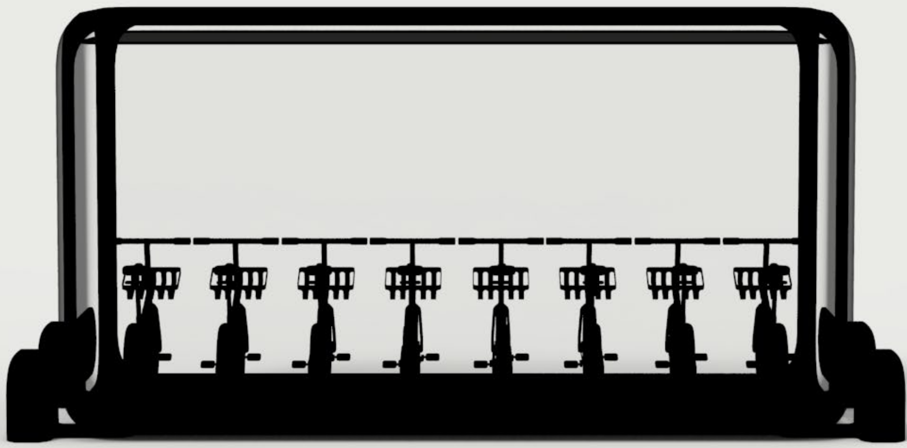
AUTONOMOUS BIKE-SHARING SYSTEM



LUND UNIVERSITY

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DEPARTMENT OF DESIGN SCIENCES

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Doing projects on your own can be quite hard sometimes and this one is no different from the others in that it wouldn't have been the same without the help from others.

I would like to send special thanks to: My supervisor Charlotte Sjödell for all the support and for pushing me to take hard decisions. Examinor Claus-Christian Exckhardt for his engagement and making me ask myself the hard questions. My girlfriend Sophia for putting up with me and listening to all my obsessions. My dear friend Petter Hillinge for encouraging me and lending a critical eye that I trust.

ABSTRACT

EN

This report covers the process of a project that resulted in a future concept for an autonomous bike-sharing system. It started with a desire to do transportation design and to explore the future of public transit and the role of the bicycle in it. The research phase started with trying to form an understanding of the current public transportation situation for cyclists and also looking into future trends, both socially and technologically. That research phase led the next research phase to focus on bike-sharing and its benefits and problems. The final research phase concluded in a system design phase that experimented with modes of operation and ways of interaction with a system of this size. From the system design a set of design criteria and focus areas was formed. The main focus of the project was to design a self driving bike-sharing station and a bicycle for it. My approach to this was to start with the context and how bikes should be accessed to then design them based on that. The final result is an future bike-sharing system that is designed as part of a multi-modal urban mobility network. It leverages autonomous vehicle technology to create a more flexible, efficient and accessible system. It consists of a self-driving station that enables instant rebalancing and scaling and a bicycle that is designed with simplicity and durability in mind. It was presented trough computer visualizations and a 1:20 scale model.

SWE

Den här rapporten redogör för processen och resultatet av att designa ett framtida autonomt lånecykelsystem. Utgångspunkten för projektet var en önskan att prova på transportdesign och utforska framtida lokatrafik och cykelns roll i denna. Efterforskningarna inleddes med att försöka skapa mig en uppfattning om dagens situatin för cyklister i lokaltrafiken samt att se på framtida trender både sociala och teknologiska. Detta ledde mig att fokusera på lånecykeln med sina fördelar och problem och hur dessa kunde adresseras i framtiden vilket i sin tur utmynnade i en systemdesignfas där olika koncept på interaktion och systemfunktion utforskades. Med ett systemkoncept kunde fokusområden ringas in och designkriterier utformas för vidare konceptutveckling. Huvudfokuset kom att bli en självkörande lånecykelstation med en tillhörande cykel. Utgångspunkten var kontexten och systemet de skulle befinna sig i och det skulle användas. Slutresultatet är ett framtidskoncept på ett självkörande lånecykelsystem som ska fungera som en del i ett multimodalt mobilitetsnätverk. Det använder autonom fordonsteknik för att skapa ett mer flexibelt, effektivt och tillgängligt system. Det består av en självkörande station som möjligör omedelbar ombalancering och anpassning av tillgången på cyklar. Cykeln är uformad med enkelhet och hållbarhet i åtanke. Det presenterades med datorvisualiseringar och en skalmodell i 1:20.

INTRODUCTION

WHY

One of my greatest interests when growing up was vehicles, especially cars. It still persists, but maybe not as strong as then. This in combination with my interest in technology was very influential in my decision to apply to the school of industrial design. But as I got into the education, my interest in becoming a specialized car designer in the traditional meaning became less appealing to me, making me focus more on consumer products, as I thought that I would have to make the choice. But my interest in transportation persisted and I started focusing more on bicycles. For my final degree project I wanted to explore how I could use my point of view and the knowledge & methods that I've learnt over the years to explore the area of urban mobility, in the context of the future technologies shifts that interest me.

Autonomous transportation, tech in general, future tendencies in how people move in the city and social factors will most likely reshape the mass transit we know today.

Looking at the role that the mass transit system fill in today's city and look at why they have looked largely the same for soon a century, and how they can better adapt to the future. Also looking at how these new and old modes of transportation could exist in relation to the bicycle on a local and regional scale.

Bikes are becoming again an ubiquitous part of today's inner and inter city infrastructure. With Bike-Sharing it has become even more accessible in many cities. How can healthy transportation habits be facilitated trough synergies in modes of transportation?

HOW

I will try to deal with this huge subject area by first forming a general understanding of the current day situation. All major modes of transportation, urban planning, and the digital side of public transportation. Also the system of stops/stations and bikes/car-sharing. What challenges are there today? E.g. Electrical buses and their technology. What are the pain points for today's commuters? Trying to quickly draw conclusions and identifying opportunities.

But also looking at what could the future look like in these areas? Look at future tendencies in tech, transportation, legislation, living & behavior in big cities. E.g.. using big data, internet of things & future tech to improve the experience. To make this manageable I will concentrate on a few key areas. Based on the findings of this research a future scenario of a specific city will be developed, as a framework to build the ideation on. This scenario will be to the greatest extent possible be based on visions and plans with a foundation in the actual city plan.

All this will primarily be evaluated in the context of the Scandinavian cities Copenhagen, Malmö and Stockholm as especially Copenhagen is considered a progressive city in terms of urban planning and cycling culture. The research however, will have a global scope to gather as much relevant information to draw conclusions from.

Research will be categorized and evaluated continuously, identifying opportunities. After an initial research phase a well defined subject area will be chosen and looked at more closely in both a qualitative and quantitative way.

R1: THE PRESENT

BIKES IN PUBLIC TRANSIT

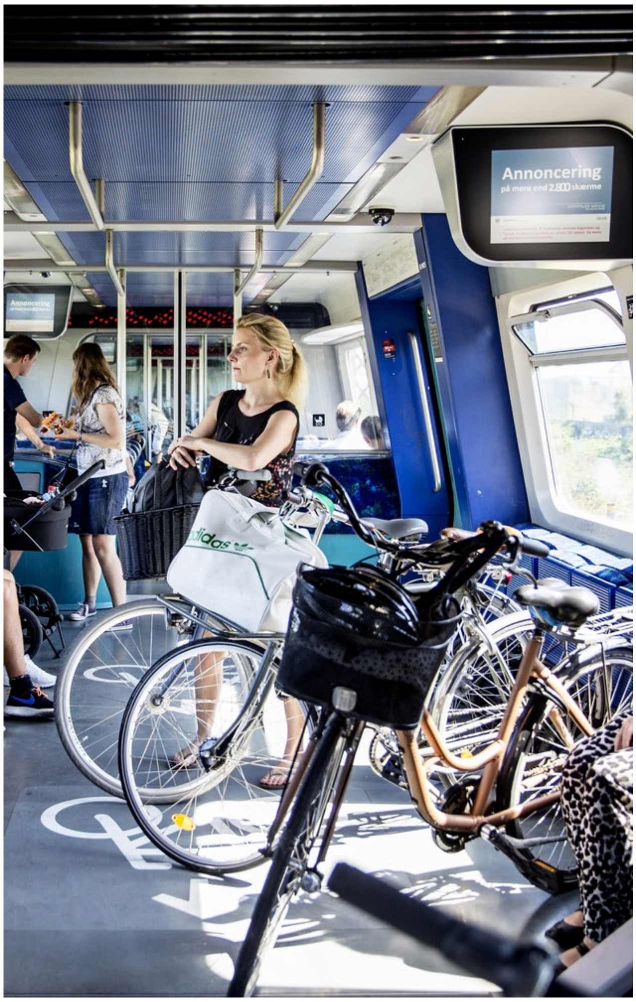
Bringing a bicycle on today's public transit isn't always an easy task. Living in possibly one of the most bicycle friendly countries in the world, Sweden, this might come as a surprise. The reason for wanting to do this might be that you want to use a bicycle at your end destination, either for the last kilometers to the final destination, general practical reasons or for recreational purposes.

Often a lot of rules apply to the venture of bringing a bicycle on a bus or a train. More often than not it is actually forbidden on inner-city buses in Sweden (1) due to limited time during stops, short distances easily ridden by bike. Although a majority of the buses used have room inside, this area is designed for use by passengers with strollers, wheelchair and walkers. Also due to this the risk of soiling other passengers with dirty bicycles or the safety risk when breaking. This due to no proper bike storage or retention. In Copenhagen a maximum of two bikes are allowed on the buses, but strollers, disabled and elderly are prioritized, especially during rush-hour. (2) However on regional buses bicycles can be brought on rear mounted bicycle racks. In Sweden it is illegal to mount things on the front of the bus, but the consequence of this is that it is virtually impossible to keep an eye on your precious bicycle. (3) In some regions they can be used all year round, but in southern Sweden they are only available during weekends and the summer. (1)

Ironically this is a much simpler endeavor in most North American cities. (4) Cities like Chicago, Vancouver and Austin has adopted a system where it's often free to attach your bicycle to an easy to use front rack. Here clearly the time is available, and the cyclist is recommended to sit in front to keep and eye on the bike.

Looking at the same situation but on trains it is a little less grim. Though on many long distance trains it isn't allowed to bring bicycles unless they are folded to a compact size or in a bag or box. Some trains have special facilities for bikes and luggage. (5) (6) On regional trains in Sweden there's often a designated area for bikes, but just as on the bus this is only available when not occupied by children in strollers, disabled, elderly or large luggage. (1) In Copenhagen this is much easier on the regional S-Trains where it's free to bring bicycles in the special bicycle car of the train. On the Metro it costs DKK 13, and is limited to space and time outside of rush-hour. (2)


MATIATIA FERRY 1
via SURFDALE


Annoncering
på mere end 2.300 skærme

BIKE-SHARING

Bike-Sharing is a relatively new mode of transport where users have access to public bicycles distributed around a city freely or at stations. It enables point-to-point, human-powered transportation feasible. With it's first generation launched in 1965 i Amsterdam, Holland. It was called Witte Fietsen (White Bikes) and where more or less white bikes for the public to use freely and leave wherever they wished. Though this program collapsed within days as bikes where thrown into the canals and appropriated for private use.

In the early 90s a second generation of bike-sharing was started in a couple of small Danish cities. In 1995 the first larger scale system was created in Copenhagen called Bycykeln. This model utilized stations where users paid with coin to pick up and return a bike. The system was run by a non-profit organization and the bikes featured solid rubber tires and where covered in advertising. Though these systems had no way of tracking the customer, so problems with theft was widespread.

To deal with these issues a third generation was launched in 1996 at Portsmouth University in England where users used magnetic strip cards to rent bikes. Further developments in other cities utilize position tracking technologies, smart cards, electronically locking racks or bikes and other means of connectivity.

Following the introduction of 3rd generation systems the growth was initially slow, but has accelerated in the recent decade. Today there are circa 980 cities that have automated 3rd generation systems with around 1,258,000 bikes in use. (8)

One of the benefits with bike-sharing systems is a larger share of bicycle users in the inner city, many cities with an already low bike use has seen a 1 - 1,5 % rise. Also general use of public transportation increases by helping the first/last-mile problem that many public transit users have. Mostly bike-sharing reduces car trips instead of general public transit use. (7)

An example of a successful bike-sharing system is the Dutch OV-fiets. An advertising free, inexpensive to run (ca 400 dollars per bike) and use system that many local commuters use as the last leg of their journey. A not as successful example would be the latest generation of the Copenhagen bike-sharing system that is packed with technology, but not very popular with locals as it's expensive and seen as a tourist gimmick. This due to that the expensive (ca 3000 dollars per bike) are equipped with tablets and electrical assist (that costs extra to activate, but makes the bike almost unrideable when not active). Their high cost has also led to them not being able to implement them as widely as planned. Imagined to be used 3 times a day by local commuters they are instead used 0,8 times a day by tourists. (9)(10)


citi bike


citi bike

Generally the current bike-sharing systems aren't without their problems either. One of the major problems today is the rebalancing of bike-sharing systems. As they are used an imbalance is created in the inventory of the different bike stations over the city. Resulting in too few or too many bikes at stations, making picking up and dropping of a bike hard for some users. This need of rebalancing the system is a major cost for the organization running it. Currently plenty of research has been done in the area on both how to calculate the right amount of bikes to add or remove, but also what route to drive to distribute them properly and efficiently. One example of this is BICO, a London based company. (11)(12) The same problems occur with so called free-floating systems, where users can leave the bikes wherever they wish. In the report "GPS-Data Analysis of Munich's Free-Floating Bike Sharing System and Application of an Operator-based Relocation Strategy" it is described how bikes still cluster at certain zones leaving some empty. This requires the significant effort to maintain balanced. (48) Some try to solve this by incentivising travelers to stay within certain areas or dropping of at certain places. However this to me seems like treating symptoms, rather than the decease, and who suffers is really the user who can't move freely. (49)

The installation of bike-sharing systems is also often complicated and expensive. Involving connection to ground electricity and digging into asphalt and pavement. It is a permanent addition to the street-scape. Some have tried to address this with solar panels and on-ground stations that's bolted instead of cast into place.

IMBALANCE

MAINTENANCE

PERMANENCE &
INFLEXIBILITY


80 90


Rent This Van!


capital bikeshare

CAR-SHARING

Another vehicle-sharing trend recently is car or ride-sharing. Many cars are mostly parked for a large part of their life. A way to reap the benefits of a car, without the extra work and costs that is associated with owning a car. Car-sharing is taking several forms, and what is offered is largely dependent on your geographic location. Recently services such as Uber and Lyft has revolutionized the taxi-industry by letting private drivers give other people rides and earn money doing it. This trough an app that lets you connect to users of the service. (13) Lyft has also the opportunity for users to share the same vehicle with strangers going the same way. This would classify as ride-sharing.

When it comes to car-sharing there's services like Car2Go, Sunfleet and Audi Unite. Sunfleet, an initiative by Herz and Volvo that allows members of the service to access cars parked on certain spots around the city. The cars can then be used as much as you can pay for. In some large European cities, among them Copenhagen and Stockholm, a similar service by BMW and Sixt called DriveNow as started. There you get access to a floating fleet of cars that you locate and book via the smartphone app. In Copenhagen it works with your public transit card, Rejsekortet. (47) Similarly Audi Unite allows users to share a car, but within a specific group. You book the car through an app, and have then a smaller group of people using the same car. For this you pay a monthly fee, and then the car is taken care of for you. (15) (16)


DriveNow
BMW 1er
M-DX8739
10:00
Minimieren
Verlängern

URBAN PLANNING

The planning of urban spaces and infrastructure largely dictates the situation for all modes of transportation and people in society in general. Cycling and public transit is seeing a resurrection in today's cities after a slump in the mid 20th century.

A good example of the impacts of innovative transportation systems is Curitiba, Brazil. A city where problems of large amounts of car traffic and noise & air pollution was rising. To deal with this city major and architect Jaime Lerner helped develop a rapid bus transit system with dedicated bus lanes and later on an innovative bus stop system borrowing from modern subway systems. (17) Thanks to this and other initiatives in the city Curitiba has gone through an impressive transformation from a city of 361,000 (in 1960) to 1,828 million (in 2008), this without congestion, pollution and less public space. Despite a large increase in density the amount of green area per person has increased from 1 km² to 50 km². It has the highest rate of public transit use in Brazil and little air pollution. Fuel usage is approximately 30 percent lower than in other major Brazilian cities. (18)

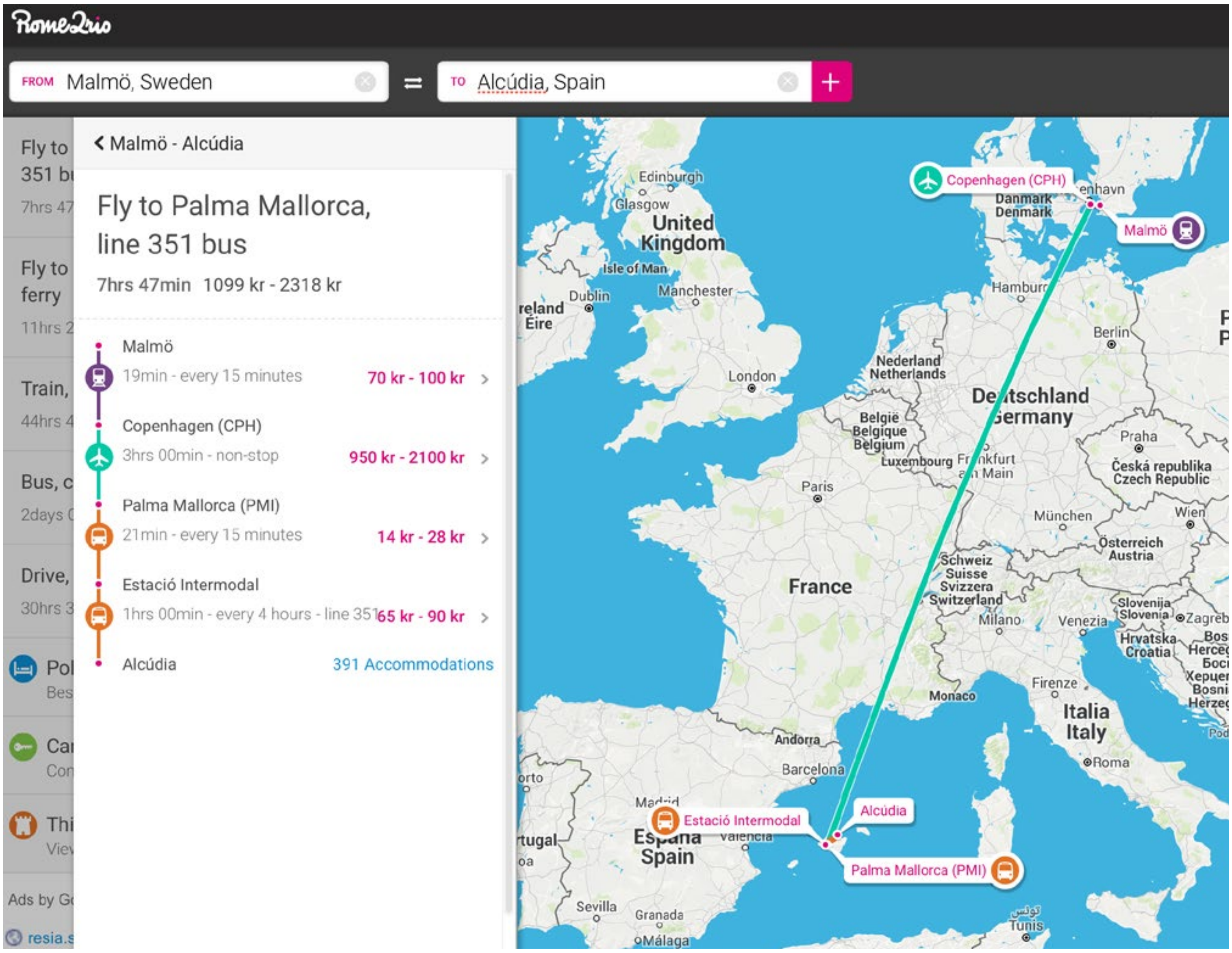
A bit closer to here is Copenhagen, a city that has become a role-model all over the world for its efforts in bicycle infrastructure. As many as 84% of Copenhagen residents have access to a bicycle and of them 64% cycle at least once a week. As many as 50% cycle to work or school. This has been made possible through large initiatives over a long time where cyclists have been prioritized above cars. Good infrastructure and short routes make it an attractive option to ride a bicycle in Copenhagen. This has payed of for the city as well. The total socioeconomic return of people cycling more was in 2010 calculated to around 1,7 billion DKK. This due to better public health, less air and noise pollution and less wear on the city infrastructure. The net social gain per cycled kilometer is DKK 1,22 and the net social cost per driven kilometer is DKK 0,69. This is something more and more cities are realizing. (19)

EAN AIR VEHICLE
DASH
12302
CHINA
LIKE NEVER BEFORE

JOURNEY PLANNING

Transportation is also entering the digital age. Not only with the services previously mentioned, but also in smart journey planning. Digital journey planning has existed for a while in services isolated to one transportation company. But what is becoming increasingly popular is so called inter-modal journey planners. (20) The user enter a start and stop destination and sometimes additional parameters to receive a complete trip spanning both public and private transportation. Some are like a service called Rome2Rio, which plans a trip complete with pricing on the different alternatives. (21)

Applications like Waze are less about inter-modality but more about sourcing public and community generated information to navigate traffic. It adapts your route according to road conditions and considers congestion and accidents. In general navigation is becoming smarter and smarter, resulting in safer and more efficient trips.


FROM Malmö, Sweden
TO Alcúdia, Spain
Malmö - Alcúdia
Fly to Palma Mallorca, line 351 bus
7hrs 47min 1099 kr - 2318 kr
Malmö
19min - every 15 minutes
70 kr - 100 kr
Copenhagen (CPH)
3hrs 00min - non-stop
950 kr - 2100 kr
Palma Mallorca (PMI)
21min - every 15 minutes
14 kr - 28 kr
Estació Intermodal
1hrs 00min - every 4 hours - line 351
65 kr - 90 kr
Alcúdia
391 Accommodations
Copenhagen (CPH)
Malmö
Estació Intermodal
Alcúdia
Palma Mallorca (PMI)
United Kingdom
France
Deutschland
Germany
Italia
Italy
España
Spain

R1: THE FUTURE

INTERNET OF THINGS

One of the hottest buzzwords of today. Internet of Things is the concept of now not only connecting personal computers to the internet, but also many of the products around us. Today millions of sensors collect data and generate information that then enable experiences and functionality that otherwise would be impossible or cumbersome. It allows devices to exchange data, generating smart systems, like "smart homes" and eventually "smart cities". (23) (27)

The utilization of "Big data" will also be a large factor in the future. Big data is the data generated from the massive system of sensors and other digital footprints from transactions etc. Data often to big and complex for traditional data processing applications. Processing of big data can generate knowledge about how to make processes and systems more effective and will have a great impact on further automation of systems. (24) Some predict that by 2022 there will be up to 1 trillion sensors around us, a figure rising to 45 trillions by 2035. This will profoundly transform things like mobility being able to quickly analyze and respond to events dynamically. (26)

This future interconnectivity will together with other technical advancements probably lead to a more ambient user experience. Creating a continuous experience across existing boundaries between platforms and devices letting us interact with the environment of the devices rather than specific devices. (25) (26) (27)

ARTIFICIAL INTELLIGENCE & AUTONOMY

In the future it is safe to assume that artificial intelligence will have evolved a lot. An factor in this is machine learning, the ability of a smart machine to change its future behavior. Some believe that in a not to far away future a large portion of our interfaces will be autonomous agents controlled by AI. (28) Already we are seeing a wide adoption of interfaces such as Apple's Siri and Microsoft's Cortana. Most importantly the way we are able to communicate with AI will have to change, from prompts and commands to recognition of natural speech and languages. (29) This could replace menus, forms and long series of actions.

A hot topic directly related to artificial intelligence and machine learning is autonomy in products. Meaning the ability for them to function self sufficiently. An especially interesting area where the possibility of autonomous development is the car industry, where technology already is in place for a relatively well functioning autonomous car. Through radars, lasers and cameras the cars have the ability to drive public roads safer than a human. (30) Google and many auto companies are testing their cars on the open roads and Google is aiming to have an autonomous car on the market by 2020. (31) The potential benefits of autonomous driving is enormous. It could greatly reduce the amount of deaths on roads, and potentially dramatically reduce the amount of cars on the roads. Autonomous vehicles could be summoned when needed and continue on to the next person when it has fulfilled your task. The challenge is that it could encourage individual car use if not handled right. Not having to drive yourself you are freed up to do other activities, something that is good for overall productivity, buy could end up increasing commute times as distances are less of a problem. Traffic could increase as this would be a more comfortable option than public transit. But a possible scenario could be a healthy blend of private, shared and public autonomous vehicles. (32) At the same time governments are scrambling to set the framework of rules that facilitate the development of autonomous cars. (33) Other car makers such as Audi and Tesla is already driving their cars fully autonomously on highways. (34) In the case of Tesla, its founder Elon Musk predicts that their cars will be able to drive themselves across America in two years. Although the current highway autopilot was just a software update to the Model S, he sees that a fully autonomous car would need more technology to function without humans as a backup. (35)

The societal impacts can according to researchers be fundamental. As most cities today are built around the car, when the car change, so can the city. In a study by Earth Institute and Columbia University researchers found that 18,000 shared driverless cars could replace 120,000 owner driver vehicles. This would achieve wait times of less than a minute with a utilization of 70% of the fleet. This means that cities will be able to reclaim vast amounts of parking and road space for public use, like cycling, walking, parks, etc. In turn this has been proven to increase public health, crime rates and social cohesion. (36)

Autonomy, artificial intelligence and automation in general doesn't come without it's problems. Many of these technologies will lead to the replacement of human labor. Autonomous mobility will maybe eventually remove the need for truck drivers. Just as many industrial robots and machines replaced people working in factories. You could say that many jobs that are repetitive has up until now been replaceable, but going forward jobs that are predictable are also in the danger zone. As much as 47% of the jobs in a country like the US could be replaced, and in a country like Ethiopia it's a whopping 85%. Raising the concern for premature de-industrialisation in many developing countries. Countries where these jobs are less likely to be replaced by higher educated jobs. (67) But automation and autonomy can also act as a facilitator for human labor. Making it more effective and reducing strain on the human body.

THE SHARING ECONOMY

Already today we are seeing strong indications of a technology enabled social shift. The sharing economy is becoming a reality for many with car-sharing services and AirBnB. AirBnB lets users of the service to rent or rent out apartments or houses all over the world. (37) The safety is held simply through a rating system of both parties and personal accounts. Car-sharing deals with this simply trough financial liability if anything happens to the car. The basic idea is that access to things and competences is more important than owning them. The benefits you typically see is lower costs, less waste and creation of communities. There are three types of platforms for this: product-service systems that facilitate the sharing or renting, redistribution markets that enable re-ownership of things and lastly collaborative lifestyles that enable sharing of assets and skills. (38)

Services as AirBnB is meeting a lot of resistance from hotel chains as it is effectively taking their customers. It is also creating controversy in cities like San Fransisco where underused property is solely used as vacation rentals while the city has to little housing for its citizens. (39) Similarly ride-sharing service Uber has met a lot of resistance from taxi-companies as it has broken the monopoly that many taxi-companies have in cities. However a valid issue is how tax revenue is to be collected from revenue. (40)

URBAN MOBILITY

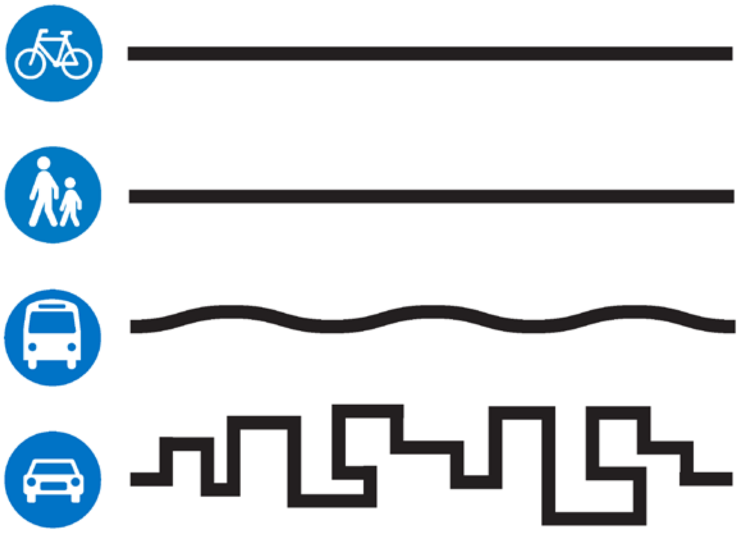
The growing rate of urbanization will be a big challenge in the future. The UN predicts that by 2050 the world's urban population will be as big as the world's total population on 2002. (41) This can lead to more pollution, congestion and urban poverty if not dealt with properly and requires innovative solutions for a sustainable city. Some of the key approaches are unleashing spare capacity, cutting out peaks, small-scale infrastructure thinking and people-cantered innovation. (41) Some of these approaches has already been dealt with in this report.

The increasing urbanization will lead to denser cities. Stockholm's population is projected to increase by 25% until 2030 with 100,000 new homes in the city. In the future strategy for 2030 The City of Stockholm describes how the increased transport of people and goods in the city and higher density will demand an increase in surface efficient and high capacity transportation modes. Meaning focusing on walking, cycling and then public transit. The densification of the city will also make more things in the city accessible by bike and walking. They describe it as a city with cars, not for cars. As they recognize that the car has also a purpose in the future city. This along with the well known socio-economical gains of benefiting walking and cycling, as mentioned before in the report. Some cities like Oslo go so far that they state to ban cars from the city center by 2019. (43)

This development has led to governments and companies like Ford to start talking about mobility rather than transportation. (44) Acknowledging the beginning shift towards a more multi/inter-modal future of mobility where many modes of transportation work together to provide people with the best ways to get to where they want in the city. Already now it's starting to happen with car- and bike-sharing systems gaining popularity in big cities, all delivered digitally to users. A report by the American Public Transportation Association shows that "millennials", the biggest and most diverse generation to date, prefer to embrace the sharing economy model of mobility and choose whatever mode of transportation that fits best at the given moment. Rather than sticking with one. (45) (46)

Research show that as many as many as 54% of bike-share users in Washington D.C. use it together with public transit for multi-modal trips. The challenge is to integrate these seamlessly to facilitate an efficient flow between modes of transportation. Currently there's a mix of smart cards, key fobs and mobile applications. (45)

With the breakthrough of the internet more and more people has less of a need to actually work at a certain place. Much of the communication can now be done digitally and wherever you want. This in combination with the rise of internet shopping also will also have an impact on the way people move in the city.



CONCLUSIONS

The life of a cyclist isn't easy when it comes to interacting with other modes of public transportation and it's safe to say that there is a lot of room for improvement. There's a lot of untapped potential in allowing people to finish the last kilometers of their journey by bike or just use it in general at the destination. Logistical issues make bringing bikes on these modes of transportation a tough task, theres maybe opportunities in the future if these modes of transportation could become more specialized. Locally the need might be small, as the trend we are seeing is towards better bike infrastructure. But regionally both trains and buses has a lot of potential in relation to the bike. But how the future looks for public transportation is fuzzy as we are merely seeing the prologue of what is to come when autonomous vehicles becomes adopted.

Though in the area of bike-sharing there is also a lot of untapped potential in that if it is attractive enough, it could in the spirit of the sharing economy replace your own city bike just as well as a car-sharing system could. What if there was a range of bicycles available and you chose the one suited to your needs at the moment? This could very well eradicate most of the need to even bring a bicycle at a larger scale on other means of public transit.

Undeniably the bicycle plays a big part in the future cities, with less car traffic and more walking, cycling and public transit. Already today bike-sharing systems serve an important role in many cities as the last kilometer option after a car, bus or train. Also there is already a growing group of inter-modal trip planning applications that point towards a if not universal, at least seamless mobility system. How can this experience be designed to achieve this for the citizens?

The problems of today's bike-sharing systems are limiting its potential. They require as covered earlier a lot of money and manpower to manage and install. Studies today show that this could be aided by optimizing the work through algorithms, but what if you could take out most of the human factors and automate the system to the extent that it autonomously handles this for better accessibility and dependability? Existing examples of bike-sharing use both a station and floating model. Can the benefits of both types systems be reaped while exploring the possibilities of on-demand access as proposed with autonomous cars? How about the effects of autonomy on the labor market? In my project I will try to deal with this and see how autonomous aspects can complement human labor and vice versa. In this project I will have a relatively optimistic approach to this issue, today we have many jobs that we couldn't imagine 30 years ago.

Bike-sharing systems are also expensive to install and permanently connected to power, which makes the system static and unresponsive. What if the system could respond more fluently to the pulse of the city and function off the grid? A big factor in the future will undeniably be analyzing real time big data and creating the smart infrastructure that drives the smart city. How can the bike-sharing of the future better use this data and become a part of the internet of things?

With a growing portion of the vehicle traffic in the inner city being autonomous the need for parking space is vastly decreased in the city, this space can now be reclaimed for public use. More space can be reserved for public transit and more green space can be created. This could play an important part when designing a bike-sharing system.

That leads into the issue of security and privacy, something that surely is a challenge in the future. If everything is connected, who has all the information and where is it stored? I will try to consider this by carefully selecting the level of connectivity and tech that is actually needed. Does a bike really need to be high-tech? Examples from today say that you should rather move the technology into the infrastructure and keep the bikes inexpensive, maintainable and functional.

Importantly the business model needs to be defined, who makes the money and how is it maintained? Is it a public system or a private actor?

At a certain point in time someone decided it was worth while to dig tunnels underground for subways, and place hundreds of bus-stops in the city. In my concept I want to explore how bike-sharing would look in the future if it got the same attention and resources as the rest of the public transit system.

THE SCENARIO

WHERE

To establish a foundation on which to ideate and calibrate decisions against I chose to work with a future scenario of the Scandinavian cities Malmö, Copenhagen and Stockholm the year 2020. Stockholm as a city is interesting not just because it's the capital of Sweden, but it has a complex public transportation situation with subway, tram, train and buses in the city. People live outside the city and commute into it every day for work and school. Cycling has maybe not yet reached the levels of cities like Malmö or Copenhagen, but there's ambitious initiatives on how to improve and expand the infrastructure. It has a bike-sharing system in place and if expanded it could maybe even be aided by that owning a bike isn't as ubiquitous there as in Copenhagen. There are ambitious plans for Stockholm as they too realize the socio-economical benefits of more cyclists and pedestrians. (50) In Stockholm there is upwards to 100,000 people commuting on a daily basis from outside of the municipality into the city to work or study. (54) A large amount of people that could benefit from a last mile option like a bike-sharing system as they likely don't have a bike in the city. Cities like Malmö and Copenhagen similarly have a large amount of people traveling into the city, and as these regions grow, this number will likely increase. All of these cities also have changing seasons, that is a challenge to public transit systems today, and it would be interesting to explore how my project can deal with this.

WHEN

As a framework for crafting a future scenario the University of Hawaii developed four categories to give a nuanced picture of a potential future. Transformation, Growth, Constraint and Collapse are starting with transformation highly optimistic going to the pessimistic collapse scenario. I chose to work with transformation as it is disruptive of some old patterns/values and developed some new ones, rather than returning to old ones. It embraces innovation both publicly and privately. (51)

Looking at what industry is saying, tech like autonomous cars will already be here by 2020. (35) The internet of things and harvesting of big data is already seeing growth, and identification and payment systems have been advancing rapidly. The Swedish government too is realizing this, and in its ambitious future plan for design and architecture "Gestaltad livsmiljö – en ny politik för arkitektur, form och design" they describe the opportunities and challenges with technical progress, the increasing urbanization and need for smart cities. (52) The impact of the sharing economy will likely be even bigger as we move on to 2020, as services today will become mainstream an likely influence new initiatives.

WHO

As touched upon earlier in the report a lot of factors point towards designing a bike-sharing systems for the commuters. Solely aiming for tourists has proven to alienate commuters who don't want to resemble tourists. I will focus on bike-sharing as a part of an inter-modal mobility system that mainly is in place for serving the citizens, but secondarily cater towards tourists in terms of accessibility ease of use. The brand new bike-sharing system in Malmö are primarily directed towards the 62,000 people who go to Malmö from outside the city for work and study without a bike in the city. The city of Malmö too see it as an addition to the bus and train traffic system. Secondarily it's for citizens that already have a bicycle, tourists and visitors. (53)

BRIEF

Design a fourth generation bike-sharing system for larger Scandinavian cities 2020. This as a part of a connected inter-modal mobility system enabled by future technology and analysis of big data. Addressing issues with rebalancing, installation and unresponsiveness.

MULTI-MODAL MOBILITY NETWORK

Bike-sharing integral part of public transit & commuting

AUTONOMOUS MOBILITY

limited inner city traffic that's largely autonomous

BIG DATA AND SEAMLESS CONNECTIVITY

Optimized, responsive and personally tailored systems

R2: BIKE-SHARING

In this report I previously discussed the history of bike-sharing, some benefits but also shortcomings in today's systems. In this second phase of research I intend to look more closely at bike-sharing systems and its components.

BENEFITS OF BIKE-SHARING

The reasons are many that more than 600 cities around the world have bike-sharing systems, a number that is steadily growing. They are proven to reduce congestion and improve air quality, increase access to the city, increase reach of transit, improve the status of cycling, Be a useful alternative to some public transit trips, improve public health, attract new cyclists, improve a city's image and generate investment in local industry. (55)

THE BUSINESS MODEL

There are roughly six different models of provision for bike-sharing systems. Basically many of them are variations on completely public or private or a mix of both. This include governmental, quasi-governmental transport agencies, universities, non-profits, advertising companies and for-profits.

The governmental model means that the bike-sharing service is operated by the locality just as any other public transit service. However the government might not have the same experience as existing operators, and take a risk many governments avoid.

The transport agency model is where an organization partially run or owned by the government runs the system. An example of this is Deutsche Bahn of Germany, which operates a bike-sharing service called Call a Bike. This to offer a complete mobility service to citizens. The benefits of this model is that the bike-sharing service provider has knowledge that the transport agency doesn't have to develop internally. At the same time the transit agency is mostly interested in providing a useful service rather than generating revenue. However if not released for a tender, there might be a better qualified operator than the transport agency.

The University model is when the educational institution provides the service, mostly contained within the campus area. The backside of this is of course that it is limited to the campus and doesn't benefit the rest of the city.

The non-profit model uses an organization specifically for the bike-sharing service or together with other interests. One example is the City Bike Foundation of Copenhagen which runs Bycyklen. Apart from the revenue from users they usually receive funding from the local governing body. The benefit of this model is that it removes all liability from the government but with the drawback that they are dependent on the public sector for a majority of its money.

The advertising company model is when a private company like JCDecaux or Clear Channel offers a bike-sharing service in exchange for the right to advertise in public space, such as on billboards, bus shelters and kiosks. The benefit is that this is a very cost-effective option for governments. But a drawback is that due to that the revenues often goes to the local government there is little incentive for the advertising company to expand and innovate the service. In Stockholm the system has yet to reach full service as they had difficulties finding space for the stations attractive enough to advertise at. (56)

The for-profit model has a private company that provides the service with little or no involvement from the government. The benefit is that the service can be started as an entrepreneurial effort rather than waiting for the public sector. Though it may not receive public funding as other models and would require governmental support to access public space. (7)

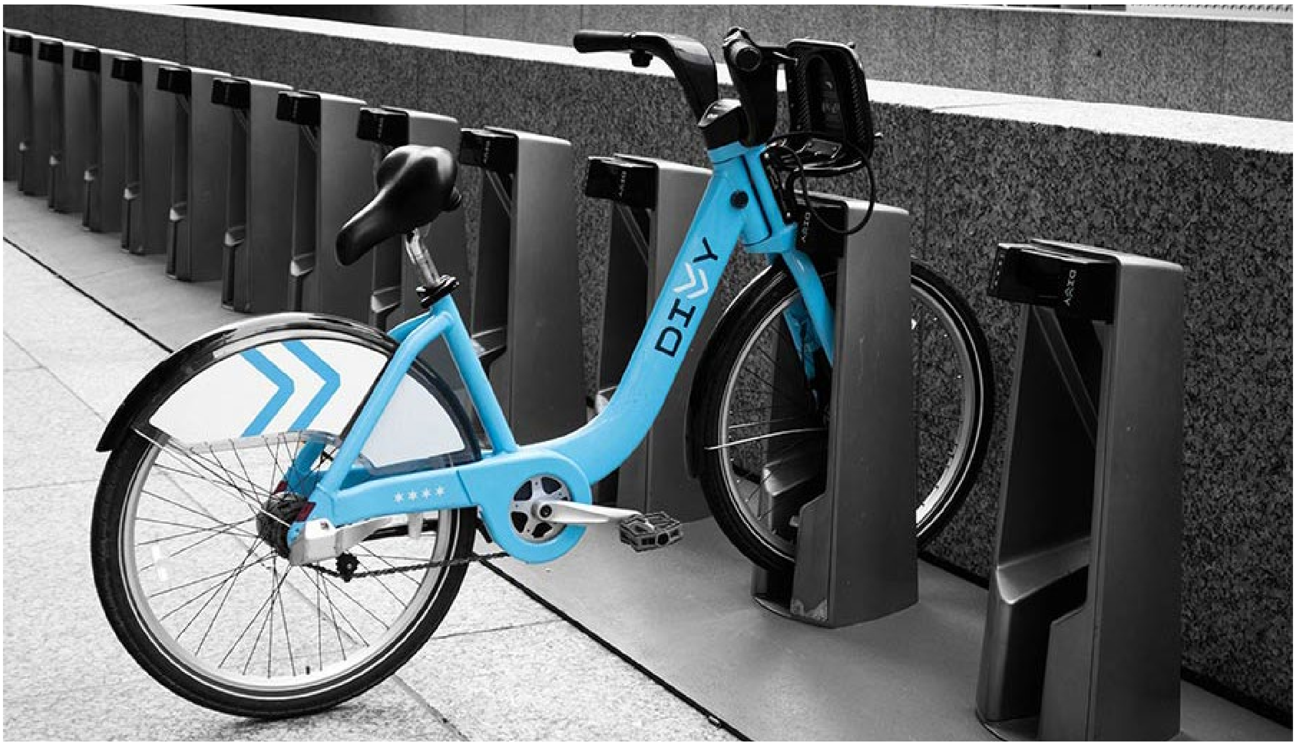
COSTS & MAINTENANCE

Whoever the operator of the service is, the system needs to be maintained and paid for. The capital costs include assets such as bicycles, stations (which consists of docks and terminals), IT system components, control center, maintenance equipment and service- and redistribution vehicles. Operating costs include staffing, redistribution costs, replacement parts, fuel for service vehicles, marketing, web site, internet for the stations, membership cards, insurance and administrative costs.

The bikes themselves often are a relatively low part of the capital costs, but the cost of bikes greatly vary between systems (Between 100 dollars and 2000 dollars). The stations and especially the docking spaces often is a greater cost in the systems. Then you have depots for control center and maintenance, which can be shared with other modes of transportation such as the bus. One significant investment is the redistribution vehicles, often vans, flatbed trucks or in the case of Paris, an average size bus.

Maintenance of the system is a major cost that often amounts to about 1000 dollars per bike every year. Some repairs are done on site as bikes are reported broken, but for preventive maintenance bikes are brought back to workshops. Many try to combine the maintenance and redistribution. In some systems you indicate a broken bike by turning the saddle backwards, and some systems have a button to press for this and the bike is taken out of service. This is often sabotaged as some press all the bikes at a station to prevent anyone from using it. Systems like the Clear Channel one offer a smartphone app where you not only can locate stations, but you can report damage on a bike directly in the app.

As mentioned before in this report the redistribution is a major challenge for operators and amount to about 30% of all operating costs. It is critical to the viability of a system from a user standpoint. Even during peak-demand hours some stations may need to be rebalanced.




URBAN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STATIONS, DOCKS & TERMINALS

The station where you pick up or drop off a bike consists of docks, where the bikes attach, and the terminals, where users can get information about the system and pay. These often also serve as a visual indicator to locate the system in the urban environment.

Systems can be either manual or automated. In a manual system the station is manned by an employee that checks in or out the bikes. In an automated system the user checks in or out the bike and pays electronically either at the terminal or dock. These often use specialized key cards or fobs. Some have a mix of both with attendants at high demand locations. Automated systems are technically complex and more expensive, but inexpensive to run. The opposite can be said about the manual alternative. In some systems the terminals are unnecessary as the docks can handle the check-in and out procedure.

Stations can also be either modular or permanent. It largely dictates it's impact on the urban environment. Modular stations are often constructed on a base that can be bolted into the pavement. These require solar power to function. The permanent stations require excavation and underground access to power. The benefit of modular stations is clear as big costs of excavation is avoided while keeping the system fairly flexible to at least an initial calibration against how it's actually used. With permanent systems a great deal of care has to be taken estimating stations sizing and placement before implementation.

There are two type of docking styles. Either you have docking spaces that is less space efficient but is less obtrusive in the urban landscape or you have bike parking areas where bikes are parked within a secured are on regular racks, these are more space efficient but more intrusive as a whole. Docking places are often a pole that you put the front wheel into and that the frame locks into or a long bar where the front of the bike is attached or hung. To deal with the high costs of rebalancing bikes systems increase the amount of bikes and docks to reduce the need of rebalancing. That way you create a buffer when for when stations are in peak use. (55, p64-73)

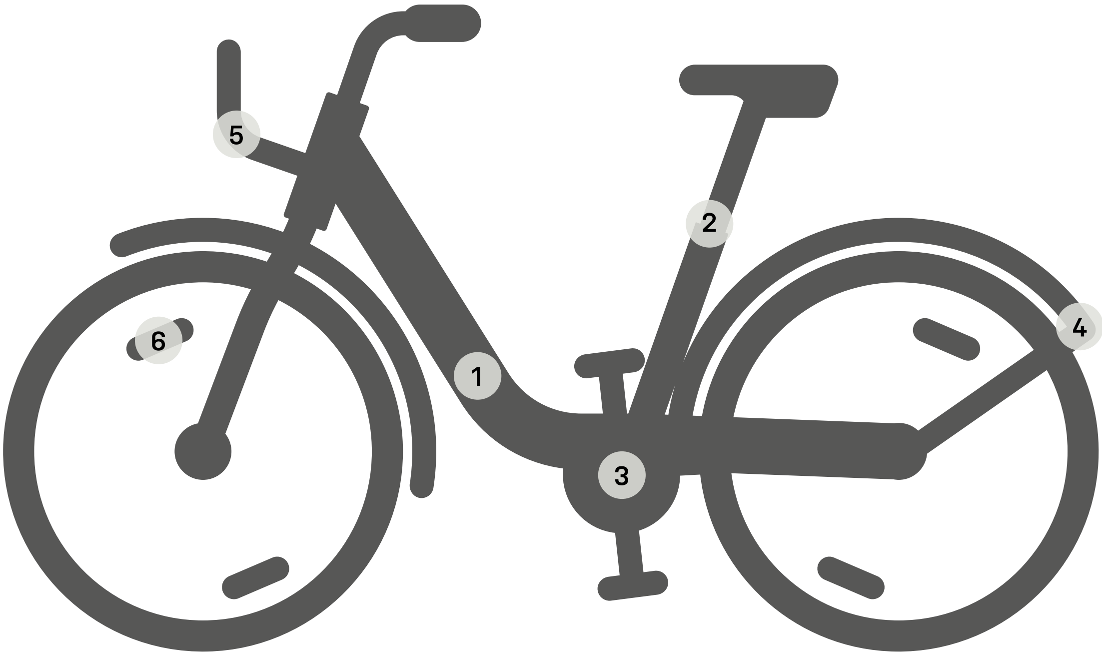
The placing and sizing of the stations is a crucial part of how successful the system will be. Today the position and size of the stations is determined by pre studies and surveys among citizens. The amount of bikes at a station can vary between 10 to 100. The density of stations should ideally be around 300m in between. The stations should then in turn be placed well in the street-scape and ideally be placed along existing bike lanes, near street corners, on parking spaces and near mass transit stops & stations. Paris and Barcelona converted over 1000 on-street parking spaces to accommodate upwards to 4000 bikes. Otherwise the stations can be placed in areas between trees, planters or trash bins. Alternatively they can be placed beneath bridges, but this can present a safety issue and conflict with solar powered stations. (55, p55-61)


B
B-cycle

THE BIKE & THE HELMET

The latest bike-sharing systems feature one type of bike that to a large extent has been custom designed for extra durability and security. Parts are of a proprietary design so they are difficult to steal and resell, and elements of the bike are designed so that they are hard to break. Typically a bike-sharing bike last 3-5 years and as gone through the maintenance of it is a major cost in running the system. Some common characteristics of a great bike-sharing bike is: one size with adjustable saddle height, robust design, low-maintenance, secure locking, proprietary tooling for disassemble, safety lights and reflectors, functional storage that discourage a second passenger and dirt protection. Recent technological advancements in solid puncture free tires, belt drive and drum brakes has drastically reduced the need for maintenance.

One issue is the helmet as many argue its necessity while riding a bicycle. Some systems have tried to deal with this but ended up not demanding or supplying helmets. It is major deterrents from use as if the system needs to supply them it also has to prevent loss or theft, also users are reluctant to use helmets used by others, there would be challenges facilitating them on the bikes and people rarely bring them for spontaneous bike rides. Systems in Washington D.C. and Mexico City has tried but dismissed it due to hygiene and social equality reasons as it poses an additional cost to users. (55, p 76-81)



1. DESIGN

To deter theft the frame and components they should mostly be custom in their design. Everything should also be designed with durability in mind as these bikes get used vastly more than a personal bike.

2. ADJUSTABILITY

The frame should be a unisex base that the user can adjust the seat height for a proper fit. The adjustment should be easy to do without tools or getting your hands dirty.

3. DRIVETRAIN

The focus when selecting the drivetrain should be ease of use and maintenance. Internal gears with belt drive provide an oil and durable option to a regular chain. Based on the geography of the city there might be need for more than three gears, and even electric assist.

4. PROTECTION

Mudguards, chaincovers and other comforts are necessary to make the system usable all year round.

5. STORAGE

A basic means of storage should be on the bike. It should be robust, and designed so that things cannot be forgotten in it or a passenger can sit there. It should be located in the front so the rider can keep an eye on its belongings.

6. VISIBILITY

A good bike sharing bicycle should provide enough visiblity to be used legally during nighttime. Integrated dynamo powered lights in the frame and reflexes in the wheels are the basic necessities.

USERS & PAYMENT

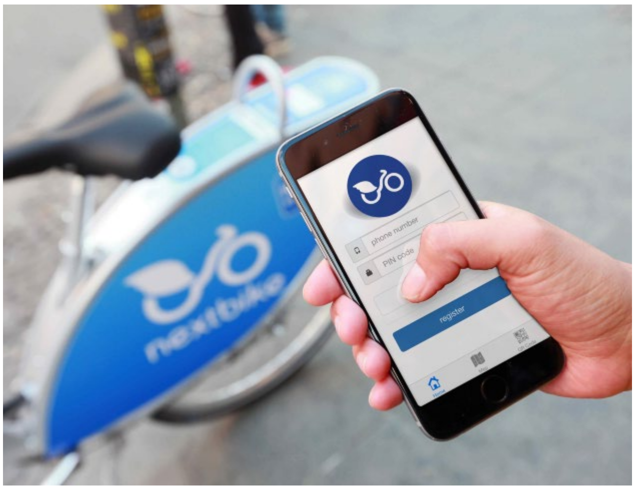
To pay for the service most providers use cards in some form (smart RFID cards, magnetic cards or credit cards). The next most popular option is to use code locks. Some systems are free of technology and some uses a key.

There are two types of users that need to be accommodated in the payment technology and model. You have the long-term users who are registered members and use it on a regular basis and short-term users like tourists who use it sporadically or just once. Access cards only work for long-term users as this could be difficult to access in many situations for short-term users. This requires an account connected and deposits to be paid to assure the safe return of bicycles. To allow short-term users often can pay with credit card or phone where a deposit is held until the bike is returned. Ideally the payment system should be the same as other modes of public transit. (55. p74-75)

One of the most technologically progressive systems is the Austin B-Cycle system has teamed up with RideScout, an inter-modal transit app, to allow users to pay and check out bikes with their NFC (Near Field Communication) equipped smartphone or Apple Watch. (61) In London users can pay through the smartphone app and get issued a PIN to unlock the bike. (62)


B


RENTED
ok


nextbike
phone number
PIN code
register

HOW ARE THEY USED TODAY

To get an idea of how bike-sharing systems are used today on a more detailed level I've chosen to look at usage of both the New York Citi Bike system and the Indego system of Philadelphia. They both provide a an example of a diverse public transit offering and changing seasons.

In both cities you can see inflow and outflow patterns at certain times of the day. In the case of New York there's a clear inflow of cyclists from the Outer Boroughs to Manhattan in the morning. During the day the amount of trips sinks to a stable moderate level to the increase as cyclists go from Manhattan to the Outer Boroughs. There's also a flow within Manhattan where many go from both north and south into Midtown to presumably work. (57) This can be seen in detail down to the hour in certain studies. (67) Some stations become full in the morning while some in the evening are empty when commuters are to return home, data readily available to analyze. (69) High demand commuter stations in New York now even have valets that help users drop off and pick up their bikes. (68)

In Philadelphia you see a similar flow between residential, business and educational districts. But looking at it over the week, it is clear that some stations is mainly used by commuters, while others are mostly or also used for other things during evenings and weekends. One example is a station that is an outflow station during the weekdays but are also popular during weekends as they are situated in a popular area with bars and restaurants. (58) Looking at it seasonally there's a clear correlation between temperature, precipitation and other environmental factors. During the winter months riding decreases drastically in New York, as they often have snow during their winters. (57) Contrary to many systems in cold weather locations that shut down during the winter. Still a respectable about of people have the elements to continue using the system. With severe weather approaching operators are required to remove the bikes to reduce risk of damage. (70) A factor not mentioned in any literature is temporary events and festivals, where you most likely could see shifts in the usage of certain stations.

As mentioned before the rebalancing of a bike-sharing system is crucial for it to function as intended, and it demands serious resources. To continue looking at New York as an example the issue is clear just looking at their on-line map of the system. In New York some users have coined the word "dockblocked", as they're stuck between a dock and a hard place being unable to leave their bike where they want to, as the station is full. The reason for this can be that the station is at the foot of a hill, in a business or educational district. As many other Bike-Sharing systems there's now the possibility to monitor the status of each station and sometimes book bikes via a website or smartphone app. Sometimes in the case of the Citi Bike system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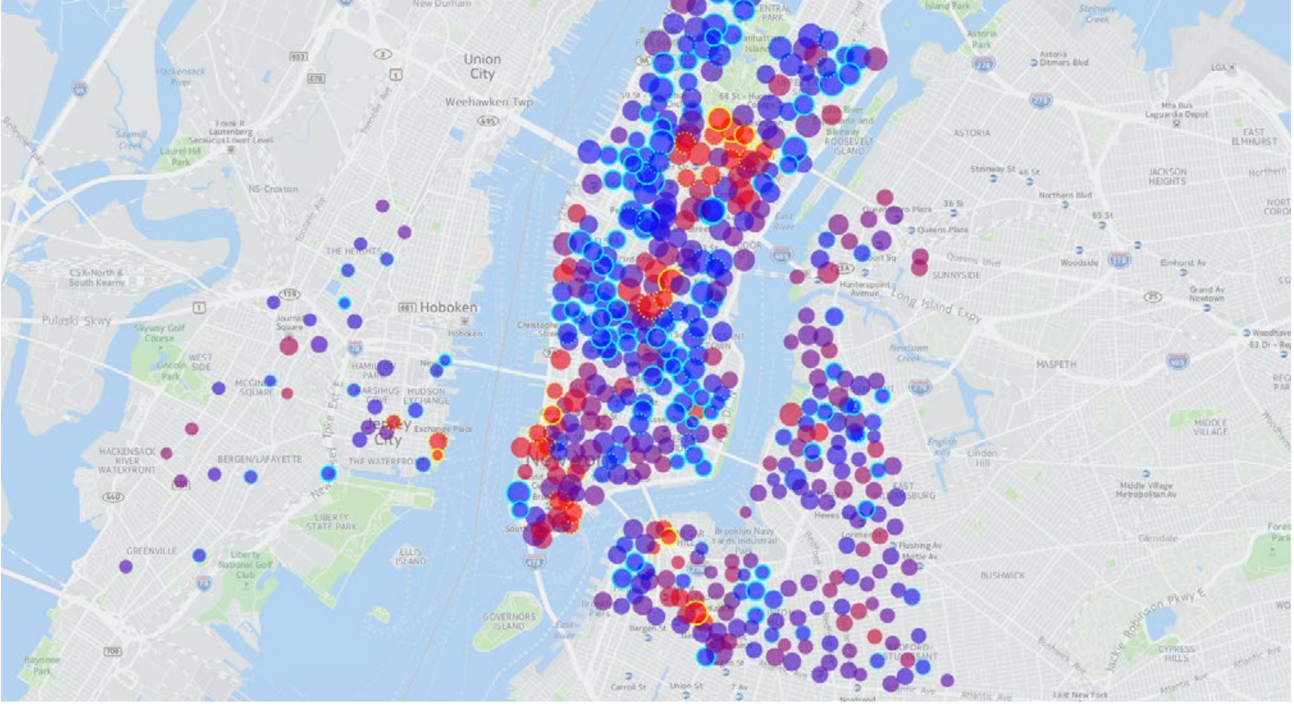
these can be misleading and the station can be empty upon arrival. (59)

Similarly bikes can disappear as quickly as they appear at Penn Station during rush hour. The city deal with this by hauling dozens of bikes by truck. Two employees is needed per truck and loading a truck takes about 45 minutes. Cyclists are quicker, so by the time the they are finished unloading and ready to leave, there's only a couple of bikes left at popular stations. The efficiency of the redistribution largely depends on how well the routes of these trucks can be calculated, and how well the amount of bikes to pick up and drop off can be calculated. When this doesn't function well it causes frustration among commuters who get uncertain of if they can trust the system to get them to work in time. Consigning it to weekend duty when time is not of the essence. (60) (71) The way that systems deal with the imbalance by scaling up the systems doesn't really solve the problem. Research show that bikes have to be moved around, and rather in amounts that refill a station completely, rather than splitting a truckload of bikes between several stations. (72) In Paris several large buses are used to redistribute bikes. (73)

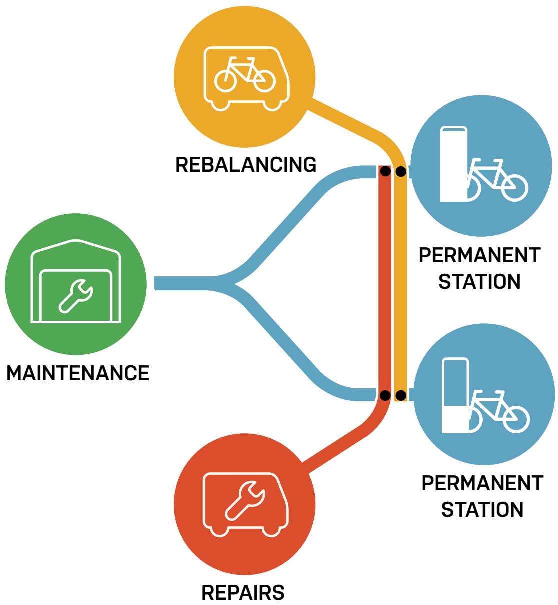
So it's clear that bike-sharing, when done right is well used by commuters. But how does this relate to existing bike ownership? How Vélib' in Paris came to be was that recent investments in bicycle lanes and infrastructure where underused, the reason was that few wanted to own a bicycle in Paris as apartments are small and people felt it wasn't safe to park a bike on the street. Which fueled the popularity of the Vélib' system. In Guangzhou, China 16% of the users of the bike-sharing system where previously private bicycle owners. (55)

So one could then question if all these resources goes into the presumably environmentally thing of cycling, is bike-sharing still environmentally friendly? Studies show that as many as 41% of bike-sharing trips in Denver replaced car trips, and this means great environmental impact. Not only does this isolated use of bike-sharing have positive impact. When integrated with public transit it contributes to more people traveling by public transit, providing a reliable last-kilometer transport. But also just as an advertising for and a gateway drug to cycling in general. This in combination with the socio-economical benefits associated with cycling in general has led to more and more cities investing into bike-sharing. (74)

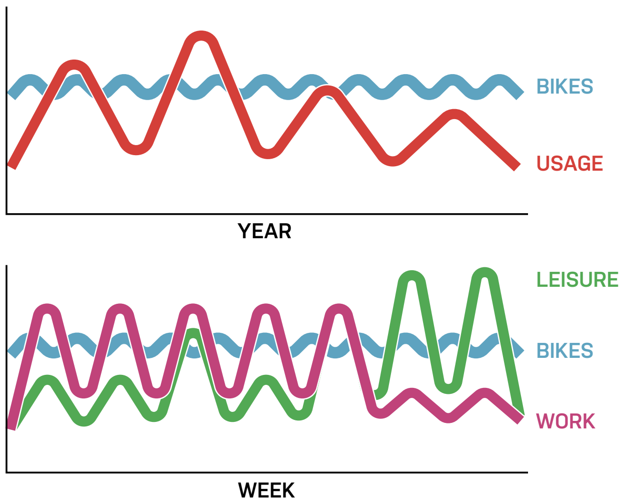
MANHATTAN INBALANCE



TODAY'S SYSTEM



USAGE



CONCLUSIONS & DEMARCATIONS

A good bike-sharing system should first and foremost function so that satisfies the needs of its users. Ideally that would be a completely free point to point system, but as research show, this can be very difficult to maintain, eventually resulting in harder to find but easy to drop-off bikes with a lot of underlying maintenance work. It needs a dense network of stations with just enough bikes and just enough empty slots. In that way you get a dependable system that also can be accessed trough intuition while walking and not solely rely on a smartphone application or website to locate bikes. How can this be achieved without enormous logistics and great expense?

The research also show that the use of these stations vary greatly depending on time of day, day of the week and month of the year. Also worth considering is temporary events such as festivals and sports events that might create temporary need for a large number of bikes, where there might not be otherwise. Today a big difficulty is calculating the placing and size of the stations. And if calculated wrong, there's little opportunity to adjust after implementation. How could the system co-exist with these fluctuations and easily adapt to the actual needs of the users? Just like bus time tables follow the frequency in which people travel over the day and week. Optimizing the use of inventory, infrastructure and city space.

How users access the system is one of the most important touch-points for the users apart from how they interact with the bike. Today most systems are cumbersome to use and feel far away from the easy to use systems found in other modes of mass transit. How can this experience be designed to facilitate both casual users and commuters? Making the check in and out procedure smooth and intuitive, both in how to pay and physically dock the bike.

The bike needs to be mostly proprietary in design but simple, durable and require little maintenance. It has to be practical and function as an everyday city bike that is easy to ride up a small hill. Depending on how the system is designed, the bike should not itself be too expensive, as most systems point towards more inexpensive bikes instead of fewer high-tech bikes. Could the system offer different types of bikes depending on time of day and location?

Bike-sharing and the use of helmets are a relevant concern, and it surely is something that could be addressed in a design project, but not in this one. For me it's a demarcation I would like to make as it involves another debate about whether they are necessary at all in cities with enough well developed bike infrastructure or if it is something that could rather be addressed in the design of helmets. Examples like Hövding show that there is definitely potential in the area and maybe it won't be a problem to bring a helmet with you in the future.

Of all the business models the one the most interesting to me would be quasi-public transportation agency model. Where my proposal would be the business of an operative company which then sells their service & system through public procurement to the local transport agency. This is the model employed in Stockholm and Malmö, where the company Arriva for instance are responsible for the operation of the buses. (67) Today users pay by paper ticket or a smart card with RFID technology. In the future it will also be local transport agency that sits on most of the data generated on how people travel in the region, something that can be leveraged to an even greater extent with more sophisticated trip-planning applications and gathered information on the usage on current bike-sharing systems. The model should lead to less public advertising and incentives to provide an as extensive service as possible. This also opens for the possibility to integrate the service with other modes of transportation even more than just a trip-planning app.

Today repairs are handled by humans hand should continue to be so, but how can the system be developed to facilitate a continuous and quick maintenance of all the bikes? Having personnel seek out bikes that might be broken seems highly inefficient as they better could be pulled out of the system and replaced while repaired.

BRIEF 2

Design a fourth generation bike-sharing system for use in larger cities 2020. This as a part of a connected inter-modal mobility system. To be presented is a basic system structure, conceptual station and bike design. The system should address issues with rebalancing and fluidly be able to adapt to changes in the city. It should be easily maintained and implemented. This being facilitated by future technology and analysis of data. The bike should be practical, comfortable and adjustable while being durable and safe.

IDEATION PHASE 1

CONCEPT OF OPERATION/SYSTEM DESIGN

To form a system that I could base my design on I had to synthesize the conclusions and opportunities gathered during the body of the research phase but also take a step away from them to ideate more freely on a concept of operation. The concepts would focus on the operational side of the system, meaning the access to the bikes, and how they are supplied around the city. Then I would evaluate each and one of them based on the set of criteria determined by me. Apart from the function analysis I would evaluate them on whether I consider them progressive enough for a future concept or feasible at all.

The most promising concepts would then be developed further to get a basic understanding of how the whole system would function. As I intend to design a future concept of both the station and bike, the design and science behind the system will just be defined to a level that it creates relevant design opportunities in this context.

IDEAS & CONCEPTS

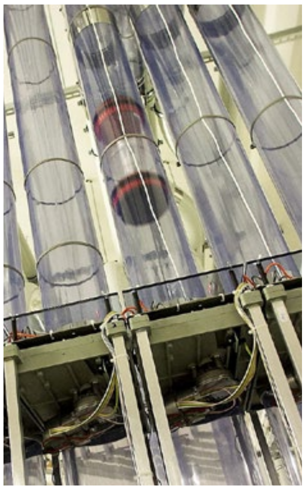
How would the bikes be rebalanced, serviced and accessed? When ideating I tried to spread between concepts that are more conventional and focus on improving some of the problem areas of current systems and concepts that are very futuristic but might deal with more issues and maybe add new opportunities.

Looking at which direction how we interact with these kinds of systems are going in the future you can already see not only a widespread use of RFID cards (Radio Frequency Identification) (75) like we are used to in current public transit, but also NFC (Near Field Communication) (76) smart-phones and watches which allows you to wirelessly pay are hinting a cash and possibly wallet free society in the future. I wanted this notion to inspire my ideation in that the actual infrastructure to pay becomes less important in the build-up of the station or system, and that it can become more decentralized.

I also looked at current distribution, storage and automated systems. Already today automated container platforms are used in ports and in many car manufacturing plants the in-progress cars are automatically driven on platforms from one manufacturing stage to the other. There's also coming out autonomous delivery vehicles from both Domino's Pizza and their DRU (77) and Starship Technologies and their Local Delivery Robot (78). Design consultancy IDEO have also along with some car-makers designed concepts exploring the impacts of autonomous technology on future mobility. (79) Similarly I wanted to explore the opportunities this technology gave me when designing a future bike-sharing system.

A: FULLY AUTONOMOUS STATIONS

B: AUTONOMOUS REBALANCING VEHICLES WITH TRAILERS



The two primary candidates that I ended up choosing between was:

A: One with motorized autonomous stations that's located on parking spaces and some public space would enable instant and 24/7 rebalancing & scaling, a smaller system and a centralized maintenance depot where mechanics could service both stations and bikes continuously as they moved around the system. Stations would move as they are needed in the system, making sure that no cluster of stations is completely empty or full.

B: A concept of stations as passive "trailers" that was moved around by autonomous rebalancing vehicles. A system that would be less resource demanding in that the amount of rebalancing vehicles could be lower than the number of stations. Though to function as a trailer and station, much of the same technology in wheels, suspension, off-the-grid power for communications and locking of the bikes is needed. The rebalancing vehicles would constantly circle around the city or strategically park docked or close to clusters of stations to be able to respond to stations going empty or full. Similar to concept A stations would circulate trough maintenance depots rather than having technicians seek out specific stations.

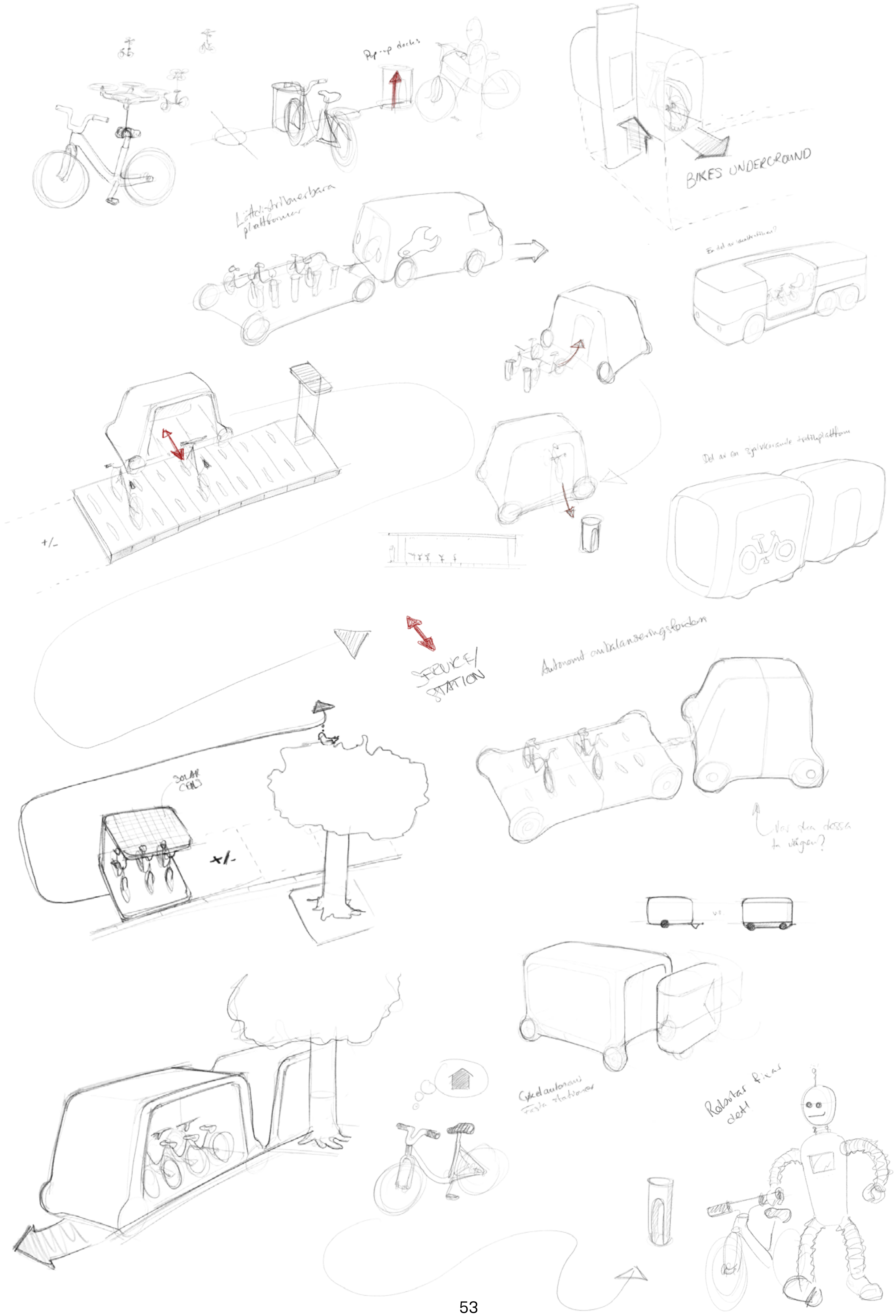
EVALUATION

When evaluating each of the concepts I had a set of criteria that I rated them against. Firstly I looked at how easy they would be for the user to access, both physically, but also the speed and how many users that could access them simultaneously. I also looked at how efficiently and responsively they could, in theory, rebalance and scale. The more responsive the smaller the system can become, as the need for a buffer disappears. Also importantly I had to consider the maintenance of the system and the amount of human labor involved in it. Would the mechanics come to the bikes or the bikes come to the mechanic? Lastly I looked at how well they used the urban space available and the visual impact they had on a basic conceptual level.

The drawback of the first concept is the potentially large amount of resources that would be devoted to the station itself. All stations would have to be vehicles themselves. How does this compare to the trucks & buses employed to rebalance systems today, weighing in the downscaling of the system as a whole, and that it doesn't require any excavation or permanent installation into the ground.

Looking at the second alternative the impact of a dedicated rebalancing vehicle would also most likely mean a less space efficient station as the rebalancing vehicle somehow has to access it. Just reducing the amount of bikes in a station by one, would require many extra stations to make up for that loss, further complicating the concern about resource usage. Also importantly this would mean a less responsive system as it would have to predict the need for rebalancing, rather than act instantly to a station being full or empty.

Going forward I decided to work with the fully autonomous system, as I felt that it was the strongest from a functionality standpoint but also it felt clearer and more interesting as a blue sky-ish future concept project. The actual realization and engineering of the concept has to take the backseat to storytelling of a future scenario that can spark a discussion and maybe inspire someone. To me you oftentimes as a designer must reject reason a little to get somewhere new, as it is easy to become comfortable and accept the status-quo. This could be on a larger scale in how a system or product works, the materials it's made of and how it's manufactured. In contrast to working at a design consultancy where there sadly often is very little opportunity for this, I wanted to work a little more with this in school.



Pop-up docks
BIKES UNDERGROUND
+/-
SERVICE/ STATION
SOLAR CELL
+/-
Autonomt ombalanseringsfordon
Robotar fixar det!

SCENARIO

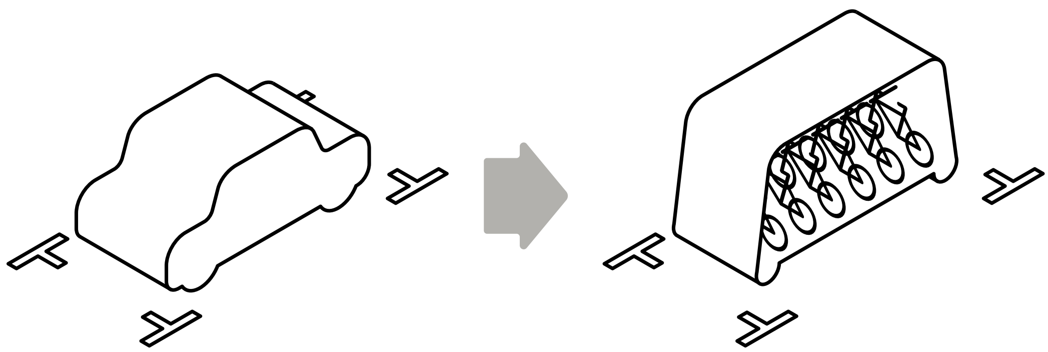
The foundation of the scenario I'm developing is the conclusions of my research. That being that a good public transit system should foremost be serving the core users by giving them freedom of movement, easy access to multiple users simultaneously and seamlessly integrate with other modes of transportation. The business model of the system is that it is a part of the regional public transit system and is maintained through public procurement. The back-end of the system, meaning the maintenance and administrative part of the system should interfere as little as possible with the front-end of the system where the user interact with it. This to avoid scenarios like you see today, where access is restricted due to rebalancing or maintenance.

SYSTEM OPERATION

The basic principle of the system is a network consisting of autonomous bike-stations equipped with docks for bikes, means for check-out, basic information and internet access, the bikes themselves and a number of maintenance depots. The stations respond instantly to how the system is used by rebalancing and scaling clusters automatically. They would be mainly located on designated parking space (just like bus stops) and additionally on public space like squares and very large side-walks if it's necessary. Something that is generally recommended. (55) The system would be divided into permanent locations which would be key public transit locations and other popular destinations that scale in size according to the level of usage over the day, week and month. These stations would be 300-500m apart and form a dependable network of stations that citizens can know will always be there. Some of these stations can offer additional service with a manned booth to purchase an RFID card or offer general customer service. The goal with this structure is to have stations where you are certain that you can pick up or drop off a bike, regardless of the time of day.

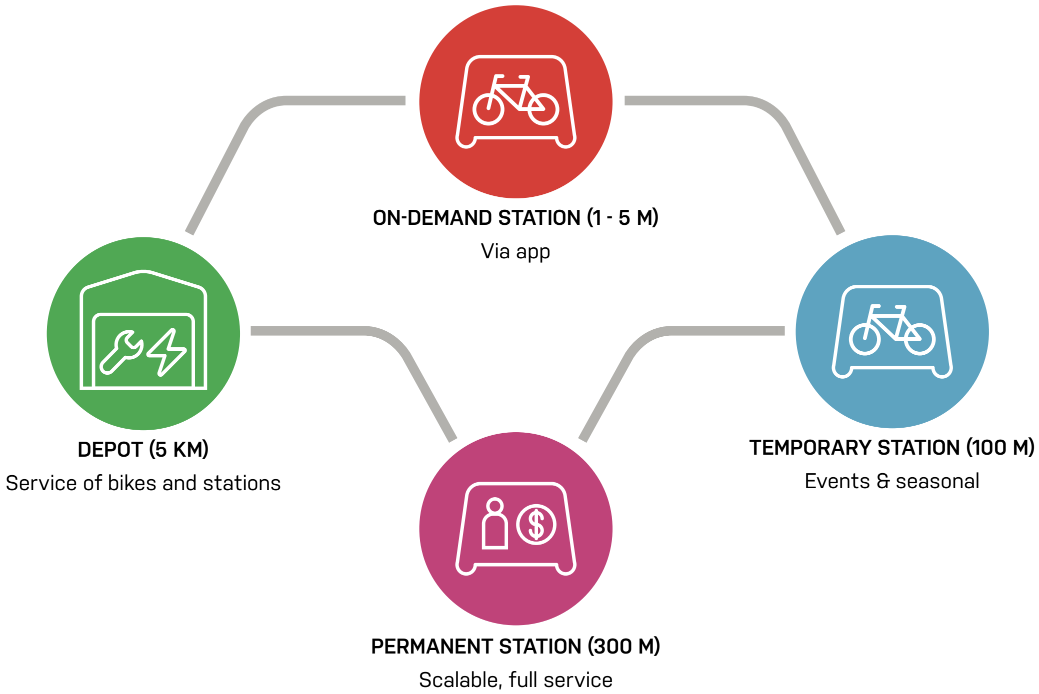
Additionally you would have the temporary locations, these could be associated with seasons or events. Many locations in the city, is virtually unused in the winter while they are extremely popular in the summer. This could be a beach or a park. But you also often have convention centers and sports arenas that have these extreme peaks and valleys. Festivals also pose an interesting challenge as they often have a large impact on the city center, where car and bus lanes are shut of and become markets, stages or just for walking. Just as the bus routes are temporarily changed bike-sharing systems can adapt similarly. These locations would densify the existing permanent network, so if a temporary station isn't there, you would have maybe 100-150m to the next one. But ideally this should work so fluently with the actual way people use the system, that these kind of problems would be very rare.

The system could also offer on-demand access as stations are regularly moving around the city. You could hail a bike from the side of the road by using



your smart-device, though this should in my opinion be limited to a certain region of the city so stations don't end up venturing out to the countryside.

The maintenance would be done though manned depots where stations would circulate through regularly to charge, and allow mechanics to service the bikes and stations. The location of these depots would be relatively central and for a bigger city there could be several depots with about 5-10 km between them. This would enable the stations to have a short range, supported by additional off-the-grid power sources.



USER

The two main user groups are long-term and short-term users. The access to the system should foremost be designed with the long-term user in mind. The payment process at the station should be fast and efficient, and the information to users should be the same. Today many public transit systems get clogged by new users busy with figuring out how it works. In my case, I would like for most of this to be done on the side, in a personal device, or at a manned service point.

As the share of smartphone users in the world has reached almost 30% and is steadily growing (64) and I'm going down the optimistic path (at least from a tech standpoint), I've chosen to build the payment/check-in & out of the system around modern technology but still allowing it to function with some then "legacy technology" payment. Today many public transit systems require users to either pay by a pre-loaded RFID/NFC card or an app. For tourists and other first time users this means buying a card in a convenient store, supermarket, service kiosk at a larger station or having access to internet. In the future internet will likely be more readily available, and soon we will see the abolishment of ridiculous data roaming fees in the EU. (65)

The stations should ideally be so closely located that users shouldn't have to walk far to locate a station, but otherwise they can find one through an application or website. At the station you can register quickly in your smartphone trough a free Wi-Fi hotspot and are then free to access the system as much as you like. The bike should also offer the same convenience of locking it wherever you need to do errands in the city. During this time the bike would be reserved for you and charge you for it. To check out you simply dock the bike at the nearest station.


PURCHASE CARD
AT MANNED SERVICE POINT
LOCATE STATION
REGISTER DEVICE
FREE WI-FI
CHECK IN
ON BIKE
LOCK & UNLOCK
WITH DEVICE OR CARD
CHECK OUT
DOCK BIKE AT ANY STATION

FUNCTION ANALYSIS

SYSTEM/STATION

HF OFFER BIKES WHERE AND WHEN PEOPLE WANT IT

N REBALANCE EFFICIENTLY

N EFFICIENTLY USE INVENTORY

N PROVIDE MEANS OF PAYMENT & CHECK OUT.

N FUNCTION OFF THE GRID

N EFFICIENTLY USE STREET SPACE

N FACILITATE MAINTENANCE

N EASY ACCESS TO MULTIPLE USERS

D PROTECTION FROM WEATHER

D PROTECTION FROM VANDALISM

BIKE

HF EASY & COMFORTABLE TRANSPORTATION

N PROVIDE MEANS OF CHECK OUT

N DIFFICULT TO STEAL

N DURABLE

N PROTECTION FROM DIRT

N LOCK

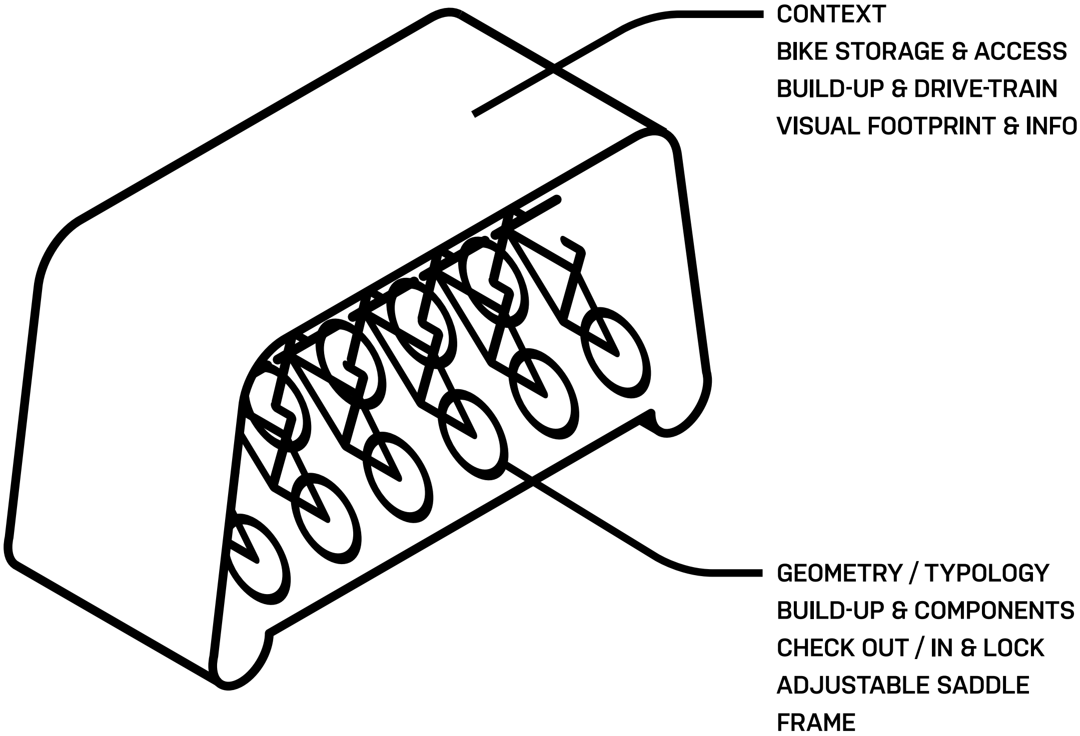
N VISIBILITY & SOUND

N ADJUSTABLE

D LITTLE AND EASY MAINTENANCE

D OFFER STORAGE

D OFFER NAVIGATION


CONTEXT
BIKE STORAGE & ACCESS
BUILD-UP & DRIVE-TRAIN
VISUAL FOOTPRINT & INFO
GEOMETRY / TYPOLOGY
BUILD-UP & COMPONENTS
CHECK OUT / IN & LOCK
ADJUSTABLE SADDLE
FRAME

ID1: STATION

Though it might be tempting to some to delve deeper into the design of the system, create payment models, calculate the flow of bikes and design an app and a website I felt that was somehow secondary to what I wanted to achieve in this project. Ideally the software, hardware and the whole infrastructure should be designed in tandem, but for a lone master's student this seemed a little daunting, and after all, it's an industrial designer that I'm trying to become.

The most important parts of the system to focus on in this project would be the physical design of the station and the bike. To design the direct interaction the user has with the system, but also the way it's perceived in the city, both stationary and moving. To holistically apply a method of solving problems and giving form to make everything belong together.

To help myself in this I started out by identifying the most important factors that affected the design of the station and bike. Be it how you best access it in the context that it stands in, how the bikes are stored or how they then have to be built-up. These where based on the function analysis that was then developed more in detail to then identify some general areas on which to ideate on. The premise of this would be to design the station from inside-out, throwing all preconceptions of vehicles away rather than outside-in which many cars seem to be the way that most cars are designed today.

CONTEXT

The location that the station would be in would mainly be roadside parking. In the scenario that I'm designing for this is vastly more available, and it is possible to claim a larger area used for public transit. The parking lot has some limitations in how you can access it due to that you mostly have traffic on one side and the sidewalk on another. This mostly due to safety, and clarity, that the bikes ideally are accessed where it's least risk of damage to people, bikes and other parked vehicles. There are different type of parking spaces, but they all are around 5m x 2,5 m big.

The footprint of a bicycle also is an important factor that gives little extra room for actually accessing them in the space given. This would also have to be taken into account when designing the bike.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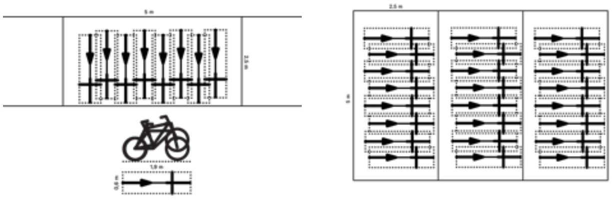
H JJ 352

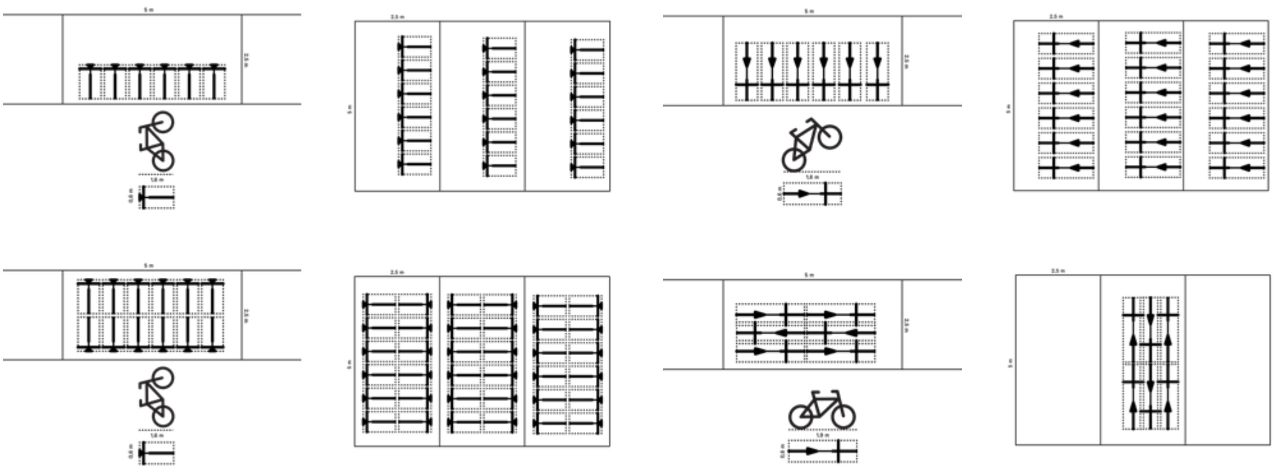
BIKE STORAGE & ACCESS

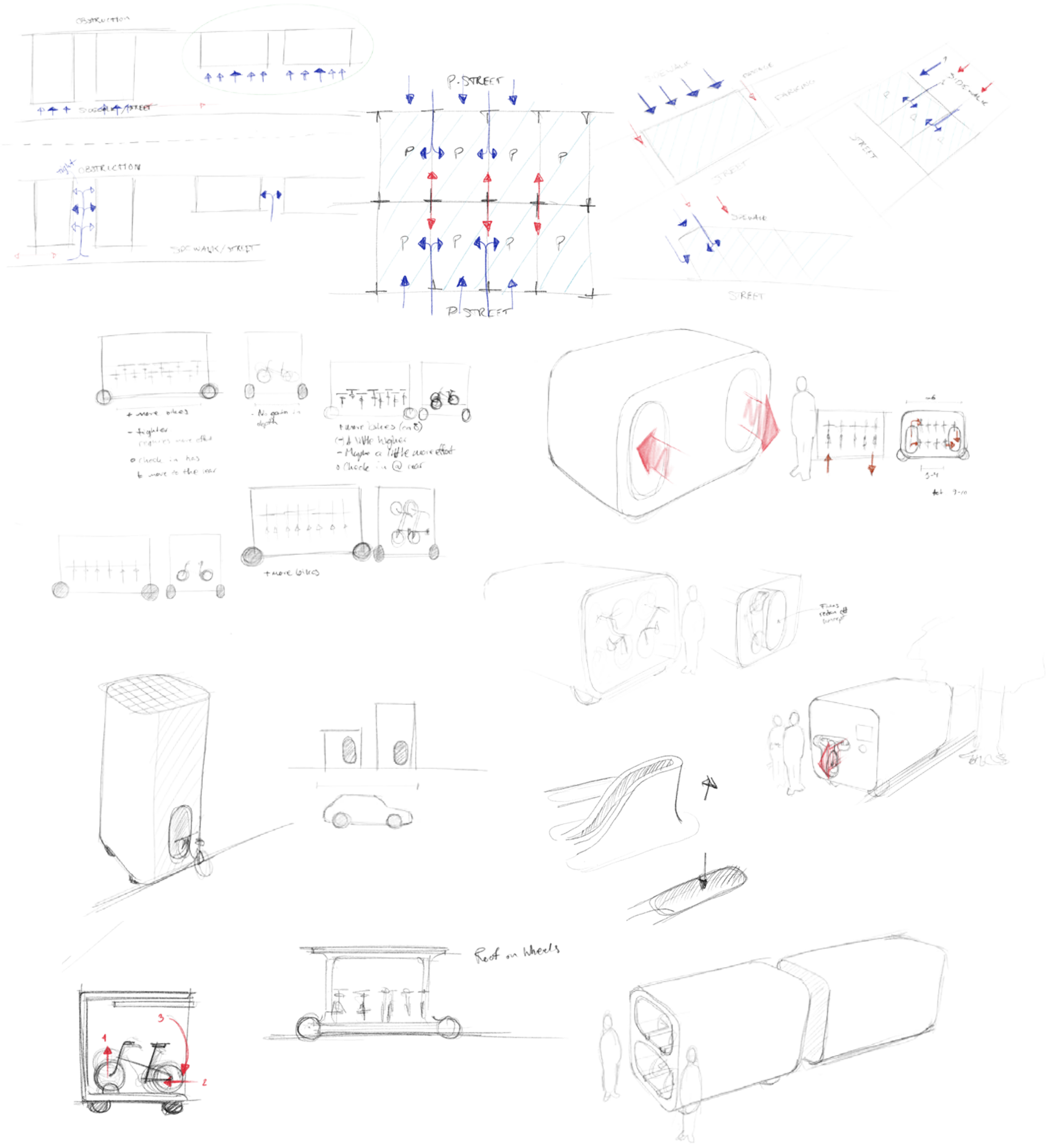
One essential part of how the station is designed is how the bikes actually are stored and accessed. Here I looked at many options with different levels of manual effort, how many that could access it simultaneously, the visual impact, how many bikes that would fit and what that would mean in terms of how easy they are to access. Some systems today requires lifting of the bikes and precise aiming to dock, something that from an universal design standpoint can be questionable as this can be very difficult for elderly and disabled. Bikes can for instance be stored in two levels, standing on one wheel or overlapping, but as my scenario was one where there's a high volume of use, especially in rush hour, there had to be very little physical effort, and time needed to access a bike. Much like subway turnstiles that are designed to minimize bottlenecks with as little complexity an as wide access as possible.

On a schematic level I looked at one and two level storage of bikes in a lengthwise and perpendicular position in the station. Evaluating options of horizontal, diagonal, overlapping and vertical orientation of the bike. Evaluating them in relation to their impact on the footprint of the station, speed & ease of access, level of mechanization required and the visual impact it will have. I decided to go with the traditional horizontal & perpendicular to the roadside option as it provide ample space between bikes still with the opportunity to reduce the stations footprint by reducing the size of the bike itself.

Looking at the docking itself it was important to reduce its visual impact while making it effortless and enabling a decentralized check-out. Examples today are more like oversized regular bicycle stands that clumsily attach to the bikes. A major part of the visual bulk of today's bike sharing stations. I looked at ways of making this process more intuitive trying to find the simplest possible way to keep a bike upright and locked. The bike can be locked trough the handlebars, basket, frame, fork and wheels, but the wheels are the only place where the locking mechanism comes out of your way, even allowing the bike to slot into the ground. Locking the bike by the rim, and at the same time keeping it upright. This alternative was prototyped and evaluated successfully.






OBSTRUCTION
SIDEWALK/STREET
P. STREET
P. STREET
STREET
+ more bikes
Roof on Wheels

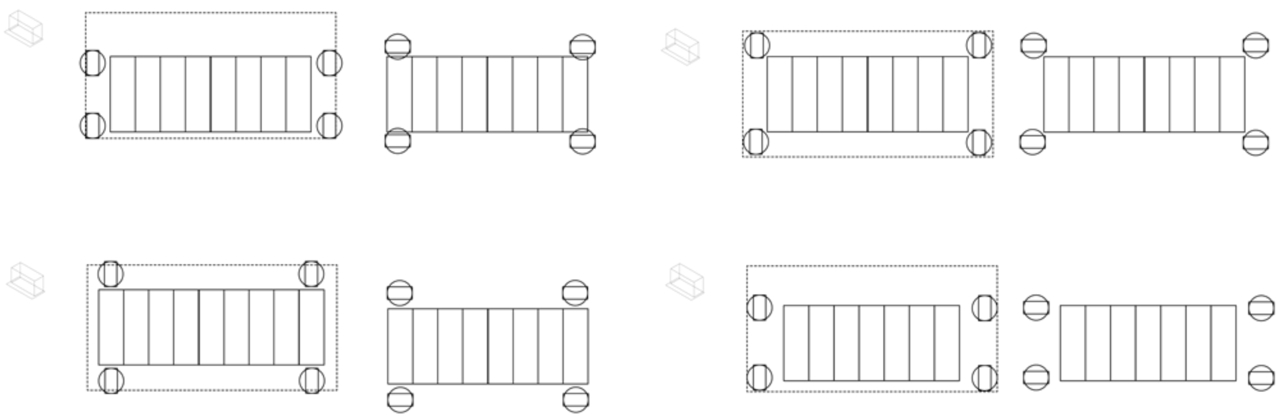
BUILD-UP & DRIVETRAIN

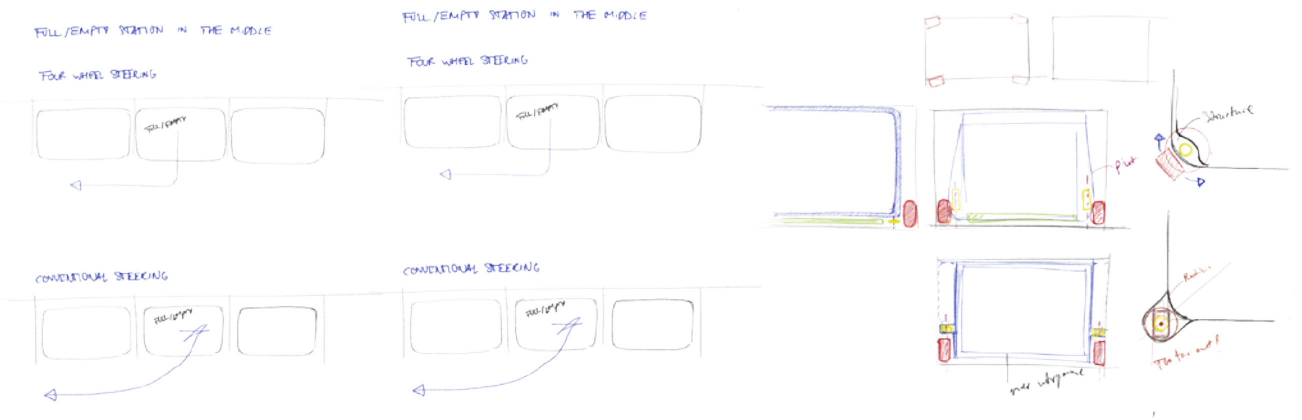
Those choices then informed the technical build-up of the station and its drivetrain. The design of the station had to leave as much surface area for bikes as possible, as they weren't stacked, while enabling a transparent appearance. It also had to use the given space of the parking lot as effectively as possible and be able to move out of these tight spaces. Also to move through a public environment that isn't designed for vehicles. So it has to navigate trees, plantations, trash bins and other obstacles found on sidewalks and squares. This in addition to navigating traffic like a regular car. To achieve this a less orthodox approach had to be taken to propel the station. The recent years it looks more and more like the future of cars are electric, though there are alternatives in e-diesel, hydrogen, natural gas and even some attempt at air driven cars has been made.

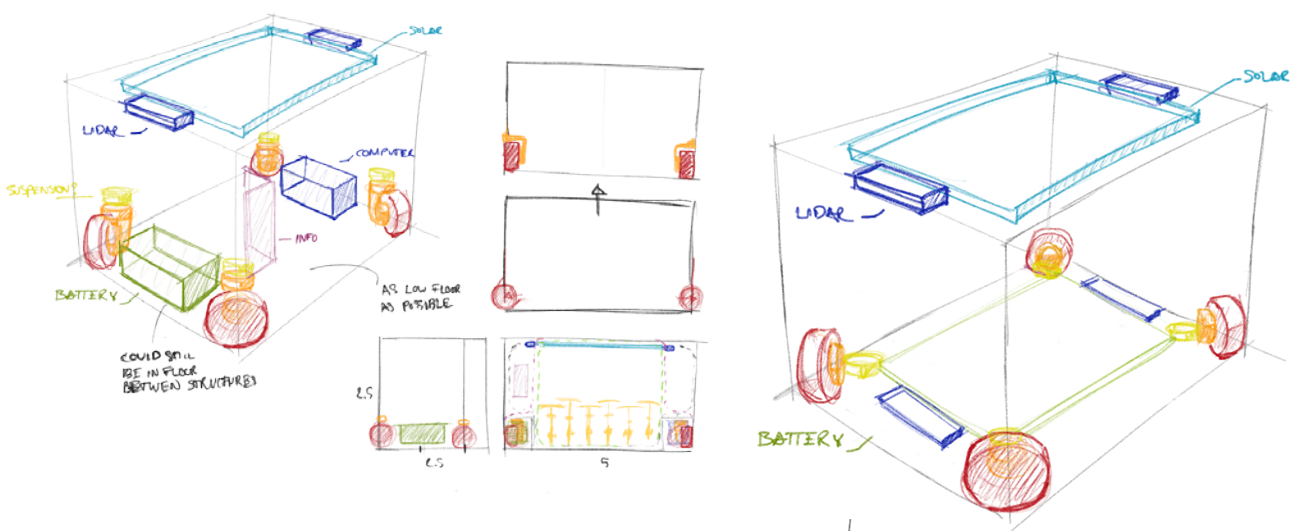
As cars go from combustion engines to electric new opportunities arise. Combustion engines are very inefficient and provide a central source of power, and to get it out to all the wheels complex mechanics are needed. With electric power the source of the electricity, the battery can be centralized just like the fuel tank, or easily divided into parts to accommodate construction and a good center of gravity. Similarly research institutes and NASA have been working on complete drive-by-wire vehicles. Like the Mars Rover. This means that engines, steering and many other components are controlled non mechanically, digitally by wire. Already today there are electric in-wheel motors complete with suspension and brake. The only addition to this would be controller, battery, steering motors and autonomous technology like laser and camera guiding systems. This enables four wheel steering (like shown in the reference pictures) and a whole new way of designing vehicles. For a low speed & short range vehicle that I'm designing I thought that this decentralized drivetrain felt like an ideal solution. After experimenting with the steering radius and the way that the wheel assembly connected to the chassis it also enabled the wheels to get out of the way when parked without taking valuable bicycle space.

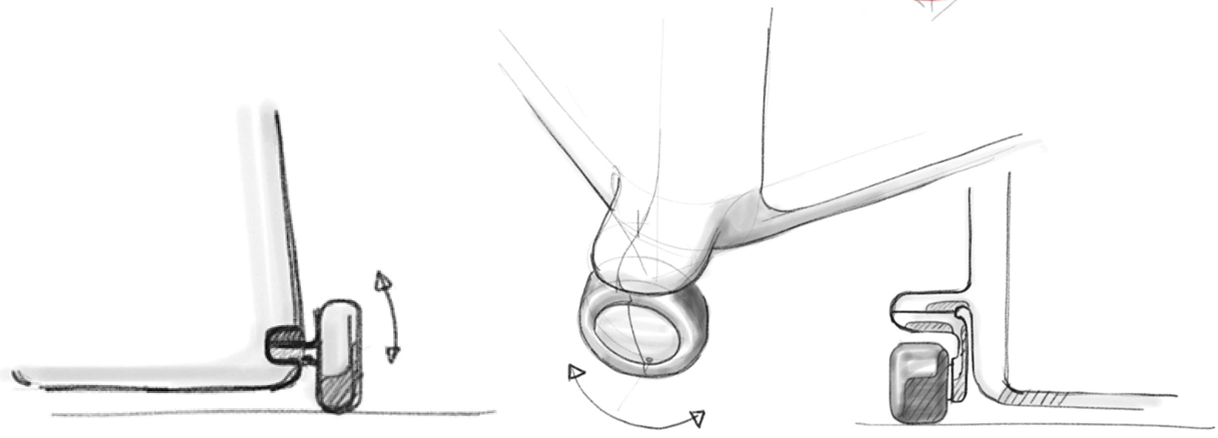
The floor could be thick, bu ideally not much thicker than how tall the curb is. The station had to be able to mostly power itself, for illumination, digital functionality and moving itself, but the power supply could be supported by charging at the depots. To achieve this semi transparent solar film on the roof was deemed the most suitable option along with a large battery filling most of the floor. This can give a low center of gravity and has as shown with cars like the Tesla Model S a relatively compact size.

In this phase I always tried to find current examples of technology and in usual futuristic fashion shrunk them a little, of course within reason trying to consider that the laws of physics still will be the same.

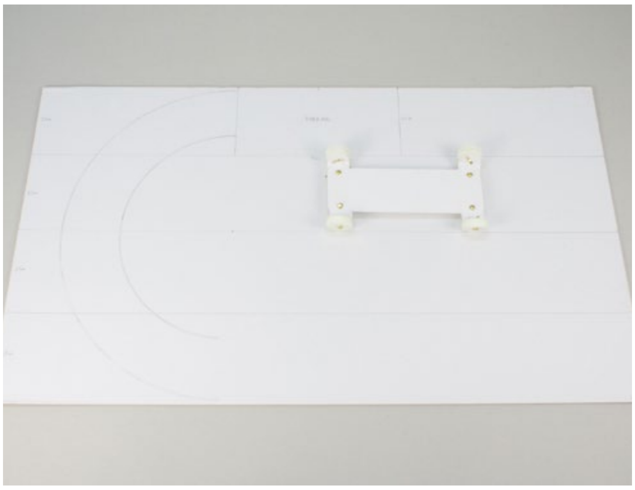


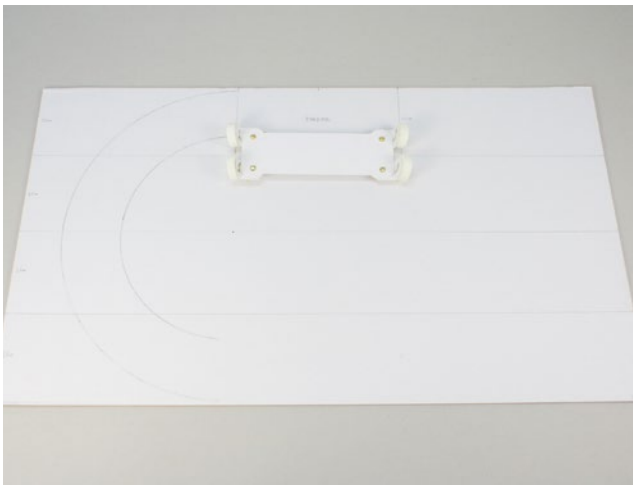

FULL/EMPTY STATION IN THE MIDDLE
FOUR WHEEL STEERING
FULL/EMPTY
FULL/EMPTY STATION IN THE MIDDLE
FOUR WHEEL STEERING
FULL/EMPTY
CONVENTIONAL STEERING
FULL/EMPTY
CONVENTIONAL STEERING
FULL/EMPTY

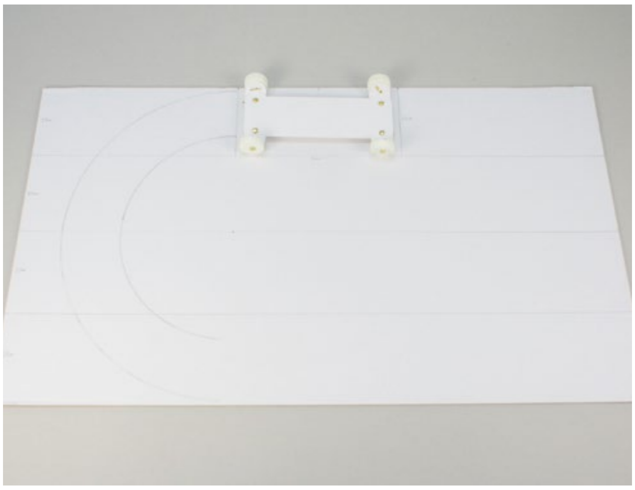

SOLAR
LIDAR
COMPUTER
SUSPENSION?
INFO
BATTERY
COULD STILL BE IN FLOOR BETWEEN STRUCTURES
AS LOW FLOOR AS POSSIBLE
2.5
2.5
5
SOLAR
LIDAR
BATTERY

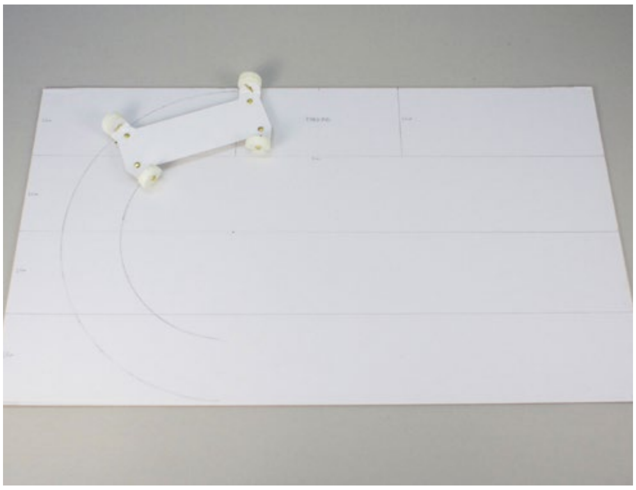


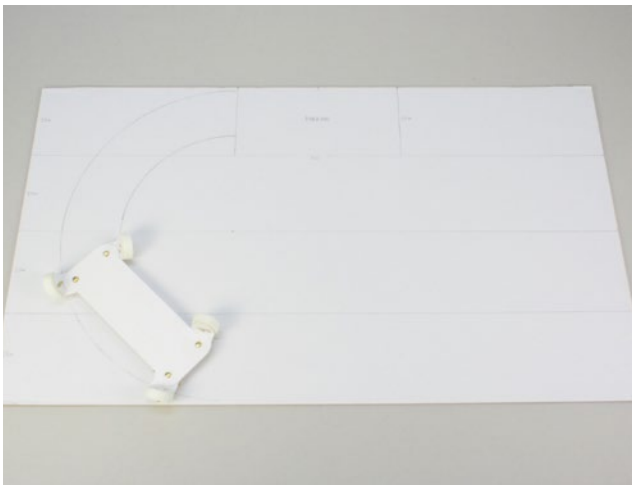
TURNING RADIUS TESTS

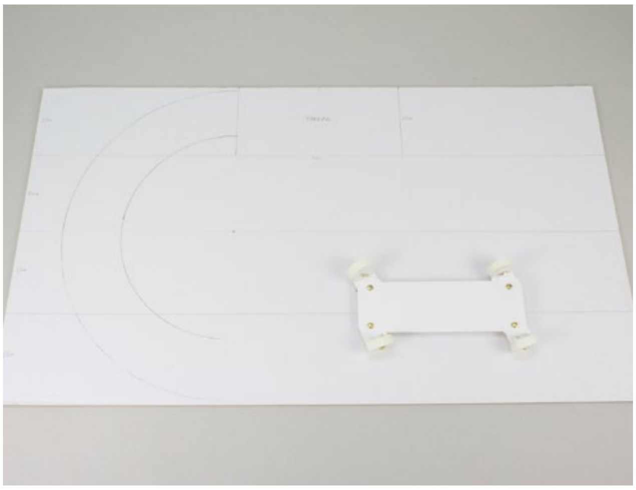




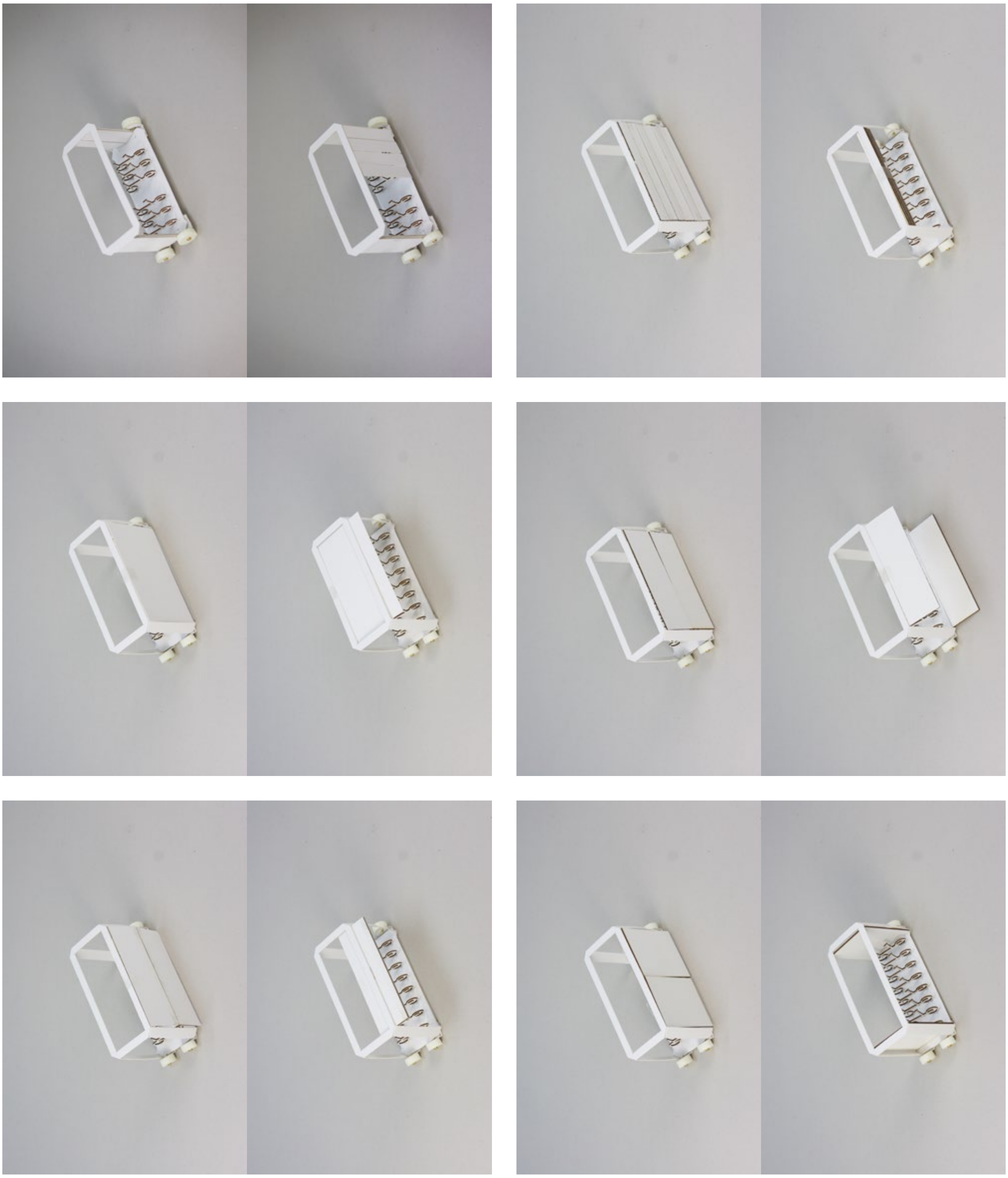








DOOR TESTS



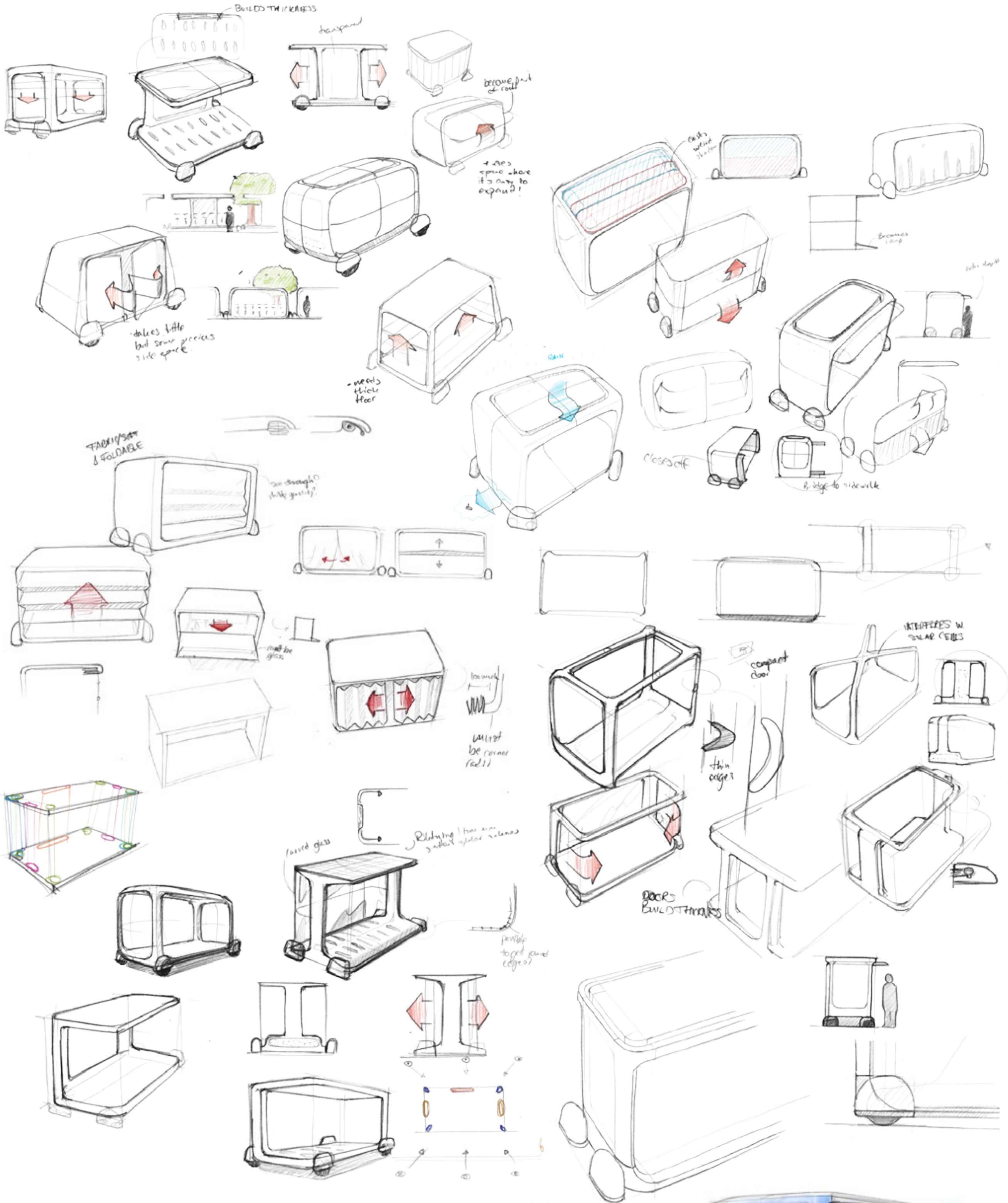
VISUAL FOOTPRINT, DOOR & INFORMATION

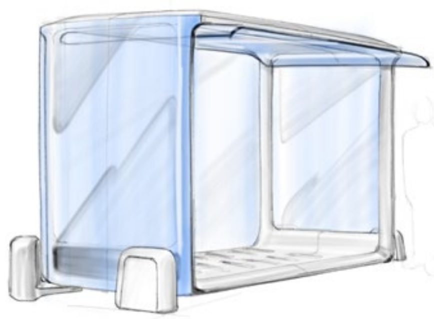
Another important element of the station is how you don't access it. When the station is moving around the city, or at certain times you want to restrict access to registered users it has to be able to close itself. In this process I looked at different ways of achieving this, both in soft & hard materials and different ways of doing it mechanically. When designing this functionality it was important that it didn't take space from the bikes, but also very importantly, that it gave the station an inviting and transparent appearance. The direction I decided to go was a simple one piece glass canopy door. Attached at four points it creates an extended roof and a clear indication where the opening is. It also take space only from the top of the station, where it doesn't affect the storage of the bikes. The door will either be up when the system is active & parked or close as it is going to drive away, so that users don't have to wait for it to open every time they want to pick up or drop off a bike. Also limiting the risk for malfunctions and accidents.

When designing the station it is important to consider what it not only singularly but plurally does to the cityscape. The overall concept of how it is built has to take as little visual space as possible, lowering things out of sight. If it has to be in the line of sight, like the roof and its supports should be designed to take as little visual space as possible. This while integrating solar power and drainage. A scenario where most of the vehicle traffic is autonomous also mean less accidents. Less accidents and in this case, no human passengers mean there's less need for safety features like crumple zones and bumpers, instead vehicles could become lighter, more compact and more transparent.

Materials carbon fiber is also becoming less expensive than before, and are starting to be used in the public environment and manufacturing of city cars. Examples of this is the public lighting on Kaptensbron in Malmö by Ateljé Lyktan and the BMW i3, made from parts recycled carbon fiber. This means extremely strong but slender construction usually not possible with aluminum extrusions for instance.

How an autonomous vehicle function is something car manufacturers still are trying to figure out. A vehicle today communicates to its surroundings trough the headlights, taillights, turn, reverse and brake signals. But in reality this isn't enough as the driver has to communicate without words to other drivers and pedestrians it's intentions. This could be a friendly wave to say that it's OK to pass or making sure that someone has seen you before you make your move. This communication has to be facilitated somehow when the driver isn't there anymore and the car drives itself. This in combination with the need for an rudimentary information system to the users of the system when it's parked. This could be how you access it and other things. The placing of these systems had to fulfill requirements of visibility in use but also to not obstruct the view of the bikes.


BUILDS THICKNESS
transparent
become part of road
+ gives space where it's easy to expand!
takes little land space, precious side space
needs thick floor
FABRIC/SEAT & FOLDABLE
Closes off
Bridge to sidewalk
INTERFERES W SOLAR CELLS
compact door
thin edge?
curved glass
DOORS BUILD THICKNESS



ID2: BIKE

IMPORTANT FACTORS

The characteristics of a good bike-sharing bike has been covered earlier in this report. Some of them are one size with adjustable saddle height, proprietary design, low-maintenance, secure locking, automatic lights and reflectors and functional storage and dirt protection.

As bike-sharing bikes are used on a whole another level than a personal bike they need to be a lot more robust in their design. Not only in the choice of parts & drivetrain, but in the overall design of the bike. But still it has to be a relatively light, comfortable and practical city bike.

GEOMETRY BIKE/TYPOLOGY

The context of the station make space a limitation. As bikes are stored perpendicularly to the length of the station the length of the bike directly affect the width of the station. Despite what many design students before me has tried to lead some to believe, there isn't much more you can do than shrink the wheels to make a bike shorter when rideable. This without compromising the handling, and ergonomy of the bicycle that much. There is a range of different types of bikes, ranging from those with 16" wheels, commonly found on foldable travel bikes like the Brompton, to the 28" wheel bikes that most of us have. Between them you have 20", 24", 26" as standard sizes. The apparent benefit of a small wheel bike is the smaller size, making it easier to fold and stow away. But small wheel bikes also more durable (as smaller wheels are stronger), more efficient in speeds up to 26 km/h and equally efficient as a 28" bike up to 53 km/h, speeds rarely achieved in a city on a citybike. They also accelerate quicker which is also a benefit in city traffic where you stop and accelerate a lot. (80)

Looking back in history these bikes where very popular in the 70s and where often called mini-bikes. Still you see many of them today despite many of the early models suffered from poor construction which led to the frames breaking over time. I think its time for a mini-bike renaissance with better frame design adapted to modern manufacturing.

BUILD-UP & COMPONENTS

The choice of components and drivetrain have to follow the same rules as the design of the rest of the bike. This to reduce need for maintenance and the risk for a bad experience for the user. A bicycle drivetrain can be other things than the regular metal chain. The problem with metal chains is that they stretch over time and need to be lubricated. This mean that they have to be regularly maintained so that they don't break. Also they need to be covered with a chain guard so that the rider doesn't get dirt on their clothes. Alternatives exist in drive-shaft bikes, but these fail catastrophically when they fail. There's also the carbon belt drive, which is


jopo
jopo
jopo
jopo
jopo
jopo








a non lubricated belt with teeth that grip cogs similar to the ones of a chain drivetrain. These are virtually maintenance free and are perfect for use with city bikes with internal gears.

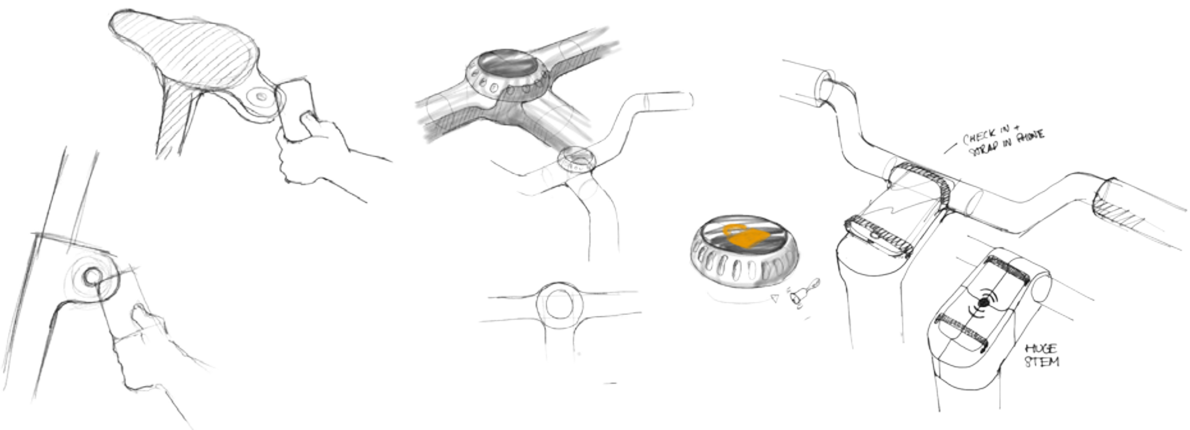
Next is just that, gears. Most city bikes have 3 to 8 gears as that enough for the terrain of most cities. Something that is becoming more common is automatic transmission on bikes, where the gear is set so that you always have a comfortable ride. It senses the pressure put into the pedals and how fast they are spinning. This system comes with backpedal brake as well, which eliminates the need for hand brakes which wear out eventually. An ideal choice for a bike-sharing system, as riders range from unexperienced to experienced.

Electric assist is another issue that is becoming more common. Batteries can be better integrated into the bike as they become smaller, and so does motors which now can be located in the front wheel hub. Though it makes the bike a little heavier when using it without the assist and poses an extra cost to the whole system as the bikes become much more expensive. Initially I decided not to include it because of these reasons, but later on I decided to include it as assist would extend the range ridden by cyclists and would also be an incentive to use it more often, as you are less likely to get exhausted or sweaty due to the terrain of your route. Making bike-sharing more competitive towards other modes of transportation.

CHECK IN/OUT & LOCK

In my system design I decided to decentralize the check out process. Usually users check out their bike at a terminal, but to prevent bottle necks and make it more intuitive I decided to put the check out on the bike itself. For the bike to be practical as an everyday bike in the city I thought you had to be able to lock it while using it. This in order to be able to use it for errands, excursions and other things that might not be within the range of a station.

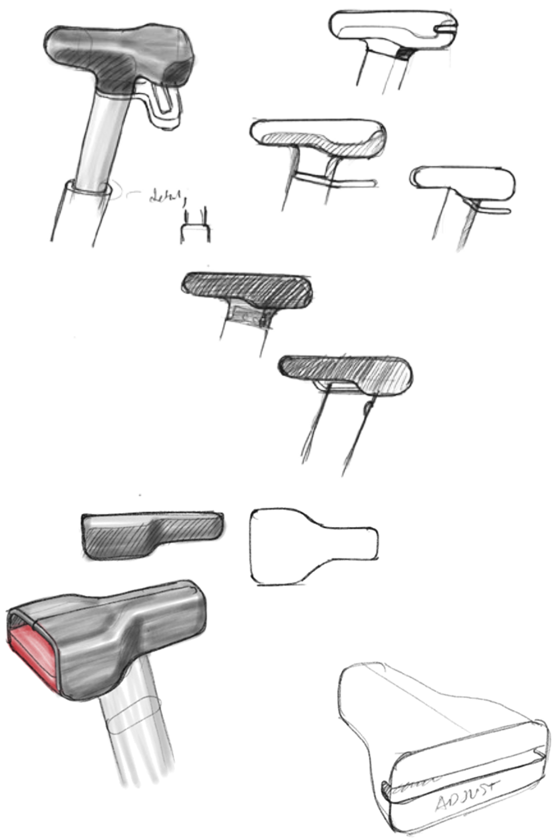
What then clearly made the most sense was to have one place on the bike where all this is controlled. To determine this I tested different locations, both with a card, phone, and smartwatch. The unlocking procedure had to work fluently with the next step, grabbing the bike by the handlebars and pulling it out of the dock. Eventually I settled on placing it on the middle of the handlebars, allowing it to potentially function as an on-bike information system. This I decided to integrate into the stem of the bikes after experimenting with more expressive alternatives, referencing common bike accessories like the bell.


CHECK IN +
STRAP IN PHONE
HUGE
STEM

ADJUSTABLE SADDLE

To make the bike accessible to people of all lengths the saddle height has to be adjustable. If a bike geometry and size is well designed an adjustable seat height is enough to achieve an more than OK fit for most people, even in the outer percentiles on the scale. Most bike-sharing systems use the common quick-release lever clamp to adjust the saddle. The drawback with this is that it is difficult to use while sitting on the bike, and therefore the correct height is harder to determine.

I wanted to get inspired by other places where seats and other things are adjusted manually with ease, like in gym equipment or car seats. Technically this could be with the help of springs or in some cases gas lift like adjustable office chairs. The best ideas was tested in full scale models, first on a regular bicycle and later on a model of the actual bike, located just below the saddle. It then had to be integrated either into the saddle or the seat mast.



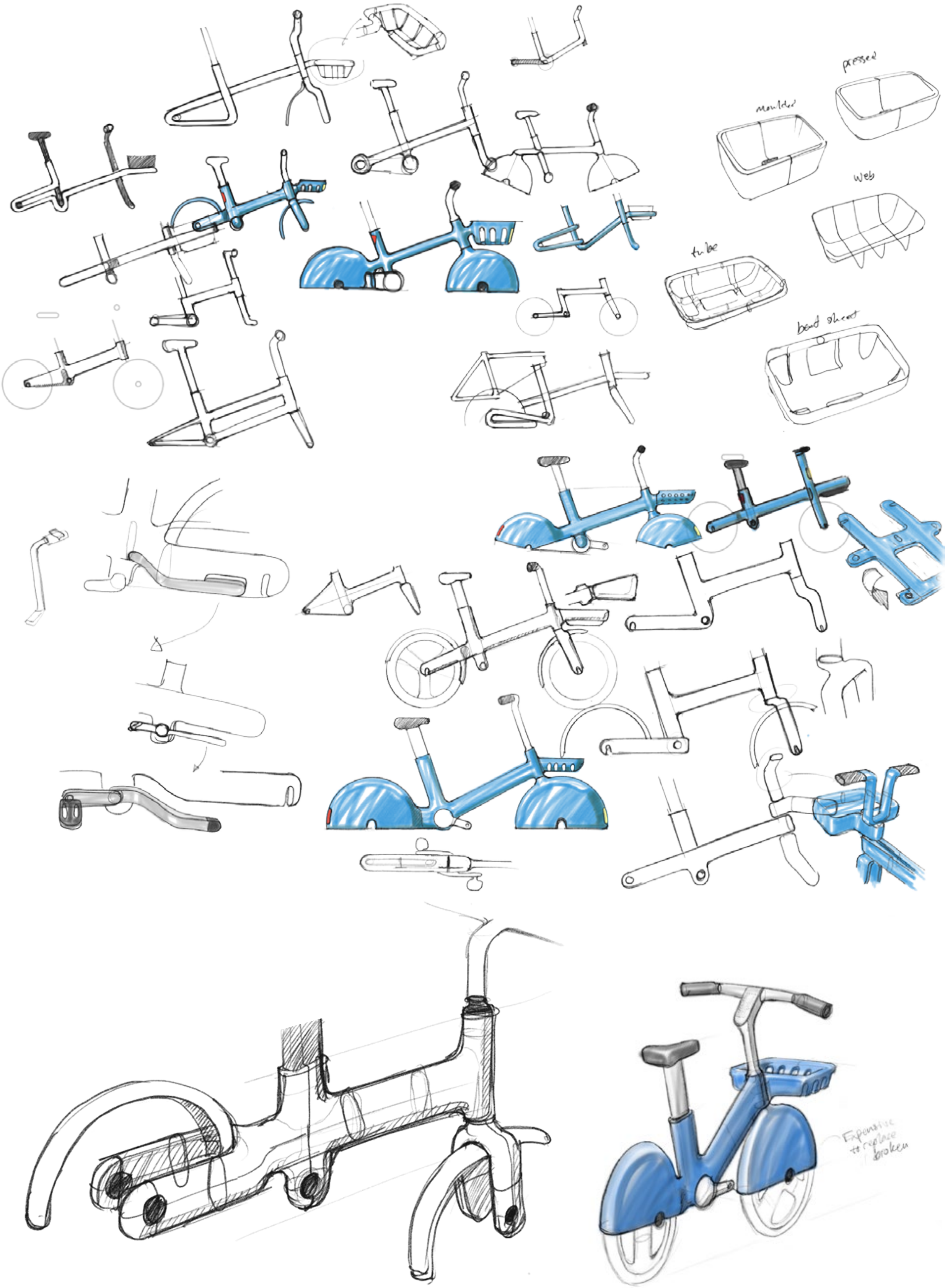
FRAME & ACCESSORIES

The other important things I wanted to look at besides the frame of the bike was the kickstand, mudguards, storage and visibility features like lights and reflexes.

The design of the frame is mostly about connecting the dots determined in the geometry of the bike and decide what it's made of an how it is manufactured. As this is a bike-sharing bike that is to be mostly proprietary in design, meaning that it doesn't need to fit standard bicycle components, a higher level of integration of the different accessories can be achieved. Looking back in history you can find examples of bikes made from not only metal tubes and extrusions but form pressed sheets, wood, plastic and other composites. They all have lessons to teach.

As I wanted my bike to be a modern interpretation of the vintage mini-bike (as explained on p. 70) and build on the simplicity found in many of them, but update the design for modern day manufacturing. I eventually settled on what is the state of the art in terms of aluminum bike manufacturing today, but still with a considerably lower cost than carbon fiber. Tube junctions would be hydro formed and then TIG welded to extrusions. With round tubes the need for extra stiffness in the frame in addressed by more frame elements, but by going for a taller, pill shaped, profile you get a stiffer, simpler but still softly shaped frame.

Similarly accessories have to be custom in the way that they attach to the bike to deter theft for use on regular bikes. The basket shouldn't invite a second passenger and is more a place to put your bag rather than a place for keys and smaller things that risk getting forgotten. Mudguards and stand has to be robust so that they aren't easily bent or dented while being integrated with the form language of the rest of the bike.


pressed
moulded
web
tube
bend sheet
Expensive
to replace
broken

REFINEMENT

ESTABLISHING A DNA

When designing the station and the bike I wanted to work in a way more familiar to the design of consumer products and how some architects do their work. I wanted to find a method of designing the whole system that holistically answer detailing questions and make the whole coherent and calm. Contrary to much car and bicycle design I wanted to be able to look at the form and have relatively clear motives why things looked like they do. The aesthetic that I was after was a soft and friendly appearance but with elements of precision and sharpness to reduce the perceived mass and give it some directionality. I wanted to as much as possible work with uninterrupted surfaces, placing elements behind transparent segments and in the gaps & transitions between materials & parts. Overall, the station should have a light and transparent perception, reducing the attention it grabs in the cityscape, this also by making it in large parts reflective, so that is blends into the surroundings, while still allowing lit up information be clearly visible through transparent glass.

When designing the station the hardest thing was to achieve a balance between architecture and vehicle. When standing still it shouldn't look out of place and like it's going somewhere, but when moving it shouldn't look like a house on wheels. The design of both the station and the bicycle should also carefully reference to known things so that they don't feel out of place in any city. Both should somehow feel familiar, despite being a new element in the environment.

CUSTOMIZATION

An important aspect of a system like this is customization as it need to blend in with the rest of the public transit, or stand out as a brand of its own. What you have to balance then is to be seen and to obscure other things while achieving that. I looked at the systems in Copenhagen (Bycyklen & DSB), Malmö (Skånetrafiken) and Stockholm (SL) to determine suitable colors but also see how the brands related to materials, transparency and logo/graphics placement.

EXTERIOR

When designing the station the starting point was the drivetrain and the steering. To achieve a compact and flexible wheelbase that allowed the wheels to turn 90 degrees to park and at the same time steer like a car when in traffic, the corners had to be of a certain radius that then is cut off on one side. This method of subtracting and segmenting of form to add/open up for functionality was then applied to the rest of the station and the bicycle. Some important areas was how the door interacted with the body of the station, transitions between the pillars and the roof and floor, wheels, bicycle docks and the information system. The focus was to as much as possible create perceived thinness and reduce volumes where visible.

The goal was to push the boundaries a bit in terms of what is possible, to end up with something that feels a bit futuristic and not diluted by too many concerns about manufacturing and mechanics. Things that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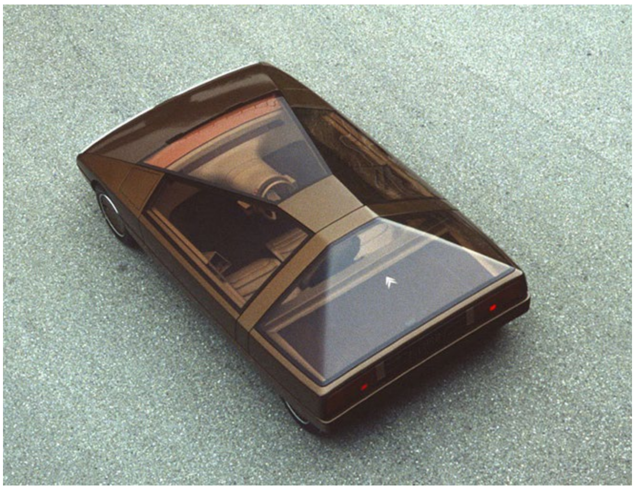
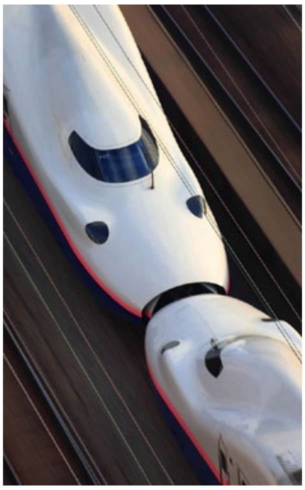
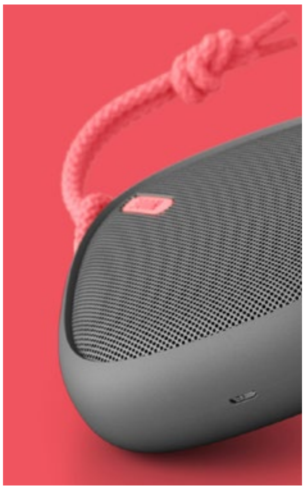
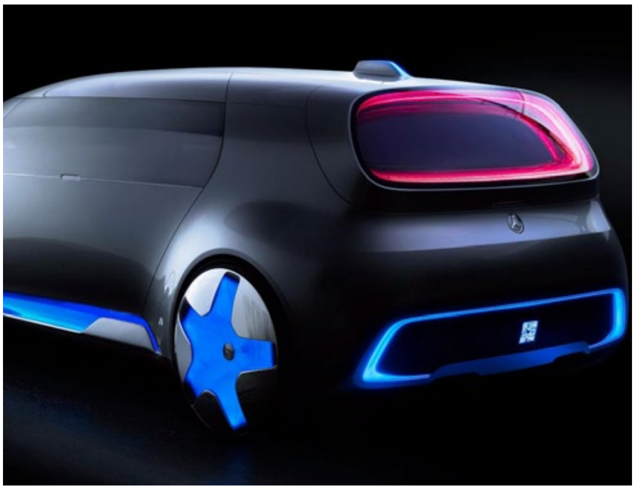
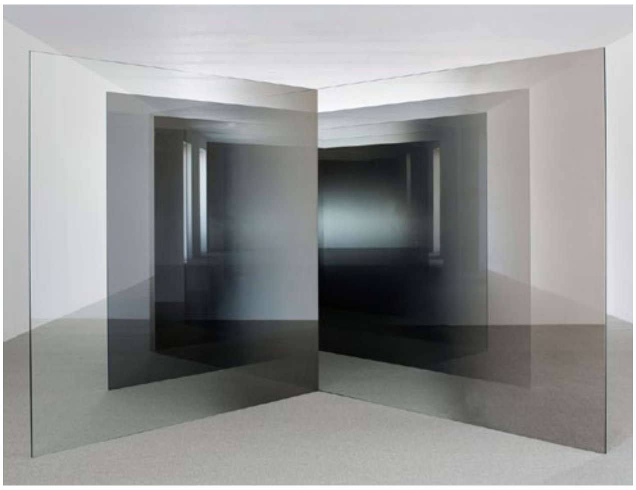
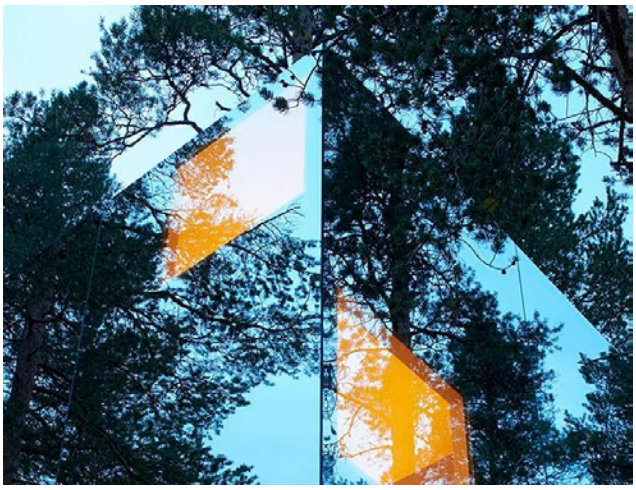












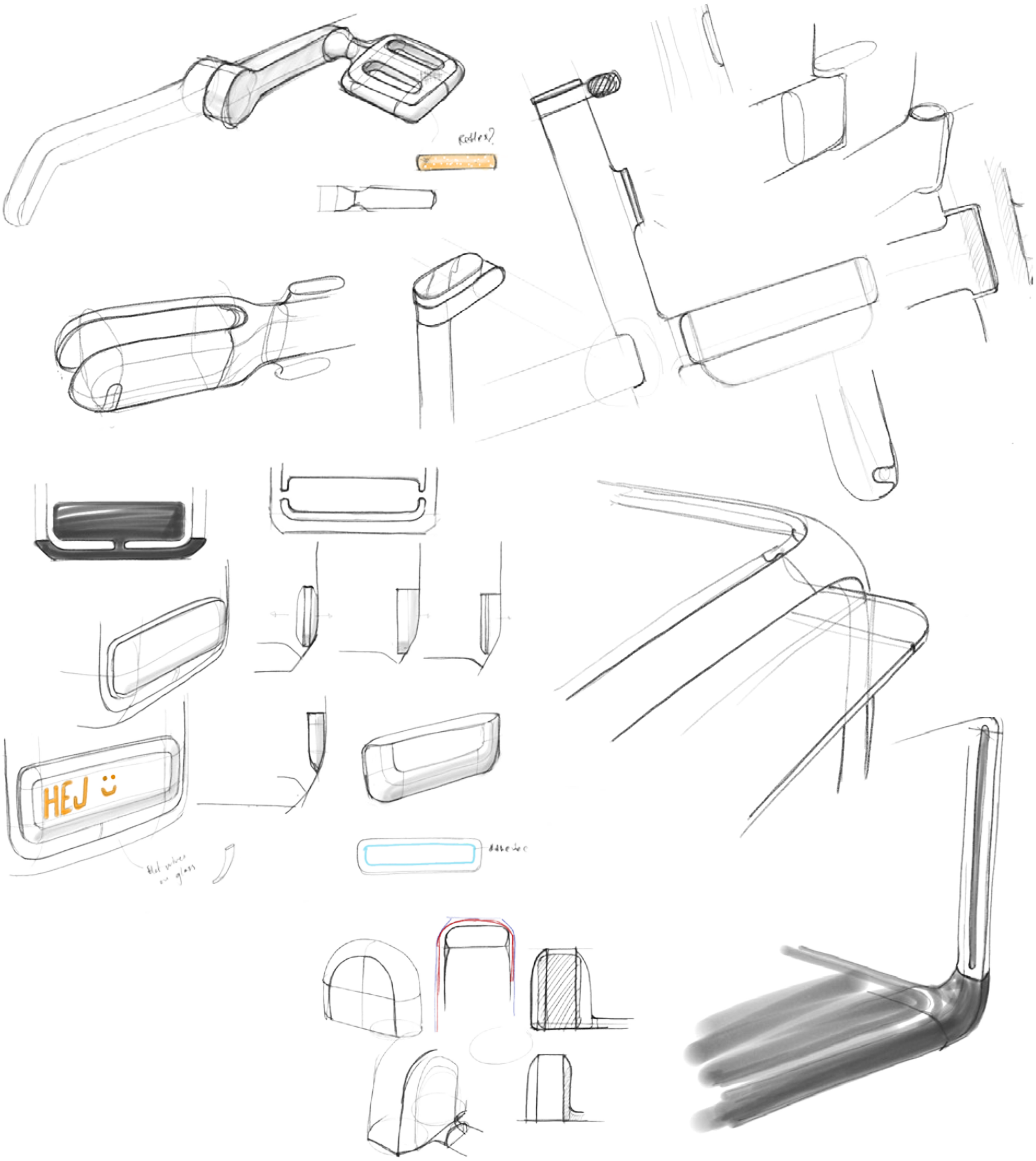
anyway is very hard to foresee, and impossible for me to address in every detail with the time given me. This was a difficult phase as my ambition as a designer is to consider every detail carefully and to as far as possible have a good foundation for my decisions. Something that I had to let go of I where to produce this future concept design. Not only aesthetically where I think that the detailing phase ideally should contain many detailed prototypes but also technically. But that have always been difficult in school, considering one's financial situation.

INFORMATION SYSTEM

Placed in the bottom of the side windows, the information module has a two sides with OLED display, one side directed outwards toward traffic and is covered by the wheels when parked. The inside is facing the bikes and the user. My focus was how this would be integrated into the station aesthetically but also importantly what information that was to be displayed and how. Balancing use of iconography and text.

BICYCLE

The idea was to design the bike with the same thinking as the station and to trust that they will belong together. Rather than focusing on the exact forms that I ended up with on the station. This to avoid situations where certain detailing decisions become more an obsession of coherency rather than solving the specific problem as well as possible. The focus on the bike was after all was a mostly custom design but using the same elements as much as possible. Making things custom is expensive, but the idea with the bike is to use the same oblong aluminum extrusions on all the frame parts, and then to split and hydro form segments that then are TIG welded together and polished. Functions have then rather been added through cuts in the tubes, than added features that then would produce additional welds.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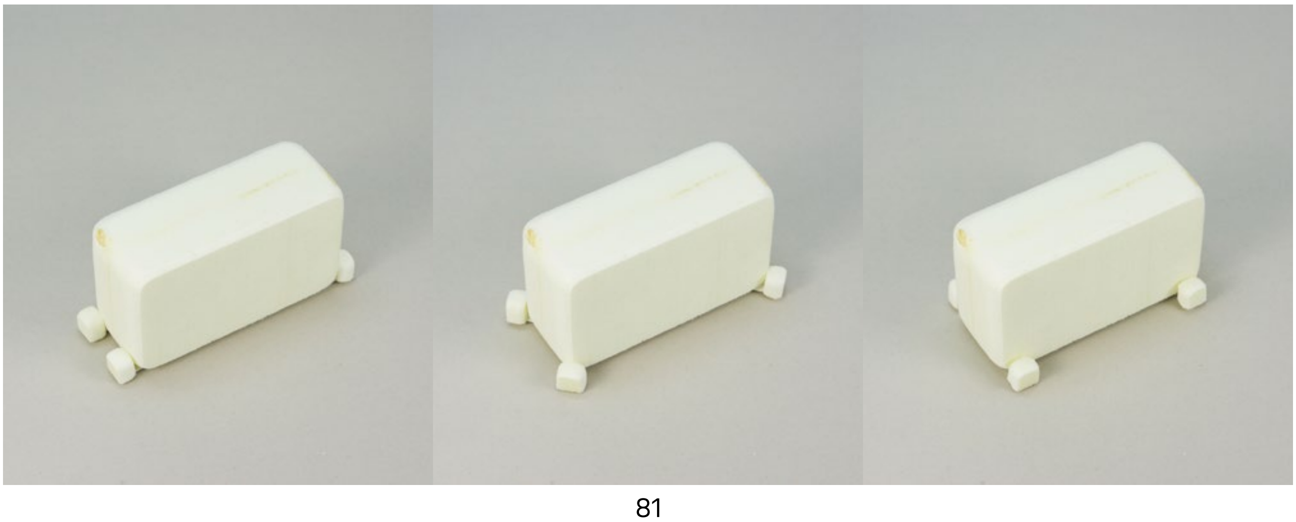
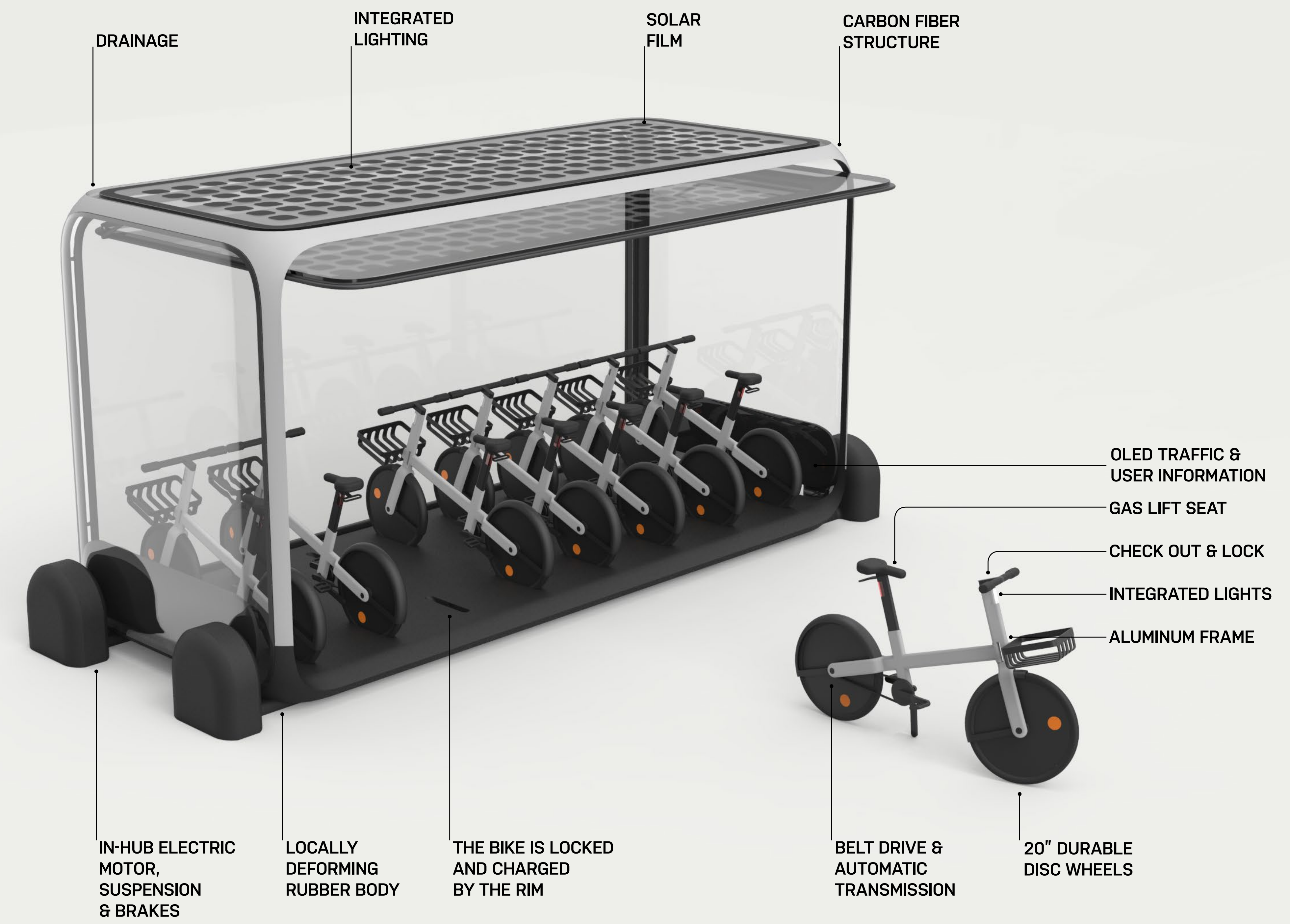


RESULT

The station is a self-driving low speed electric inner city vehicle that's charged at a depot and its own solar power. Made from a ultra light carbon fiber framework and lightweight and durable "Gorilla glass". It is designed to fit within the context of the parking space for a car and other designated locations, and enables instant rebalancing of the system and a continuous flow of stations and bikes trough maintenance depots. The system adapts intelligently to how it actually is used, so stations can for instance pop up outside popular summer destinations, adapt to temporary events & festivals, function on-demand while also scaling the permanent locations according to the need at the given moment. Optimizing use of the inventory while providing an as seamless and fluent mobility experience as possible to the user.

The bike, unlocked with a smartcard or smart device directly on the stem, is a 20" wheeled aluminum city durable and practical city bike equipped with 8-speed automatic belt drive powertrain, electric assist, dynamo powered lights, mudguards and a front basket. It has an adjustable seat with a gas-lift under the seat so that allows the user to easily adjust it while sitting on the bike. The bike can be locked to use it for errands in the city and gets you wherever inside the city without sweat.


DRAINAGE
INTEGRATED LIGHTING
SOLAR FILM
CARBON FIBER STRUCTURE
OLED TRAFFIC & USER INFORMATION
GAS LIFT SEAT
CHECK OUT & LOCK
INTEGRATED LIGHTS
ALUMINUM FRAME
IN-HUB ELECTRIC MOTOR, SUSPENSION & BRAKES
LOCALLY DEFORMING RUBBER BODY
THE BIKE IS LOCKED AND CHARGED BY THE RIM
BELT DRIVE & AUTOMATIC TRANSMISSION
20" DURABLE DISC WHEELS


CENTRALSTATION
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REFLECTIONS

Going into this project I to be honest didn't believe that I could pull off a transportation design project. My hope was that I could apply the skills and world view that I have and make something that wasn't completely stupid. Originally my intention wasn't to design another bicycle. Something I did for my BA-degree project. Mostly because I feared that I could risk putting myself into a niche as only a bicycle designer. For me cycling is a hobby and an area where I have a lot of knowledge beforehand, but I wanted to marry this with my larger interests in future tech and transportation in general. Many cyclists take pride in hating cars, while I think that they both are fantastic for different things.

In the beginning of the process I could not help getting excited about the opportunities that lie in bike-sharing systems. And for a while I considered not designing the bicycle, but in the end it felt strange designing the station only, when the bike is such an essential part of the system. Then I have to trust that the project can be presented in a way that put the focus where I want it to be.

Overall I'm happy with my process, though I would have liked to be able to spend more money on better prototypes, models and also go deeper into detail on some aspects of the design. I would have loved to make a full scale model of the bike and a larger more detailed model of the station. During the process I've learnt a lot and enjoyed researching the chosen topics.

It has been challenging structuring it all, keeping it clear the whole way through. When I look at the result I still agree with most of the decisions I've taken, but realizing that there is a lot of work to do still if a concept like this was to be taken into reality. Not only the reality of engineering and materials but also the financials of a system like this. For instance it might be necessary to make the station take more bikes to make it financially viable, something that could mean some necessary compromises.

Lastly I want to thank my examinor Claus-Christian Eckhardt and supervisor Charlotte Sjödell for their commitment and great support.

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