, structure, and manipulation are mostly the same in these interfaces compared to the two interfaces described earlier. Again form is focused upon an app that uses touching, feeling, and hearing as senses. The structure is again simple and clear by using layering and nesting within the app. Also in these interfaces' manipulation is simple so that within a few clicks or swipes the necessary action can be achieved.

Bike Deposit Workers

Andre Ryan

Age:	**25**
Sex:	**Man**
Location:	**Amsterdam**
Relationship status:	**Single**
Job:	**Bike Deposit Regulator, Actor**

Characteristics

Open

Fun-loving

Quirky

Creative

Strict (when necessary)

Stubborn

Biography

Hi, I'm Andre and im 25. I love dancing and am very big into photography, mainly dynamic portraits. I grew up in The Hague but moved to Amsterdam two years ago to pursue my acting career. In between rolls I work as a regulator in the bike depot at Rokin. My job is to make sure people properly put their bikes in the racks when they park them there and to make sure they don't leave without paying. On a normal day I don't run into many problems. Most of my time is spent greeting people, making jokes and rehearsing for roles when it's quiet. Though there's always a couple people that get rude when I tell them they 'can't park their bike there' or who start to act up when I tell them the price for parking. I'm kinda interested what this new Beyek program will mean for my job. Will it make my job easier because things like payments are now done automatically, or will it mean I lose my job because I'm now an unnecessary help?

Hobbies & Interests

Dancing

Photography

Working out

Theatre

Cooking

Use Case 1

I want to check whether people paid automatically so I can keep rehearsing my lines for a new role while im working at the bike deposit.

Use Case 2

I wanna be able to report rude customers when they park their bike wrong and refuse to listen to me when I tell them to park it in another spot when the deposit is busy and I don't have the time to convince them otherwise.

Figure 37: Persona of Andre Ryan

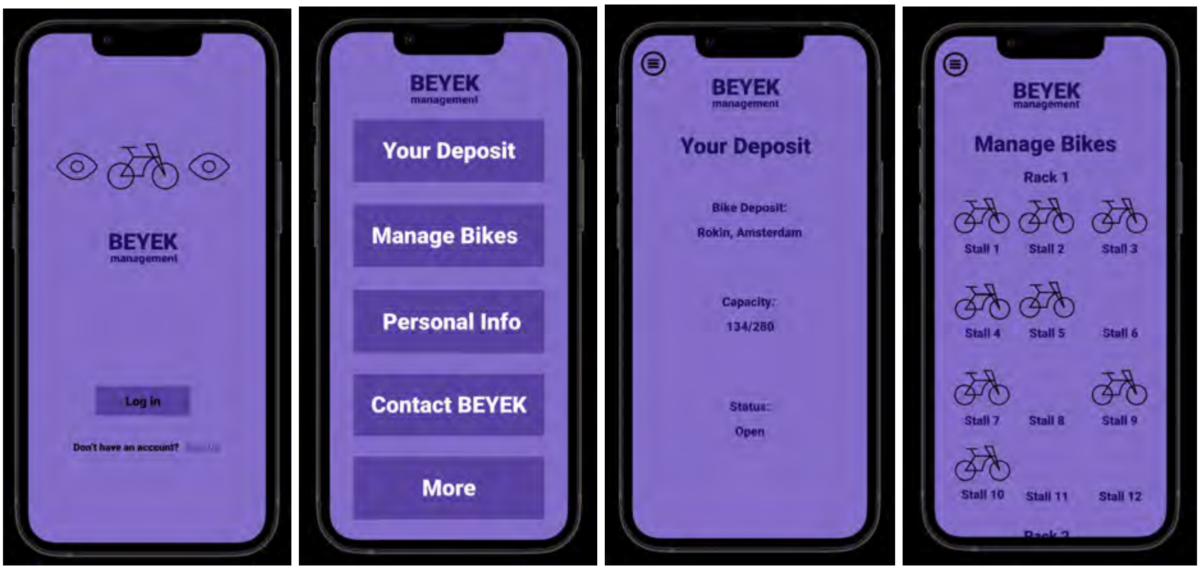

Figure 38: User interface bike deposit workers

The user interfaces shown above are made for the people that work at bike deposits that have integrated BEYEK in their program. We plan to give the employees of said bike deposits their own version of the BEYEK App, in this version they can log in as an employee and keep track of the bikes that are in the bike deposit. They can see how many bikes are currently in the deposit and in which stalls they are stalled. If people park their bikes wrong we plan to integrate an option to move them to another stall, which is then updated in the user's account, or fine the owner of the bike for parking their bike wrong.

Regular User from Amsterdam

Figure 39: Kees vd Klok

Hi, I'm Kees vd Klok I'm 24 years old and I live in Amsterdam, am an assistant at an interior design studio, and love my dog, Stella. I walk her at least three times every day. If I can't find a dog sitter for her, I take her with me to work, not all my colleagues can appreciate this equally, my boss loves her though. I like to go for drinks with my mates after work, we don't always do this at a terrace but when we do we go to Leidseplein. Since my apartment is very small we usually go and have a drink at Robert's. He lives in the city center and has a beautiful apartment, it's just a shame that you can hardly ever park your bike there. Almost everything I do outside of work I do with my boys. Henk once wanted to become a musician so we started a band for a short while. We performed twice with little success, but it did provide us with many stories. One time Robert was in a sporting mood and took us to the gym and since then we always go in January to the gym a couple of times for our good intentions and to please Robert, but we never last until February. One day I would like to be a real interior designer but for now, I have to fight every month to pay the rent. I'm just getting by on my salary so I can't afford a car or anything else, not that it's very convenient in Amsterdam, it's not a big deal because I prefer to do everything by bike anyway.

Use scenario 1:

Stella was very slow today during the morning walk, luckily I could leave her with Henk today, but now I am 10 minutes later at work, my boss will not be too happy about that. There is no separate bicycle parking at my front door so I quickly check BEYEK for quiet bicycle parking near my work. Nice there is one with 20 free spots 15m from my work and it is also free. I quickly ride to the parking lot, put my bike away and go to work.

Figure 40: User scenario 1

Use scenario 2:

I was so drunk yesterday that I can't remember where I left my bike, I was at Leidseplein but I knew I hadn't put it there. So I look on BEYEK to see where my bike is. How is this possible, it is in the Sarphatipark. Someone must have stolen it. I also see that the bike depot has marked it as "misplaced". Luckily my bike was still up against a tree and the bike depot hadn't taken it right away.

Figure 41: User scenario 2

Figure 42: User interfaces user perspective

This is a mockup for the user interface of a regular user. The interface for a regular user will be expanded upon and explained thoroughly in Chapter Three of this report.

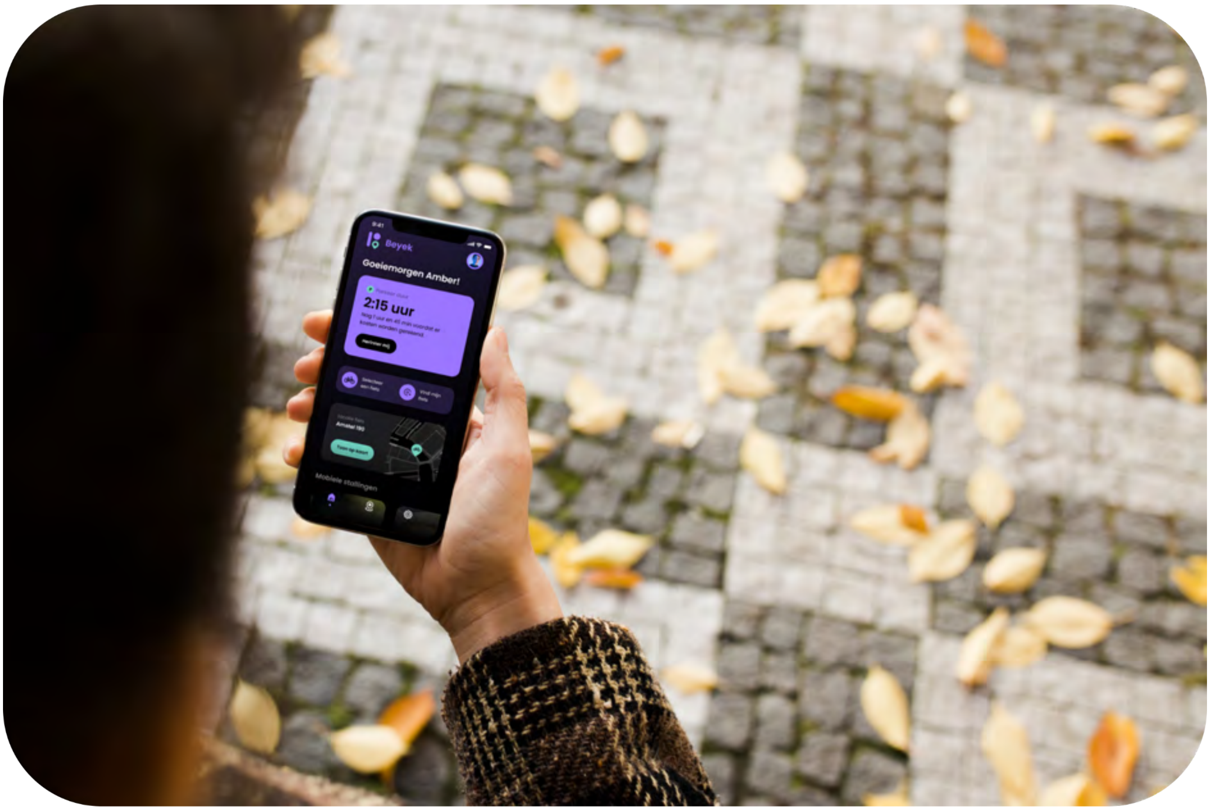

Figure 43: Girl using the Beyek app

3. Beyek made real

To create a more tangible feel of what Beyek would look like if it was ever implemented, we created an app and a dashboard prototype. In this chapter these prototypes are showcased, as well as the Beyek specific brand identity upon which they are built.

3.1 Brand identity

Our goals for the visual brand identity of Beyek, were for it to look friendly, approachable, but also trendy/futuristic. To achieve this look we carefully chose a color scheme, font, and style to use for the interfaces.

Figure 44: Styleguide of Beyek

3.1.1 Colors

As our primary brand color, we chose a shade of purple. This purple is halfway desaturated to make sure it has enough contrast when used on a dark as well as a light background. The color is relatively calm and not too attention-grabbing. When we want to grab the user's attention in the app, we use our secondary color, a shade of turquoise. The is a very bright color and should only be used subtly to not annoy the users. It is not a completely perfect complementary color, as that would have been a more yellowish-green. It is however in the tetradic color spectrum of our primary color. This makes the color feel in place in the designs while still being able to grab attention.

The digital interfaces are all built-in "dark mode". This means the background is a dark shade and the overall design is less eye-straining, especially at night. This has been a big trend in-app and web design for several years now, with iOS and Android having system-wide dark mode settings which influence all apps on the device with a dark and light mode option.

We only prototyped the dark mode for Beyek, but it could be a possibility to add a light mode in the future to satisfy as many users as possible.

3.1.2 Font

For the font, we chose the publicly available font Poppins, a Google font. This means the font is free to use for personal as well as commercial use. It is a geometric sans serif font, meaning it does not have to extend features at the end of strokes such as Times New Roman. This combined with the roundness of the font gives it a modern feel, which aligns well with the identity of Beyek.

As for weights, we used the regular and semi-bold. The regular weight is used for regular text or info of lesser importance. The semibold weight is used for headings and buttons, the text that needs the user's attention or to be easily read.

Figure 45: UI elements used in the Beyek app

3.1.3 UI elements

The corners of all elements are rounded to give the app a friendly and accessible feel. This, combined with a comfortable amount of white space to let the design breathe, strengthens the ease of understanding the designs.

In figure 45 some UI elements of the app are displayed. The rounded corners and amount of whitespace are clearly visible here. All elements are designed with the gestalt principles taken in mind. Objects closer to each other belong together. This is often reinforced by putting them in a box with a background color. Creating a mix of Lego bricks that can easily be reused or recycled for a different context, which in turn ensures a cohesive design.

Figure 46: The Beyek logo in different colors

3.1.4 Logo

As Beyek would become an important player in the everyday life of a bike owner in Amsterdam, the logo had to be simple but still easy to recognize. It had to be readable at small sizes and very large sizes, so the individual elements of the logo had to be simple without many small details.

It was also important that this still applied when the logo would be in black and white, as it would not be used in color in all situations. Examples of this would be the logo lasered onto the chips inside the bike or when Beyek would collaborate with another brand.

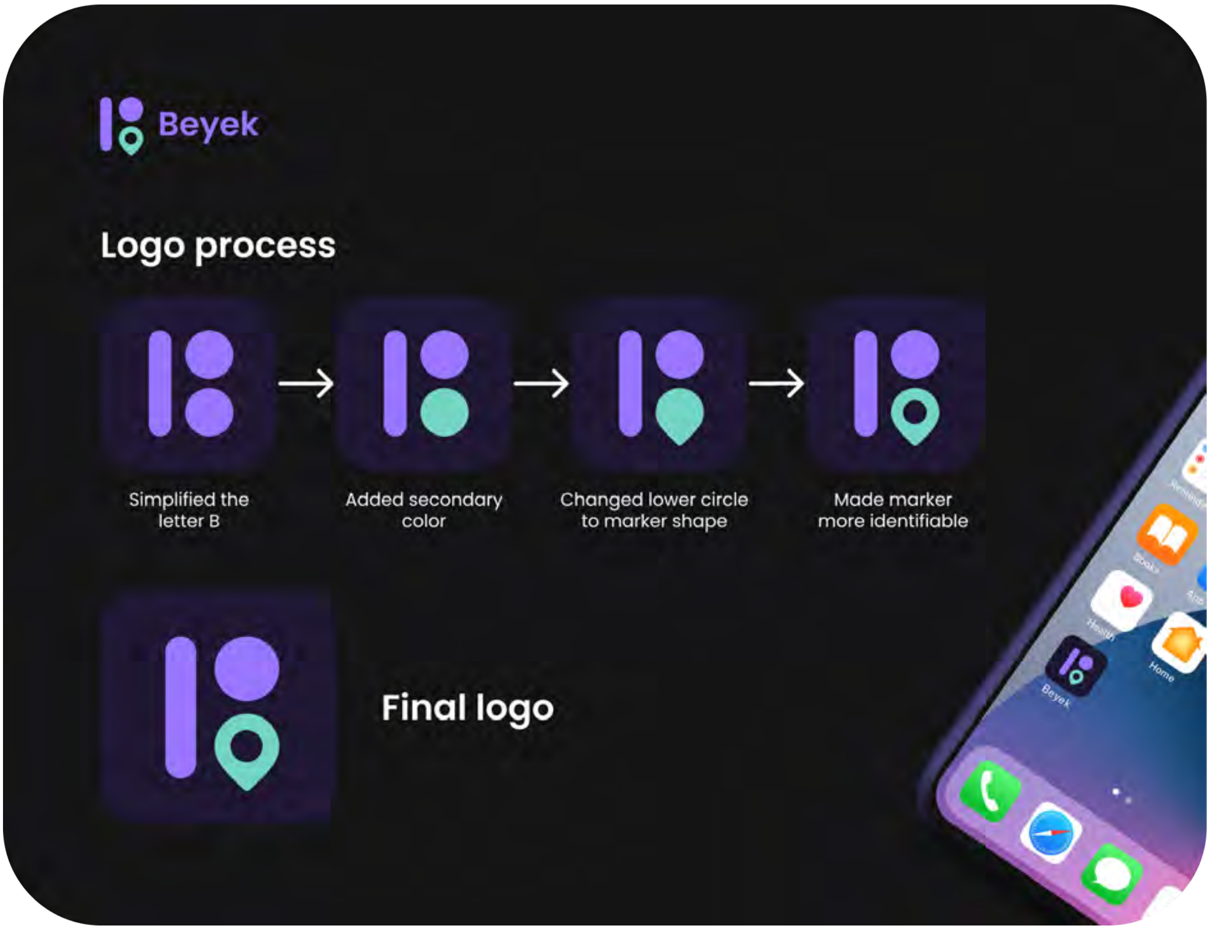

Figure 47: The design process of the Beyek logo

The design process of the logo is shown in figure 47. It started as a heavily simplified letter B. Onto this some contrasting color was applied, which would then become a location marker, tying in the function of Beyek into the logo.

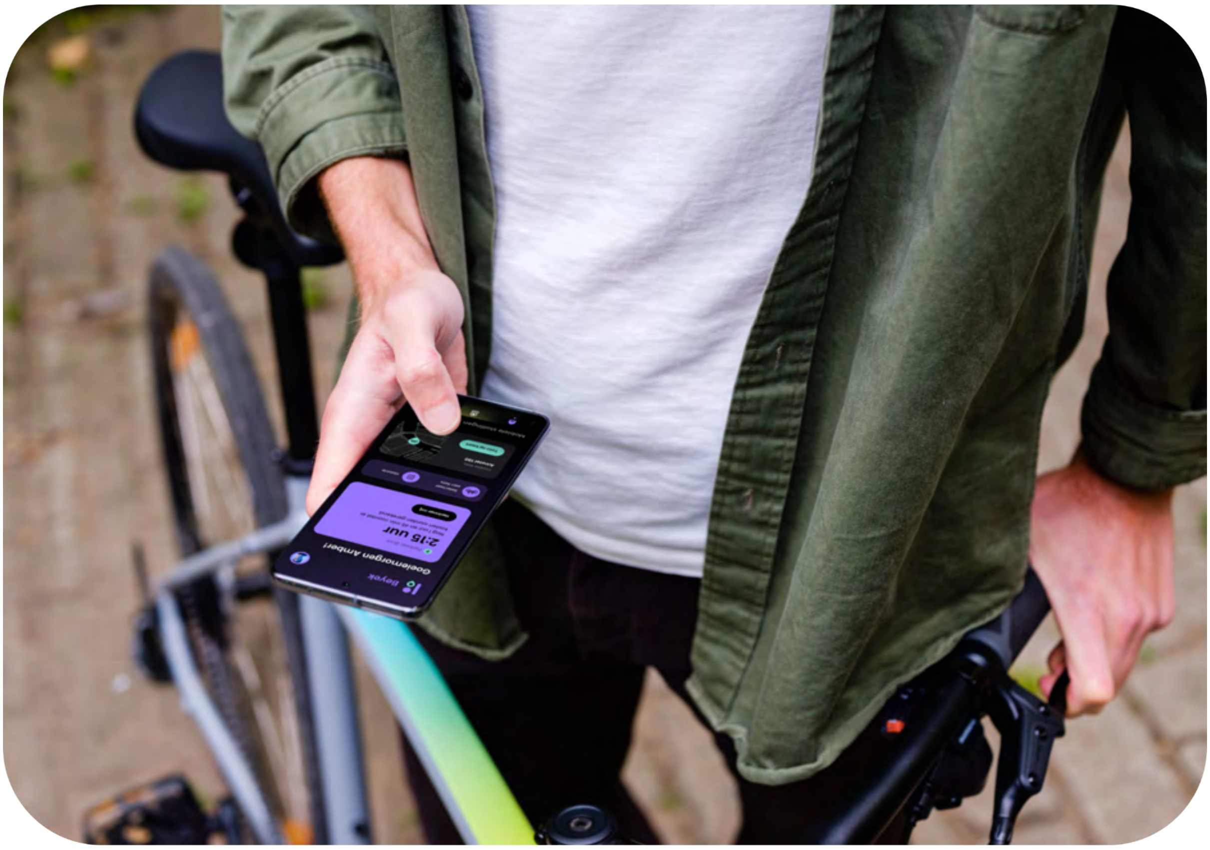

Figure 48: The Beyek app in use

3.2 App

3.2.1 Functions

The app makes it possible for users to interact with the Beyek system. It allows them to track their own bike(s) and find possible parking spaces. It features a page with a simplified and easy-to-understand version of our data visualization. All map data is also split up between multiple filters, to keep the view clean and easy to use. The app also allows users to edit their personal info and add/delete bikes to their profile.

3.2.2 Screens

To showcase some of the features the Beyek app would provide, we have made a prototype version in Figma.

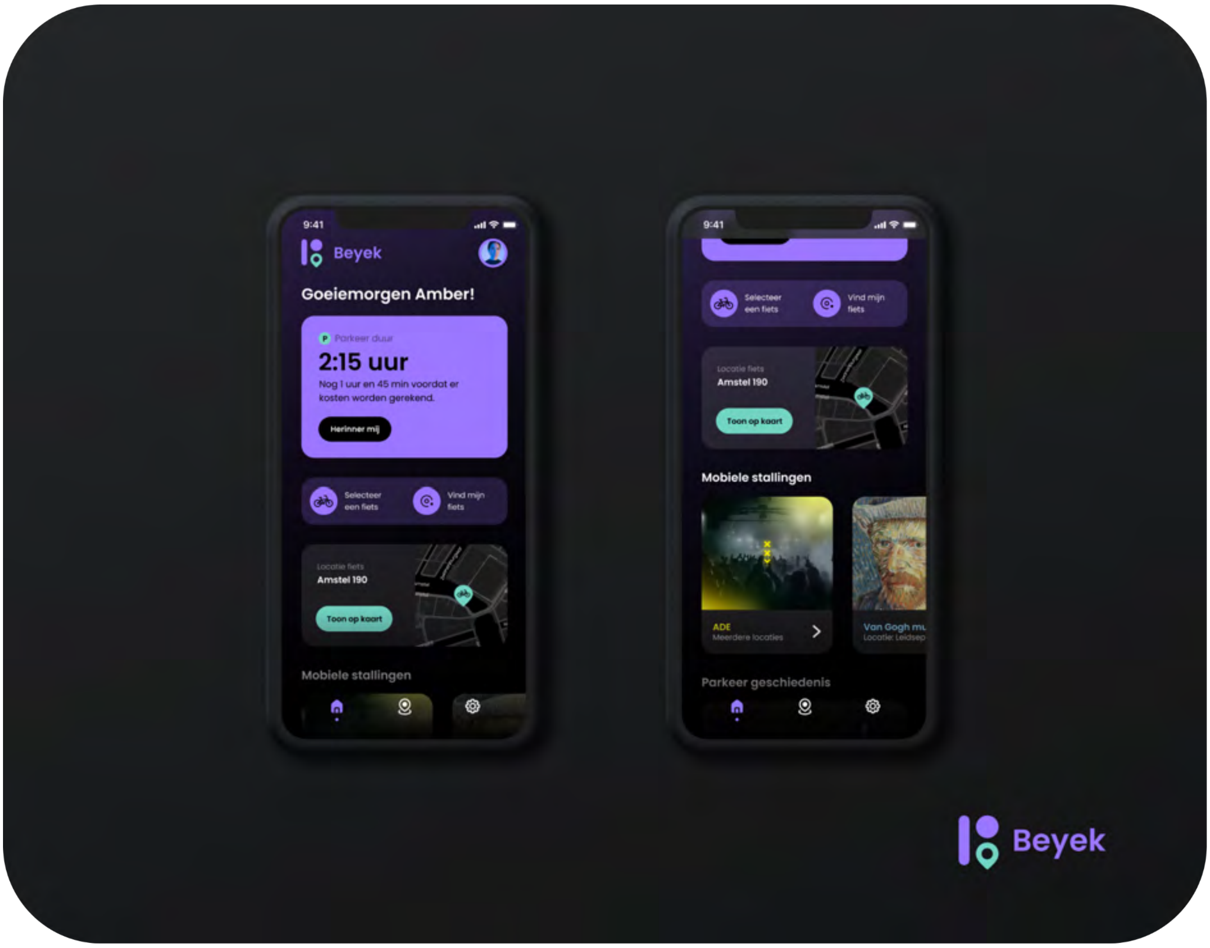

Figure 49: The Beyek app home screen

Home

The home screen of Beyek is the first screen the user sees when they start the app.

It is made to display as much useful information in a clear and easy-to-understand manner. It is built up like a tower of Lego bricks, with UI elements/blocks stacked on top of each other to form a balanced image. At the bottom is a tab bar menu, using a gradient from black to transparent as a background. This extends the screen visually, creating a more seamless experience. The icons in the menu are carefully chosen to be in the same style and to have the same line width. The active tab is a colored filled-in icon, while the others are white outlines. This combined with a dot below the active tab, clearly tells the user which page they are currently on, even to colorblind or visually impaired people.

At the top is the logo of Beyek and a circular profile picture. Clicking on this picture will take the user to his/her account page where they can edit their personal information and set a profile picture.

Below is the main element on the page, which shows how long the selected bike of the user has been parked for and if there are any fees. If the fees are duration based it shows the option to remind the user to remove their bike before the fees start to be charged.

The color of the blocks conveys a clear hierarchy and will attract the user's attention in the wanted order. The main block is filled in and stands out from the others, guiding the user to it quickly.

Below this block are two important shortcuts to actions the user can perform.

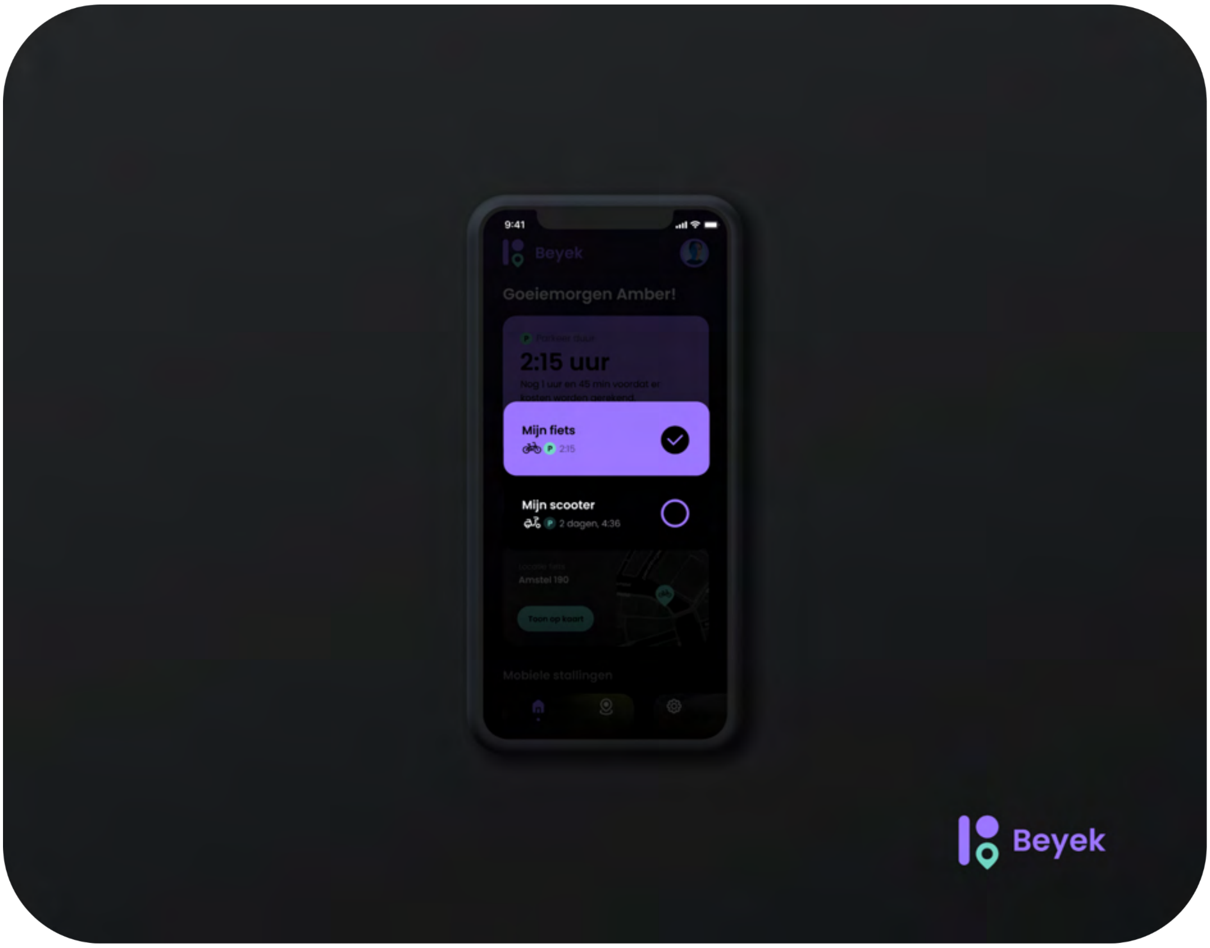

Figure 50: The popup to change your bike in the app

The first one is to change the displayed bike in the app, this way the user can see how long his/her other bikes have been parked for. Clicking on this will open a popup in which the user can select a bike or quickly view the parking duration.

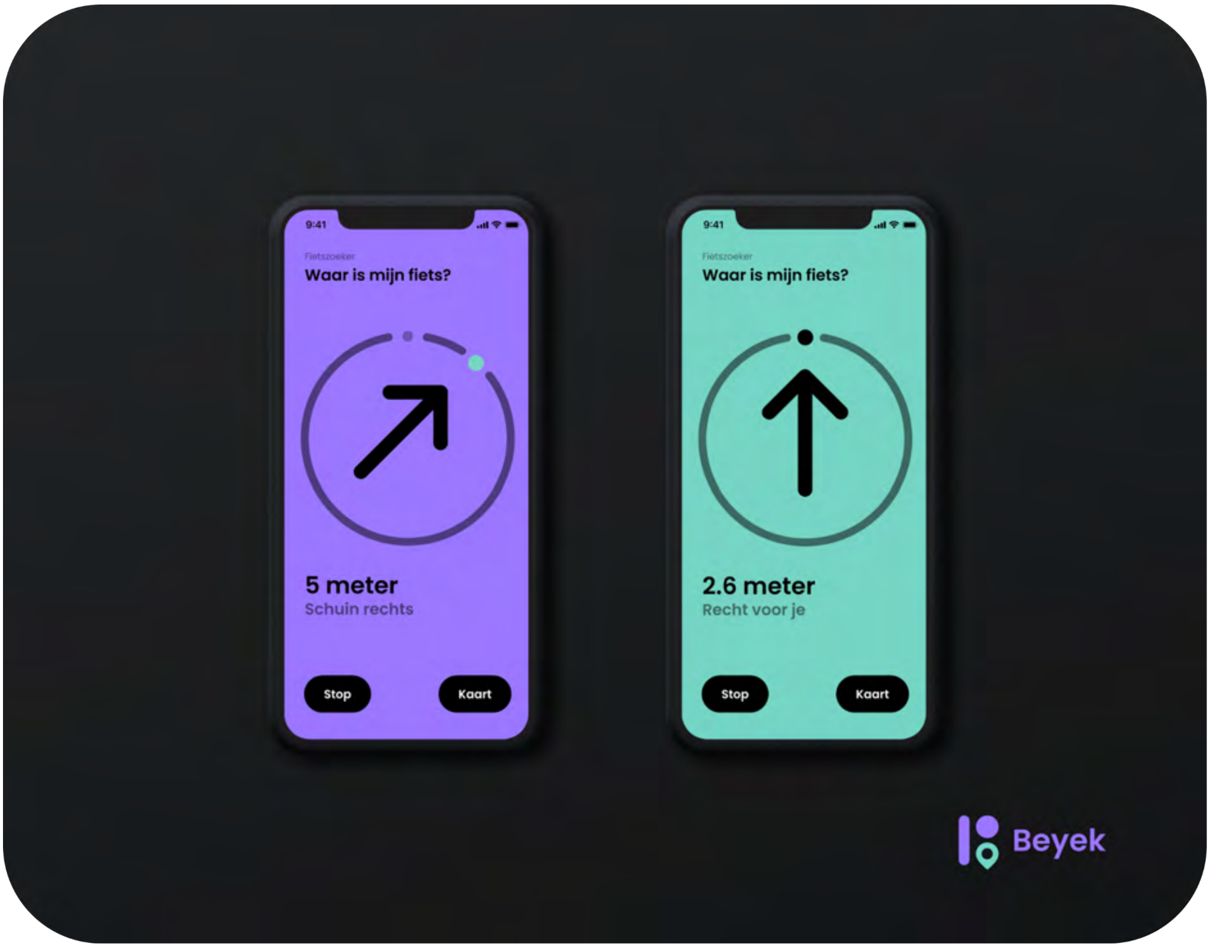

Figure 51: The bike locator page

Next to this option is the bike locator. Clicking on this will open a modal page with the bike locator in it. This feature would be useful for when the location on the map is not precise enough, for example in a big bike parking garage. The locater will start automatically upon opening the page and shows an arrow in the direction of your bike. If the bike is straight ahead of you the screen will turn to turquoise to signal that you are looking in the right direction. The background of this page is fully colored, so it is still easy to use even when you are not directly looking at your phone.

Below these 2 action buttons is a block that shows the location of your bike on the map. It shows the address and a map preview on the side. There is a contrasting button which upon clicking will take you to the full map, to show you where your bike is exactly located.

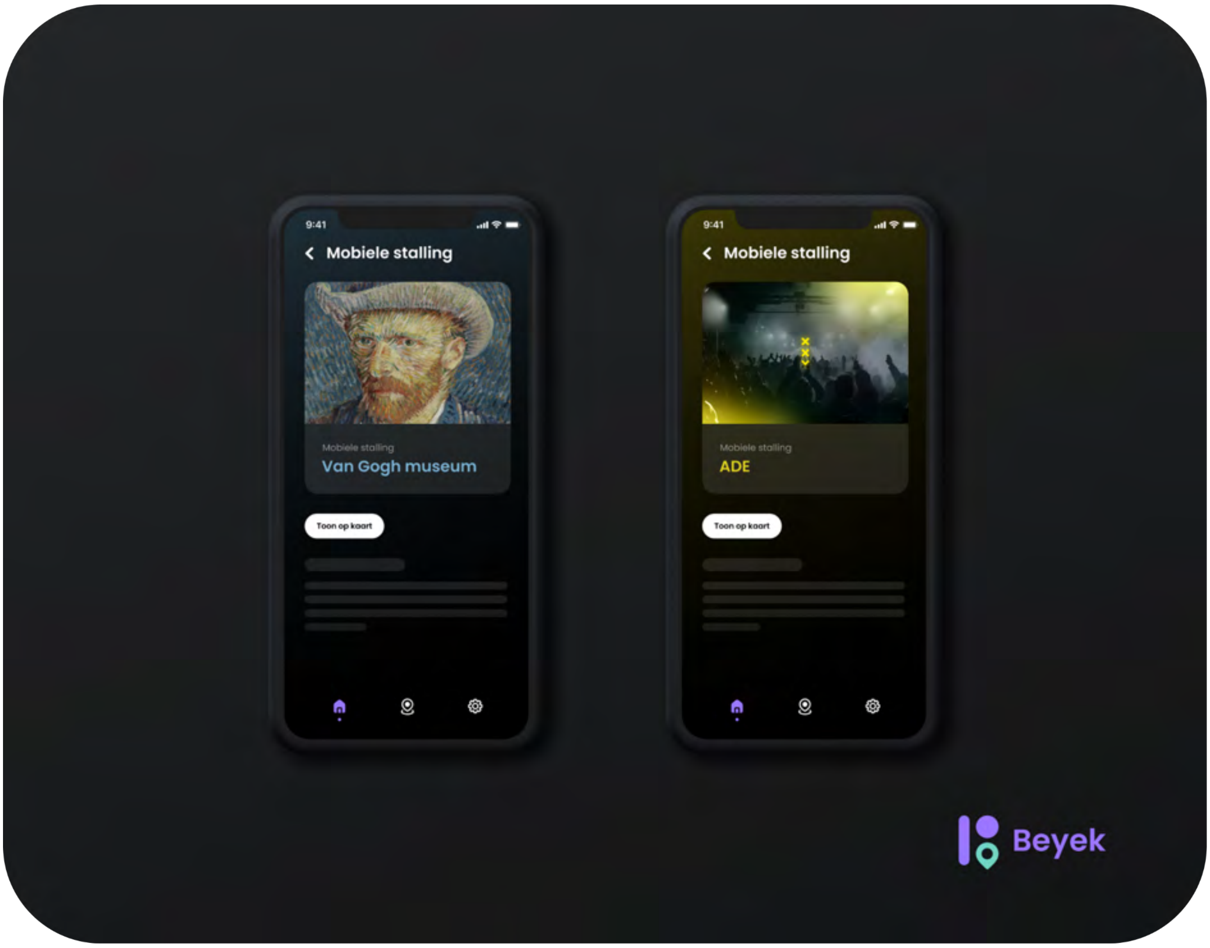

Figure 52: Example pages of themed mobile parking stations

The last section on the home screen is a collection of all currently active mobile parking stations, which are culturally themed. Clicking on one of these cards will open the page of that specific parking station, themed in the colors of that specific station.

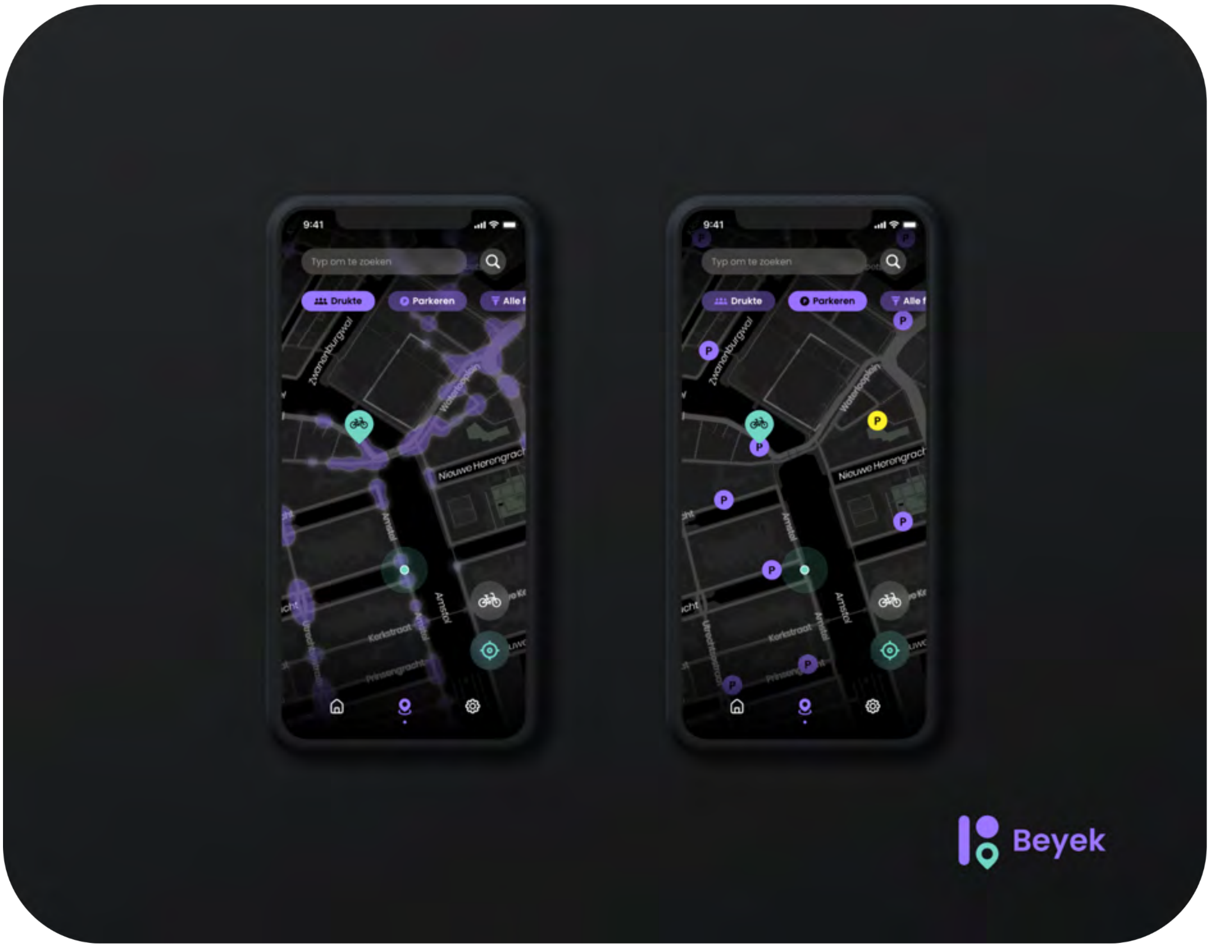

Figure 53: The map screen with the busyness (left) and parking (right) filters

Map

The second screen, the middle icon on the tab bar, is the map. On this screen, the user can visually see where it is most/least busy, find their bike, find parking spaces, and see where the mobile parking stations are located. The location of the user is shown with a dot with a circle around it, this is a common way to display the location of a user (e.g. Google Maps) and users will thus easily understand this. The location of the bike is displayed with a contrasting turquoise-colored marker. There are two buttons on the lower right to snap the map view to either of these locators. At the top of the screen is a search bar for the user to find parking locations, mobile parking stations, or just an address. Below this are the filters. These filters manage the data layers visible on the map.

On the left, is the busyness layer. This shows a heatmap of where it is most busy so users can avoid these areas.

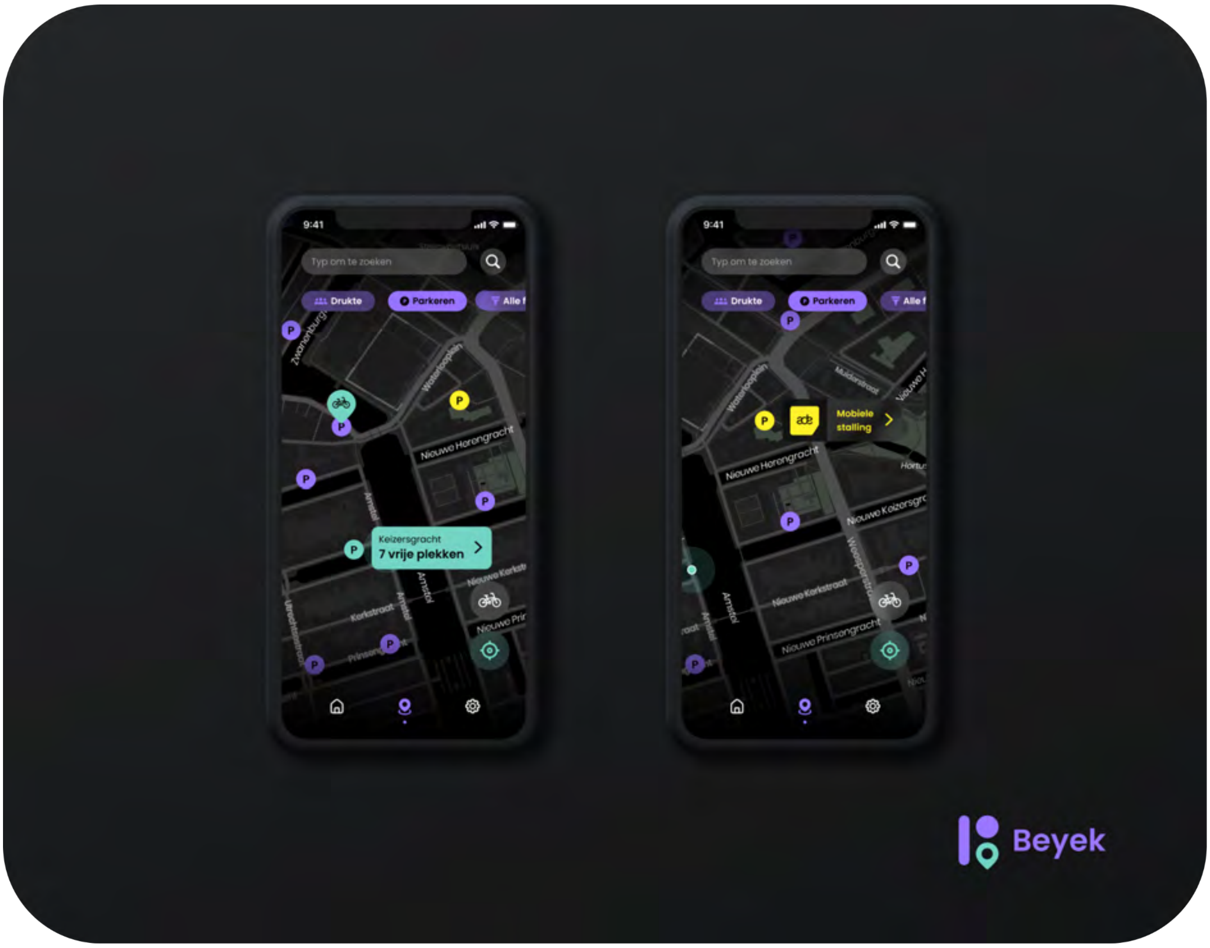

Figure 54: The parking popup that shows when the icon is tapped

Next to this is the parking spots layer. This shows all parking spaces in the city, with the color of the icon linked to its type. All purple icons are permanent parking spaces. The other icons are mobile parking stations, which are temporary and colored by their theme color. Clicking on either of these icons will open a small popup next to it, displaying a small bit of info and a button to show more info.

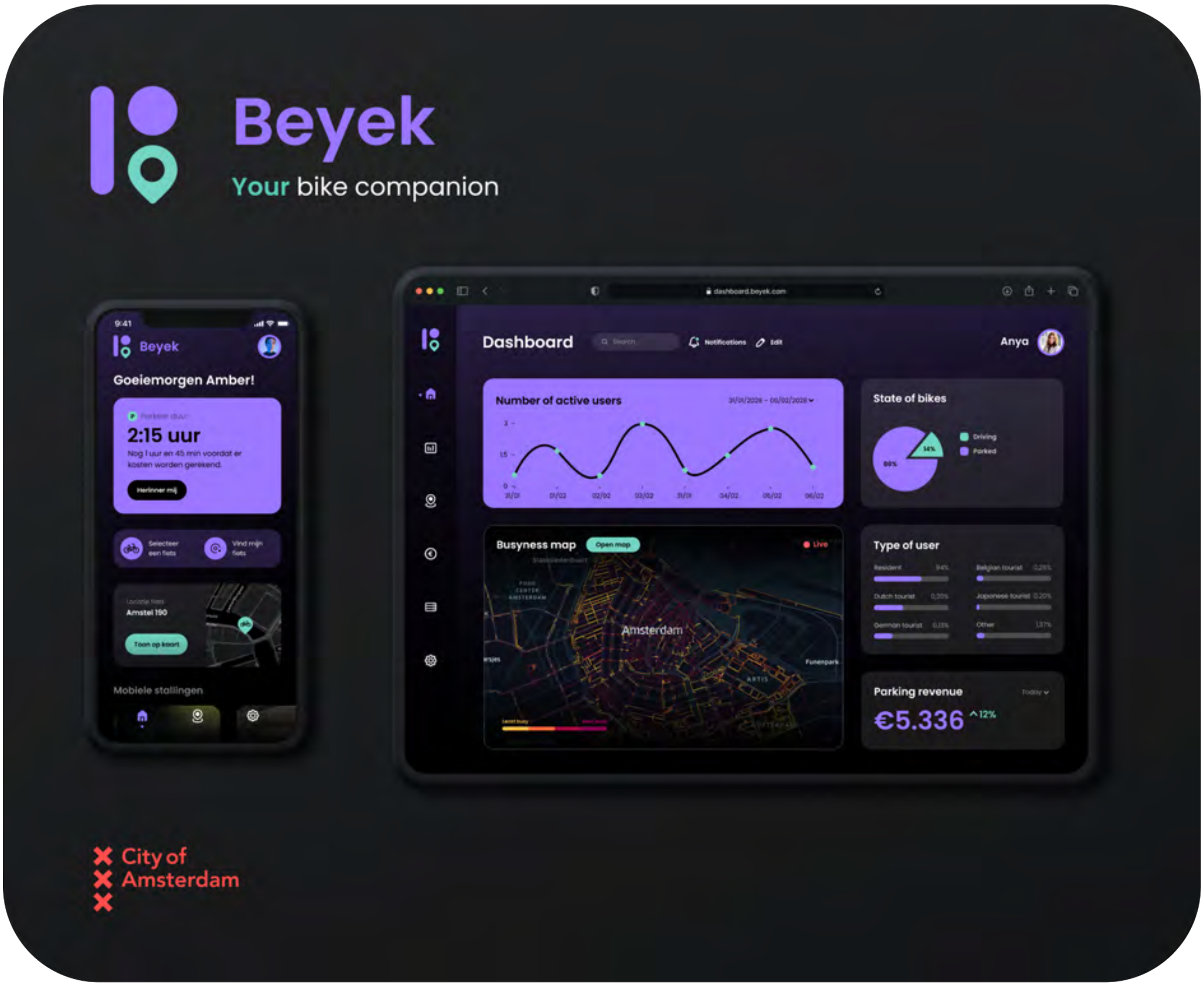

Figure 55: The Beyek app (left) next to the Beyek dashboard (right)

3.3 Dashboard

The dashboard would be the more advanced interface of Beyek. Its main focus is monitoring the system and visualizing the data it collects. The dashboard would be accessible via a website, but only accessible by the designated persons.

3.3.1 Design

The Beyek dashboard is designed inline with the mobile app, to create a harmonized system. This is clearly visible in figure 55, where the 2 interfaces are seen next to each other. The blocks are similarly colored and there is a strong sense of hierarchy because of the use of color.

3.3.2 Home screen

For this report, we created a prototype of what the Beyek dashboard would look like. The strategy of stacked blocks is even more apparent in the dashboard with 5 blocks of different sizes adding up to one balanced stack. As the dashboard would be tailored to advanced and governing users of Beyek, customizability would be of big importance. Different employees would need to see different data on their home screen. Therefore, there is an option to edit the blocks on the home screen to view selected data. This is done by clicking the edit button at the top of the page. This would make this dashboard adaptable to multiple situations, while still retaining the same brand identity.

4. A Perfect Fit for Amsterdam

This chapter will go into how BEYEK is the perfect fit to work together with the local government of Amsterdam. Accordingly, describing how Beyek works and how it will build further on the groundwork that the local government of Amsterdam has already laid. Furthermore, the revenue and data flow of Beyek will be described, and some recommendations will be made so that Beyek will work for all people.

4.1 The local government of Amsterdam

The local government of Amsterdam aims for the preservation of the city, more specifically on the cleanness, safety, and sustainability of Amsterdam. (Gemeente Amsterdam, 2021b). One way Amsterdam is realizing this now is by choosing to be a biking city. To sustain this culture they have developed a “Meerjarenplan Fiets”. (Gemeente Amsterdam, 2021). Within this plan, they started to target the parking problems of bikes in the city. As described in earlier chapters, it is essential that this biking problem in Amsterdam is solved, but also that this is done more dynamically in, to more crowded areas money. Accordingly, the local government of Amsterdam can expand its current plan by supplying more bike parking data to bikers as well as supplying bikers with mobile parking stations on locations that are currently overcrowded. The local governments' goal for solving this biking problem starts with more accurate knowledge of the problem. More precisely analyzing real-time data on the activity of bikes all around the city.

BEYEK would be an excellent addition to the previous achievements that the local government of Amsterdam has had and will take its groundwork to a higher level. Biking is a massive part of the culture of Amsterdam. With this system that culture can be sustained even with the increasing number of bikers and the problems that they might bring to the city. Giving bikers more understanding of where to park, options for easier parking and options for finding bikes back after losing them will be the core in solving the biking problem in Amsterdam.

This system has the potential to improve biking life for many inhabitants of Amsterdam. It could simplify using bikes in Amsterdam for all people, and even make life easier for all people living in the city and moving through the city. BEYEK will help Amsterdam to sustain its biking culture and simultaneously help the preservation of the city.

Figure 56: Amsterdam and its parking solutions now. (Gemeente Amsterdam 2020)

4.2 Change of the system now

BEYEK wants to solve the problem of overcrowded bike parking spots in Amsterdam. Accordingly, problems that bikers have when trying to park bikes and problems that they have when trying to find bikes are solved. Protection against theft and damage are important problems here as well. We need to change the way people look at bikes drastically to eliminate these problems. To change the meaning of bikes for people the method of design-driven innovation seemed most appropriate. Design-driven innovation targets primarily the change of culture and meaning where technology can assist. (Snelders, 2020).

Design-driven innovation can be seen in figure 57. This graph shows three different innovating strategies that are given volumes over the axis of meaning and technology. This graph shows the development in which BEYEK moves within these axes from the original position that the local government of Amsterdam had taken.

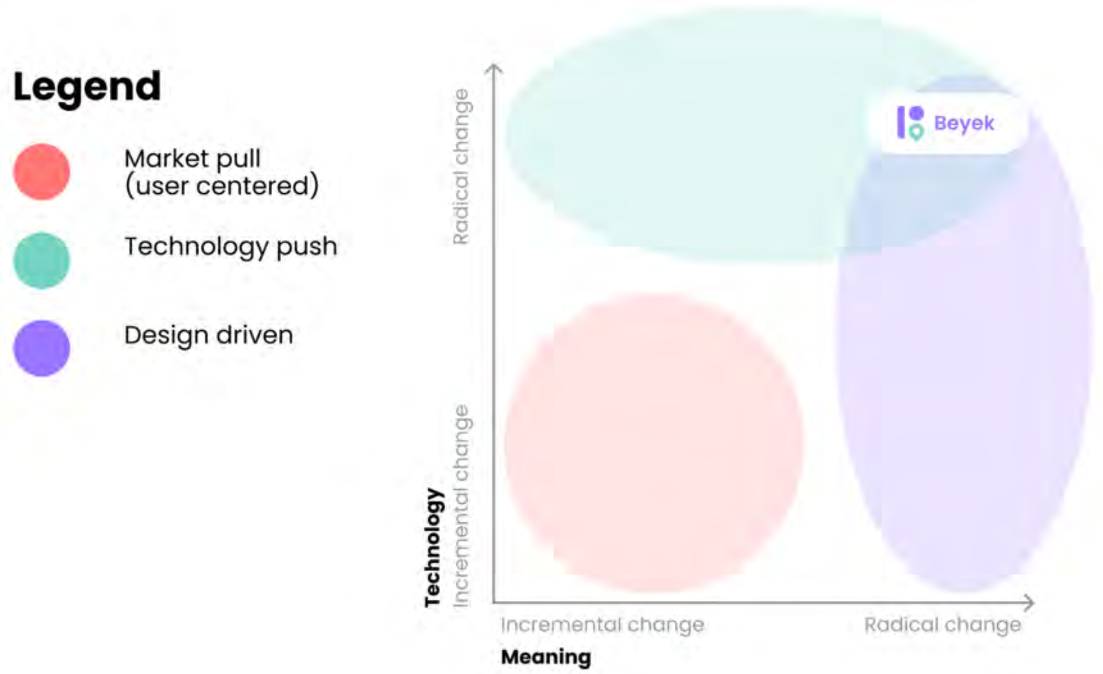

Figure 57: The innovation strategy of BEYEK, on the axis of technology and meaning.

How people use and think of bikes needs to be different. BEYEK wants to accomplish this goal using GPS and NFC chips to create smarter bikes in daily life. Doing so we enable the option for bikers to better understand where to park bikes and when to find them when lost. This is done by offering them real-time maps with available places and giving bikers options to find their bike when lost. Doing so the threshold for being a biker that makes good choices is lowered. Using this system together with charging low fees in more crowded areas will offer the solution to changing biker behavior for the best of the whole of Amsterdam.

It is a system that makes decisions and shows options that were previously difficult or impossible for bikers to make or see for themselves. The system can even help different types of people like mentally, physically handicapped people to find places to park the bikes that are closer or more suitable for them.

4.3 How will BEYEK fit the existing infrastructure

The local government of Amsterdam has the infrastructure and authority to accommodate the changes that BEYEK wants to make within Amsterdam. They have a large database on many topics relating to traffic, people, and of course bikes. However, their databases lack the quantity, precision, and speed at which the data is collected. These are things that BEYEK will improve so that the system will work and achieve its goals. Moreover, new services should be supplied, users should be supplied with an app, the local government should have a clear UI to understand the real-time activity of bikes. Accordingly, the local government can make dynamic regulations in the form of fees in areas that are overcrowded. Secondly, the local government can now more precisely install mobile parking stations to fill the lack of parking spaces needed at a specific time in a certain area.

4.4 Business value BEYEK

Beyek has several points at which it can help the values that the local government of Amsterdam has. First Beyek will help bike users by offering bikers more ease during parking, finding their bikes. They will also create mobile parking stations and help create money for empty streets and current parking places for broken or unused bikes. Making these necessary changes will stimulate bikers to have and create better parking situations for themselves, accordingly stimulating good behavior. Secondly, local governmental organizations will be granted more insight into real live biking activity data. This will help them to make dynamic regulations that are fairer and just to all. Besides, it will give the local government a better chance at predicting the future so that other regulations that may be created in the future are fairer and that their influences can be better understood before introducing them.

For the local government of Amsterdam using this product is another step towards the goal of maintaining the bike culture in Amsterdam while also preserving Amsterdam. Amsterdam could become an example for other cities and countries on how to tackle a big problem using data in an innovative way.

4.5 Revenue flow

Beyek has a very interesting revenue flow that can be most easily explained using figure 58. What is most important is that the money flow within the system goes through a cycle. This means that once the system is running it will be self-sustaining and will therefore help on its own to further grow the product and system.

Firstly the system will slowly get going by having large investments in getting every bike in Amsterdam to have a GPS and NFC chip on it. Using these sensors data is collected that is sent to BEYEK. BEYEK uses this data to monitor the positions and times that the bikes have been parked. When parked small fees are paid from the bike owners to BEYEK. BEYEK uses the fees for multiple purposes. First for paying parking location owners to create new parking places, to preserve the existing parking places, and to develop the mobile parking places that are needed to solve problems dynamically. BEYEK also uses its income for the preservation of its own system and for investing in new GPS and NFC chips, for new bikes to grow its influence. Thirdly, BEYEK gives money to the local government. The local government will give money to the bike parking owners, the bike depots for emptying the bike parking places, and will give money to help create dynamic regulations and artworks throughout the city.

On the other hand, if bikes are parked wrongly or are neglected and were to be wanted back by the bike owners, they can buy these bikes back for a small fine to the bike depot owners. They will again with this money empty bike parking places and also spend a part of their income giving it to the local government for further use.

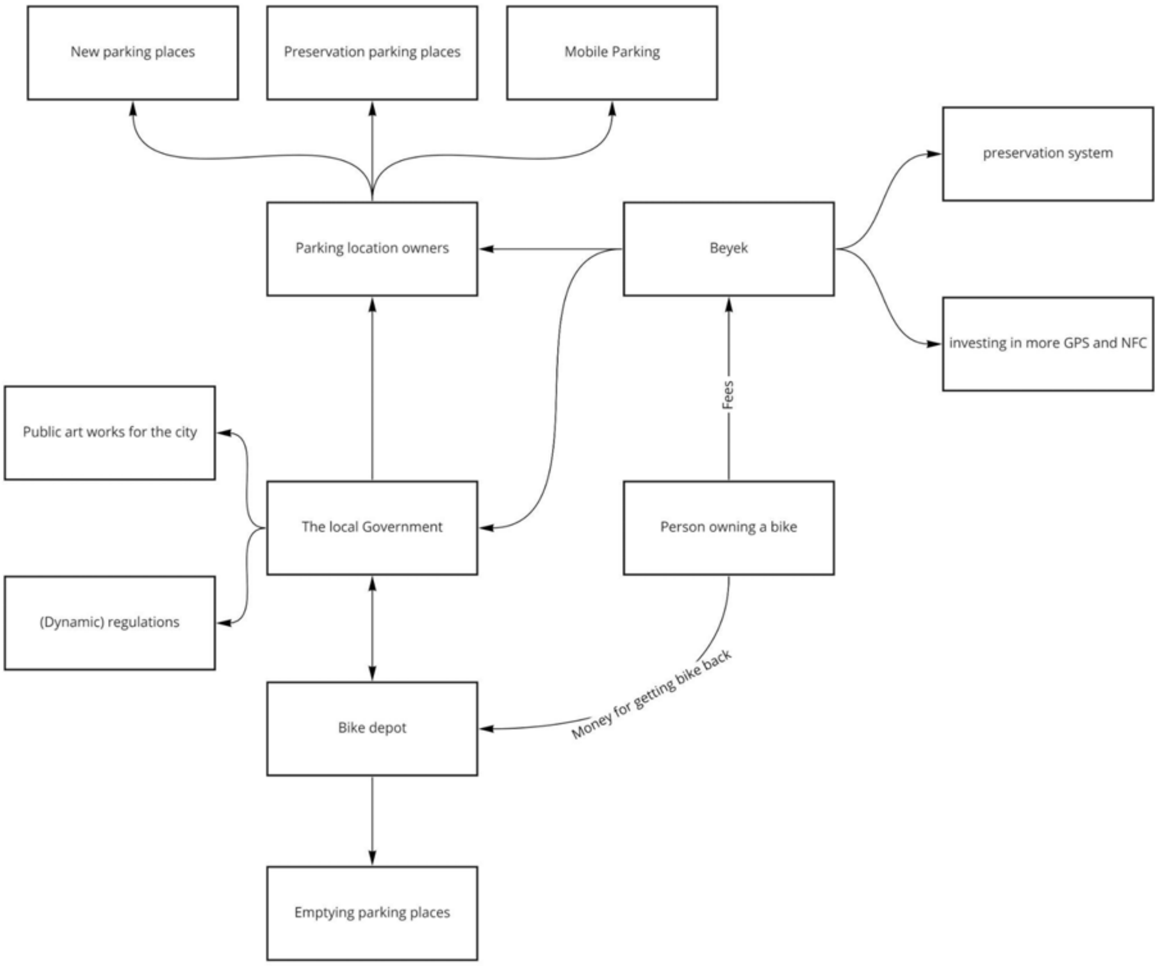

Figure 58: The revenue model of BEYEK, describing the money flow in the whole system.

4.6 Data flow

The use of better data is the core of the solution that Beyek offers and it, therefore, emphasizes why the parking department and traffic and infrastructure department of the local government of Amsterdam have to work together to solve the bike problem that currently exists in Amsterdam.

To better portray the use of data between the different stakeholders in the system the data model in figure 59 can be seen. To simplify how data is used, propose the bike, GPS and person can be seen as one part in the model. It then becomes clear that data flows only two ways. The first way is to governmental organizations, the second way is to the Beyek app that syncs with parking organizations that will use this information to create the mobile parking plan.

Data separation is another technique that will be used in Beyek, this is important to be emphasized. This separation means that all data can be divided into two parts. The raw precise location data is anonymized and sent to the server for traffic flow analysis. This data is completely anonymous and encrypted. The other part of the data is personal area data. The bike is bound to an area and this data is sent. Important is that this data is sent separately to a different server. This way if the data is obtained you can't trace it back. This data is needed for parking fees, parking time, and fines. In this way, there is no unnecessarily specific data in circulation.

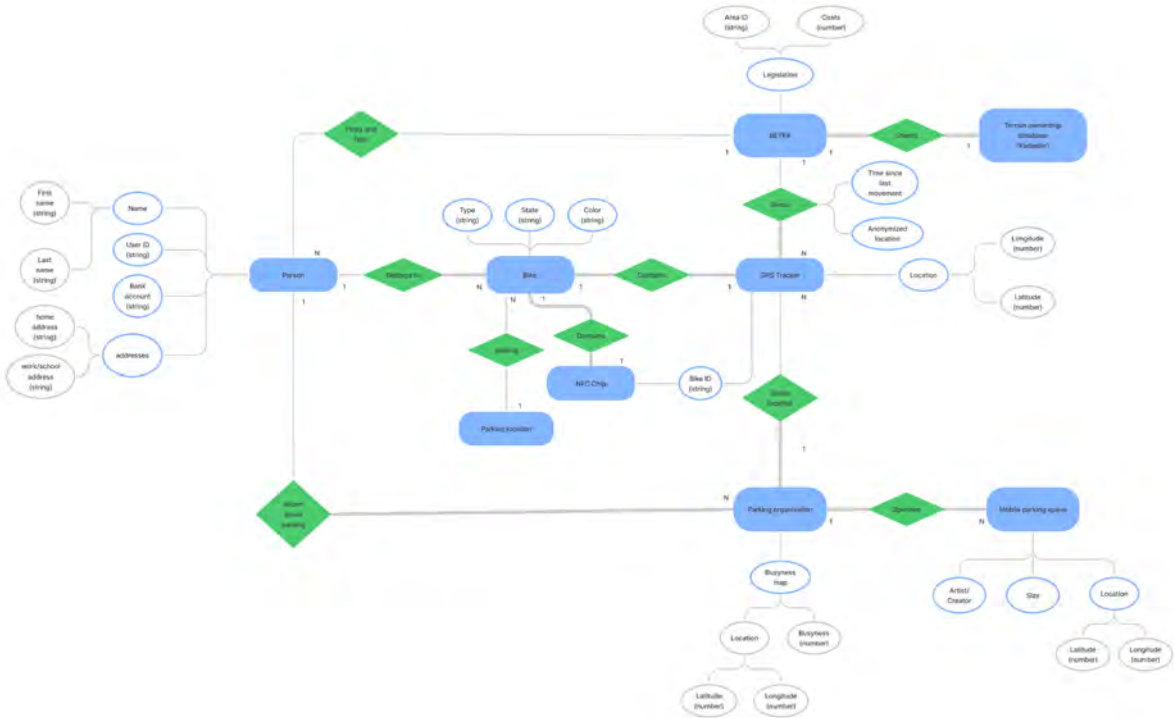

Figure 59: The data model of BEYEK.

4.7 Conclusion

Beyek is a vital product system in helping the local government of Amsterdam clean up overcrowded bike parking spots and to help maintain the bike parking situation of Amsterdam in the future. Beyek offers more information in the form of a busyness map to bike users in Amsterdam and the local government. Bike users will use this information to give them insight on where to park, where to find their bikes and to help users to protect the safety of their bikes. The local government will use the information of BEYEK to acquire more insight into the activity of bikes through all of Amsterdam and to dynamically make regulations where needed. Real-time activity monitoring of bikes in Amsterdam enables problems to be fast and easily pinpointed. This data is acquired by using GPS and NFC on all bikes within Amsterdam. Dynamic regulations in form of fees together with the BEYEK app will help to direct bike users to less busy areas that are perfect for them. The money acquired with fees will partly be spent on helping the bike depot empty all the bikes that have not moved for a long time according to the GPS and NFC. The use of these sensors will function as a scare tactic, not to steal bikes. Altogether Beyek and the local government of Amsterdam can work together to make streets more reachable for all, help bikers to more comfortably use their bikes throughout the city, while also maintaining the lively biking culture that exists in Amsterdam today.

4.8 Recommendations & Discussion

BEYEK is a system that focuses on solving the bike problem dynamically for all of Amsterdam. Older people, tourists, children, disabled people are just a few examples of limitations in the current system of BEYEK. Several improvements and recommendations therefore still need to be made so that Beyek can be the perfect solution to Amsterdam's bicycle problem.

The first limitation is elderly people living in Amsterdam. Elderly people are usually not familiar with using phones. This could be a problem since Beyek is very much an app-based service. To make their transition of integration Beyek into the daily lives of the citizens easier, Beyek wants to give these users a transition period. This period will start with making the program free for all elderly, slowly introducing them to how to use the program. In the end, the same fees will be introduced to them as well. This transition period will be for people that are now 65 years and older since smartphone ownership drops drastically from this age and up.

For tourists the problem is quite different, Beyek, therefore, decided not to bother them with the app and the system. Because tourists do not have the time to understand the system. We, therefore, decided to give them a fixed fee when they rent a bike. This fee is an average of what all inhabitants of Amsterdam are to pay so that the Amsterdam people will not feel that tourists get better treatment than them.

The third limitation is for children under 18. Children are by law not allowed to have any property since these are for their parents or caretakers. Also, it would not be morally right to charge children for parking bikes wrong when they are proven not to have a good enough understanding of using apps and, therefore, our system. Beyek, therefore, wants to make the system free for all children up to sixteen years old and create the possibility within the app for parents to add multiple bikes, including bikes for their children. This will take the responsibilities from the kids and transfer them to their parents.

Then there are handicapped people within Amsterdam. Although this group might be smaller than all others, we at BEYEK strive for including all people within the system. Of course, there are many variations in handicaps. For handicaps that are too severe for individuals to think for themselves, the same applications for children under 18 will be used. For handicapped people that are immobile due to their handicap, special parking places will be reserved and shown within the BEYEK app.

We also recommend close monitoring of the data we gather. BEYEK should always be independent of the government. They are a government institution. Failsafes should be in place to prevent misuse of data or data leakage to the government. Beyek as shown earlier, therefore, splits its data so that privacy is maintained for the people of Amsterdam.

Finally, it is important to discuss the reaction that people might have to the implementation of BEYEK. It is for example perfectly understandable that some inhabitants of Amsterdam will feel betrayed, or irritated when hearing that they have to pay fees for parking their bikes. It is therefore important for BEYEK to understand different points of view of stakeholders in the system to try to find solutions for the problems that they may have. It might therefore be interesting to stimulate users differently when they are using BEYEK. Instead of using fees, positive stimulation in the form of a point system could be used. This is just an example of how different solutions might have equal or better outcomes. It is at this point where our team does not have enough time and resources to find the best solutions. We, therefore, advise BEYEK to test and thoroughly think about problems like these, so that they are solved in the best way possible.
(P.S. Don’t forget to read Appendix F: reflection).

Sources

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