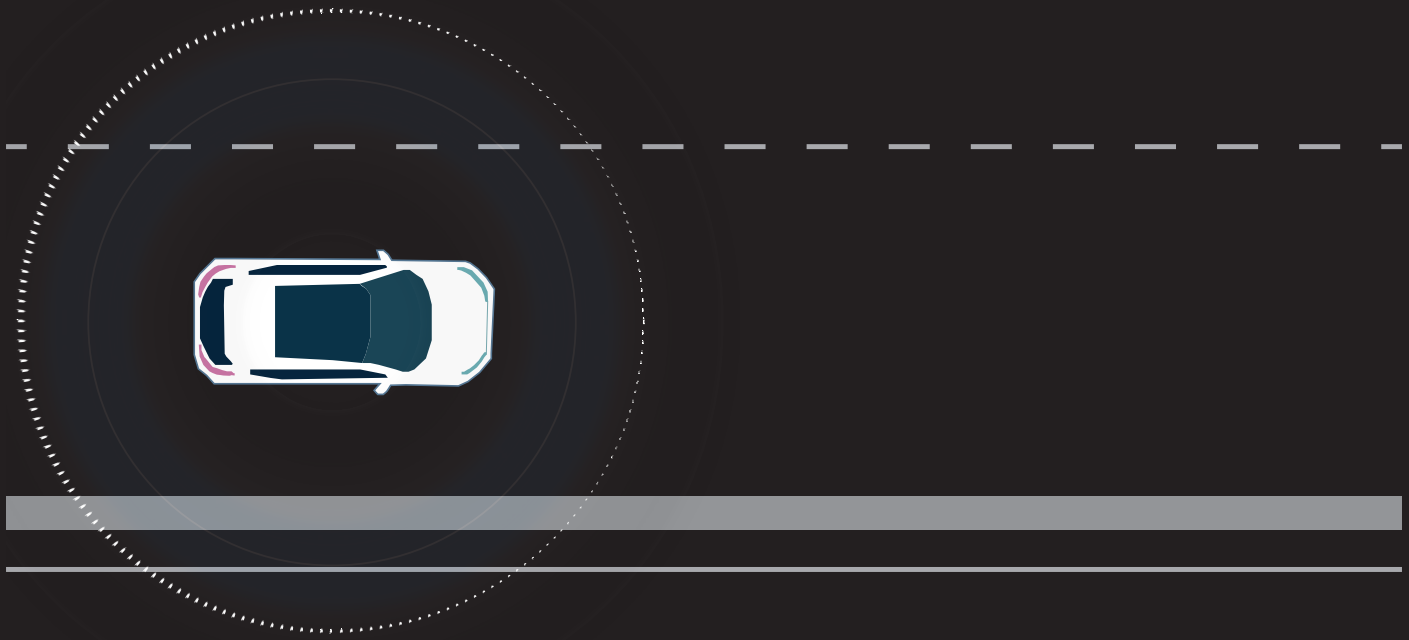

Autonomous Shared Mobility & the Cities of Tomorrow

Impact of shared self-driving vehicles on the urban form of the city of Amsterdam

Bhavana Vaddadi I Graduation P5 Report I Msc Urbanism I Delft University of Technology 29/06/2017 I 4513762

Autonomous Shared Mobility & the Cities of Tomorrow

Impact of shared self-driving vehicles on the urban form of the city of Amsterdam

Colophon

Title: Autonomous Shared Mobility
& the Cities of Tomorrow

Subtitle of shared self-driving vehicles on
the urban form of the city of Amsterdam

MSc thesis

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4513762

Keywords: future, autonomous,
urban form, space,
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to Ioana Ionescu
for guiding me in bringing my project to a full circle during the last couple of weeks.

Abstract

"*Anyone who only thinks of technology, has not yet recognized that autonomous driving will change our society*." says Dr. Dieter Zetsche, Chairman of Daimler AG, and indicates to what the future of mobility will look like.

Autonomous and shared mobility is the most talked about topic in the world of transport today. Self-driving shared vehicles will have a huge impact on urban life as they will begin to question the distinction between private and public transportation modes.

This mobility trend will help in reducing time of travel with almost 80 percent fewer cars.

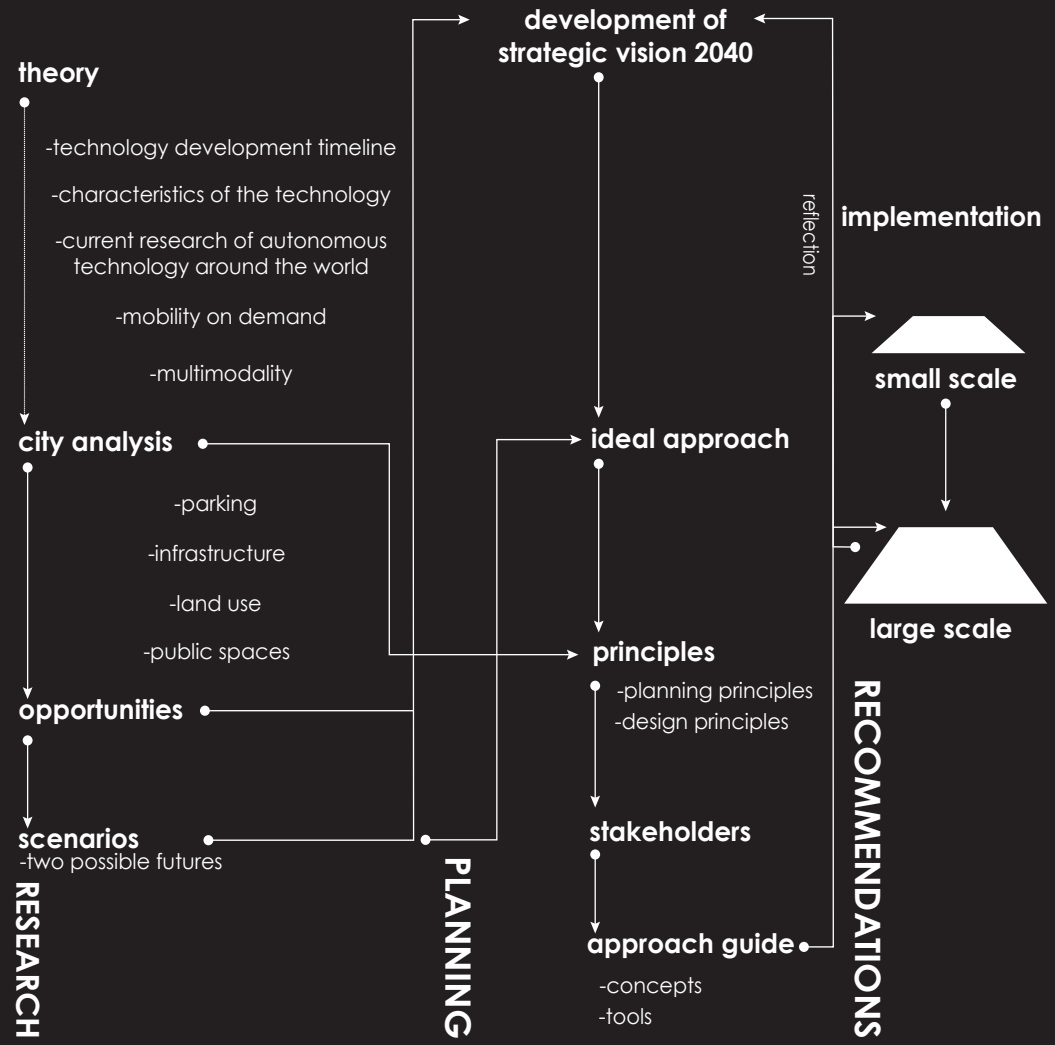
The reduction in the number of cars on road will lead to changes in environment, traffic, congestion issues, efficiency, cost of road building and maintaining, urban sprawl and parking.

With fewer cars, vast amount of land under parking, which is observed quite often in most cities today, could be freed for other public uses, thus changing the urban form of the city as we know it.

Therefore, it is time for Transport Planners and Urban Designers to concentrate on this field of development and investigate the possible impact of Autonomous mobility on the city and space to reap maximum benefits in future.

This project will explore the consequences of this mobility trend through scenarios with a thorough analysis of the possibilities for the city of Amsterdam and speculate how this will transform the city in future.

Methodology



[1] Methodology of the gradauation project
Author

The goal of the project is to understand the consequences of the changes in mobility systems that might take place in the near future.

Hence, it aims to cover three important sectors of Urbanism i.e. Research, Planning and Design as it begins with a strong understanding of the technology and exploring existing research for the technology as well as its supporting systems to derive a base for the study to hold on to.

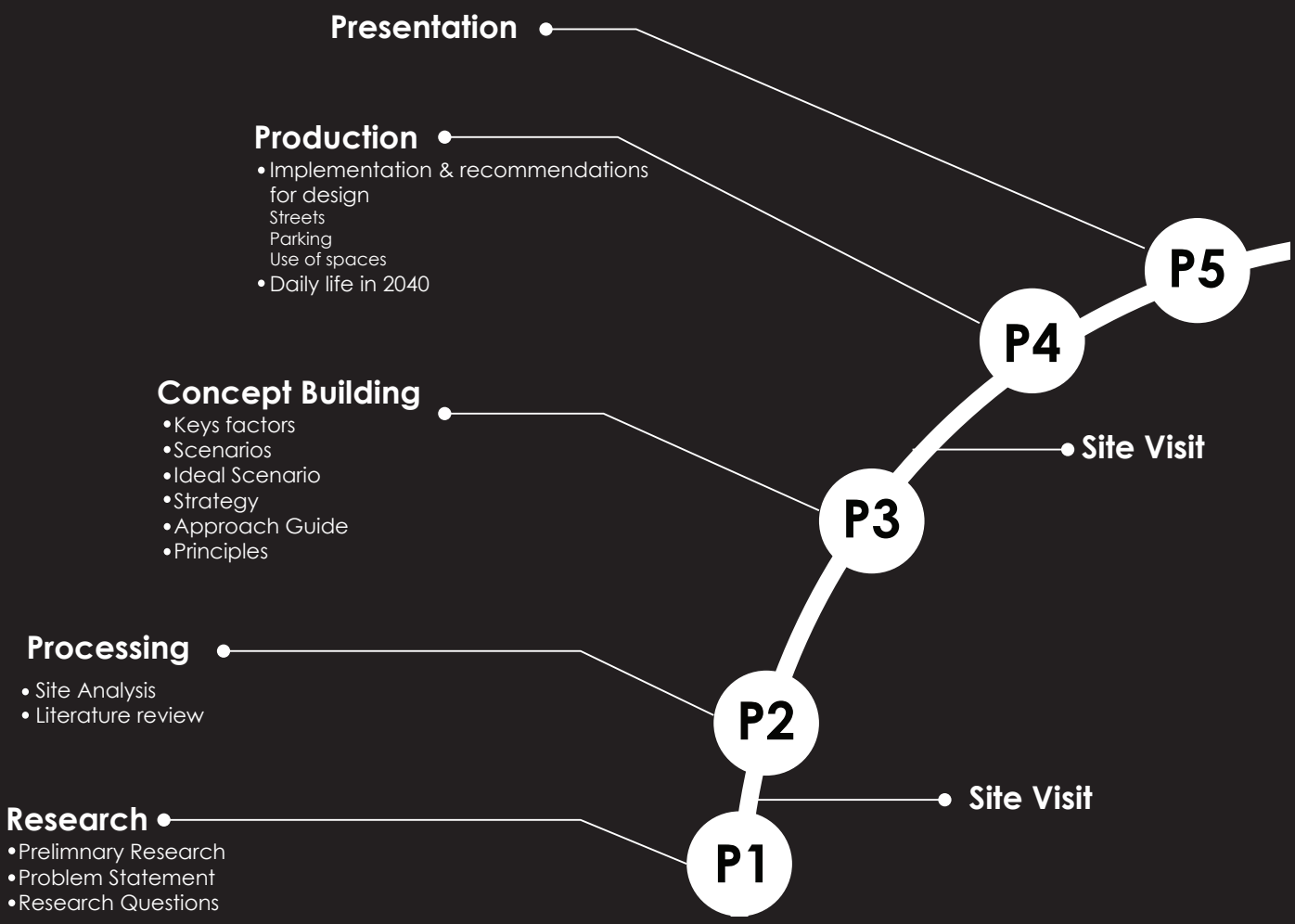
Adding to this stage is the analysis of the city of Amsterdam in order to understand the opportunities it has to offer to adapt to the technology.

At this point it is also of utmost necessity to understand the approach that has to be taken for this project to unfold, Hence, scenarios have been constructed to speculate how the future would look like. For the planning stage of the project, the combination of the opportunities and the city analysis would help in the formulating a strategy or the target year of 2040 which will help in deciding ideal scenario/ scenarios in which the city will mostly likely develop in future.

In order to achieve this scenario, an approach guide is suggested which deals with various concepts and tools that could be used.

The design stage aims mostly at the spatial translation of these tools at a smaller scale for different urban forms and understanding their impact on a larger scale which would in turn reflect the strategy that the city developed to tackle the onset of Autonomous Mobility.

Timeline of the project



[2] Timeline of the graduation project
Author

The project spanned over the period of 12 months and was carried out in the following five phases:

Stage 1- Research
This stage focused on grasping the issue at hand and exploring the topic in detail to formulate research questions.

Stage 2- Processing
Having established the trending issue at hand, the processing stage involved a deeper understanding of the concepts tied to the topic and various approaches that could be taken to take the project forward. This phase simultaneously involved getting familiar with the site and its characteristics.

Stage 3- Concept Building
The concepts, analysis and conclusions from the previous stage form a foundation for building the concept of this project. The approach of backcasting scenarios was adapted to devise a strategy for mobility for the city and various tools and guidelines have been suggested to achieve this strategy.

Stage 4- Production
The production stage focused on creating illustrations and visuals for different parts of the city to visualize the implementation of the tools and guidelines that could highlight and explain the potentials the space has to offer as a consequence of this mobility trend.

Stage 5- Presentation
The presentation stage was to work towards a display of findings and reflection of the project with final conclusions and understanding the future scope of the project.

Contents

This report aims at answering five key questions **"The WHAT WHY WHEN WHERE HOW"** with the supportive theory base in order to explore the impact of self-driving vehicles on the urban form of a city.

3 **WHEN**

4 **WHERE**

5 **HOW**

Netherlands

Amsterdam

8 **Conclusion**

9 **Resources**

1 What

Motivation

Problem Statement

Research Questions

Introduction

Current Research

Testing around the World

"The reality about transportation is that it's future-oriented. If we're planning for what we have, we're behind the curve"

Anthony Foxx

Motivation

In 2011, I, as a budding urban planner in my bachelor study in Urban Planning, was introduced to the world of transport.

A transport planner's profession, as I was taught, was to focus on the efficient movement of people and goods across the country and study the various aspects of urban life.

In the past century, private vehicles have significantly changed the idea of personal urban mobility through high speed point to point travel in cities.

However, this has posed many challenges due to its adverse impact on environment, public health and the cities itself with growing
congestion and demand for parking spaces.With technological advancements, such as Autonomous vehicles emerging today, it is highly fascinating for me to investigate how they will transform the cities as we know them today.

Problem Statement

It took 50 years to transition from the horse to the car. By 2030, 60 percent of the world's population is expected to reside in cities.(S. Bouton et al., 2013) Over the same period, more than two billion people are likely to enter the middle class wanting the privilege to own their own automobile. Hence, automobile sales are likely to rise from about 70 million a year in 2010 to 125 million by 2025, with more than half bought in cities.(S. Bouton, Knupfer, Mihov, & Swartz, 2015) Predictions have also been made by some analysts that today's 1.2 billion car fleet will mostly likely double by 2030.(Dargay, Gately, & Sommer, 2007)

This only explains that personal automobiles have now become an unsustainable solution for the future of urban mobility. The rapid increase in cars in the cities will ultimately exert immense pressure on the existing infrastructure causing the most prominent issue of congestion.

Per the World Health Organization, it has been estimated that in 2014 seven million deaths are attributable to air pollution, and a significant share is the result of urban transit.(World Health Organization, 2014) Cities consume up to 80 per cent of energy and produce 70 per cent of worldwide green house-gas (GHG) emissions which cause climate change.(United Nations, 2009)

Currently, about 31 per cent of the space in the central business districts of 41 major cities is dedicated to parking, around 30 per cent - or 45 per cent in some places- of city center traffic is made up of drivers searching for parking spaces. (Healey, 2010)

Many countries around the world have started experimenting with the technology of Autonomous Vehicles from the past two years.

Automated driving technology can offer great solutions in providing individual and group based mobility .

This graduation project aims at visualizing a city of driverless vehicles and thier impact on the spatial quality of the city and how this will play an important role in transforming the daily life of the citizens.

Research Question

How can scenarios be used as a tool to formulate a strategy to transform the urban form of the city in the age of developing technology of Autonomous Shared vehicles?

1)Why is there a need to explore Shared Autonomous Mobility in growing cities today?
2)What role could the Autonomous Shared vehicles play in changing the trends of Mobility in the city of Amsterdam?
3)What are the possible impacts of Shared Autonomous vehicles on the urban form of Amsterdam?

History

It is speculated to be the next transformative technology in the field of transportation. With this technology, a new transport system is expected to offer new possibilities in management of traffic and will change the way people travel today.

In July 2013, Vislab demonstrated BRAiVE, a vehicle that moved autonomously on a mixed traffic route open to public traffic. As of 2013, four U.S. states have passed laws permitting autonomous cars: Nevada, Florida, California, and Michigan.

In Europe, cities in Belgium, France, Italy and the UK are planning to operate transport systems for driverless cars, and Germany, the Netherlands, and Spain have allowed testing robotic cars in traffic.

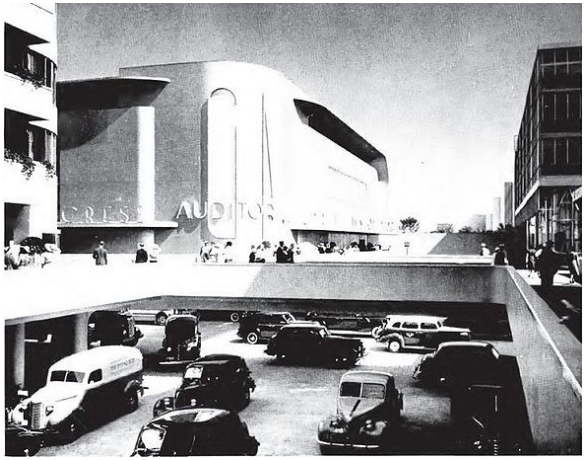
Experiments have been conducted on automating cars since at least the 1920s promising trials took place in the 1950s and work has proceeded since then.

The first self -sufficient and truly autonomous cars appeared in the 1980s, with Carnegie Mellon University's Navlab and ALV projects in 1984 and Mercedes Benz and Bundeswehr University Munich's Eureka Prometheus Project in 1987.

The self-driving vehicles are currently being tested on roads and many car manufacturers Mercedes Benz, General Motors, Nissan, Toyota, Audi, Volvo and Google are working on developing the technology for the same.

"One day your car may speed along an electric superhighway, its speed and steering automatically controlled by electronic devices embedded in the road. Highways will be made safe – by electricity! No traffic jams ... no collisions ... no driver fatigue"

The Victoria Advocate 24 March 1957



[3] A street intersection in the City of the Future; detail of the Futurama exhibit at the 1939 New York World's Fair

Norman Bell Geddes - Magic Motorways, published 1940

[4] Inspired by the efforts, the electric utility company, Central Power and Light Company, launched an advertorial that was posted on many leading newspapers throughout 1956 and 1957 and predicted automated driving

www.ngnews.nl

Introduction

Autonomous Technology
An autonomous car (driverless car, self-driving car, robotic car) is a vehicle that is capable of sensing its environment and navigating without human input. Autonomous cars can detect surroundings using a variety of techniques such as radar, lidar, GPS, odometer, and computer vision.Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

Autonomous cars have control systems that are capable of analysing sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination.

Pros and Cons
There are several advantag-es and disadvantages of this technology. They overcome the human error factor of driving, hence offering much safer journeys.

Due to the sensors on the Autonomous car, they will be able to pack closer together, allowing more cars on the road and therefore shorting traffic times.

Disabilities would no longer be a factor in driving, meaning anyone could drive. These cars would require less space for parking and they will provide the luxury of door to door travel.
However, there are disadvantages of Autonomous cars. There will always be the worry of the computer crashing or malfunctioning, resulting in a major collision. The lack of need for drivers would be catastrophic for the economy. This would be common for all driving professions, including lorry drivers, bus drivers etc. These vehicles will also lead to major conflicts in the insurance system when it comes to accidents and data corruption.

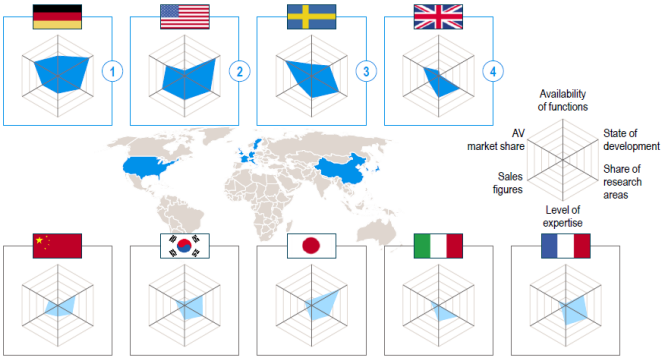
Importance in cities
In urban areas, today, Land use and transport are closely linked to each other. The urban form of the city is shaped by the mobility decisions the citizens take in their everyday life.

As the cities grow and the sprawling continues, walking and cycling are discouraged and car use is favoured strongly influences the urban form and the necessary infrastructure of the city.

The spatial development in the later part of the past century was hence driven by the availability of car and the expansion of the infrastructure to support the ever-increasing demand for motorized modes of transport.

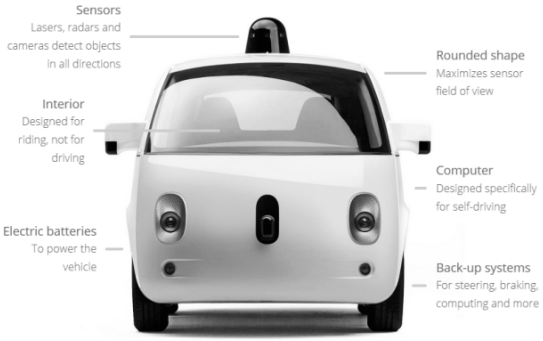
Autonomous Mobility is one of the most talked about topic in the transport industry today with cars that drive themselves, which offer the luxury of hands and feet-free driving. These communicative cars will provide increased safety which will cut accidents by as much as 90%.

This only makes it clear that the use of a transport mode. They will increase the carrying capacity of roads and help in declining the traffic congestion. It is said that driverless cars could reduce urban traffic by 80%. This technology will facilitate car sharing- shared, fully autonomous vehicles could lower the cost of personal mobility by 30 to 60 % relative to private auto ownership.



[5]Comparison of the competitive positions of the world's leading automotive nations in the "automated driving" segment

fka, roland berger



[6]Google Self Driving Car Project

www.joytekk.com

[7] Advantages and Disadvantages of AV's

Hands-Free Driving Google's New Driverless Car, article by FIX

So, what happens when this technology becomes fully operational?

The most substantial changes will be observed in cities with major changes in road patterns, traffic management, parking, infrastructure and the land use and will pose a challenge for urban planners and designers.

This study stresses on understanding how quickly this technology will transform and replace existing modes and infrastructure and explore the changes it would bring to cities and their urban form.

chadstonekia.blogspot.nl

archinect.com

mike thompson-detroit free press

[8]Glimpses of Autonomous Vehicles and their impact on society

Current Research

Currently, various authors of different professions have
started to speculate how the onset of Autonomous technology will impact cities and its various features such as parking, road patterns, public transport etc. by using scenarios and trends.

This section will explore some of the observations by these authors and the learnings that could be used from specifically for this study.

The research has been categorized into 6 concepts which have been discussed more frequently in the literature.

Corresponding to these concepts are the key words which are important and contribute greatly in the formation of the concepts and strategy for this project.


Robin Chase

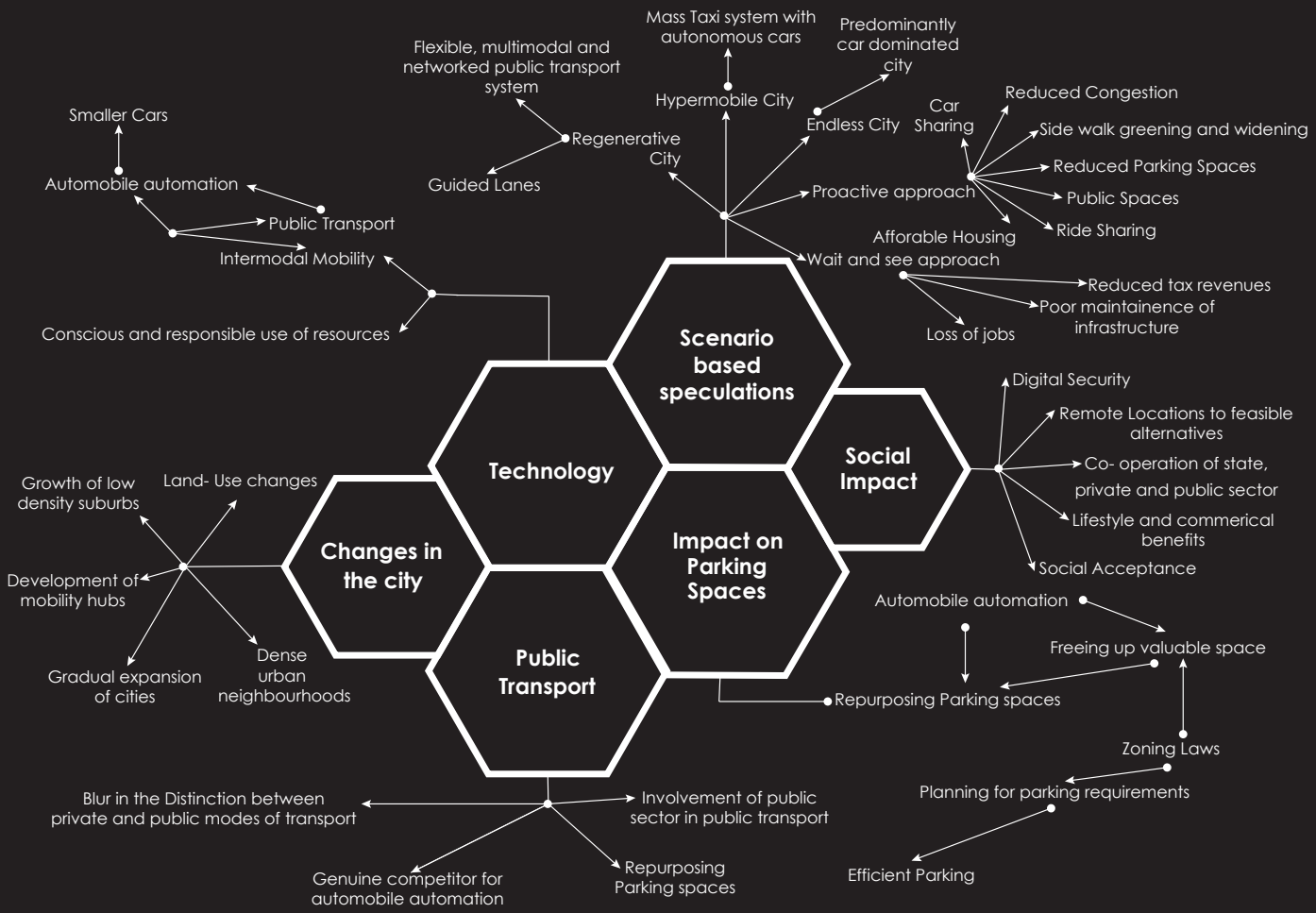

Dirk Heinrichs


Issi Romem


Carlo Ratti


Yonah Freemark


Matthew Claudel



[9]Glimpses of Autonomous Vehicles and their impact on society

Testing around the world

Besides speculations of how the technology will affect the city and its elements, many countries around the world have begun testing the technology on public roads and designated testing sites designed to test these vehicles in their initial developing stage in accordance to its surrounding environment.

The United States of America and Europe have the lead in the testing process as some of their projects such as, Shuffle City, M- city and public roads testing in Paris, Berlin etc. are considered successful.

The illustration shows some of these projects from around the world.

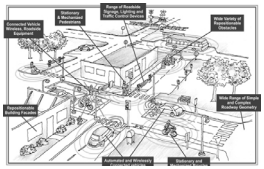
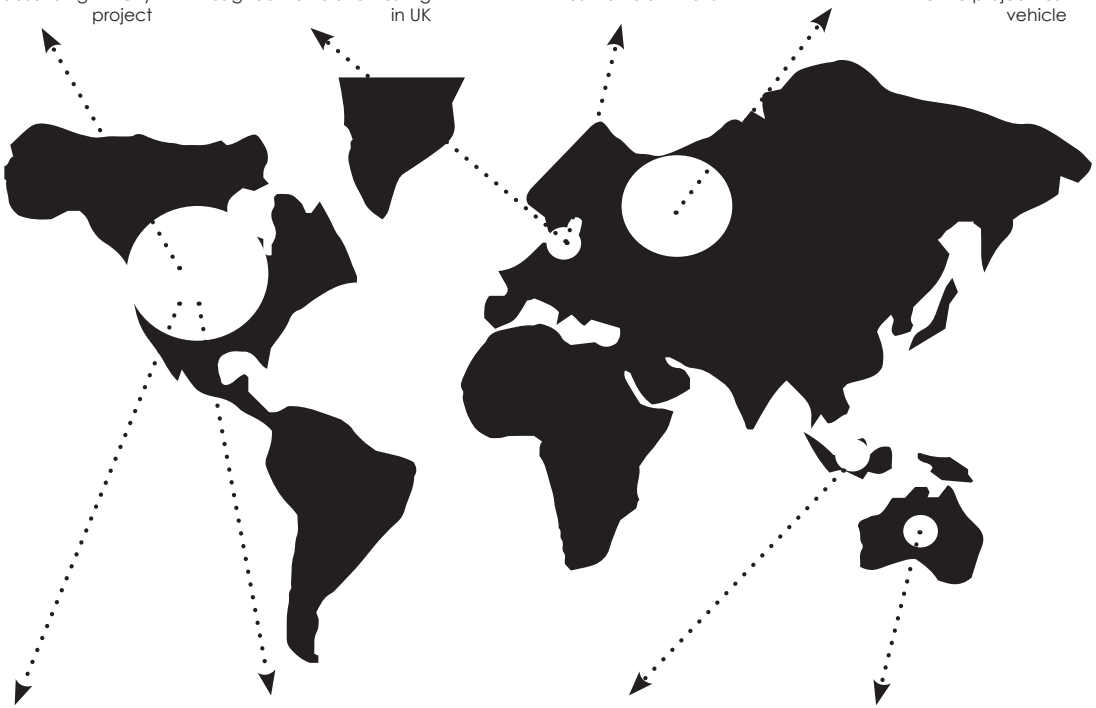


Illustration describing M- City project

Designed Vehicle for testing in UK

Test vehicle in Paris

Drive me project test vehicle



Delphi Self Driving testing car

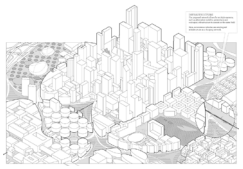


Illustration of proposed Shuffle city in Boston

nuTonomy Self Driving testing car

Nissan Test vehicle

[10] Projects around the world
google.com,author

2 Why

Need for Study

Relevance - Scientific

Relevance- Social

Need for Study

Autonomous Shared Mobility against the background of urban structures is still an **underexamined** field of research.

Hence, there is a **need** for Transport Planners and Urban Designers to investigate the **relationship** between cities and a new transportation technologies and the possible impacts of Autonomous mobility on the city and it's structure to reap **maximum benefits** in future.

Relevance- Social

As stated before the benefit of self-driving vehicles is that a driver can run other errands than staying behind the wheel. With self-driving cars, a new trend of mobility will soon emerge in the coming future.

This new technology will provide easy and quick mobility for different types of citizens and will also permit living in remote areas. It will also play an important role in reducing the time spent looking for parking spaces in and around the city limits saving valuable time. Additional benefit is the safety factor.

Communicating vehicles will allow driverless cars to modify their routes, thus evading hazards and will provide mobility to different types of citizens.

Relevance- Scientific

The World Road Association (2013) estimates that human behavior is a contributing factor in more than 90% of road accidents. More than one million people are killed every year in road accidents worldwide, with 20-50 million suffer ing non-fatal injuries. By 2020, under current trends, the World Health Organization (2013) estimates that annual fatalities will increase to 1.9 million people worldwide.

Driverless cars could significantly reduce the risk of road accidents through co-ordination between vehicles and infrastructure, faster reaction times and elimination of driver error.

It is of utmost importance that, we, as urban planners, and designers understand the consequences of the changing mobility trends and their impact and the role they will play in our cities when implemented in future.

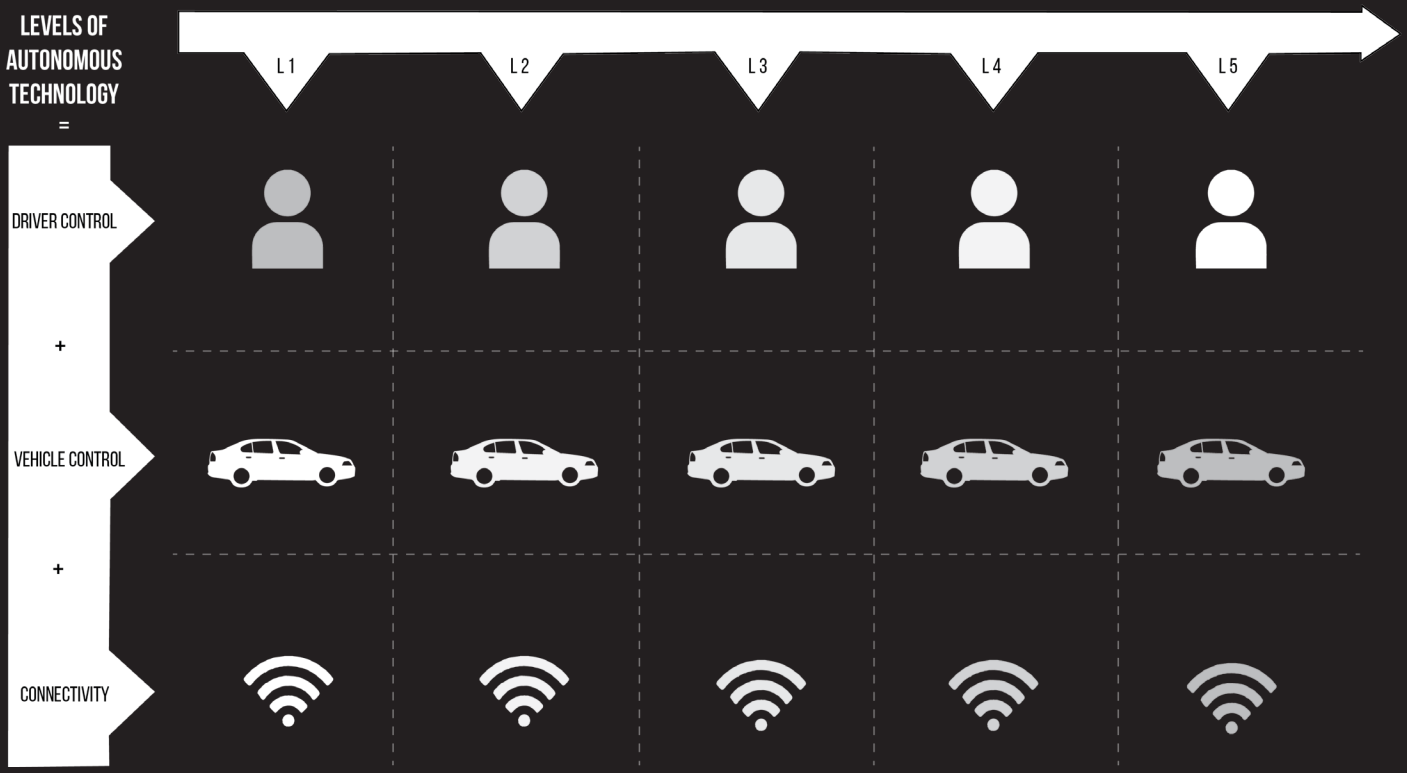
For the new mobility system to improve spatial quality in the city, various tools and concepts need to be explored and researched.

The most important characteristic is the spatial translation of the supporting tools and concepts to ensure and evaluate how it will impact the public realm to create sustainable solutions

3
When

Timeline for autonomous technology

Timeline of development of Autonomous Technology



[11] Illustration for different levels of autonomous technology
www.vox.com

Autonomous Technology will take a certain time period to develop to it's fully potential. Following are the five levels of autonomous technology which will upgrade as years pass by:

Level 1: This driver-assistance level means that most functions are still controlled by the driver, but a specific function (like steering or accelerating) can be done automatically by the car.
Level 2: In level 2, at least one driver assistance system of "both steering and acceleration/ deceleration using information about the driving environment" is automated, like cruise control and lane-centering.

It means that the "driver is disengaged from physically operating the vehicle by having his or her hands off the steering wheel AND foot off pedal at the same time," according to the SAE. The driver must still always be ready to take control of the vehicle, however.

Level 3: Drivers are still necessary in level 3 cars, but are able to completely shift "safety-critical functions" to the vehicle, under certain traffic or environmental conditions. It means that the driver is still present and will intervene if necessary, but is not required to monitor the situation in the same way it does for the previous levels.

Jim McBride, autonomous vehicles expert at Ford, said this is "the biggest demarcation is between Levels 3 and 4."He's focused on getting Ford straight to Level 4, since Level 3, which involves transferring control from car to human, can often pose difficulties. "We're not going to ask the driver to instantaneously intervene—that's not a fair proposition," McBride said.

Level 4: This is what is meant by "fully autonomous." Level 4 vehicles are "designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip."

However, it's important to note that this is limited to the "operational design domain (ODD)" of the vehicle—meaning it does not cover every driving scenario.

Level 5: This refers to a fully-autonomous system that expects the vehicle's performance to equal that of a human driver, in every driving scenario—including extreme environments like dirt roads that are unlikely to be navigated by driverless vehicles in the near future.

4

Where

Netherlands

Netherlands Today
The Netherlands had an estimated population of 16,785,403 on 30 April 2013. It is the 10th most populated country in Europe and the 63rd most populated country in the world.

The Netherlands is the 24th most densely populated country in the world, with 408.53 inhabitants per square kilometre. The Randstad is the country's largest conurbation located in the west of the country and contains the four largest cities:

Amsterdam in the province North Holland, Rotterdam and The Hague in the province South Holland, and Utrecht in the province Utrecht. The Randstad has a population of 7 million inhabitants and is the 6th largest metropolitan area in Europe. Mobility on Dutch roads has grown continuously since the 1950s and now exceeds 200 billion km travelled per year, three quarters of which are done by car. With a total road network of 139,295 km, which includes 2,758 km of express ways, largely shaped by the sea and the rivers that constantly shifted the low-lying geography. The Netherlands is divided into north and south parts by the Rhine, the Waal, its main tributary branch, and the Meuse. The Netherlands has a developed economy and has been playing a special role in the European economy for many centuries. Since the 16th century, shipping, fishing, agriculture, trade, and banking have been leading sectors of the Dutch economy. The Netherlands has a high level of economic freedom. The Netherlands is one of the top countries in the Global Enabling Trade Report (3rd in 2014).

The Netherlands has one of the densest road networks in the world. The Dutch are estimated to have at least 18 million bicycles. Cycling infrastructure is inclusive.

Busy roads have received some 35,000 km of dedicated cycle tracks, physically segregated from motorised traffic. There are large bicycle parking facilities, particularly in city centres and at train stations. The prehistory of the area that is now the Netherlands was.

Amsterdam Today
Amsterdam is the financial and business capital of the Netherlands. Amsterdam is currently one of the best European cities in which to locate an international business.

Amsterdam

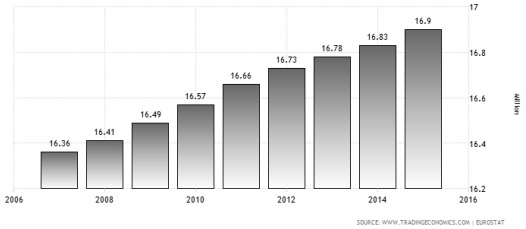
Though many small offices are still located on the old canals, companies are increasingly relocating outside the city centre. The Port of Amsterdam is the fourth largest port in Europe, the 38th largest port in the world and the second largest port in the Netherlands by metric tons of cargo.

Amsterdam is one of the most popular tourist destinations in Europe, receiving more than 4.63 million international visitors annually, this is excluding the 16 million day trippers visiting the city every year.

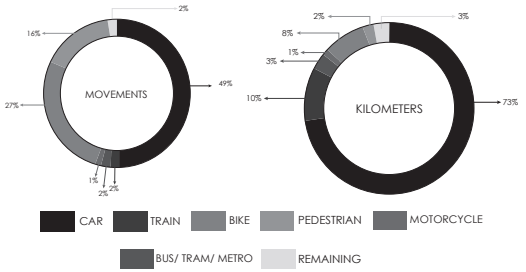
Amsterdam is the capital and most populated municipality in the Netherlands. Its status as the capital is mandated by the Constitution of the Netherlands.

As the commercial capital of the Netherlands and one of the top financial centres in Europe, Amsterdam is considered an alpha world city by the Globalization and World Cities (GaWC) study group.

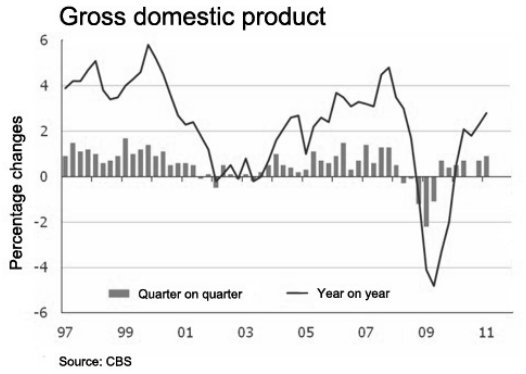
The city of Amsterdam looks back on a long and interesting history, and today it prides itself on a rich cultural life and a diverse population.



[12] graph showing population rise since 2006 in the Netherlands
www.tradingeconomics.com



[13] percentage of distance travelled and mode share for the Netherlands
KiM, Mobiliteitsbalans 2013

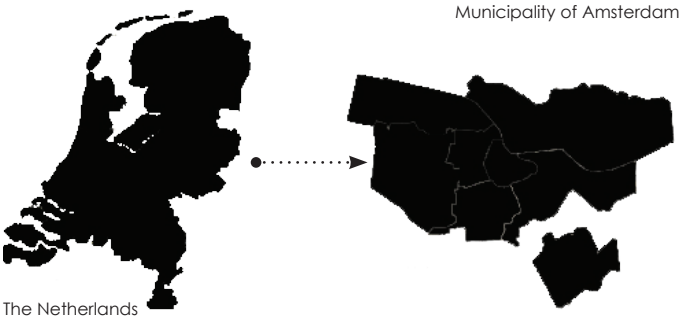


[14] graph showing the changing GDP of the Netherlands
CBS

Population History
Population numbers have increased since the 1990s, and the numbers are still doing Amsterdam was not always this popular. Between 1980 and 2010, the population in Amsterdam increased from 715,000 to 790,000 and It is expected that Amsterdam will reach a population of around 925,000 inhabitants by 2040.

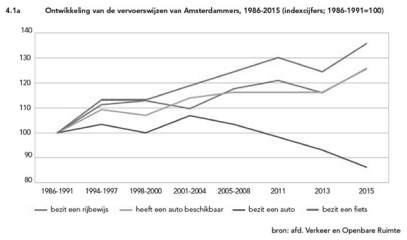
In the 1970s and 1980s, families started leaving the city for the suburbs and businesses vacated to areas more accessible along the motorways and where space was cheap and plenty.

Amsterdam gained its popularity in 1990s as it became more attractive for young people and families. Trendy neighbourhoods, began to attract young, educated and well-paid population, who preferred the historic surroundings and cultural attractions. New urban redevelopment projects were developed and the city has been expanding ever since. In the near future, Amsterdam wants to house the increasing population mostly by densifying the existing city.



Author

(municipality & urban, Feb 2017 (CBS); metro 2014 (OIS Amsterdam); Randstad, 2011)



[15] graph showing the usage of different modes of tranport from 1986-2015 for Amsterdam

Verkeer en openbare ruimte

[16] graph showing the change in the population of Amsterdam from 1975- 2015

OIS


© 2014 Amsterdam RAI

[17] Illustration of all the neighbourhoods in Amsterdam

www.iamsterdam.com

Neighborhoods of Amsterdam
Amsterdam is home to many exciting and vibrant neighborhoods. Here is an insight into some of them:-
The Central area of Amsterdam is a high prized commercial and residential district in the core of the city. Canals, breath-taking architecture and lovely hidden gardens create an ideal environment

Oud Zuid also known as the posh neighborhood of Amsterdam is one of the most popular areas for expatriates with 20th century residential spaces. **The Vondelpark** area has excellent transportation and a myriad of restaurants, luxury shops and cafes offer the best of urban living with a suburban feel. Duivelseiland is also another desirable location with numerous market shops, restaurants and apartments blocks.

Right next to the main canal rings is the old working class neighborhood of Jordaan which consists of small canals and streets and hosts numerous cozy restaurants, cafes and well -known markets (Saturday and Monday).
De Pijp is the so-called Latin Quarter of Amsterdam which is a lively, multicultural district with long, narrow, parallel streets.

Westerpark is a recently regenerated neighborhood with the enormous park, trendy cafes, old (industrial) buildings, rolling fields and constantly rotating events schedule adding to the overall living experience.
Eastern Docklands consists of several man-made islands connected by bridges. The historic location of Dutch shipping companies has become the biggest post-war building project in Amsterdam (IJ river). **Amstelveen** is one of the the famous Amsterdam suburbs located close to the city's largest park and Schiphol airport. A green area with lots of restaurants, cafes, international companies - including the International School of Amsterdam. Narrow streets and the large number of canals make congestion a major problem in Amsterdam. Although a cycling city with the average citizen cycling 8.7 km (or 51 minutes) a day, the number of vehicles in Amsterdam has increased by 5 per cent since 2008. (Van Der Pas Jan-Willem, 2008)

The city's parking challenge is quite high as 330, 000 vehicles push to fit into 156,843 parking spaces. Up to 63 per cent of Amsterdam´s residents avoid using their cars for fear of not finding a parking space; up to 40 per cent consider moving because of the problems. Parking on the street in the Netherlands is the most expensive in the centre of Amsterdam (€ 4.60 per hour). The rate is like other European capitals, which usually must be paid between 3 and 5 Euros per hour. (Gemeente Amsterdam, 2016)

In Amsterdam, today, searching for parking spot: 50,000 km/day. Residents living in its city center spend on average 12 minutes looking for a parking spot, unnecessarily causing drivers to travel extra kilometres and cars to spout additional dirty exhaust fumes. (Kun et al., n.d.)

Traffic safety also became a critical issue. In 2006, there were an average of four persons per day wounded in the Amsterdam traffic. (Gemeente Amsterdam, 2016) Around 22 per cent of accidents are caused by cars in Amsterdam. (Archive, 2017)

Greater numbers of city-dwellers, are raising the pressure on public space in Amsterdam, which is already in scarce supply, while at the same time making more exacting demands regarding the city's accessibility.

Amsterdam has 16 municipalities and over 1.5 million people, with nearly 800 000

living in the city. (Van Der Pas Jan-Willem, 2008). From 1980 to 2010, the population in Amsterdam increased from 715,000 to 790,000 and it is expected that the city will reach a population of around 925,000 inhabitants by 2040.(Gemeente Amsterdam, 2016).

The car ownership in the city center of Amsterdam is 42 per cent per household and 50 per cent – 59 per cent per household in areas around city centre. (Kun, Directorate, & City, n.d.)

The Dutch economy began to boom in the post-war era, which increased the affordability of cars by more and more people and urban policymakers assumed that the car is the future of mobility.

Amsterdam is currently one of the least congested major cities in Europe.

As the economy prospered in the city, a great amount of development was observed which only meant that this development was centred around automobiles.

The rapid suburbanization of Amsterdam led the average daily commute of residents to increase from under four kilometres in 1957 to over 23 kilometres in 1975.

The percentage of trips by bicycle also declined significantly to a low point of less than one-quarter of all trips in the 1970's.

Amsterdam's downtown was unable to handle the massive arrival of auto traffic. Narrow streets and the large number of canals made congestion a major problem in Amsterdam.

Traffic safety also became a critical issue. It is suggested that, Autonomous vehicles could be the answer to these issues.

Autonomous Technology in the Netherlands

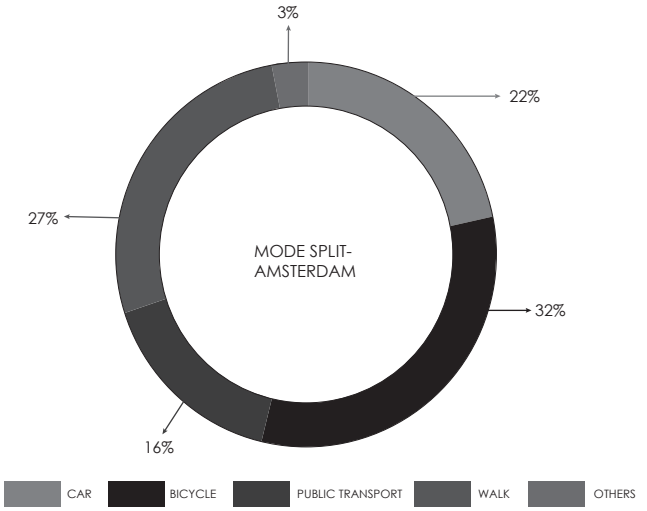
Netherlands is now advancing towards autonomous road travel. The declaration of Amsterdam was signed on April 14 by the 28 transport ministers of the European union member states.

A strong vision of road future. Steps for developing technology and formulating rules and regulations for autonomous vehicles were formulated. The aim is to achieve "the co-existence of connected and automated vehicles with manually controlled vehicles" (Cameron, 2016).

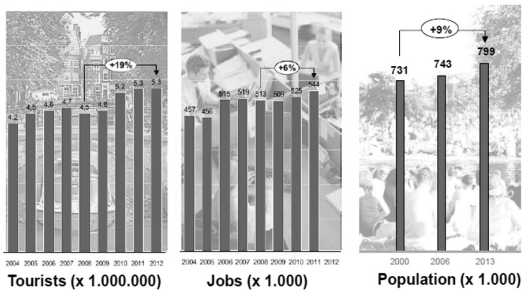
The goals of this declaration on cooperation in the field of connected and automated driving are as follows:

ACKNOWLEDGING that connected and automated vehicle technologies offer great potential to improve road safety, traffic flows and the overall efficiency and environmental performance of the transport system;

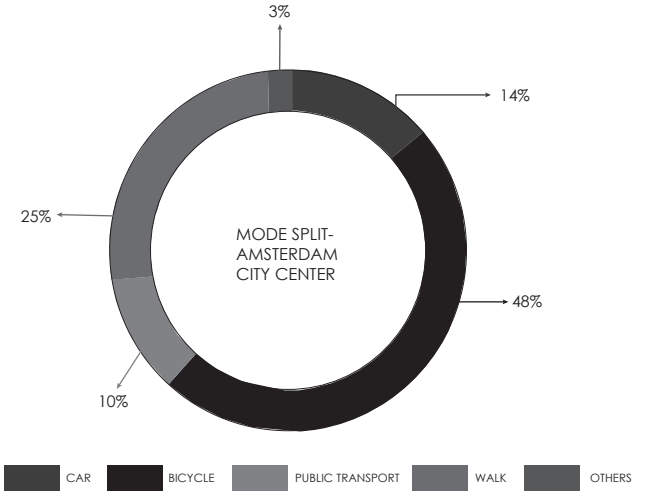
RECOGNIZING also the long-term potential for social inclusion and increased mobility in remote areas, as well as the link with other developments such as the shared economy, smart citiesand the transition towards zero-emissions mobility and the circular economy;



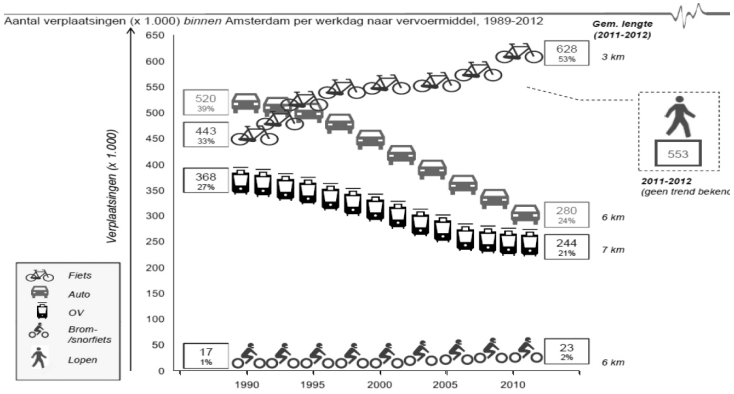
[18] graph showing the mode split for the city of Amsterdam



[19] graph showing the increase in number of tourists, jobs and population rise in Amsterdam



[20] graph showing the mode split of city center of Amsterdam



[21] graph showing the rise and fall of different modes of transport in Amsterdam from 1990 to 2010 and prediction for 2012

Municipality of Amsterdam

RECOGNIZING the technological, societal, legal, privacy-related, safety and security challenges and uncertainties related to the development of connected and automated vehicles;
EMPHASIZING the importance of Member State and EU initiatives supporting innovation in the field of connected and automated driving, in particu lar through the C-ITS platform, the Round Table on connected and automated driving and Gear 2030;
ACKNOWLEDGING the importance of strengthening the position of Europe as a world

Public Testing of Autonomous Vehicles in The Netherlands
Many research institutions along with the ministry of infrastructure have worked out pilot projects across the country. Here are some of the projects(Hottentot, Meines, & Pinckaers, 2015):
 Scania, a swedish truck manufacturer along with Transport en Logistiek Nederland in 2015, tested partially autonomous trucks on Dutch Public roads.
 TNO along with DAF tested Truck Platooning on the N270. They are now developing pilot projects for Massvlakte near Rotterdam.

Province of Gelderland along with municipalities of Ede, Wageningen and research institues of Wageningen, Technical University of Delft started the WE- Pod project to pilot in 2016 with a phased development approach.

 The Dutch Automated Driving Initiatvie in collaboration with the Ministry of Infrastructure, TU Delft, RDW, Connekt and TNO is working on real cars fitted with autonomous technology and are testing them on current roads with real traffic, focusing on human factors and safety aspects of the technology.

 The royal Dutch touring club along with Dutch Integrated Testsite Co- operative Mobility and Ministry of Infrastructure are also working together to bring in consumer involment and understand the acceptance of technology by the public.
Amsterdam 2040
The municipality of Amsterdam has set goals for the city's development by the year 2040 for an economically strong and sustainable city. The Structural Vision is a scenario based framework that provides a setting for the city's agendas for investment.
A list of goals is set by the council that must be achieved in the period of 2010- 2040.

[22] Truck Platooning testing in the Netherlands
english.eu2016.nl

[23] The DAVI testing vehicle in the Netherlands
pressvisuals.com

[24] The WePOD project
Gizmag

Amsterdam has intentionally chosen for densification of the city center. The city has not chosen for growth by increasing its surface area but for intensification of the existing urban territory and for transformation of business zones. By building 70,000 new living areas with amenities within the city's existing boundaries, the city aims to expand its center, making it more attractive by providing and improving services like public transport, public spaces etc. They have formulated seven spatial tasks for the city:

- Densify
- Transform
- Public Transport on Regional Scale
- High quality layout of public space
- Invest in recreational use of green space and water
- Converting to sustainable energy
- Olympic games, Amsterdam 2028

These tasks will be achieved by four goals or thrusts suggested by the vision:

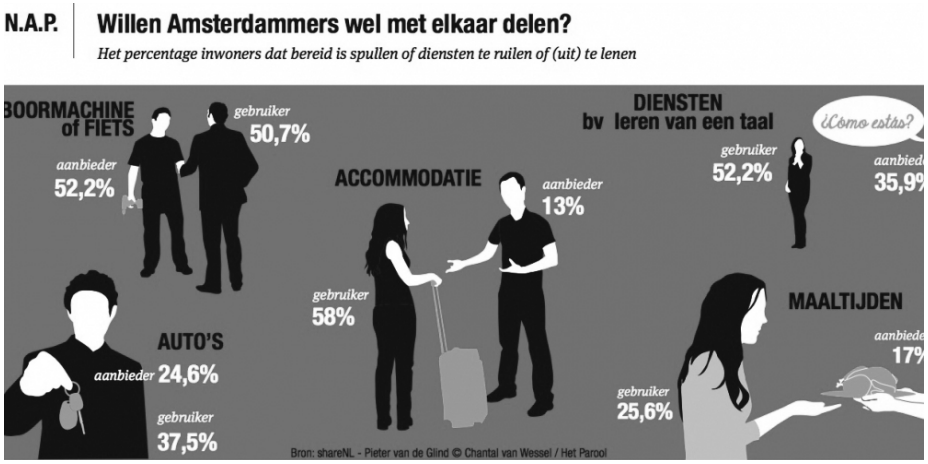
- the roll-out of the city center;
- the interweaving of the metropolitan landscape and the city;
- the rediscovery of the waterfront;
- the internationalization of the city's southern flank.

Amsterdam Sharing City

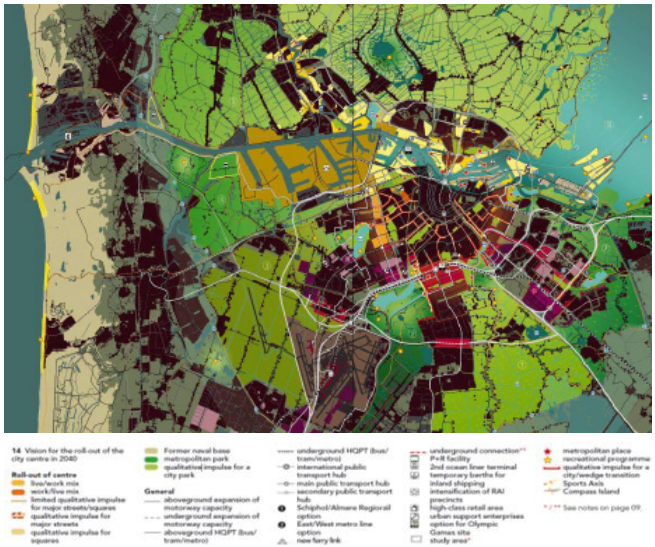
Founded in 2013 by Pieter van de Glind and Harmen van Sprang, Amsterdam Sharing City is the first named Sharing City in Europe. The purpose of Amsterdam Sharing City is to, as a city utilize the opportunities that the collaborative economy offers in the areas of sustainability, social cohesion and economy.
Additionally, the project aims to formulate answers to the challenges that the rapidly growing phenomenon of the collaborative economy entails. The project was initiated as a response to several observations: a willingness to share in the city of Amsterdam (84% of the Amsterdam citizens showed motivation to share); an established digital infrastructure with more than 90% of the citizens with Online access an environment that encourages sharing economy start-ups; an atmosphere of promoting innovation entrepreneurial spirit and ambitious initiatives within circular- and sharing economy and sustainability and the potential of applying the Sharing City concept in Seoul to a European city.

In collaboration with the Amsterdam Economic Board, a position paper was put together; a network of ambassadors around the city was established; and, with the City of Amsterdam on board, Amsterdam Sharing City was launched in February 2015. 'The consumer has in recent years become increasingly powerful. The sharing economy is a huge opportunity. It just fits well with Amsterdam. That's why we want to be known as a Sharing City' – Kajsa Ollongren (vice mayor City of Amsterdam)
Ambassadors have developed several interesting and innovative Sharing Economy projects:

- THNK: Amsterdam Sharing City Challenge
- Airbnb & Library: introductory workshop for (senior) citizens
- Amsterdam Airport Schiphol: mobility / skills / real estate
- Klein Amsterdam (school)
- Community Center Corantijn: awareness + information in community
- Accenture: sharing economy at the Zuidas business district
- Achmea: self-reliance and social cohesion in the neighborhood
- Sandd: providing logistics to sharing economy startups
- BPD (Bouwfonds): developing new houses based on sharing



[25] concept of Sharing city Amsterdam
http://www.sharenl.nl



[26] Amsterdam 2040 strategic vision map
Municipality of Amsterdam

• Peerby Go: pilot with renting instead of borrowing from neighbors

There are numerous opportunities that grow out of the Sharing City initiative, such as: of new means of existence;
• making accessibility easier and empowering for example entrepreneurs.
• an increased sustainable- and efficient use of scarce resources;
• an enhanced affordability and accessibility of products and services for consumer;
• nurturing innovation of products & services;
• attracting creative industries and fostering a knowledge economy; • increasing social cohesion and safety;
• improving efficiency of space and mobility;
• creating opportunities for new public-private partner ships;
• enabling growth of local economic investments;
• identifying possibilities
The Sharing City initiative can create challenges such as:
• an unfair playing field;
• a risk of market dominance;
• exponential growth and monopoly;
• doubts and difficulties regarding social security and labour laws;• questions concerning when to be considered a consumer/citizen and when an entrepreneur;
• difficulties in monitoring quality, safety, disturbance and when to intervene;
• oversimplified image;
• there is not enough attention on the perspective of the user;
• a difficulty to predict the development of the trend and impact.

"Mayor and Executive Board of the Municipality of Amsterdam agree on the Action Plan on Sharing Economy and herewith gives space to the opportunities the sharing (or collaborative) economy offers to the city.

Sharing economy is a broad concept, amongst other things it is about making more efficient use of goods, services and skills. By using online platforms, people can for example exchange, rent and borrow stuff from each other more easily. The consumer is at the center and gets more affordable and easier access to services and goods.

The Mayor and Executive Board want to stimulate the sharing economy where possible without losing sight of any excesses. Risks include an uneven playing field or a lack of social security. Thus the sharing economy is not a question of ban or authorize, but of monitor and seize opportunities where possible.

Such sharing platforms in turn trigger further enter goods. There's no disputing the fact that the economy has been expanded with a new way of linking together supply and demand.

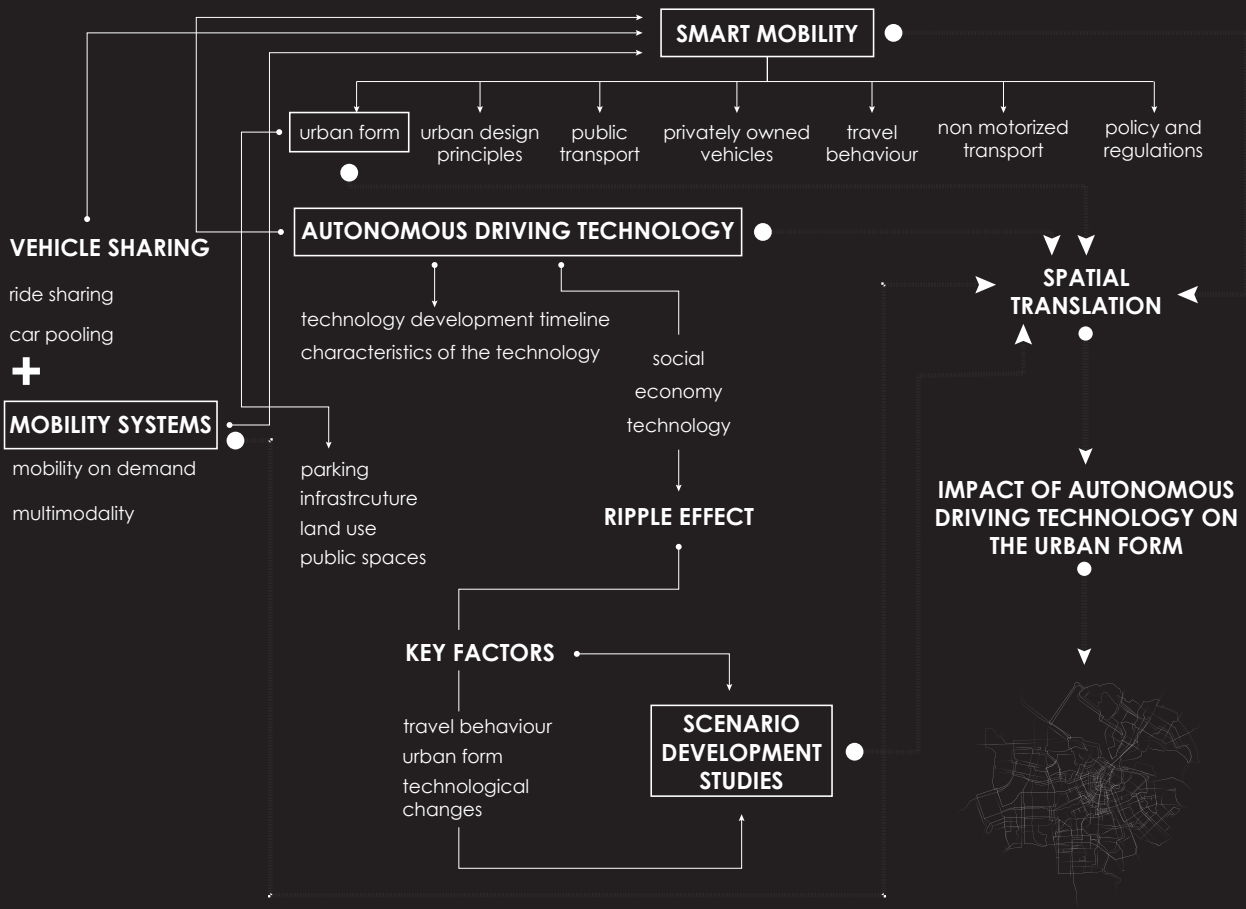
The platforms are here to stay, Based on the above information, The next couple of pages give an insight into the urban form of the city of Amsterdam through spatial analysis of the city. Starting from the growth of the city to deriving the potential areas of redevelopment in order to develop a strategic vision for the city based on these opportunities.

5

How

Theoretical Framework

Theoretical Framework



[27] Theoretical Framework of the graduation Project
Author

Smart Mobility
Smart Mobility is a theme of global proportions. Half of the world population lives in mega cities and this number increases every year.

In all densely populated metropolitan areas, mobility, in logical tandem with the quality of life, is one of the most important issues in today's society. Throughout the world, Smart Mobility is the object of turbulent development.

In Europe, the topic has been high on the innovation agenda for many years, and the European Commission provides incentives for research and development and application projects. Smart mobility solutions, such as autonomous cars, can contribute significantly to the enhancement of sustainable mobility, free-flowing traffic and greater traffic safety. To gain a better understanding , the project explores deeply into four main concepts namely, Autonomous driving technology, mobility systems, scenario development studies and the area specific urban form. Having gained the knowledge of these concepts, the project aims to study how they can be translated spatially.

This spatial translation will serve the purpose of understanding the impact of the Autonomous mobility systems on the urban form a city. These concepts will then be projected on the site; the city of Amsterdam along with the opportunities the city has to offer in order to derive a strategic vision.

Autonomous Driving Technology
The theory of Autonomous Driving Technology and the current on going research as well the development timeline for the same have been throughly discussed in chapters 1 and 3 Autonomous Driving Technology can be implemented in any type of existing mobility systems in the city if planned well. For the this project, two **mobility systems** are considered important which are, Mobility on Demand and Multi-modal transportation system.

Multimodal Systems
Today, metropolitan cities around the world are striving to achieve a system of public urban transportation by providing users with different ways of moving in order to deliver a long-term sustainable service capable of adjusting to the changes in the social and geographical conditions in cities. To this end, cities are rapidly adapting the multi-modal transportation systems in which different mobility technologies co-exist,something which gives users access to an entire transit network to reach their destination. Multi-modal Transportation System refers to the transport of goods or passengers using different effectively integrated transportation options.

Some of the best-known multi-modal transport systems in the world are London's, which brings together buses, metro and ferries, and Hong Kong's, which inter connects trains, trams, buses, minibuses, taxis and ferries. Supporting many modes of transport needs multiple actors in the planning process, with different priorities. More travel choices also mean private entrepreneurs will take the lead on services usually offered by the public sector for example bus services, parking management etc. Technology plays an important role in developing the concept of multi-modal transport systems in cities today. Today, most transportation systems require that travelers use transit smartcards, bike sharing key cards, and car sharing mobile apps and/or smartcards to access modes independently.

Mobility on Demand

Another such technology dependent mobility system is that of Mobility on demand. The market for personal mobility is changing due to shifting social and cultural trend and technological advances such as smart phones and widespread data connectivity. New demand responsive mobility concepts and solutions, are providing citizens with flexible and appropriate transportation options. Mobility on Demand (MoD) systems are fleets of lightweight electric vehicles at strategically distributed electrical charging stations throughout a city. MoD systems aim to address the "first and last mile" issue of public transit, providing mobility between transit station and home/workplace.

With a swipe of a smart card, users can use a vehicle to get to their desired destination. An autonomous MOD system can provide immense convenience compared to private vehicles. Customers will be able to call a vehicle from their smart phones just prior to leaving their home, and by the time they step outside, the vehicle will be waiting for them. Customers can be productive while inside the vehicle and upon arrival at their destinations, would not need to worry about finding parking. Through intelligent coordination, autonomous MOD systems has the potential to drastically reduce the number of vehicles we need. In order to approach these mobility systems, it is important to choose an appropriate tool of speculation of future events.

There are many ways to speculate how the technology will impact the city in future. When it comes to Autonomous Technology, the research at this stage is on the technology itself, such as , Fuzzy cognitive mapping, Scenario based studies, Back casting, Agent based modeling and site specific approach. For this project methods under scenario based studies have been adapted to understand the future.

SCENARIO BASED STUDIES

"Scenarios are hypothetical sequences of events constructed for the purpose of focusing attention on causal process and decisions points". By seeing a range of possible worlds, decisions will be better informed, and a strategy based on this knowledge and insight will be more likely to succeed.

Scenarios do not predict the future, but they do illuminate the factors of change: understanding them can only help to take greater control of their situation. The scenario based studies can help in imagining the consequences of different choices of decision or a strategy in each of the imagined futures.

A form of scenario studies assists the user to design a preferred future and devise strategies for reaching this future which is commonly referred to as Backcasting method. (Banister and Stead, 2004).

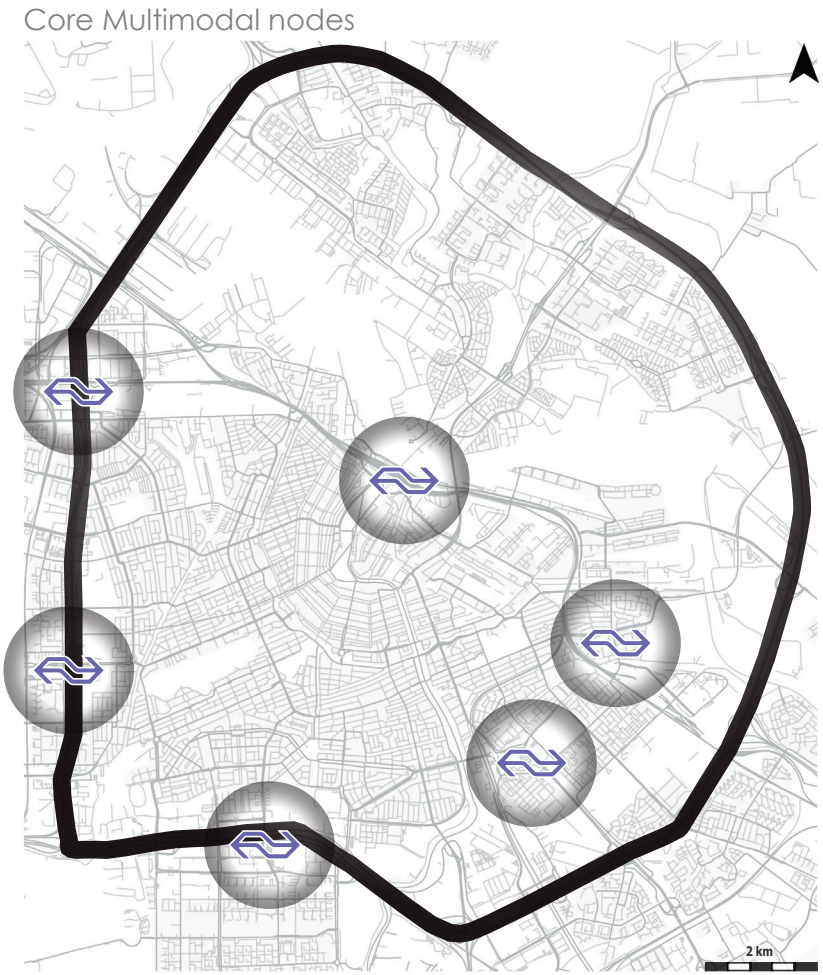
BACKCASTING

Backcasting is a strategic problem-solving framework, searching the answer of how to reach specified outcomes in the future. In the backcasting process one visualizes a desirable future, and plans to achieve this future through certain strategies and guidelines from the current situation.

For futuristic projects to achieve sustainable development these types of scenarios would be considered most effective.

[28] A sketch representing multimodality in everyday life
www.vectos.co.uk

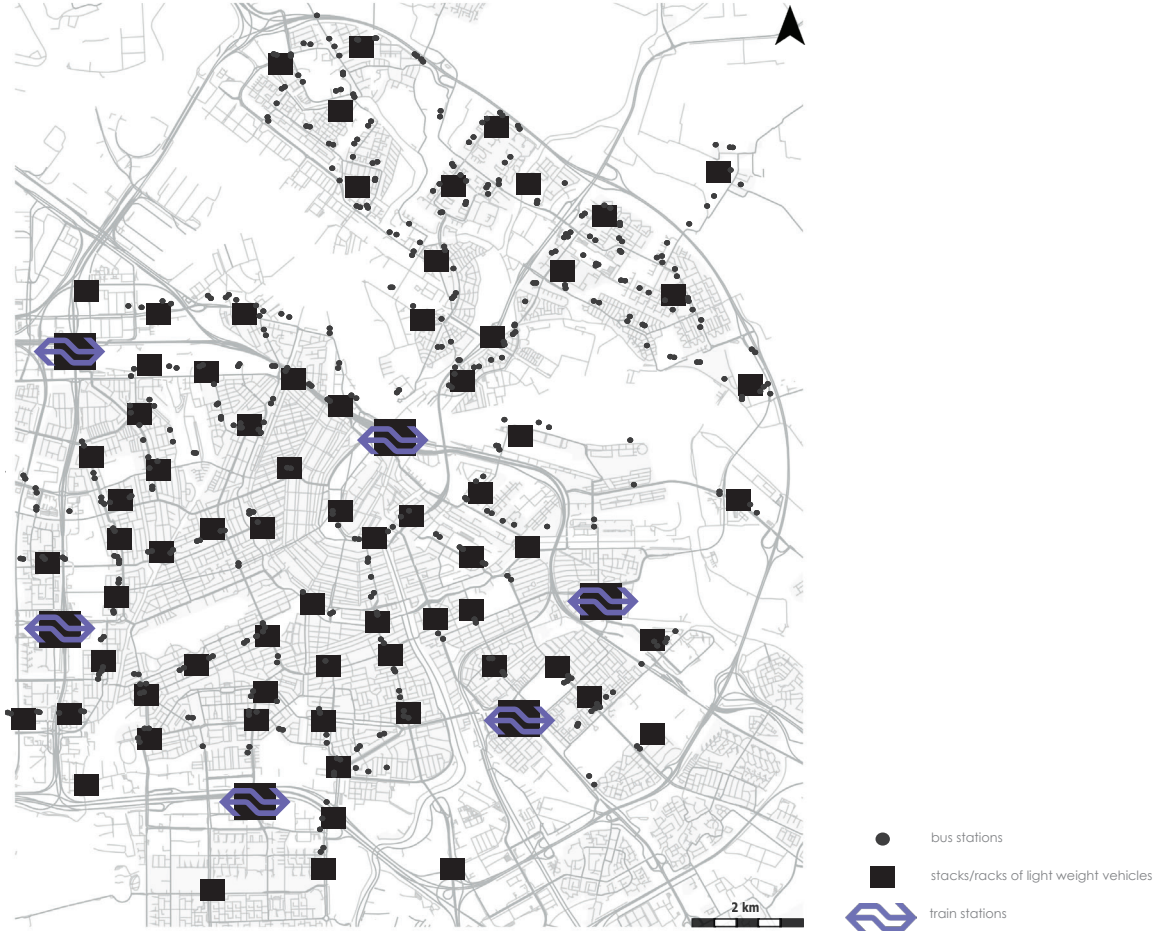
[29] A sketch representing ideal mobility on demand scenario in a street
MIT



[30] Multimodal nodes suggested in Amsterdam

Author

Possible Locations for light weight vehicle stacks



[31] car stacks and racks placed close to public transport stops
Author

Key Factors
There are many factors that are to be considered for building futures. These are, social, technological, economic, environmental and political. When it comes to the concept of smart mobility, there are many factors that have to be considered as mentioned in the previous section.

But, due to time restrictions of this project, it is of utmost importance to choose a group of factors that will work according to the results expected in the end.

In the case of autonomous mobility, factors such as Social, Technological, Economic and the factors of urban form matter the most as autonomous vehicles are said to have a ripple effect on various aspects.

Policy and society related implications of automated driving: a review of literature and directions for future research, a study by Dimitris Milakis, Bart van Arem and Bert van Wee from the Department of Transport and Planning, Faculty of Civil Engineering and Geo sciences and Transport and Logistics Group, Faculty of Technology, Policy and Management, TU Delft explains this ripple effect.

Ripple Effect
The "ripple effect" has been widely used to describe the sequentially spreading effects of events in various fields. Autonomous driving is the central field of the graph to reflect the source of the sequential first, second, and third order effects.

The first ripple comprises the implications of automated driving on traffic, travel cost, and travel choices. The second ripple includes implications of automated driving with respect to vehicle ownership and sharing, location choices and land use, and transport infrastructure.

The third ripple contains the wider societal implications (i.e. energy consumption, air pollution, safety, social equity, economy and public health) of the introduction of automated vehicles.

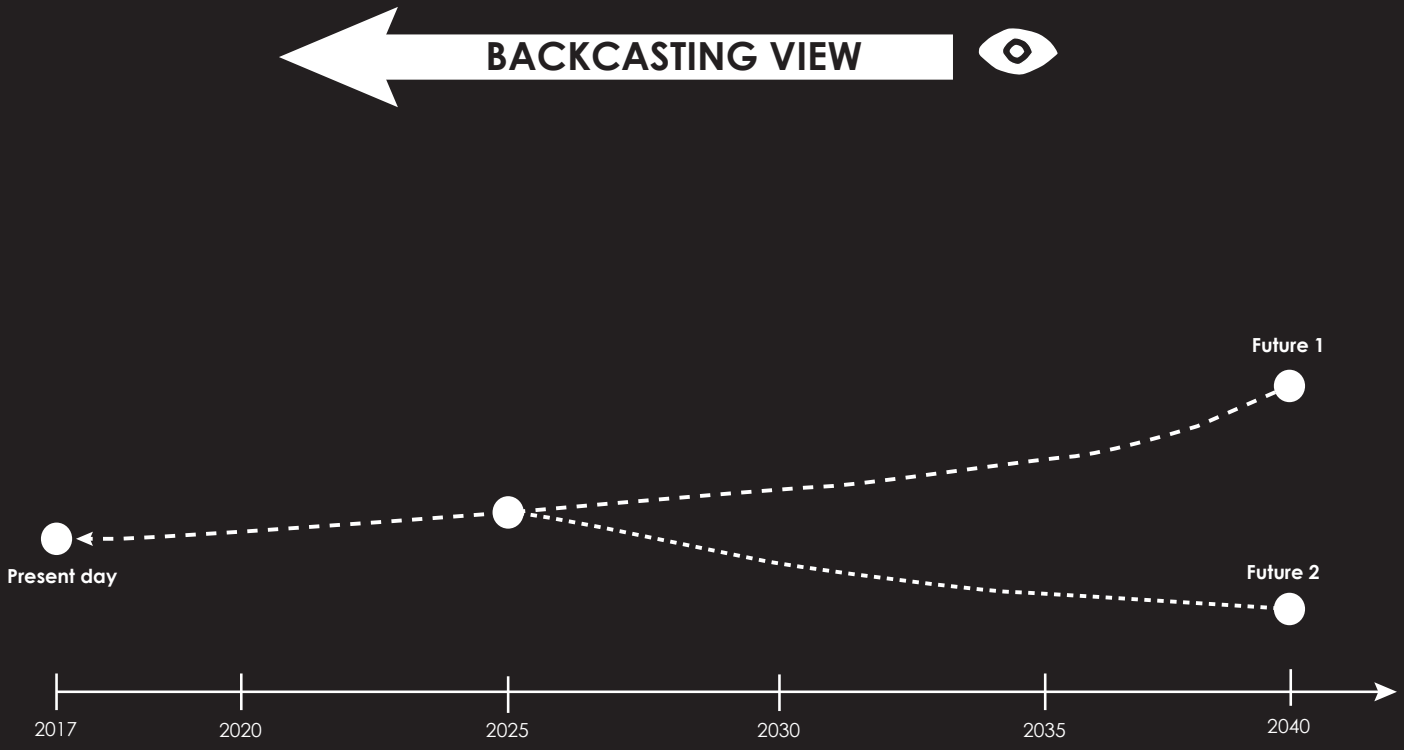
Based on this concept suggested by the study, keeping in mind the time constraints, the project takes into account three major factors, Technological advancement, Travel Behavior and Urban form.

These factors in themselves are quite extensive. Hence, it is important to choose certain aspects of these factors(as shown in the figure- Chosen Factors).

The scenario method carried out in this study will concentrate on three factors namely, Technological Advancement, Travel Behavior, and Urban Form mentioned above(as shown in figure- concept diagram).

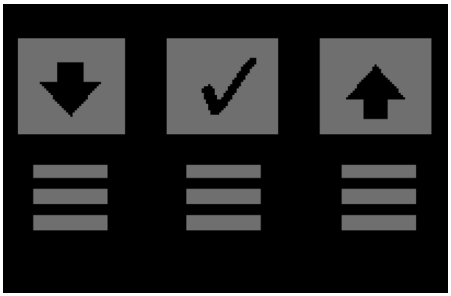
The concept with these factors is that; as the technology advances, the way people travel will change which will transform the urban form of the city which will make it easy to facilitate more advancement in the technology in the future as it keeps upgrading.

The concepts of **Urban Form** are explored in next chapter in detail with a site specific approach in order to understand the city and its layout better.

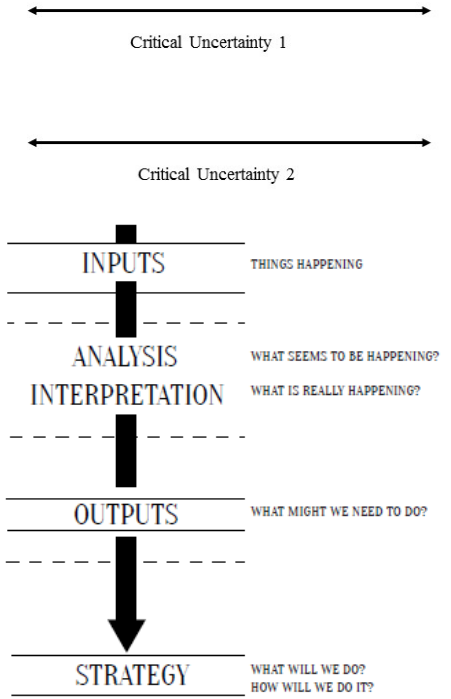


[36] Backcasting method

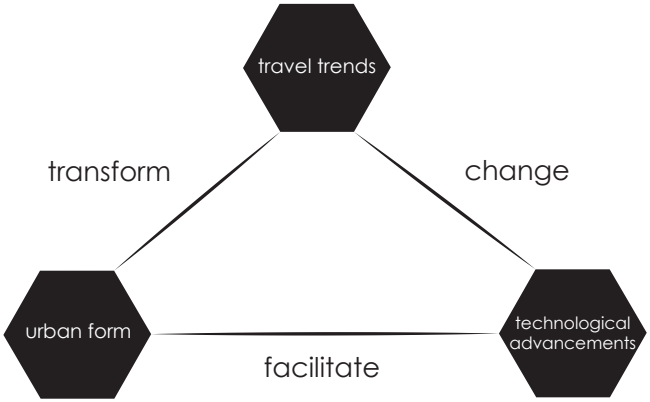
author



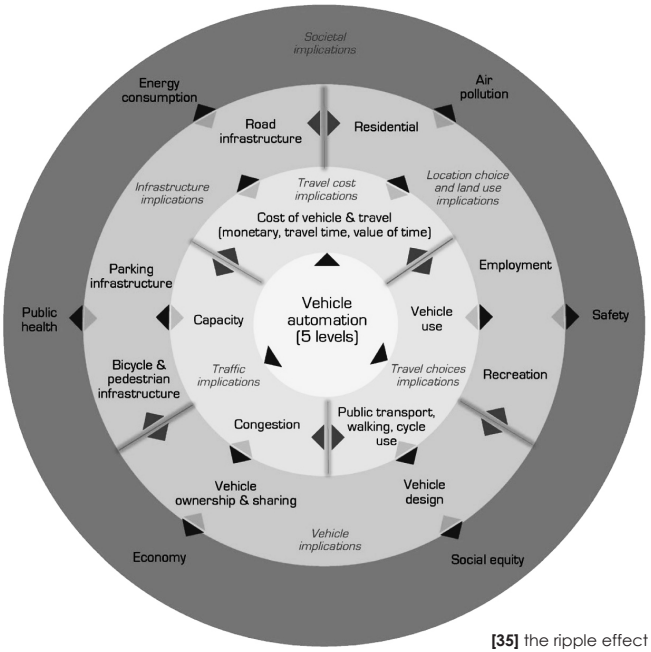
[32] Scenario Based Studies
pinsdaddy.com



[34] Understanding the scenario buidling process
Slideshare



[33] key factors of the graduation project
Author



[35] the ripple effect
Policy and society related implications of automated driving: A review of literature and directions for future research. Milakis, D.Van Arem, B.Van Wee, G.P.

City Analysis

Scenarios

Strategy

Approach Guide

Principles

6 Products

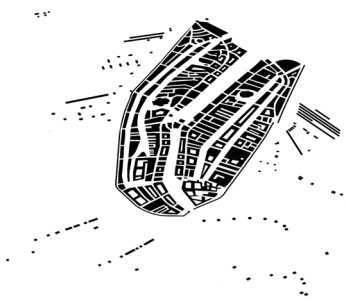
City Analysis
Growth of the city

In order to understand the urban form and the dynamics of the city, it was important to look into the characteristics the city has developed over the years.

This chapter focuses on gaining knowledge of the different sectors of urban characteristics such as spatial growth, urban typologies, population statistics, functions, infrastructure, technology, mobility and parking in Amsterdam and combining to form nodes of these functions.

These nodes will hence contribute to providing information on areas that are lacking in these concepts which will form the test sites in the strategic vision and will help in focusing the design solutions for the same.

1320



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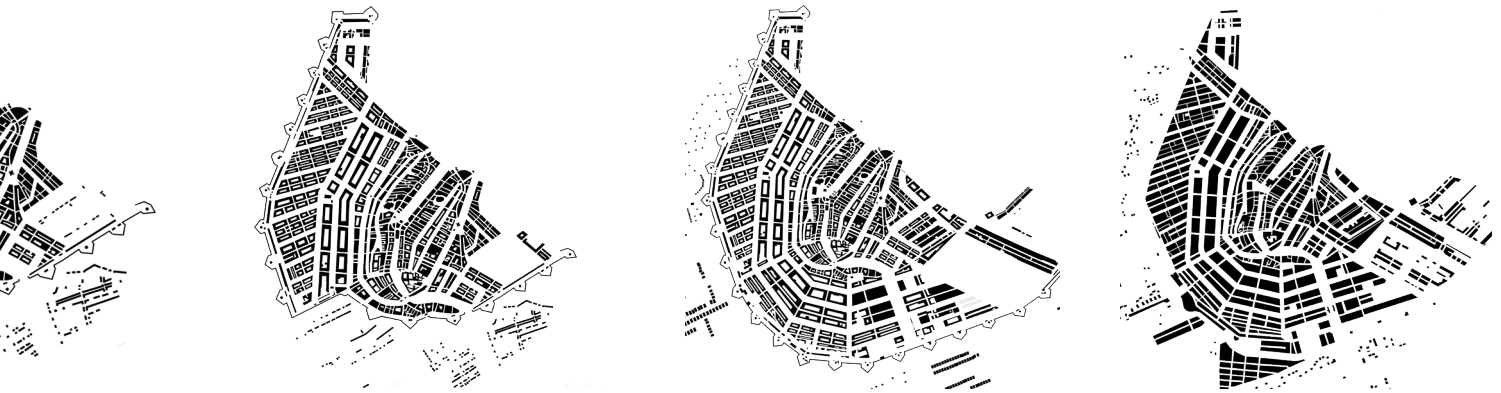
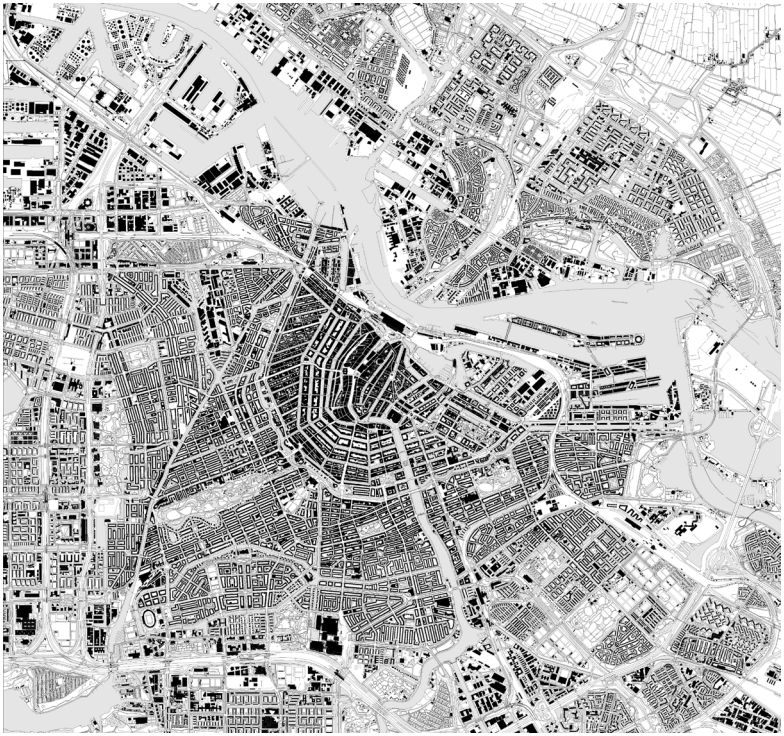


[37] Amsterdam over the years
J. Brandes, D. Newman



[38]Present day Amsterdam

J. Brandes, D. Newman

[39]Present day road structure of Amsterdam

Author

Public Squares

A Dam Square
B Nieuwmarkt
C Waterlooplein
D Spui
E Rembrandtplein
F Koningsplein
G Leidseplein
H Museumplein
I Marie Heinekenplein
J Markenplein
K Muntplein
L Noordermarkt
M Oudekerksplein

[40] Profile of public squares
Google, Author

Recreational Spaces

Outdoor eating and drinking spaces
Cultural Spaces
Nature Playground
City Parks
Other recreational green spaces

[41] Profile of recreational spaces
Google,Author

[42] Profile of public spaces
Google,Author

City Profile

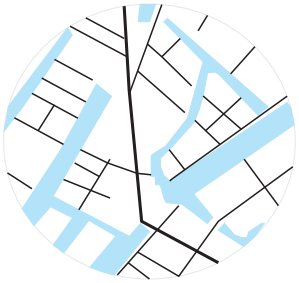
[43] Different Urban Typologies in Amsterdam

Google,Author

[44] Population Density in Amsterdam

Google,Author

Typology Characteristics



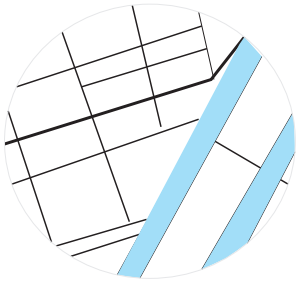
[45] Profile of Historic city center
Author, Google Street Views

The historic inner city of Amsterdam holds a great importance to the city even today. It houses various tourist attractions and famous commercial spots.

The inner city comprises of narrow streets with various functions such as prime residential space, commercial spaces and recreational spaces and forms a dense fabric.

Most of the streets in this area are along side a canal and are usually shared streets which provide the ease of walking and biking comfortably.

Its close proximity to the railway station hub at the Amsterdam Centraal attracts tourists and citizens alike to visit for leisure or work purposes.

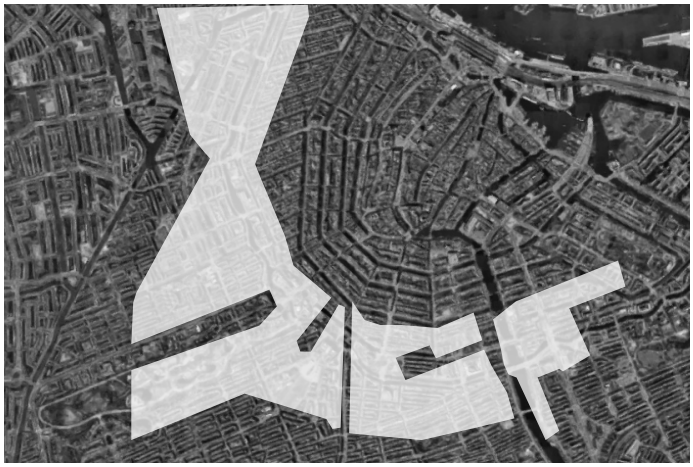


The canal belt region of the city surrounding the city core is one of the most famos places in the city.

Once home to warehouses, the original separation between residential and working canals no longer exists. The warehouses are now repurpoused homes, and businesses.

While the main roads are wide accomodating various mobility functions such as public transport, the inner most streets are narrow and also posses the shared street quality as in the city center and mainly serves the purpose of the neighborhood traffic.

[46] Profile of Canal Belt
Author, Google Street Views

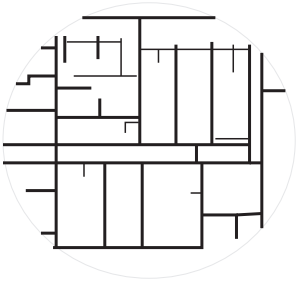


The first extension of Amsterdam house some of the trendiest and most vibrant neighborhoods in the city with various recreational and commercial functions combined with ample amount of greenery interms of parks and gardens.

The main streets accommodate dedicated public transport lanes, on street parking, outdoor cafes and car lanes.

The neighborhood streets although green and lush are mostly used up for on street parking with a very narrow lane for general traffic.

[47] Profile of the First Extentions
Author, Google Street Views



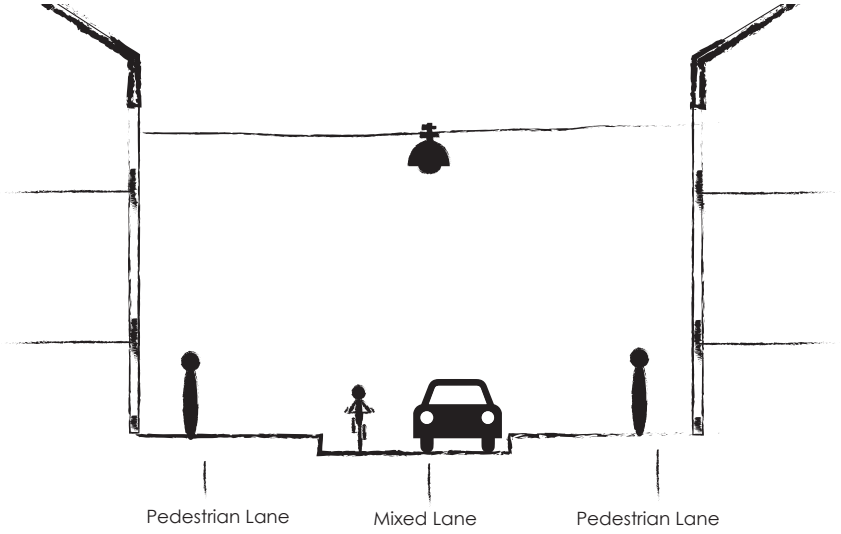
[48] Profile of the habour and industry areas
Author, Google Street Views

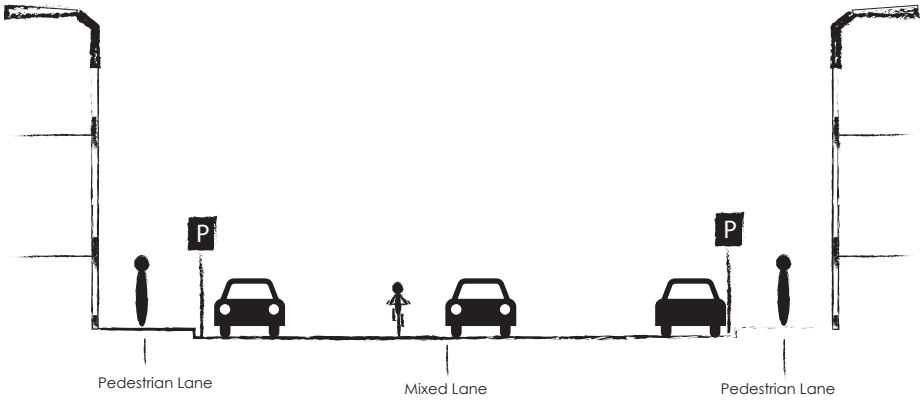
The harbour and industry zone of the city has a dense charactersitic in terms of the built form.

The streets in this area are quite wide and are closely place to the major highways and rail line for the ease of movement of goods.

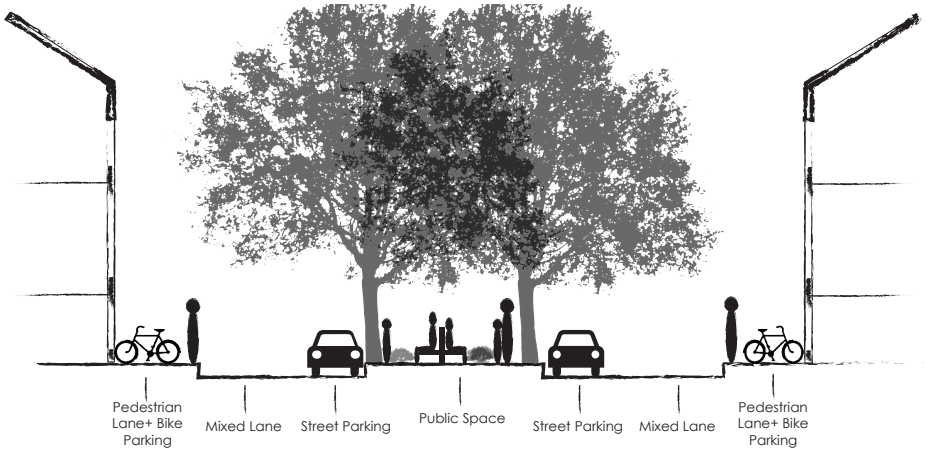
Although some of the warehouses and factory spaces are still operational, there are some spaces in terms of buildings or waste land which could be repurposed for a flexible use.

For example for parking during off peak hours and as recreational or commercial space during peak hours.

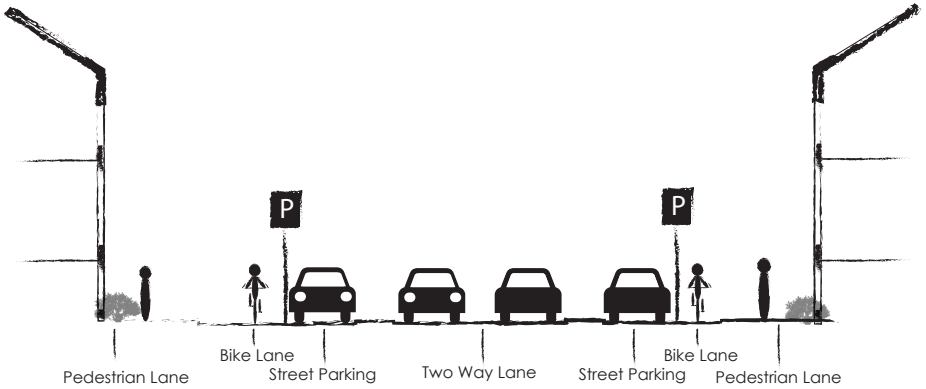




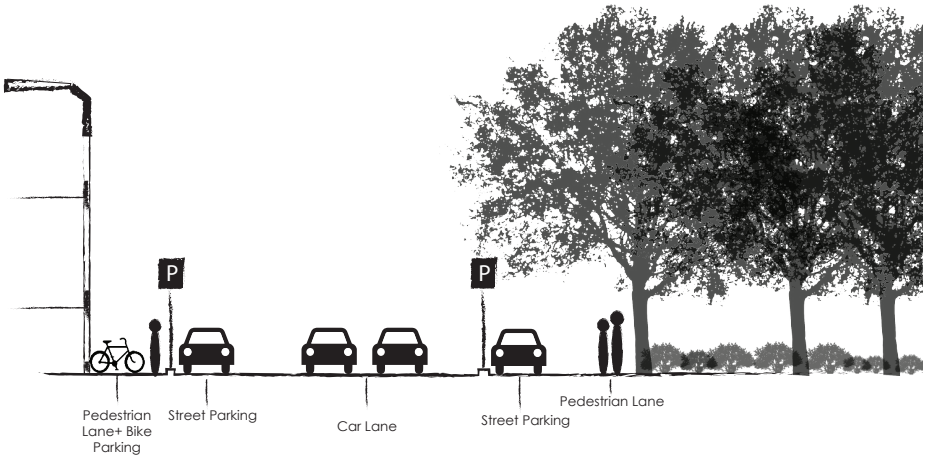
[49] Section of neighbourhood street
Author, Google Street Views

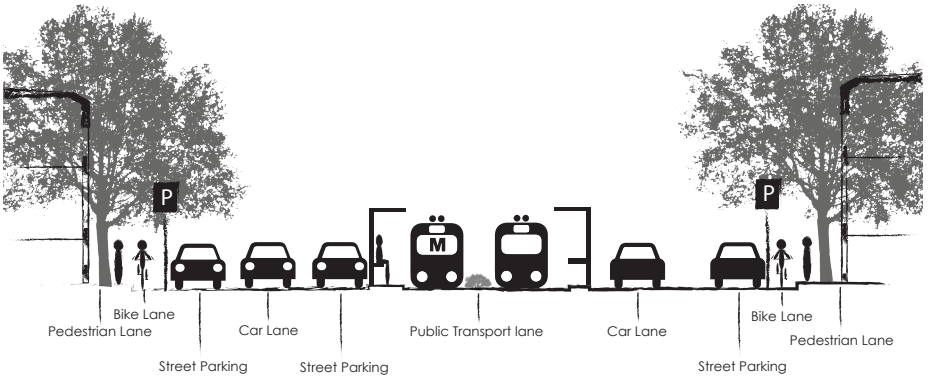


[50] Section of Main Street

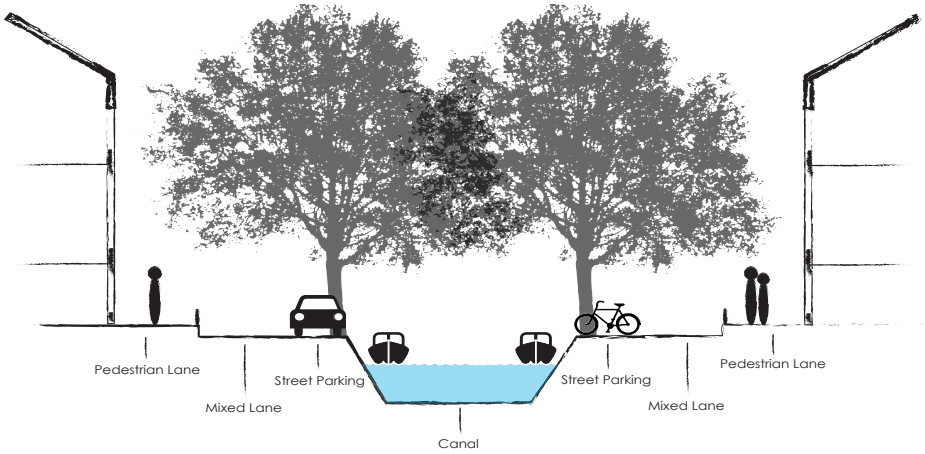


[51] Section of Main Street
Author, Google Street Views

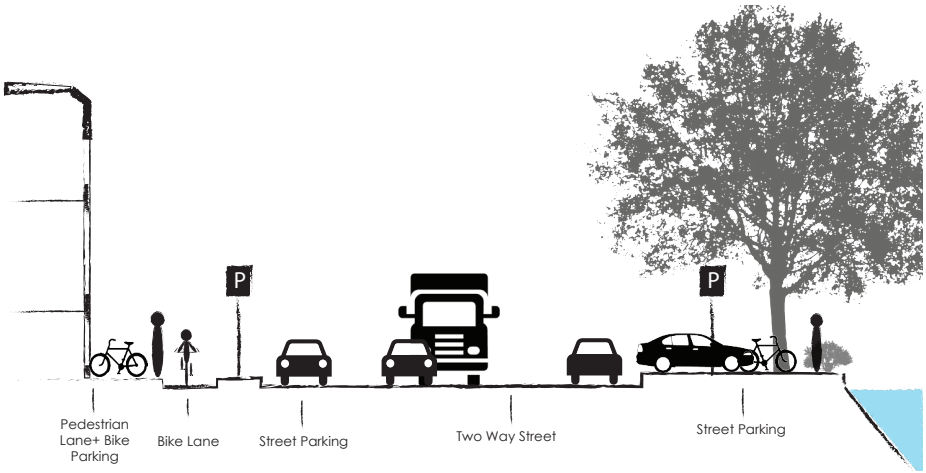




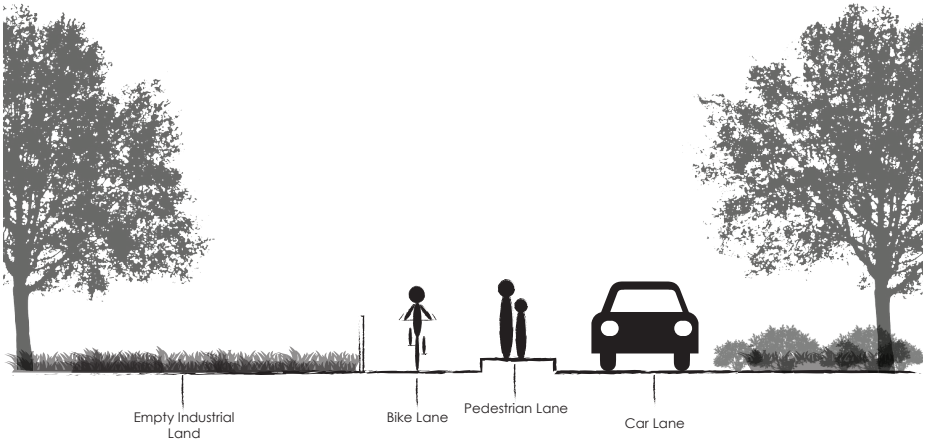
[52] Section of Main Street
Author, Google Street Views



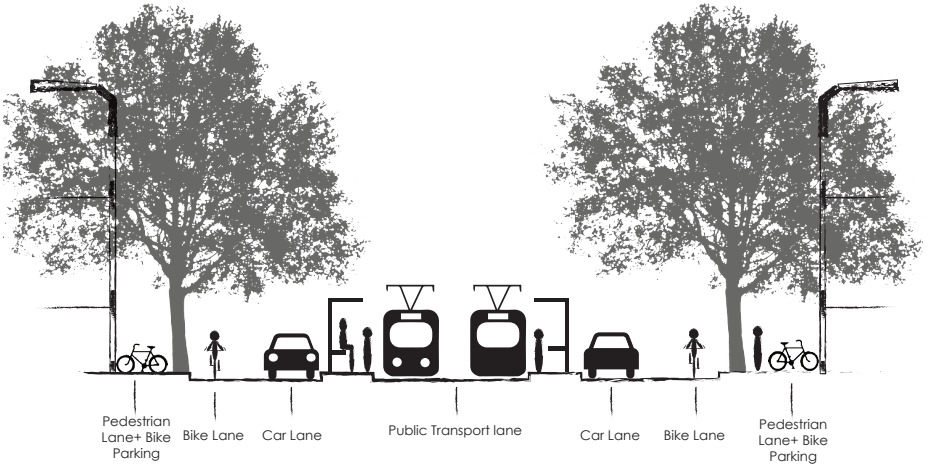
[53] Section of Canal Street
Author, Google Street Views



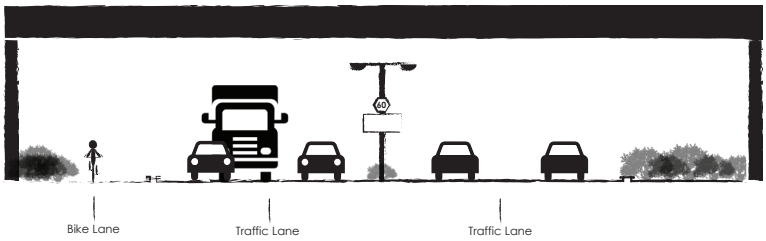
[54] Section of outer ring road
Author, Google Street Views



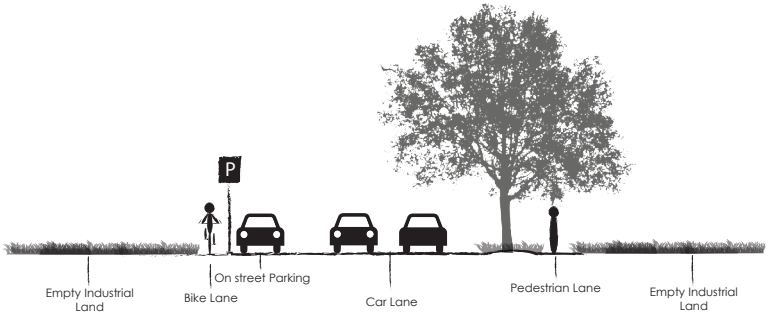
[55] Section of industrial street
Author, Google Street Views



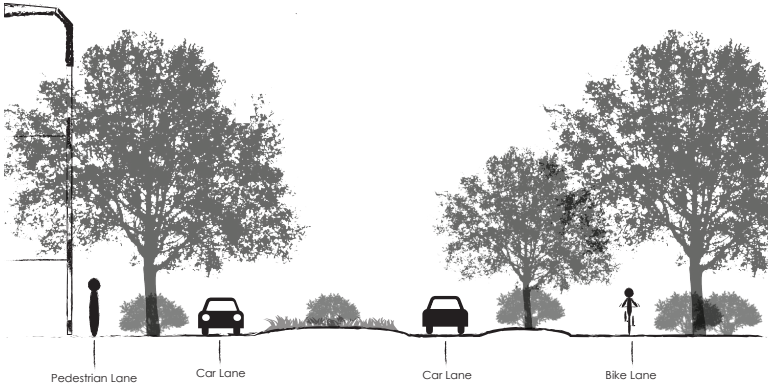
[56] Section of Main Road
Author, Google Street Views



[57] Section of underbridge highway
Author, Google Street Views

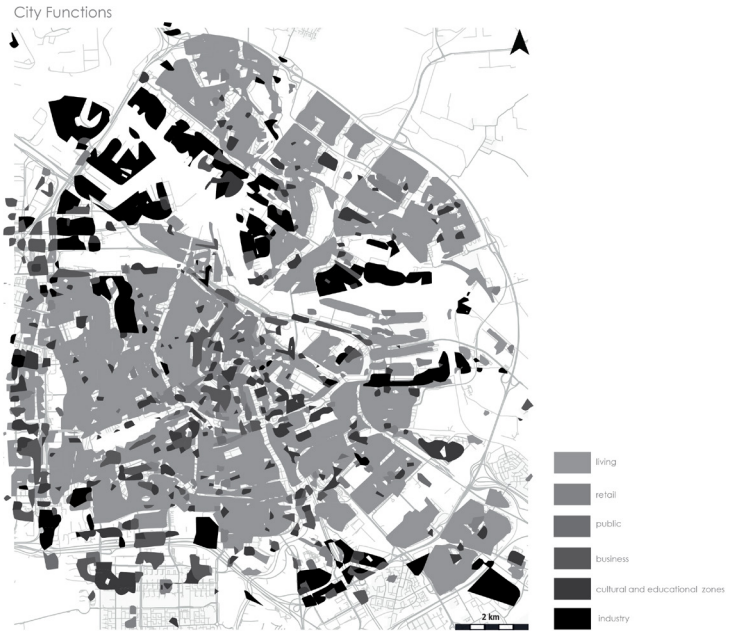


[58] Section of industrial street
Author, Google Street Views



[59] Section of highway
Author, Google Street Views

Functions of the city



[60] Various different functions in Amsterdam

Google,Author

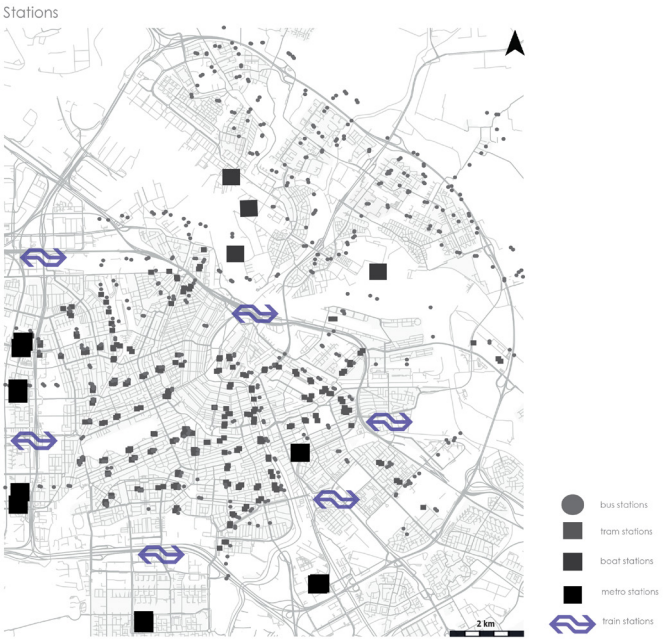
[61] Prosperity levels in Amsterdam

Google,Author

Mobility network

[62] Plusnet mobility network in Amsterdam

Google,Author



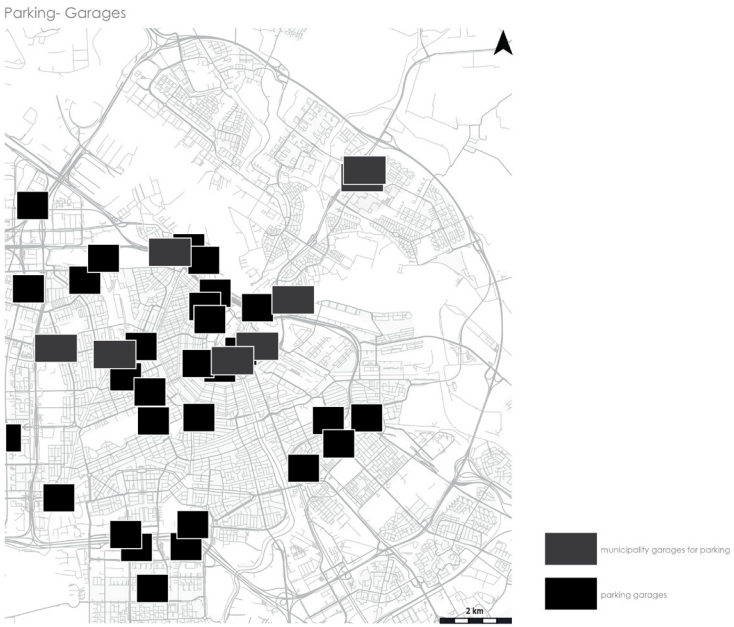
[63] Bus, Tram, Train, Metro & Boat stations in Amsterdam

Google,Author

Nodes of Mobility

[64] Mobility Nodes in Amsterdam
Google,Author

Parking Facilities



[65] Parking Garages in Amsterdam

Google,Author

[66] Park and ride facilities in Amsterdam

Google,Author

[67] Parking Prices in euros in Amsterdam

Google, Author

[68] Bike Parking Facilities in Amsterdam

Google, Author

[69] on street parking in Amsterdam

Google,Author

[70] Taxi Parking Facilities in Amsterdam

Google,Author

[71] Underground Parking

[72] Underground parking

[73] Underground parking

[74] On street parking

[75] Multistorey Parking

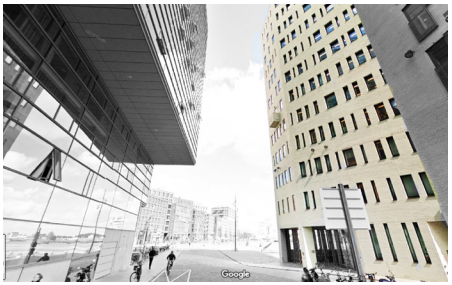
[76] On street parking

[77] Park and Ride

[78] Underground Parking

[79] Underground Parking

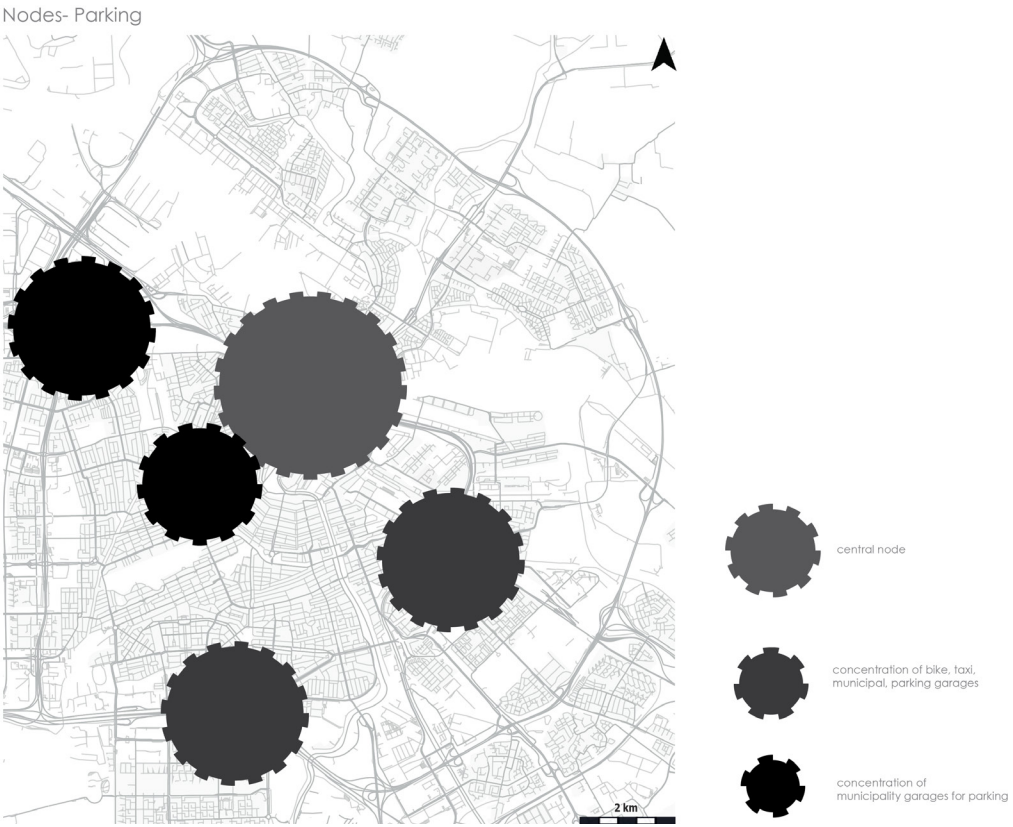
[80] on street parking



[81] Multistorey Parking

[82] Bike parking

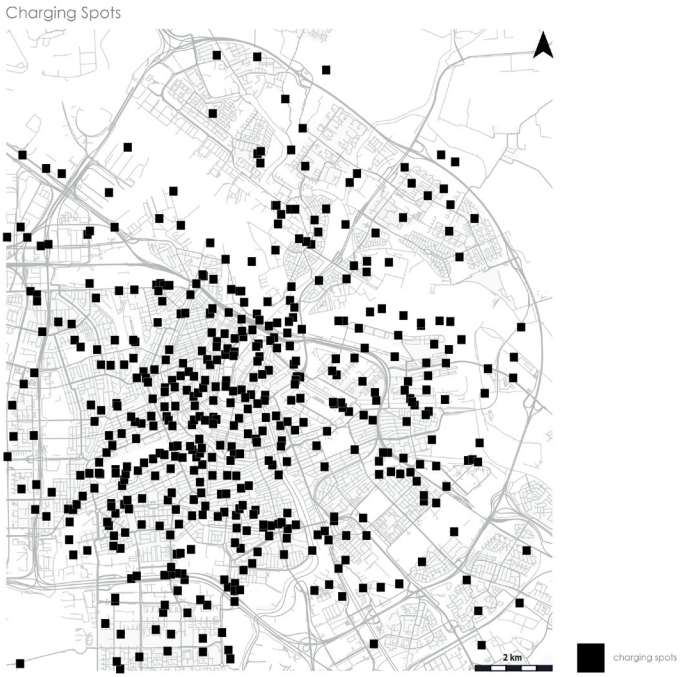
Nodes of Parking



[83] Parking Nodes in Amsterdam
Google,Author

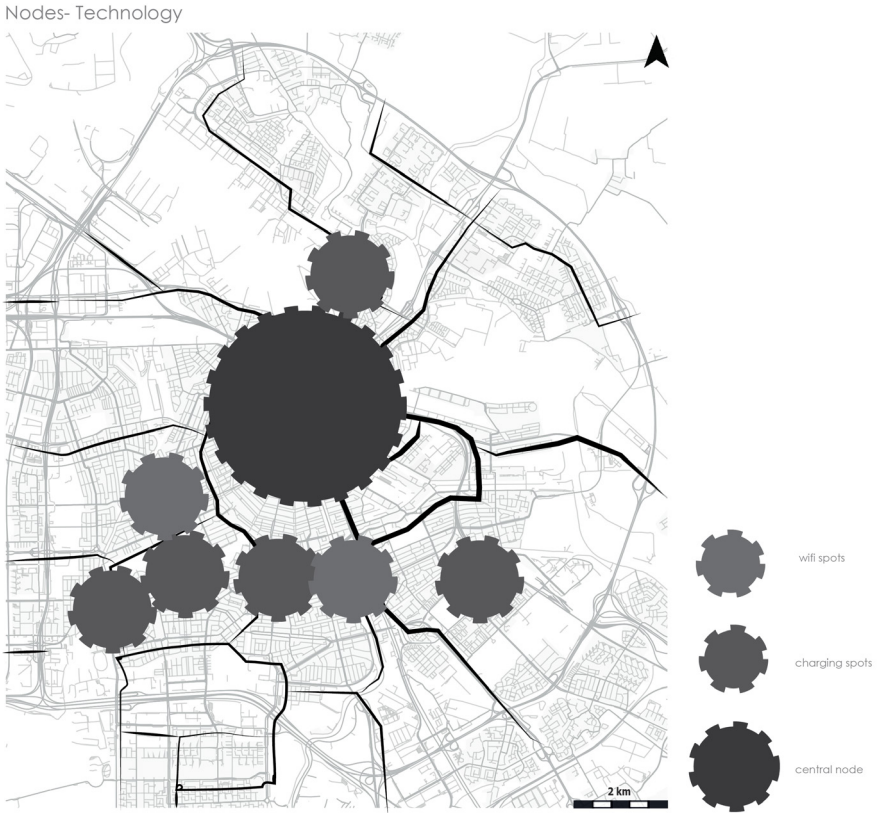
Technological Infrastructure

[84] Wifi Spots in Amsterdam
Google, Author



[85] Electric charging spots in Amsterdam
Google, Author

Nodes of Technological infrastructure



[86] Technological Nodes in Amsterdam
Google,Author

As mentioned in the previous chapters, Amsterdam offers various opportunities to this project. One of them being the municipaliy's strategic vision for the city from the year 2011- 2040.

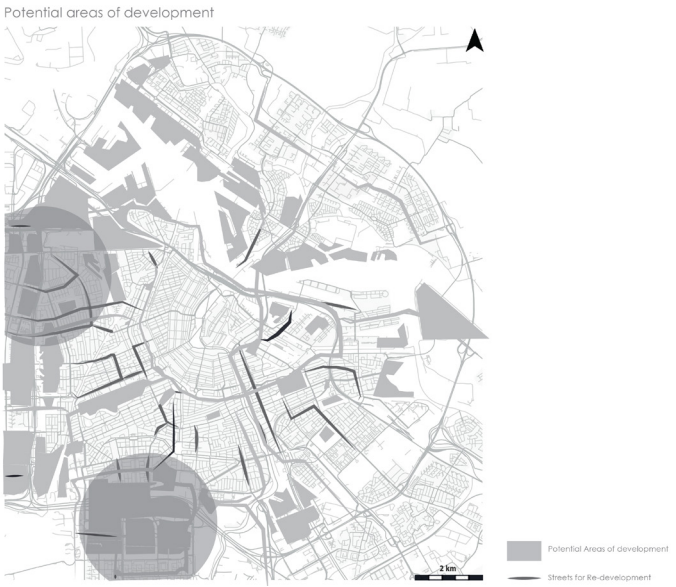
Overlaying all the information from the different concepts of the city led to the formation of nodes of different functions.

When these nodes are overlayed along with redevelopment zones suggested by Amsterdam 2040, the resulting analysis forms the basis and identifies certain areas that have the immense potential to serve as test sites for the strategy as shown in the conclusive map in figure.

Potential areas of redevelopment

[87] Redevelopment areas Suggested by Municipality of Amsterdam in Amsterdam 2040 Strategic Vison

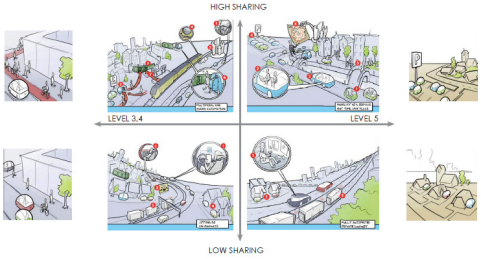
Google,Author



[88] Potential redevelopment zones as per city analysis

Google,Author

Scenarios

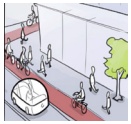


[89] Scenarios suggested by KiM 's Project Driver at Wheel
KiM, Netherlands

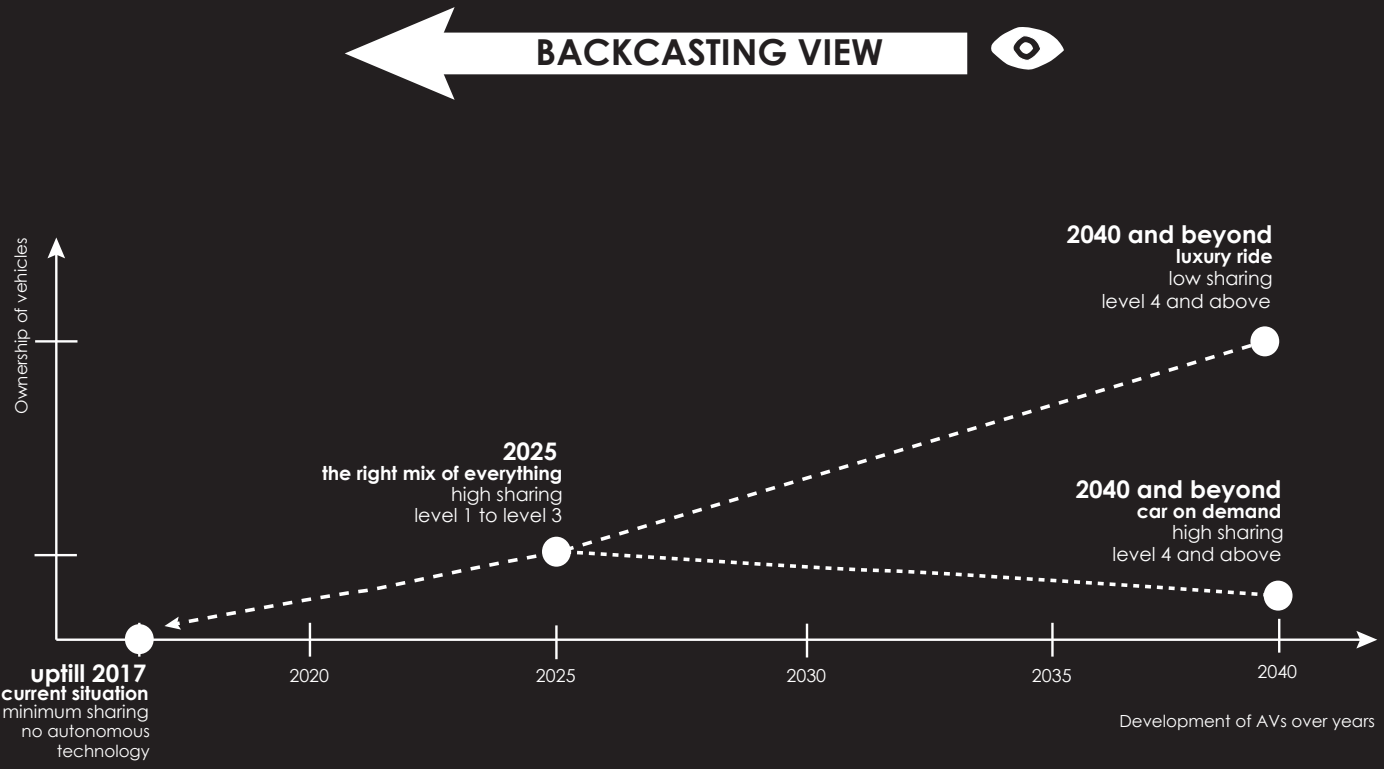
In the first scenario, the assumption is that the technology is developed to a high level and that consumers are extremely willing to share their transport mode. Mobility has become a service, and self-driving cars are always and everywhere available.

In the second scenario, consumers are fervently attached to the ownership of their own cars. The technology in these cars has been developed to the highest level possible.

In the third scenario, the technology is less developed. In the congested, chaotic cities, car drivers must still drive the selves. A minority of drivers are prepared to share a car. The majority opts to own their own cars.



In the fourth scenario, sharing a car is the most natural thing in the world to do. Fully automated driving is not yet feasible, the technology is not yet sufficiently developed, and support is limited.



[90] Scenario timeline suggested for the graduation project
Author

There have been many studies to predict the ideal future from a technological point of view and from the impacts it could have on cities. The most relevant study for this project is the scenarios developed by Ministry of Infrastructure and Environment.

The study called Driver at the wheel? Self driving vehicles and the traffic and transport system of the future is developed by KiM - Netherlands Institute for transport analysis.

The scenarios they formulate envision the possible traffic and transport systems of the future and hence speculate the advantages and disadvantages. This study examines various aspects and implications of the technology on them, such as social, spatial and economic implications. The scenarios developed in this research are the result of exploratory and qualitative research.

The constant uncertainty factors here are level of automation and level of sharing. The scenarios were then reviewed and adjusted during four expert sessions involving specialists from various knowledge organizations, government agencies and private companies. For this project, the research Driver at the wheel? by KiM acts as an inspiration for development of the scenarios.

Taking these scenarios as an inspiration, in this context, two possible futures are visualized for the city using the backcasting approach. This approach will concentrate on three factors namely, Technological Advancement, Travel Behavior, and Urban Form which have been mentioned in the theoretical framework.

The concept with these factors is that; as the technology advances, the way people travel will change which will transform the urban form of the city which will make it easy to facilitate more advancement in the technology.

Based on the timeline suggested by the Morgan Stanley research , autonomous technology will become operational by 2020 and will be fully autonomous by 2040.

The constant factor remains that the from 2020 onwards, the cities will enter the age of autonomous vehicles.

	year	technological advancement	travel behaviour the trend of sharing	urban form
current scenario	2017	level 0-1	low sharing	no notable changes
the right mix of everything	2025	level 2-3	intermediate sharing	-upgradation of intermodal mobility hubs – reduced land consumption for urban parking spaces due to new parking systems
car on demand	2040	level 4 and above	high sharing	– City centers of high density -Upgradation of parking spaces - Reduced street congestion - opportunities for development of public spaces
luxury ride	2040	level 4 and above	low sharing	- Increase in the number of vehicles on road - More space required - parking in the outskirts of the city

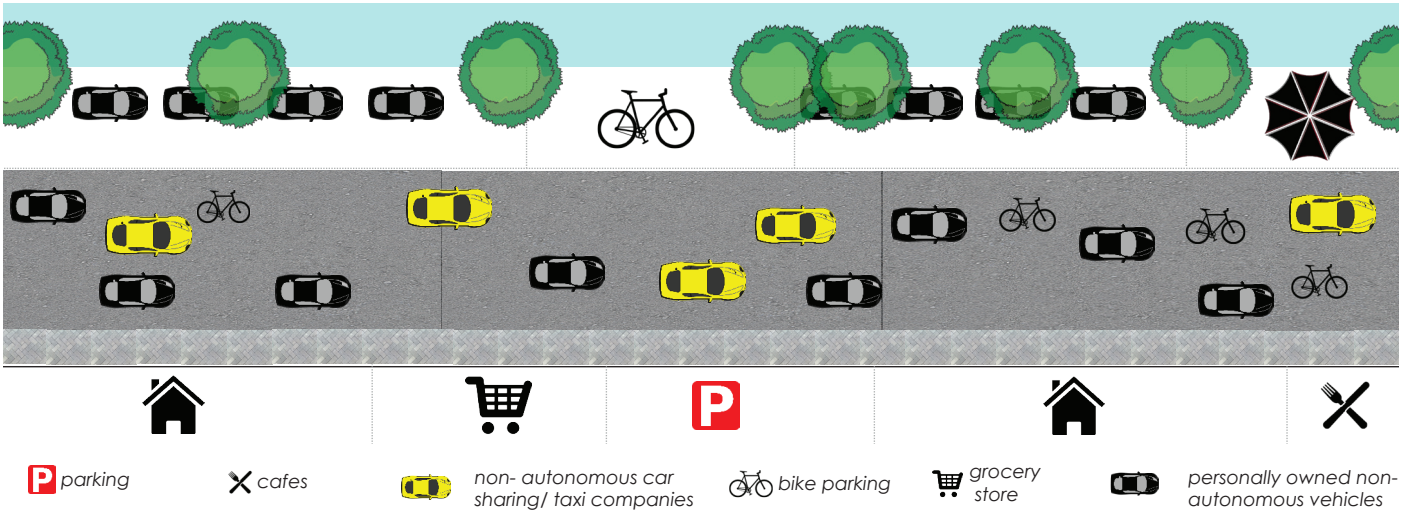
[91] Understanding the impact of scenarios on urban form
Author

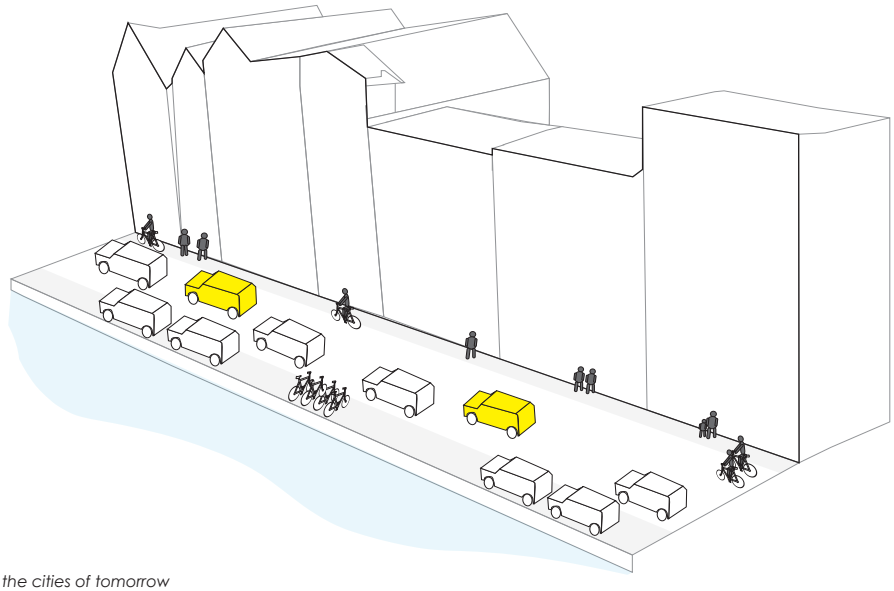
There are two futures imagined in this study. The first point in future is assumed to be at 2020 and from there it is speculated to form the basis for two different futures. One leading to a multi-modal mobility on demand future and the other leading to a future of luxury driving.

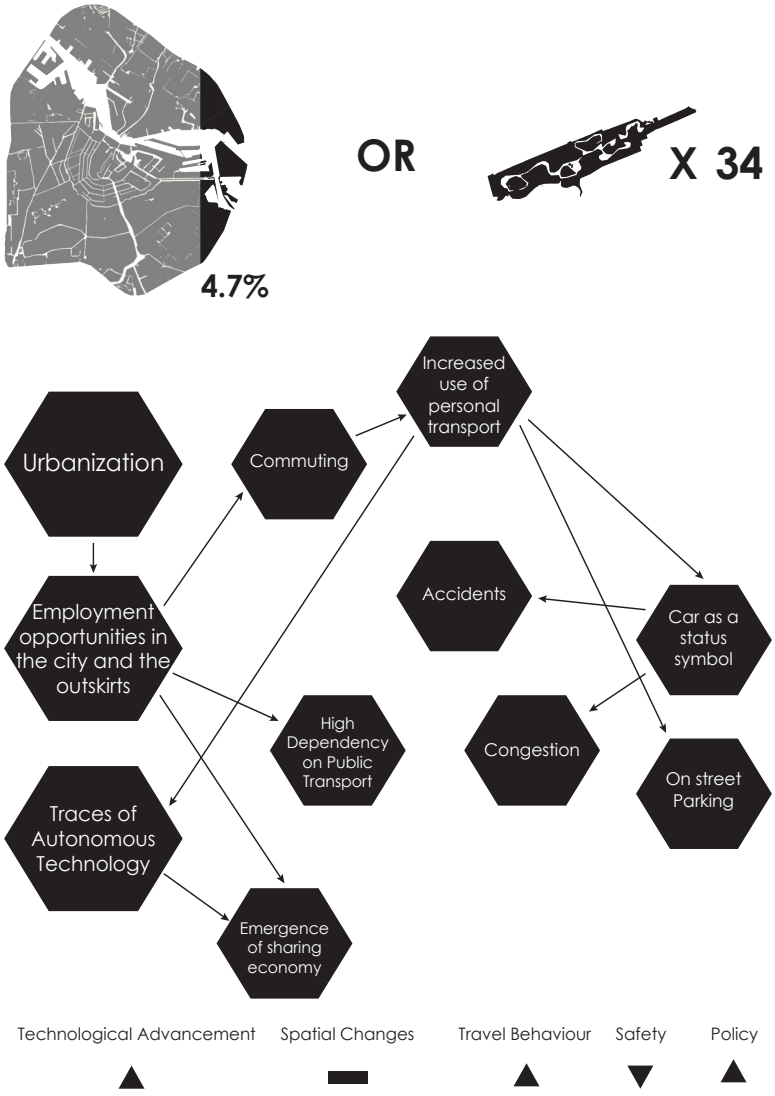
An assumption has been made that, the latest trend of the sharing economy will contribute to the travel trends and will remain the constant factor through out the future. The idea is to understand the implications on the technology on the spatial quality of spaces in the city.

Using a section of a street near the outer ring of Amsterdam city center, the following ilustrations aim to depict the implications of the technology on space. These points in the two futures will be explored in detail and will show the various aspects in the city that will have an impact and an approximation of space freed up in the city.

Current Situation







[92] Current scenario
Author

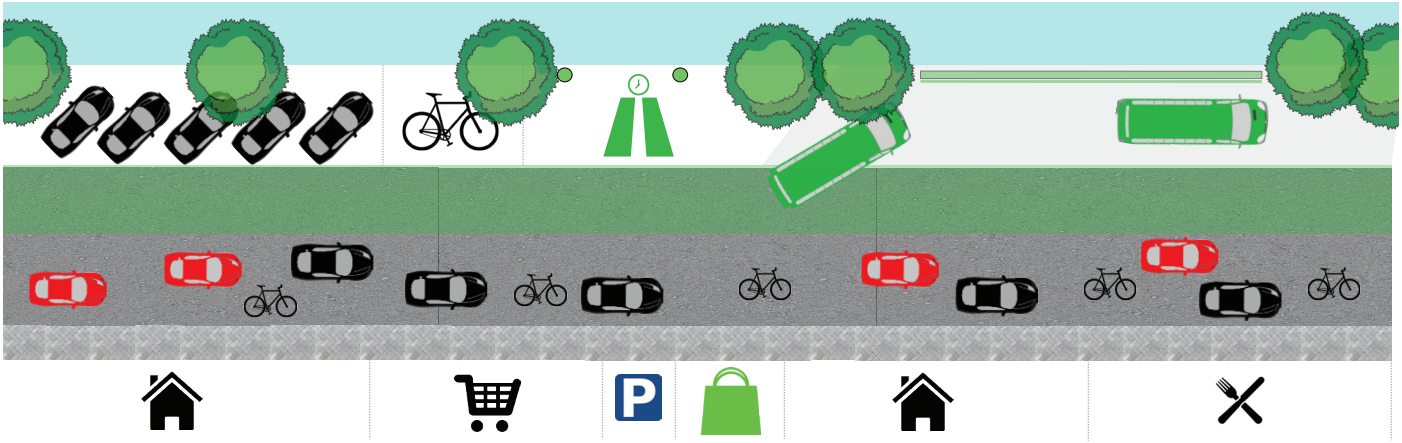
The underlying assumption here is that technological innovations are not yet completely developed to any great extent.

With regard to mobility and urban structure, this scenario envisages the city which is still continuing on the multi-modal systems but it is observed that estentially, bikes and cars dominate the system.

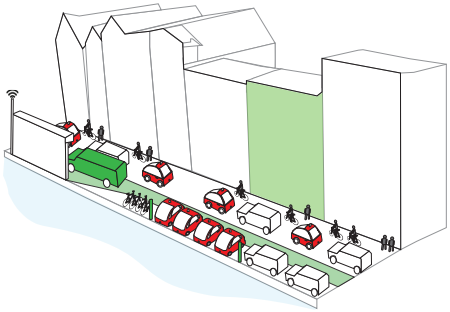
Spatially, the city will exhibit high density city center with fragmented settlement structures surrounding it. In this regard, the scenario is extrapolating a trend that is currently observable globally.

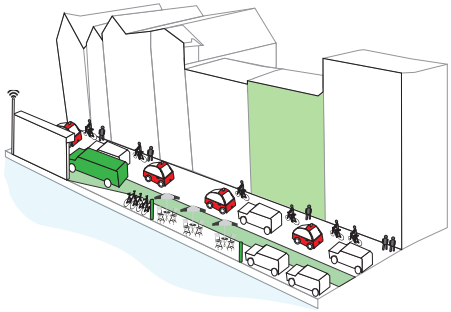
In todays situation, the parking space occupied by the cars is also quit high and as mentioned before, is quite difficult to find.

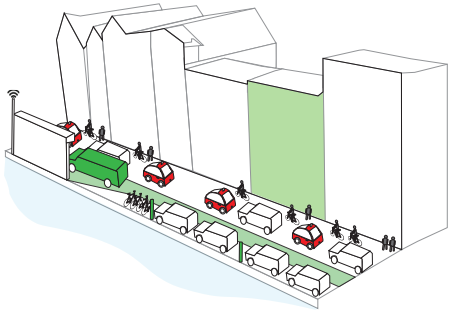
The Right Mix of Everything Situation- 2025

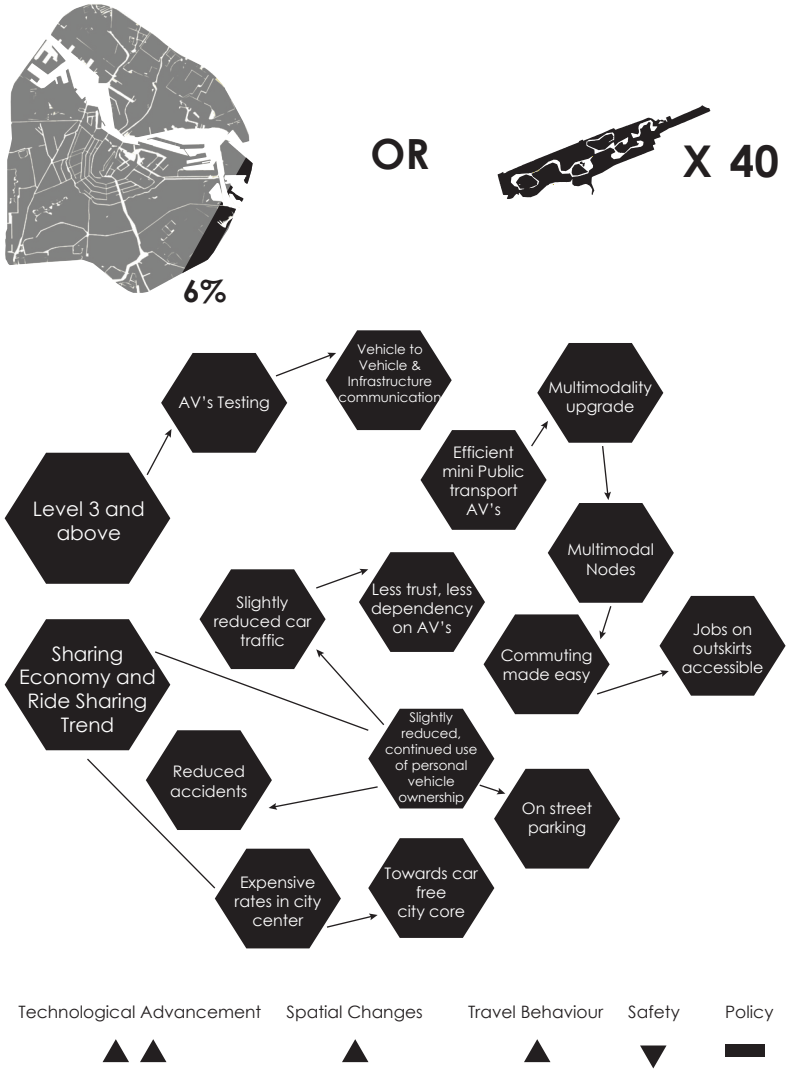


parking
cafes
autonomous cars - car sharing companies
priority lane- partially autonomous public transport
bike parking
charging stations
partially autonomous public transport
flexible infrastrcuture
commericial developments
grocery store
self owned non-autonomous cars









[93] The right mix of everything scenario
Author

In this scenario, the technology has not yet developed to fully autonomous cars. In this case it will coexist with other modes of transport, preferably public transport. Organizations are working hard towards promoting the sharing city concept today and since car sharing in the Netherlands began its ascendancy in 1990, it forms a good basis to develop efficient car sharing system.

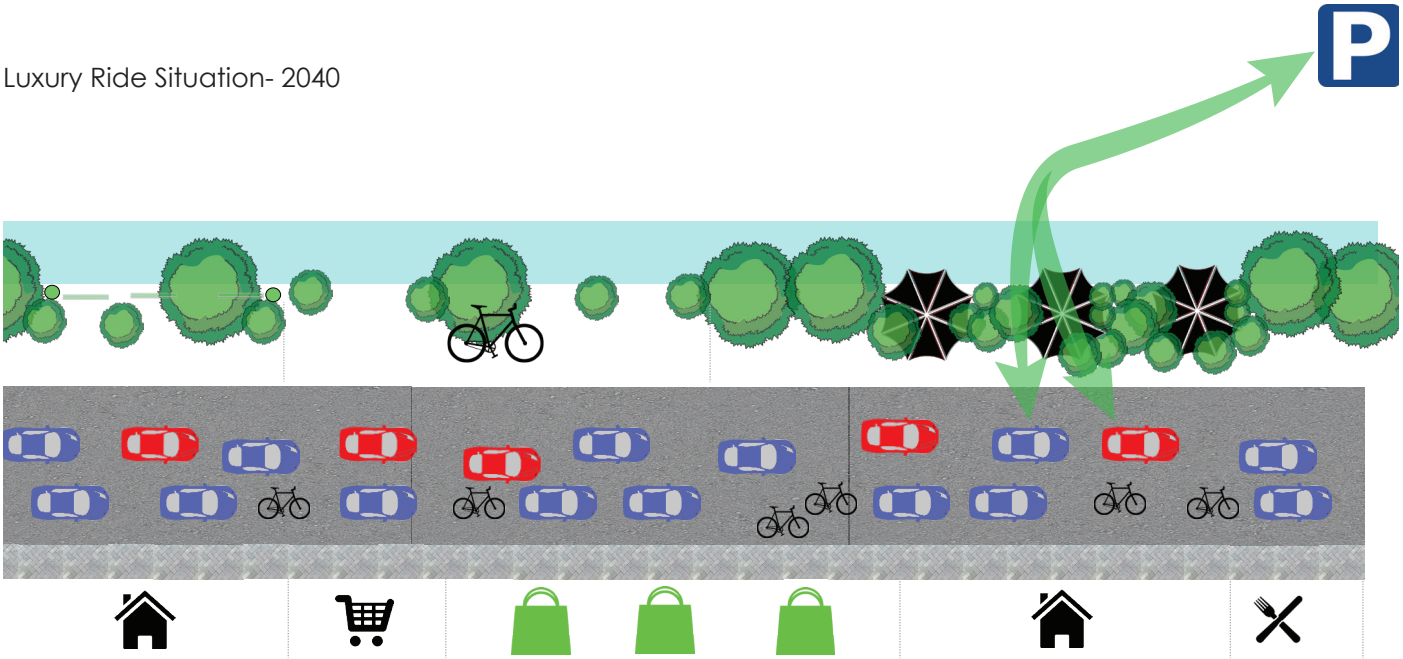
Trains/trams/metros will also experience the technology with high frequency of travel and the government will encourage the use of public transport in the city.

The acceptance of the technology will not be as much but automobile drivers might be influenced by the value and utility of car sharing will bring to the society making it more livable and sustainable, in line with the Plan Amsterdam 2040. The organizational structure for the operation of the shared cars might differ.

They may be handled via organizations or by neighbors among themselves. As sharing cars and rides becomes more frequently used and adaptable, the number of cars will considerably reduce. This will have an impact on the parking infrastructure around the city.

They can be reused as flexible public spaces, bike parking, street widening to accommodate pedestrian activities or for development of various functions such as commercial or residential. The shared cars can be parked in a car park and servicing center in the neighborhood for easy access. The buses and trams will continue to operate on the routes with a high demand.

Luxury Ride Situation- 2040



parking

cafes

cafe extentions

commericial developments

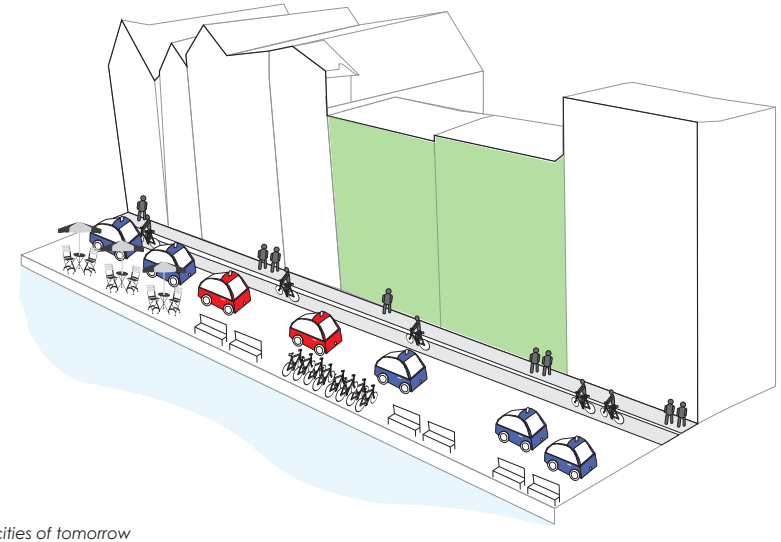
grocery store

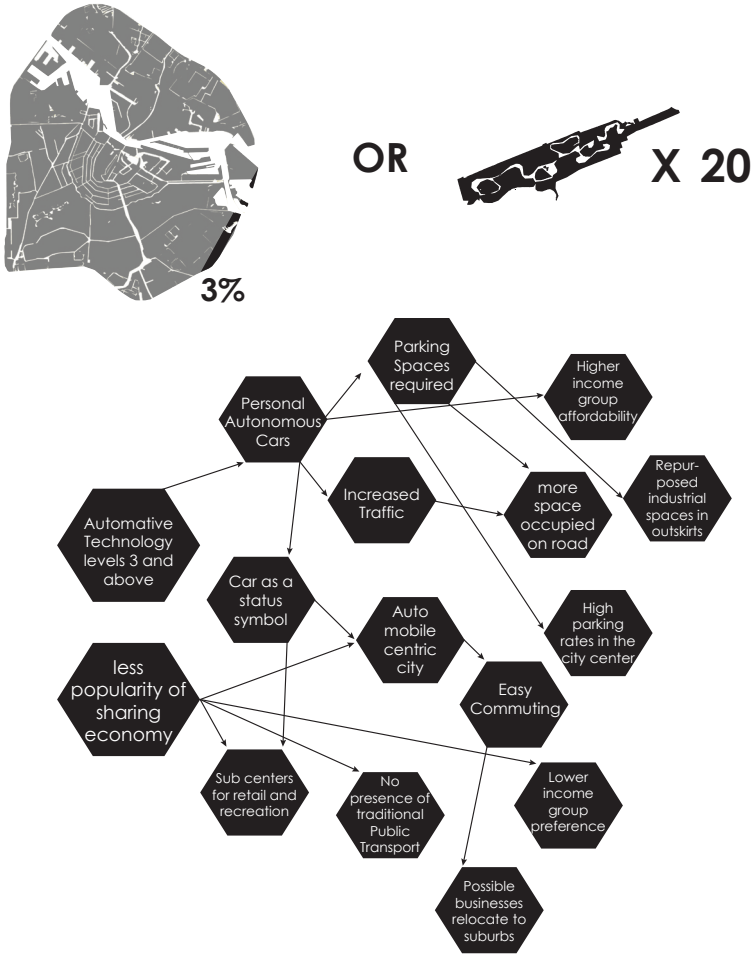
autonomous cars - car sharing companies

bike parking

charging stations

self owned autonomou cars





[94] Luxury Ride Scenario
Author

In this scenario, consumers are attached to the ownership of their own cars. The technology in these cars has been developed to the highest level possible. The car ownership rates hence, remain high but from the overall car fleet, a reduction would be observed.

However, this would also cause a high demand for parking places and these vehicles will keep occuping large amounts of space. This would also lead to increase in on street parking In the core areas, this can lead to parking problems, but they can be prevented by higher parking fees.

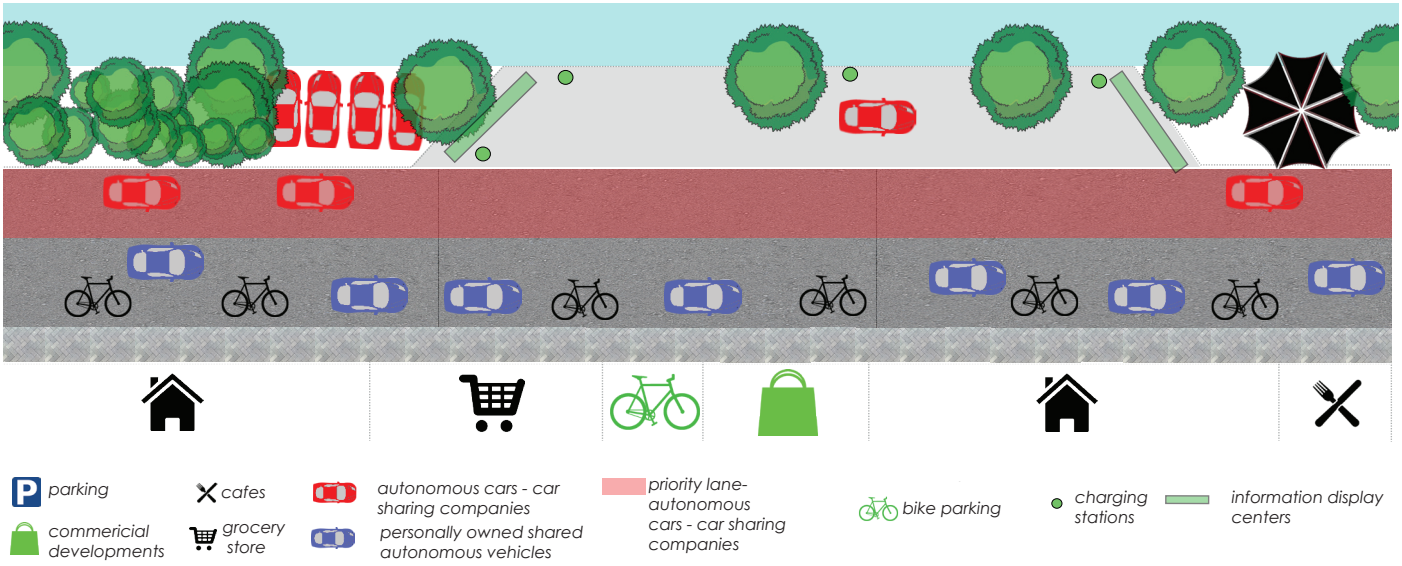
If necessary, the cars are parked in less expensive areas on the outskirts of the city. Due to the ease of travel, people rarely share rides, traffic pressure in the city initially increases.

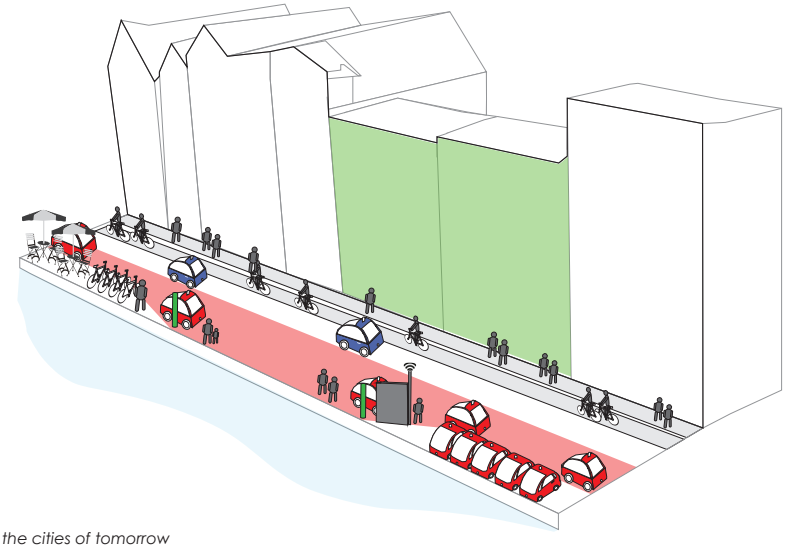
The city will continue to attract people as a place to live and work as it does today and this will lead to formation of subcenters where people find recreational and commercial functions.

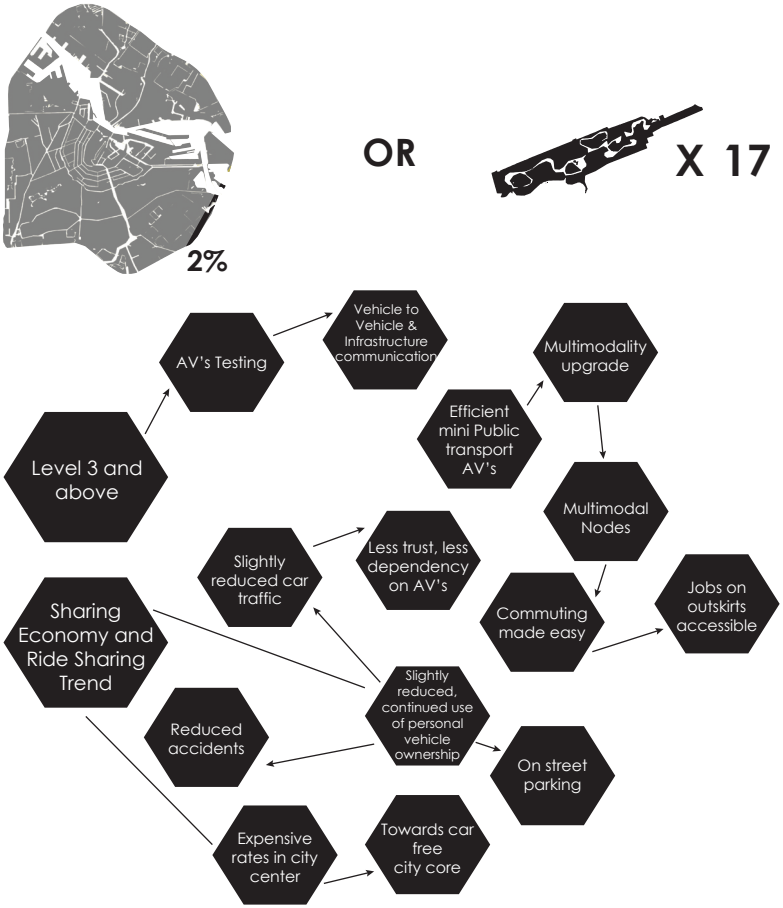
The countryside is now more accessible. A certain number of people now live in areas that were previously not accessible.

The small group of peoplewho do not own cars or could not afford these cars will rely on the self-driving shared cars or the rare traces of public transport present in high demand routes.

Car on Demand Situation- 2040







[95] car on demand
Author

The assumption here is that the technology is developed to a high level and the concept of sharing continues. The major change, however, is that there is no trace of the traditional public transport due to the increased wide spread acceptability of the technology. Mobility will become a service and this will also enable efficient door to door travel for the consumers.

Changes in policy and rules and regulations will give self-driving vehicles high importance. Owning a car is no longer needed as sharing rides and the car itself makes it easy to travel from point A to B. Car manufactures and taxi and mini bus organizations will begin to manage the vehicles and offer personal digital assistance to arrange the routes. To travel alone will only mean that the price of travel would be higher compared to the prices for traveling with shared vehicles. Owing to the ease of travel by self-driving cars, the city will become more accessible in every way helping in achieving the goals of Plan Amsterdam 2040.

As the ownership of cars reduces along with car sharing and ride sharing systems, fewer parking spots are required, freeing

Strategy

up a significant amount of space for other recreational functions. When the cars or automated vehicles are not driving, they will navigate themselves to parking garages and servicing stations in the city.

The idea is to develop shared streets with a dedicated lane for autonomous cars and designated drop off and pick up zones surrounded by activity zones for safer and livable streets. The goal of the project is, through scenario building, explore the impact Autonomous Shared vehicles will have on different parts with different characteristics of Amsterdam.

Keeping this in mind and assuming the city grows to the ideal future of the right mix of everything to a car on demand scenarios, a strategy is developed for Amsterdam.

As discussed before, with the help of Amsterdam 2040 and the analysis of the city, certain potential areas in the city were identified. Combining these areas with the opportunities provided by Amsterdam sharing city project and the Amsterdam Smart city initiative, the strategy combines Amsterdam 2040 goals and actions with the technological advancements from the period of 2017- 2040.

Adding to the goals is the idea of upgrading infrastructure to adapt to autonomous technology in the city by resourceful use of finances of the city.

This goal could ideally be achieved through adapting a proactive role in the development and deployment of autonomous vehicles.

To understand the proactive role to achieve the strategy, potential multi-modal nodes around the city are mapped and public transport stops are used to locate car and bike stacks around the city within biking or walking distance of the neighborhoods around the city for better accessibility and to maintain multi modality throughout the years.

GOALS

Density

Transform

Public transport on regional scale

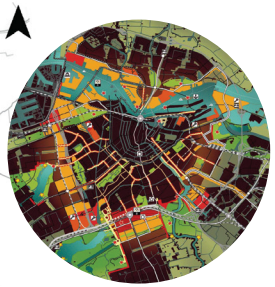
High quality layout of public space

Invest in recreational use of green space and water

Converting to sustainable energy

Olympic games Amsterdam 2028

Upgrading current infrastructure to adapt to autonomous vehicles



amsterdam sharing city

amsmart erdam city

current residential zones

potential zones for the development of ASV

potential industrial zone for the development of ASV

potential green spaces

potential public squares

potential streets for the development of ASV

plusnet car network

ACTIONS

Adapting a pro-active role in the development of ASV's

The roll out of city center

The interweaving of metropolitan landscape and the city

The rediscovery of the waterfront

The internationalization of the city's southern flank

[96] Vision 2040 for Amsterdam

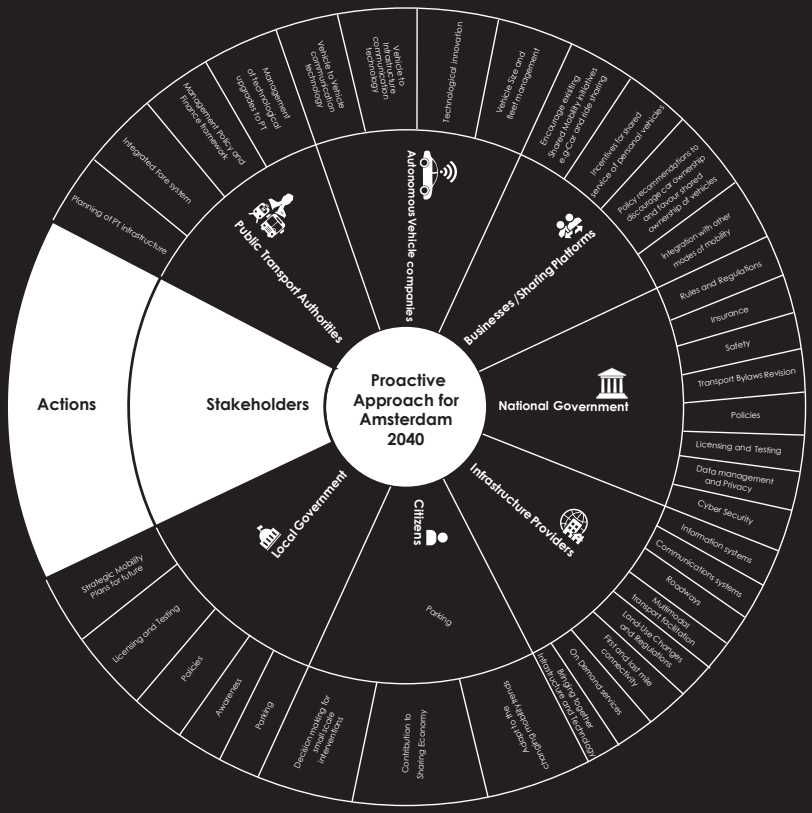
Author, Municipality of Amsterdam,Amsterdam Sharing City, Amsterdam Smart City

Stakeholders

There are various stakeholders who will play a very important role in realizing this strategy in Amsterdam. For a proactive approach to the technology, the local and national government will likely play the most important role in terms of developing policies, rules and regulations and testing the technology on public roads which will also contribute to providing awareness for the citizens about operating and accepting the technology.

The Infrastructure providers should take up the responsibilities of handling the immense amount of data required for these vehicles. Amsterdam currently has many platforms and business models promoting the concept of sharing. These platforms will hence help in encouraging people to opt for sharing their own vehicles as well as shared mobility options offered to them. The public transport authorities along with the autonomous vehicle providers can contribute greatly towards bridging the gap between public and private transportation.

It is important note here that citizens are the most important stakeholders in this project. A project like this is completely in the hands of citizens as their acceptance is what drives the decisions taken by the other stakeholders to implement a complex mobility strategy.



Public Transport Authorities

Autonomous Vehicle Companies

Businesses and Sharing Platforms

National Government

Citizens

Infrastructure Providers

Local Government

[97] Potential Stakeholders involved in the vision
author

Appraoch Guide

The findings from the backcasting exercise along with the conclusions from the city analysis have been properly cataloged in the previous chapters to make them usable during the recommendations phase.

To approach the recommendations phase, it is important to implement the strategy with a set of tools which from here on would be referred to as an Approach Guide.

Instead of focusing on a single issue brought up by the application of autonomous technology in cities, a guide book of tools are presented to improve various issues that might be faced as the technology develops in the city in order to increase the livability and sustainability factor of the built form.

While some these tools in the guide can be used Individually, the ideal way to implement these tools is to create combinations that work together to produce better results.

These tools are enhanced by the autonomous mobility technology.

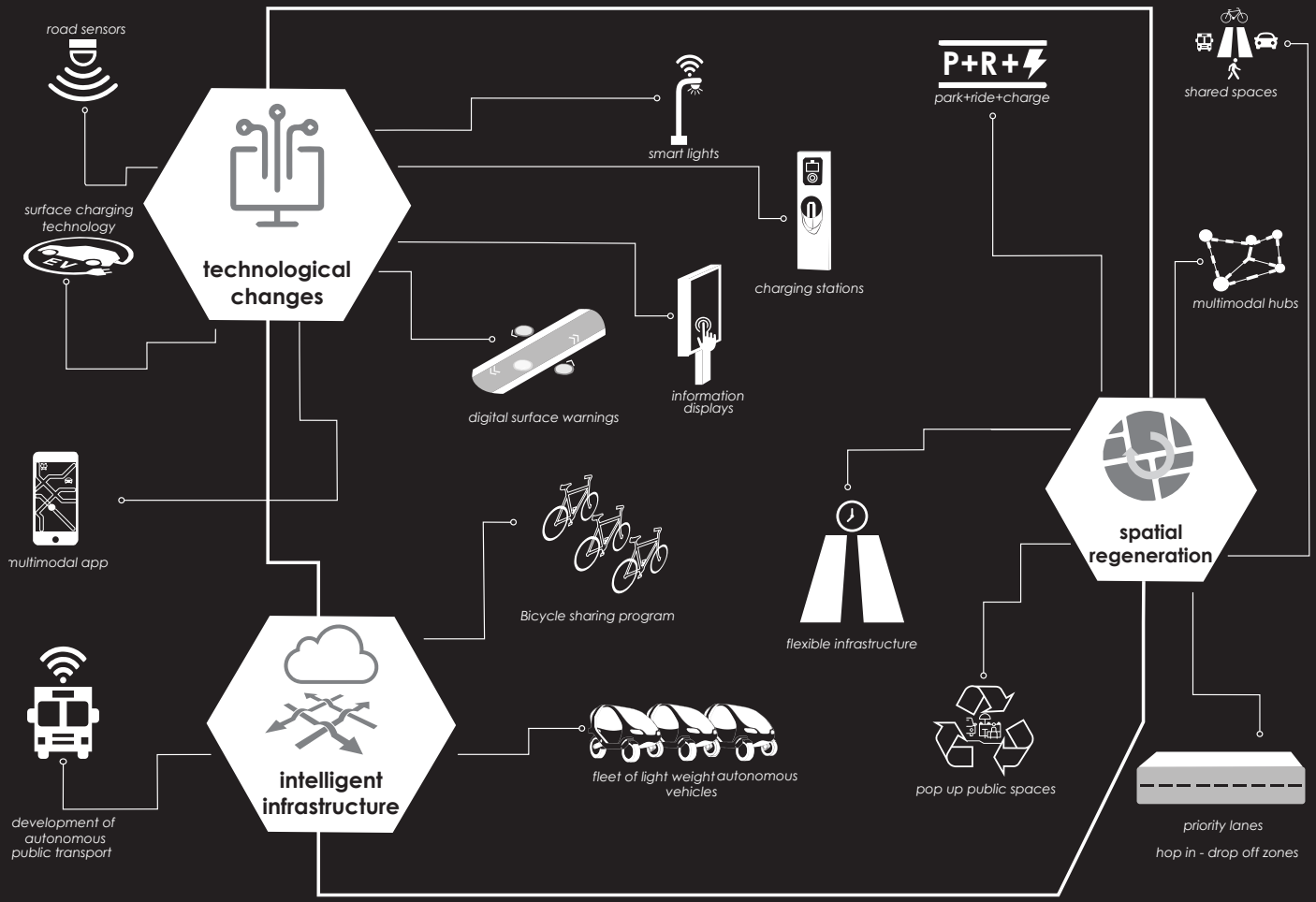
This section will elaborate on each of these tools in detail and will show the timeline of the development of these tools as the project focuses closely on the timeline of the development of the autonomous technology.

After that the best combinations of these tools is constructed to show which of the tools work together while which of them need the support of the other to begin in the first place which will be implemented in different characteristics of Amsterdam.

There are many factors that fall under the category of application of Autonomous vehicles as discussed in the previous chapters. As a planner, to understand the impact on spatial quality in the different parts of the city a better and refined categorization of the tools has been suggested. They have been sorted under three distinct concepts namely, Technological changes, intelligent infrastructure and spatial regeneration.

As a planner, the aim is to intervene into the concept of spatial regeneration while combining it with other concepts which have strong impact of it.

These concepts then open up to more specific tools and techniques to achive the ideal future at hand to implement the strategy proposed at a smaller scale.



[98] Tools of the approch guide
Author
101

Tools

1] road sensors

2] surface charging technology

3] smart lights

4] digital surface warnings

5] multimodal app

6] information displays

7] charging stations

8] development of autonomous public transport

9] bicycle sharing program

10] fleet of light weight autonomous vehicles

11] flexible infrastructure

12] park+ride+charge

13] pop up public spaces

14] priority lanes
hop in - drop off zones

15] multimodal hubs

16] shared spaces

[99] Detailed tools of the approach guide
Author

1] ROAD SENSORS

It is quite obvious that with autonomous technology, a huge leap in innovative upgradation in infrastructure has to be made. With complex integration of algorithms running on powerful processors, making critical decisions based on large streams of real-time data coming from a diverse and complex array of sensors can be made possible.

Sensors fitted on to the roads hence play a very important role in this upgradation process. These sensors will help the cars at the initial stage identify its surroundings, understanding traffic signals and hand signals by driver driven cars. As the technology reaches its perfection, these senors will eliminate the need of traffic signals and predict its environment effortlessly. Although this process is quite long and expensive but for a long term it is quite important to invest resources into this.

It is crucial to have a clear, complete and accurate vision of the obstacles around the vehicle in order to define free areas to which the vehicle movement would be safe.

2] 7] CHARGING TECHNOLOGY

"Autonomous vehicles will need power – and they in turn have the potential to become a moving power source for other connected devices" At the initial stages of the technology, the current charging stations across the city might be upgraded to suit the initial stage of technology. These charging stations can be either close to the multi-modal hubs or decentralized across the city or can have designated park and ride and charge hubs across the city.

In the more advanced stage of the technology, the whole point of the charging process is to take people out of the process just like with high levels of autonomous technology. An inductive charging surface has the ability to wirelessly charge the battery of an Autonomous vehicle through electromagnetic induction. When required to charge, with a press of a button on the smart app, the vehicle will park itself over a charging surface and automatically top up the battery without ever plugging in. Charging vehicles through induction can ease the use of electric vehicles and thus be an important step in introducing electric automated vehicles to the public.

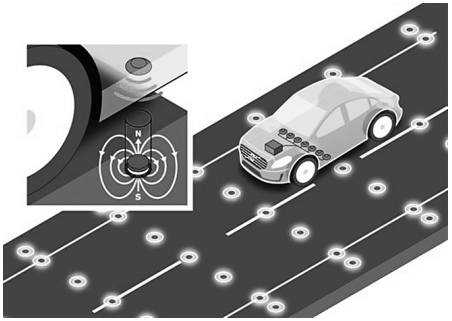
3] SMART LIGHTS

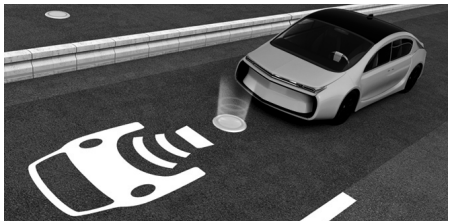
The existing infrastructure must aim to upgrade to adapt to the technology. The roads will experience and upgrade in the lighting systems installed in the city. CitySense is one of the innovative and is an award-winning street light motion sensor which helps in integrating wireless lighting control with its surrounding environment.

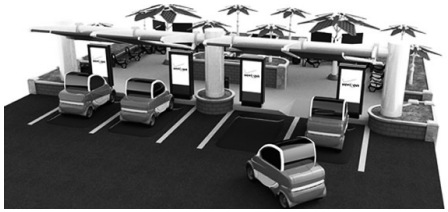
With adjustable adaptive on demand lighting, based on the presence of pedestrians, cyclists or cars, lights will help in improving the efficiency of the traffic systems as well as safety in Amsterdam. As the technology enters its peak it is expected that these light will receive an upgrade to maintain and amplify the efficiency of the intelligent infrastructure system.

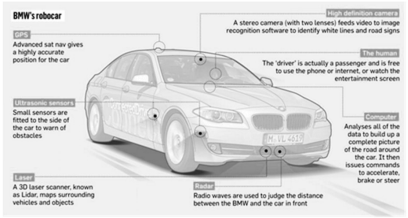
4] 6] DIGITAL INFORMATIONS DISPLAYS

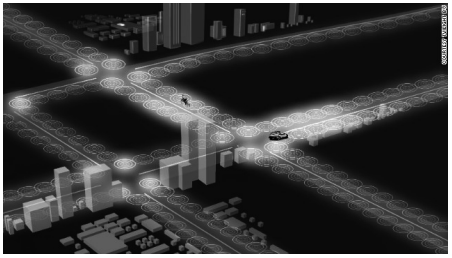
Digital information displays are solar powered interactive passenger information systems which could be ideally installed at public transport stops and hop in and drop off zones across the city. These display centers are Wi-Fi enabled and could be used to get accurate information regarding travel time, arrivals , departure bookings etc to optimize the travel experience.











[100] Road Sensors
google

[101] Charging technologies
tesla, audi urban initiative,google

[102] Smart Lights
audi urban initiative

Similarly, as a part or intelligent infrastructure, Digital road surfaces also play an important role when combined with autonomous technology. Digital road surfaces are roads that function as digital displays. The purpose of using these road surfaces is to guide not just the people but the communicating cars as well as warnings signs of the surrounding or upcoming traffic around them. These warnings could be crossing a road, a vehicle approaching and the speeds of these vehicles. These surfaces hence tend to optimize traffic flows, prevent waiting at intersections, and help avoid collisions.
For a city specific implementation, as these surfaces are expensive to operate and maintain, certain roads that cater to maximum traffic during peak hours can experience this feature as the technology matures to its highest level.

5] MULTIMODAL APP DEVELOPMENT

Multi-modal travel aims to optimize cost, comfort, attractiveness, duration and other aspects of a trip by combining the use of different other available modes of transport. But due to the availability of so many choices, the challenge lies in finding the best and quickest way to reach the destination with the appropriate combination of modes.

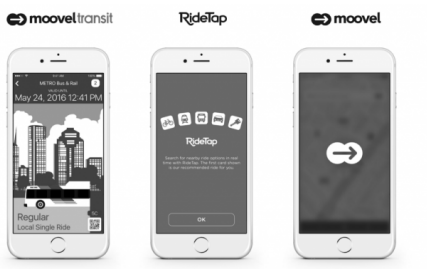
Multi-modal apps aim to make this process convenient for the end user. Research states that today, the idea of a smart phone is one of the best innovations in the world of transport. (Goldwyn, 2014)
It has also been proven that real- time data regarding infor mation of available modes of transport affects the choices made by the end user. (Brazil & Caulfield, 2013; Tseng, Knockaert, & Verhoef, 2013).
Although many companies have designed these apps for the consumer's convience, perfection has not yet been achieved. This is due to the fact that, traffic data changes every second and is quite unpredictable. (Manwaring, Carter, Romijn, Van der Lans & Soetendal, 2013). But, Autonomous technology starts to mature, this issue could be solved as they are not subject to human unpredictability. At the initial stage of autonomous technology, the existing apps from NS and 9292 would be considered for an upgradation to show more accurate timetable and combinations of different modes.
As the technology upgrades, an all new multi-modal app is excpected to develop which not only shows the best combinations of modes, but will also help in locating the nearest car stack, smartcard details, charging and recharing details for the vehicles.

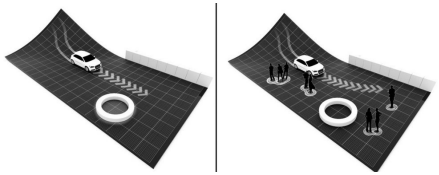
8] DEVELOPMENT OF AUTONOMOUS PUBLIC TRANSPORT

Urban public transport today caters to millions of commuters everyday. With the onset of autonomous technology, it will be obvious that the public transportation systems like buses and metros will adapt to it soon enough. Relevant to this project is the autonomous mini buses or shuttle buses for example the Park Shuttle project testing and operating in Rotterdam, The Netherlands. These buses are light weight vehicles with autonomous technology and travel shorter distance with increased frequency. This in turn creates more efficiency and will result in elimination of traditional public transit systems in the city as the technology upgrades.

9] BICYCLE SHARING PROGRAMS

Bicycle sharing programmes have been around for a while. The idea was first pitched in 1965 by the Dutch Provo movement under the name witte fiets. The idea was not realised until much later in 2000 when it was implemented under the name depo. Bicycle sharing programmes have been around for a while.





[103] Digital Information Systems
google

[104] Multimodal Apps
moovel

[105] Bicycle sharing programs
citibike

The idea was first pitched in 1965 by the Dutch Provo movement under the name witte fiets. The idea was not realised until much later in 2000 when it was implemented under the name depo.

10] FLEET OF AUTONOMOUS VEHICLES

For the purpose of achieving the car on demand scenario which has been chosen as a proactive role for the strategy proposed for this project, stacks and racks of light electric vehicles and bicycles at closely spaced intervals throughout a city plays a very important role. When the consumers which to get to certain destination, they can use a bike or walk to the nearest stack and pick up a car and reach the nearest stack to their destination or arrive directly at their destination. For example, the CityCars project proposes lightweight electric cars which fold, making them compact and efficient in the use of urban space. In Amsterdam's context these vehicles could be placed closer to smaller mobility hubs surrounding bus stops at the later stage of the technology. These cars could be integrated with smart multi-modal apps and will be placed closer to the hop in and drop off zones with a priority lane.

11] FLEXIBLE INFRASTRUCTURE

A user makes use of the infrastructure provided in the city in many ways depending on the situation. During peak hours, a street can be used for commuting, while in the off peak hours it could be used for recreational or commercial purposes such as markets, gatherings etc. This type of flexible infrastructure is already quite famous in Amsterdam. Currently however, this generates a lot of disruptions because not all users are aware of this temporary change where streets are closed down to automobiles and bikers alike. With the onset of AVs, these changes would automatically be recorded in the cloud and an immediate response can be made.

12] PARK+RIDE+CHARGE

The park, ride and charge hub is a parking garage that not only charges autonomous vehicles but also allows the user to leave the vehicle there while in transit to a certain destination and could be picked up on the way back. These garages are the solutions to re-purpose existing park and ride spaces in Amsterdam. These Park and Ride spaces are usually underground or multistory garages places in close proximity to major mobility hub and infrastructure. Currently, approximately one in four parking spots in Amsterdam's center are positioned in a garage (Gemeente Amsterdam, 2013b). If all privately owned vehicles were to be replaced with centrally owned rentable vehicles, a reduction of 80% in vehicles would be possible (Claudel & Ratti, 2015), combine this with the premises that automated vehicles will require less space for parking (Fagnant & Kockelman, 2015) and it could become possible to cater to all parking needs with existing garages if the sharing economy flourishes and people are encouraged to use their car as an important asset to the sharing economy. In their project 'Auto Correcting', De Waart and Nap (2016) have explored park and charge hubs in combination with hop in drop off zones in Amsterdam. Here, the hub takes over the vehicle storage function of parking spots and is an active spot during off peak hours located sloe to infrastructural advantage points

13] Pop- up public spaces

With the onset of the technology, smarter cars will mean cars that occupy less space which will lead to less resources associated with parking spaces.

[106] Autonomous Public Transport
EZIO

[107] Fleet of autonomouc light weight vehicles
MIT on demand Mobility Systems

[108] Park,Charge and Ride
Flexway, Autocorrecting

[109] Flexible infrastructure
Flexway, Autocorrecting

As technology advances and more cities begin to adapt, the shift will put pressure on the municipalities to re-purpose empty floors of parking garages and eliminate on street parking. As the cars can valet themselves, flexible spaces around the city could be use to park these cars at peak hours and off peak hours.

A quick revision of zoning laws and far sighted planning, these spaces could be regenerated to adapt to the developing technology. As the space empties out and most of the on street parking is Eliminated, these spaces could be used to bring in the concept of flexible and pop up public spaces. The parking garages could be re-utilized for commercial and recreational purposes and the space saved up from the on street parking could be used for creative bike parking, hop in drop off spots for autonomous buses and cars, BBQ spots, seating areas etc. to improve the living quality of the streets.

14] PRIORITY LANES AND HOP IN DROP OFF ZONES

A priority lane as it name suggests, gives priority to its users, meaning that people using a priority network theoretically never have to stop.

Priority lanes can be designated for any mode of transport. In the context of this project, priority lanes are proposed for bikes, autonomous cars and autonomous public transport system. The importance of priority lanes for autonomous vehicles lies in providing flexibility to other r modes of transport as these vehicles can concert their arrival time at intersections, maintain a constant speed and travel in convoy driving.

Hop in drop off zones are zones located around the city where people can summon and get picked up by an Autonomous Vehicle or can get dropped off by an Autonomous vehicle. In their project Auto-correcting, De Waart & Nap, 2016 describe these zones in detail coining the term Hodos for these zones.

These zones also comprise of wifi enabled digital displays which indicate vehicle arrival times and can be used to summon a vehicle by users who do not own a smart phone. For this project, these zones are placed along side the public transport stops or to re-purpose on street parking.

Additional functions can be paired along with these zones such as autonomous car stacks, bike racks, benches etc.

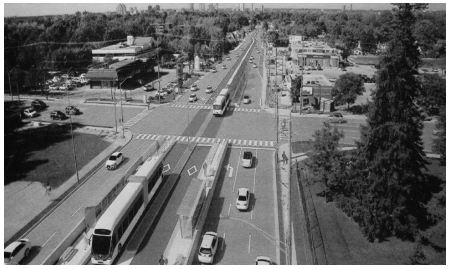
Ideally these zones and public transport spots should be placed within walking distances for ease of access. These spots might also be indentified as a network of sub nodes of a large mutimodal node system for greater efficiency.

16] SHARED SPACES

Shared space concept comes from an urban design tool developed by Dutch traffic engineer Hans Monderman (Hamilton-Baillie, 2004).

Its goal is to provide priority to susceptible road users and to reduce separation between different modes of transport by eliminating curbs, road surface markings, and signage (Pharoah & Russell, 1991). The concept aims to make roads safer by removing safety measures.

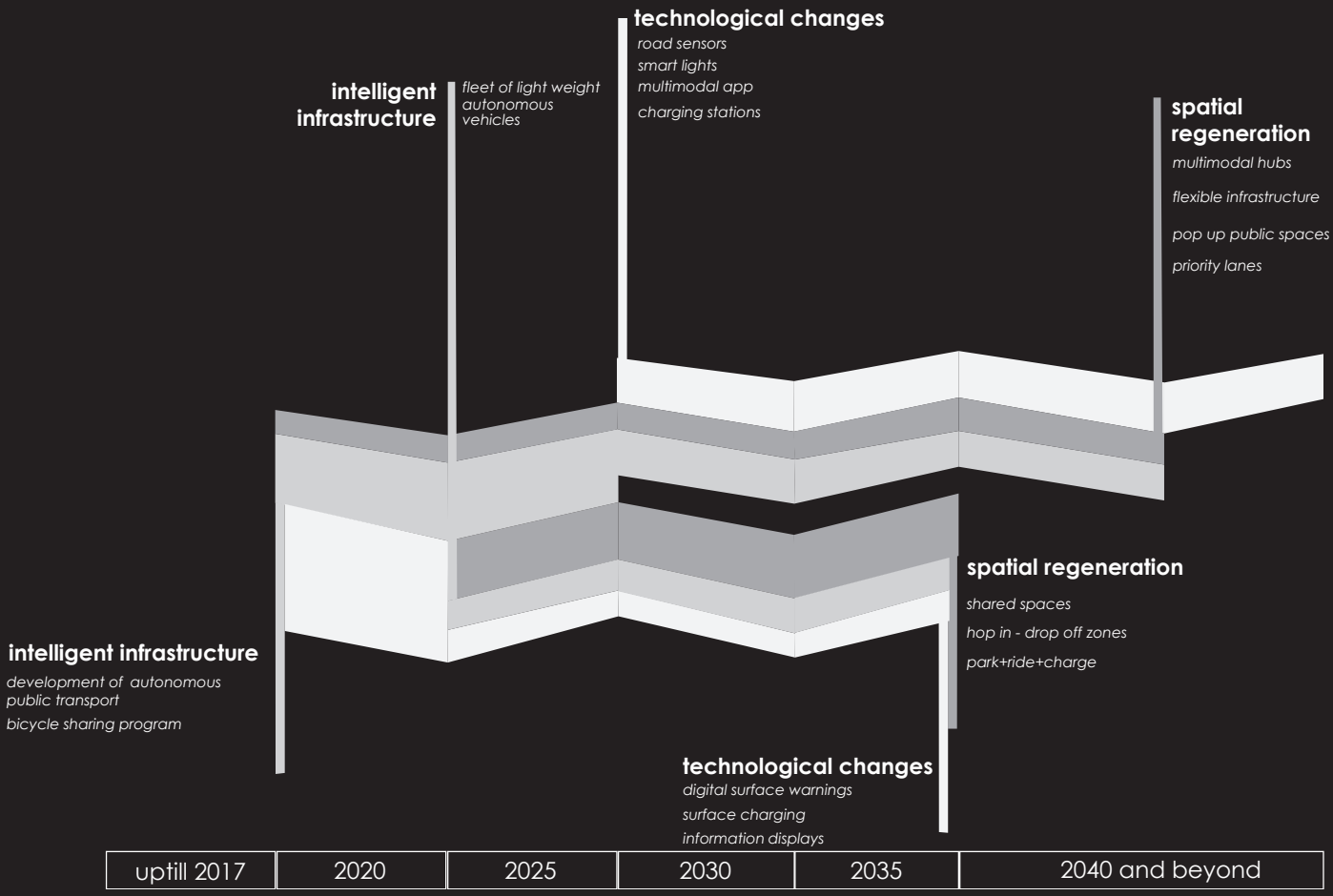
Automated vehicles can improve the functioning of shared space because they are not prone to human error and can thus interact with other modalities more safely and efficiently.



[110] Pop up public spaces
google

[111] Priority Lanes and Hop in Drop off zones
google, autocorrecting, audi urban initiative

Timeline and Combination of tools



[112] Timeline of the tools in the Approach Guide
Author

Timeline of Tools
After establishing the approach guide and the tools it suggests, it is important to understand the timeline of the implementation of these tools. As the autonomous technology will appear in stages, these tools correspond to these stages and develop along the way.

The first stage before the onset of the technology more or less begins with the government initiative sand the tools that fall under it. From 2020 onwards changes will be observed in the form of intelligent infrastructure while the technological advancement is still at its formative stage.

As it matures, technological changes will occur more rapidly than expected in order to adapt to the upgrades.

Combination of tools
As each of these concepts have spatial implications, the regeneration process begins hand in hand with the development of intelligent infrastructure and keeps developing till the technology is fully matured by the year 2040 and beyond.

These tools could be implemented separately but they have more value when they work together in combinations. Hence, it was important for this project to research these combinations which would later be applied to various aspects of the city.

The illustration also shows the dependency, support, co-existence and leading relationship between these tools. This gives a better insight into using these tools in the best possible combination to contribute to the urban design and urban planning interventions to be taken at different parts of the city.

Guidelines

Planning Guidelines

Co-operation of public transport authorities and the autonomous car companies in terms of creating integrated mobility hubs

Establishing improved multi-modal transportation solutions in the technology

Regulations on Road User and Parking Charges

Incentives and initiatives to encourage sharing economy

Strong mobility business models

Public awareness and acceptance

Policies and regulations to promote new forms of public- private collaboration

Planning Guidelines
In order to implement the tools mentioned in the previous sections, following guidelines are suggested.

1) Co-operation of public transport authorities and the autonomous car companies in terms of creating integrated mobility hubs

2) Establishing improved multi-modal transportation solutions in the technology

3) Regulations on Road User and Parking Charges

4) Incentives and initiatives to encourage sharing economy

5) Strong mobility business models

6) Public awareness and acceptance

7) Policies and regulations to promote new forms of public- private collaboration

These guidelines help in achieving the long term goal of developing a city with mobility on demand model.

To regulate on street parking and use of shared autonomous vehicles, policy and regulations on road users and parking form a great basis to implement elements of On demand mobility model.

In the initial stages of the strategy, the government and local bodies are advised to incentive the use of shared vehicles, especially the use of personal vehicles as shared transport among neighbors.

Amsterdam today has already established initiatives that encourage sharing in terms of housing, mobility, tourist facilities etc. These incentives will strengthen this idea of sharing among communities contributing to the economy.

These guidelines suggested are intended to assist urban planners and designers while implementing the tools mentioned in the previous sections.

Urban Design concepts

Flexible spaces

Technology Friendly

On street parking to on street parklets

Integrate multiple activities in a safe environment to demonstrate the co existence of various activities along with modes of transport

Decultter the streets

Repourposing existing car parks

Urban Design Guidelines
The urban design concepts are guidelines for tools with strong spatial implications such as the set of tools under Spatial Regeneration concept.

These concepts allow the planners and designers to re-create spaces which are flexible and people friendly.

The following are the urban design concepts that form the foundation of implementing car on demand mobility systems in the long term.

1) Flexible spaces

2) Technology Friendly

3) On street parking to on street parklets

4) Integrate multiple activities in a safe environment to demonstrate the co existence of various activities along with modes of transport

5) Decultter the streets

6) Repourposing existing car parks

These guidelines aim to promote the reuse of space in the long term as the number vehicles taking up space on ground is expected to reduce. The space thus saved could be used for various other activities along with mobility functions.

It is expected that the num ber of vehicles parked on street might reduce drastically by the year 2040. This assumption has made keeping in mind the Amsterdam 2040 strategy is successful.

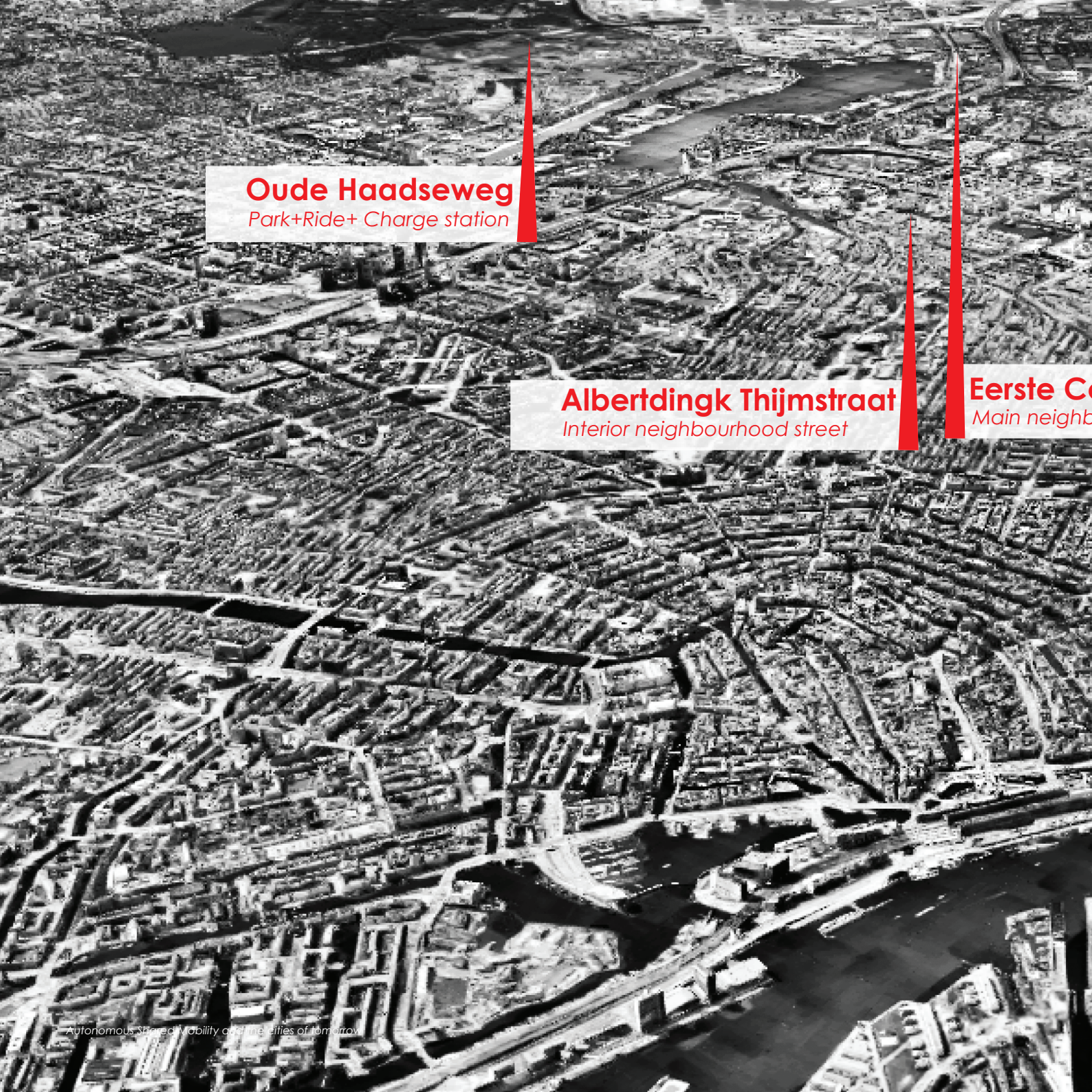
The car ownership will likely decrease and the number of cars on street could be diverted to the underground parking systems in the city and repurposing them as parking hubs with integrated commercial and business functons.

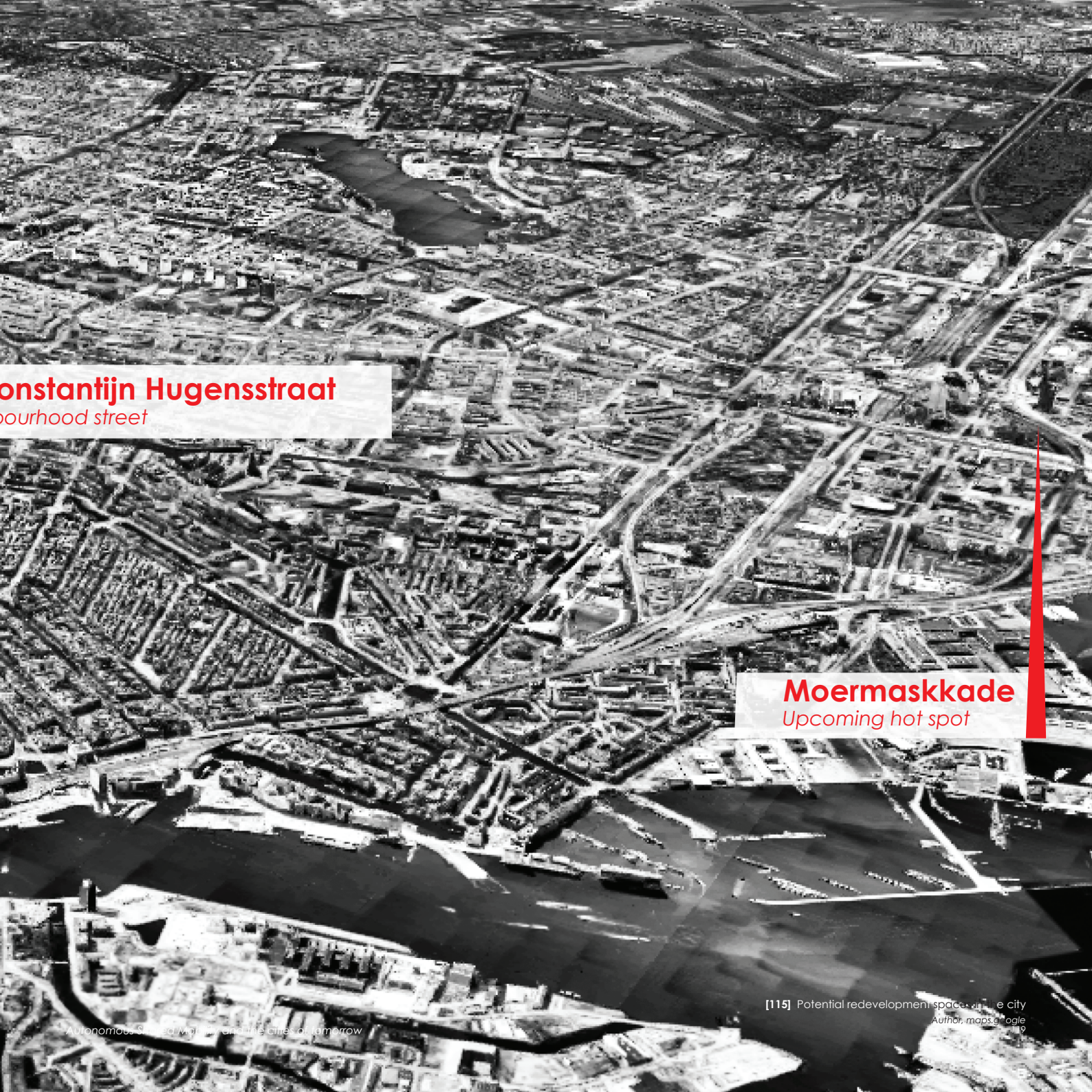
As the strategy works so closely with the technology, it is expected that the designers of this freed up up space integrate the technological elements with the design of the new space.

The next chapter will focus on suggesting these guidelines and tools in different parts of the city such as park and ride surface parking stops, vacant industrial plots and neighbourhood streets.

7
Recommendations

Quality
of
spaces


Oude Haadseweg
Park+Ride+ Charge station
Albertdingk Thijmstraat
Interior neighbourhood street
Eerste C
Main neighb



[115] Potential redevelopment space in the city
Author, maps.google

This section will dive into revealing the potentials space has to accomodate the long term strategy for Amsterdam by the year 2040.

The outcomes of this project would consist of illustrations of selected futures, representing the impact of Autonomous shared vehicles in different locations in Amsterdam. The purpose of the is not just to provide visualization but an understanding of the opportunities the technology will offer to the city.

With the help of guidelines and the approach guide and its tools, the idea is to apply them onto to aspects of the city such as streets and parking spaces with the best possible combinations to understand the impact the technology would have on the city with each of them explained in a chronological order of current, 2025 - the right mix of everything scenario and 2040- car on demand mobility systems.

Each of the illustrations depecits the tools used and the new features developed in the process. The illustration shows the different kind of spaces that have been chosen in the city.

Parking

As discussed during the city analysis stage of the the project, there are various types of parking spaces in the city. Most prominent of these spaces are the underground parking garages. These garages will play a very important role in taking the cars parked off of the streets.

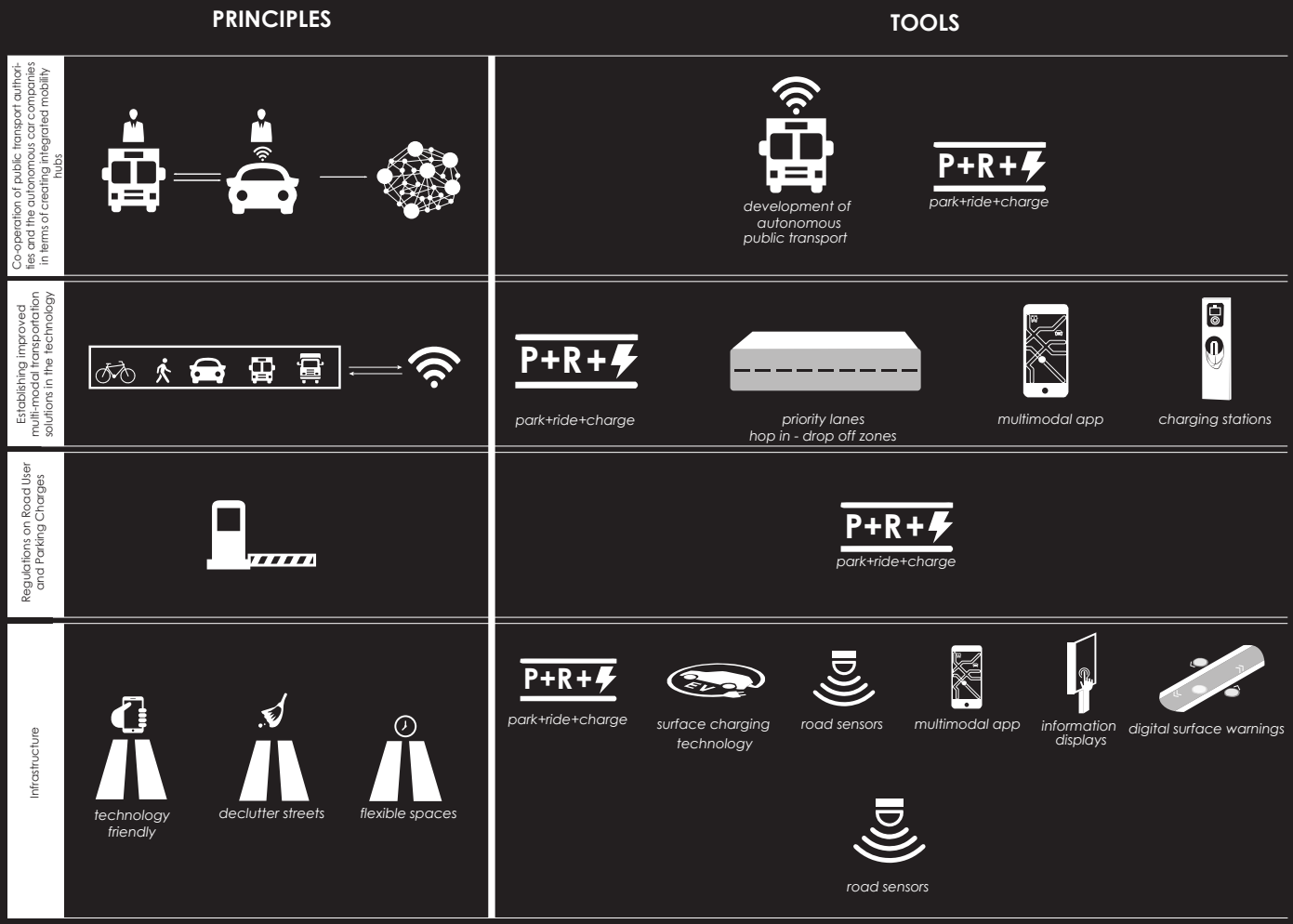
The design of these garages is purely technological and many studies have already been conducted and hitech underground garages have been designed. such as sub canal parking. It is assumed for this study that in long term underground garage shave gone through this change.

Another type of parking space observed in the city is the Park+ Ride systems. These are of two types. One is the usual underground or multistorey parking and the second one is on street parking placed closed to public transport stations.

These park and ride systems are placed either at highways or at places where use of private vehicles is restricted. These systems act as a perfect transition point where a person can leave thier vehicle and use the public transport to get to thier desired location.

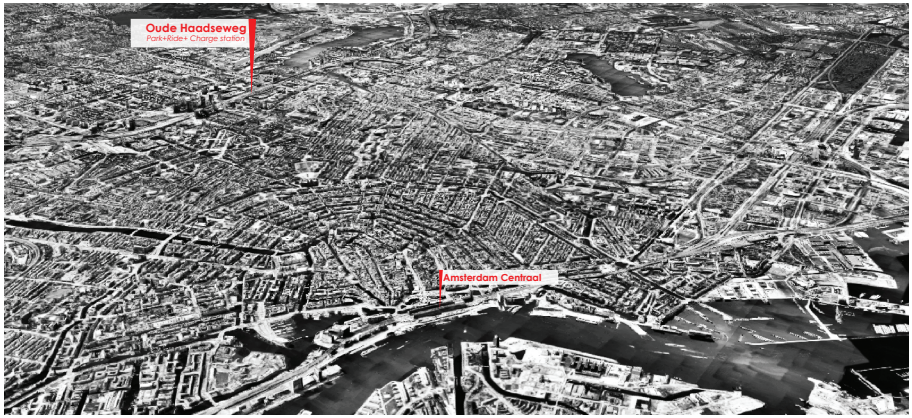
To integrate the technological aspect to these park and ride systems in the city, its necessary to think about the fact that autonomous vehicles will essentially run on charging systems. Hence, to re use the already existing infrastructre, these spaces could be upgraded into park, ride and charge systems integrated with autonomous public transport.

The illustration on the next page shows the guidelines and tools suggested to tap the potential this space has to offer.



[116] Guidelines and tools for implementaton on street parking

Author



As indicated in the map, A park and ride system in the Oude Haadseweg was chosen. The following illustrations use this existing Park and Ride space in the city and provides an upgrade of Park, Ride and Charge space

[117] Oude Haadseweg
Author

[118] Oude Haadseweg in the transition stage in the year 2025
Author

During the transition stage from the current situation to an autonomous multi-modal city situation by the year 2025, The space will observe some major changes mostly in terms of technology and intelligent infrastructure.

Hence, following the guideline and tools, the following features are suggested:

1) App controlled vehicle pick up and drop off area

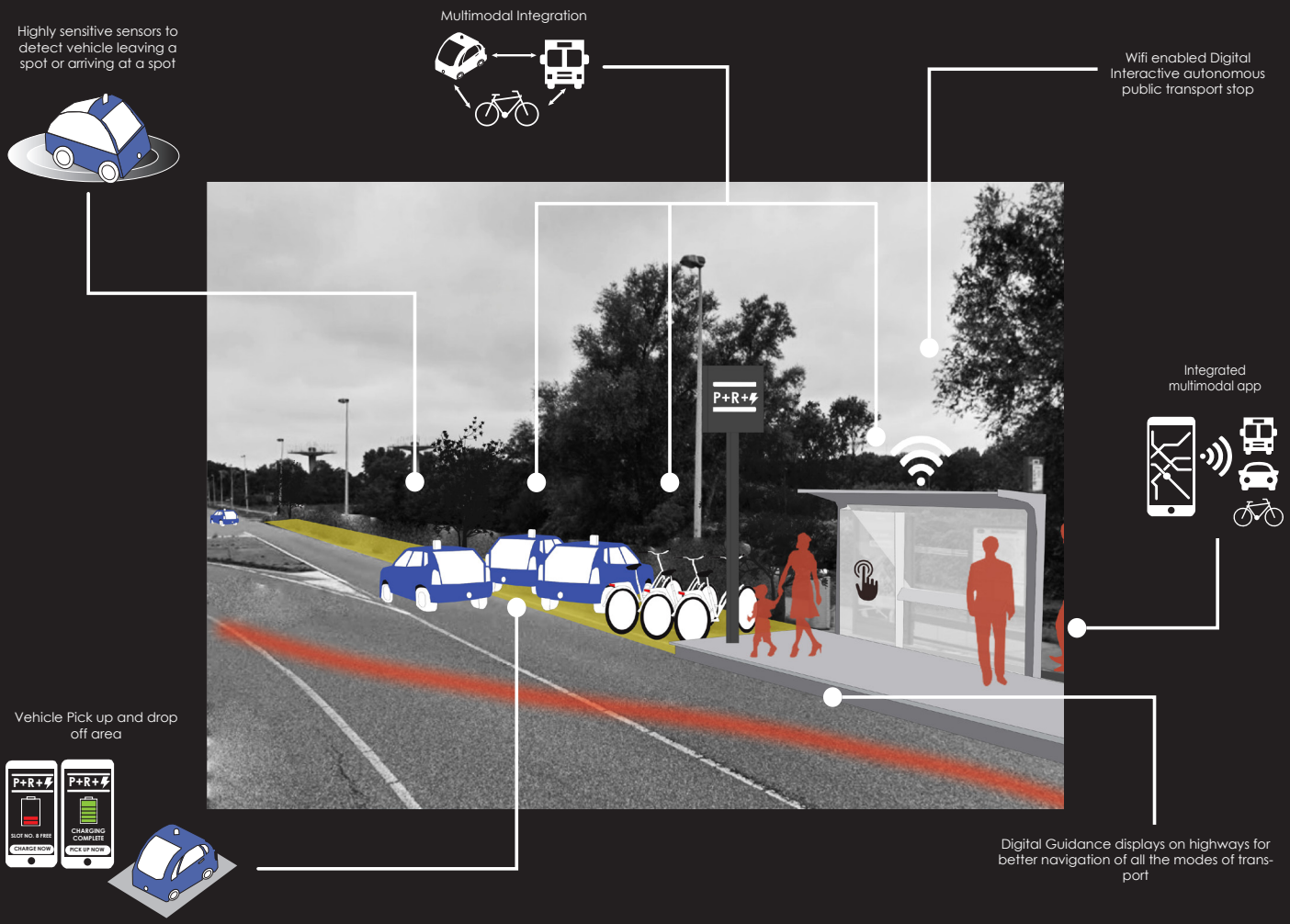
2) Priority Lane for the upgraded Autonomous public transport shuttle buses

3)Wifi enabled public transport stop

It is also important to note here that the number of vehicles parked on the street might slightly reduce and road sinages might not remain.

These features are accompanied by primary senors in the infrastructure and in the cars. This space also stands as an example for multi-modal integration of available modes of transport at the initial stages.

These features also enable efficient regeneration of haphazard parking space and add the efficiency factor to it.



[119] Oude Haadseweg in the long term by the year 2040
Author

By 2040 this space will be transformed into a more efficient Park, Ride and Charge space with the following added features:

1) Accessibility of this space will completely lie under the hands of the integrated multi-modal app

2) Wifi enabled Digital interactive public transport stop offers an efficient and smooth travel experience.

3) With an upgrade for charging stations and sensors fitted to the vehicles and roads, the process of finding a spot for the car is easy and comfortable.

It is important to note here that these spaces not only offer a stack of centralized car sharing vehicles but used also for personal autonomous vehicles which would still persist. These vehicles would be charged to pay more in order to keep their use limited.

A bicycle rack is also available at this stop making it a sub multi-modal node with the availability of different choice of modes.

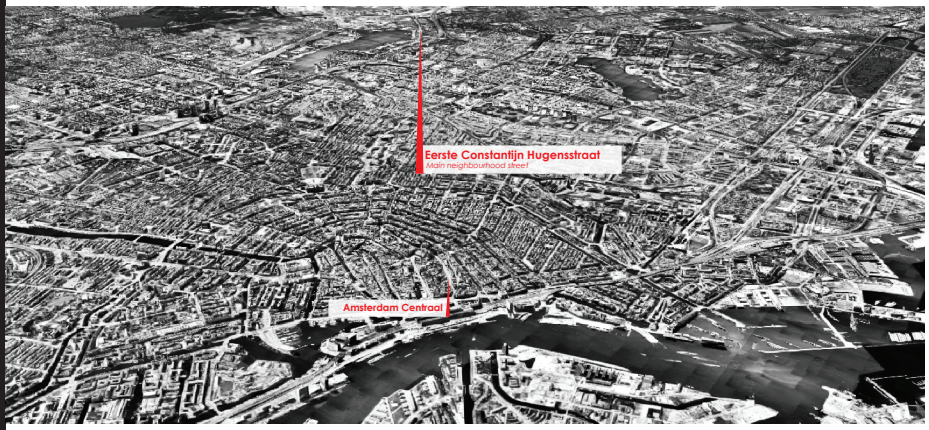
Streets

The next aspect of the city to explore the impacts of the technology is the streets of Amsterdam.

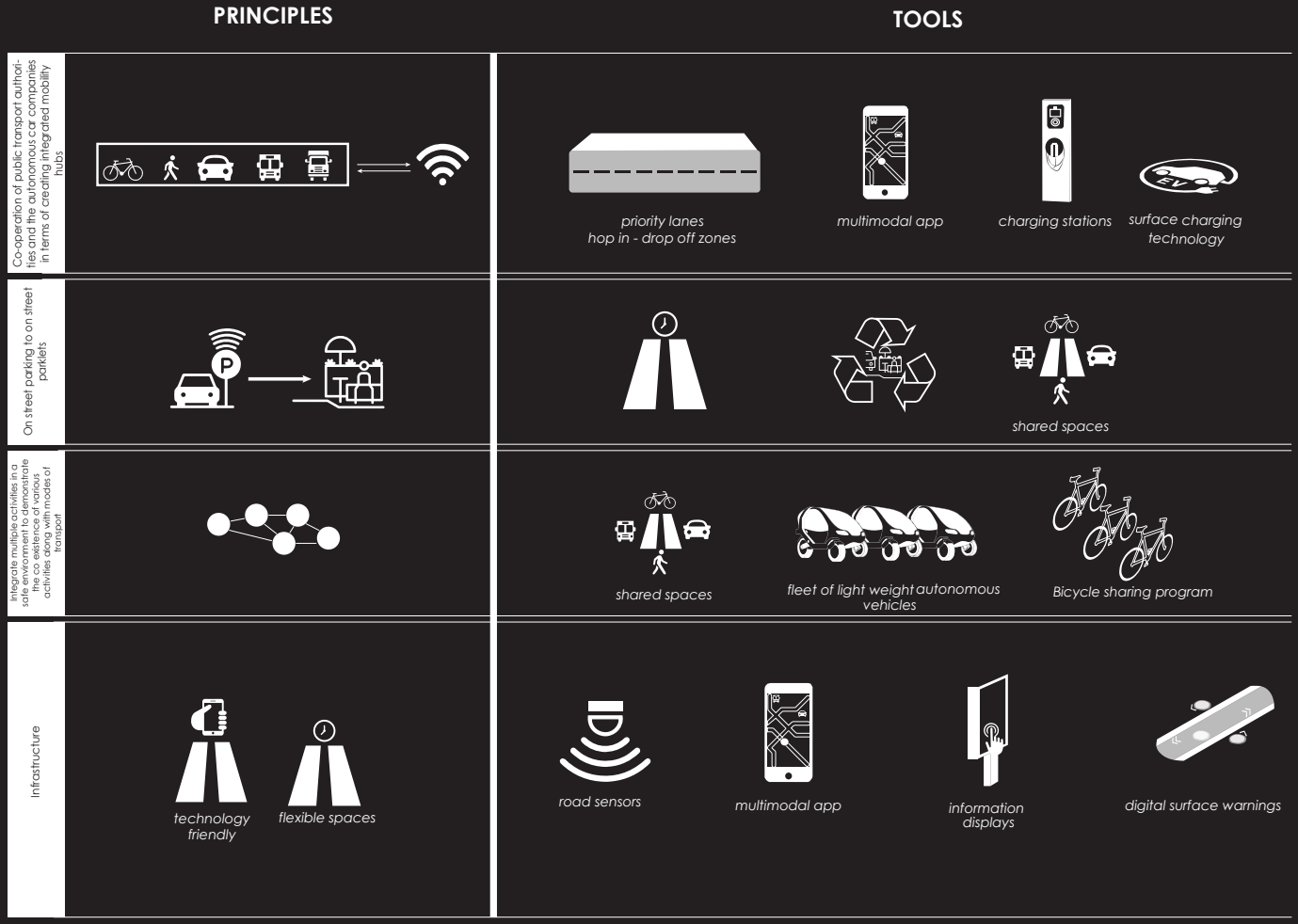
For the convenience of the project, a neighborhood block in the oude west neighborhood of the city was picked.

The idea is to show how the streets change over time as the technology keeps getting upgraded i.e to the current situation, 2025 situation and 2040 situation in sequence.

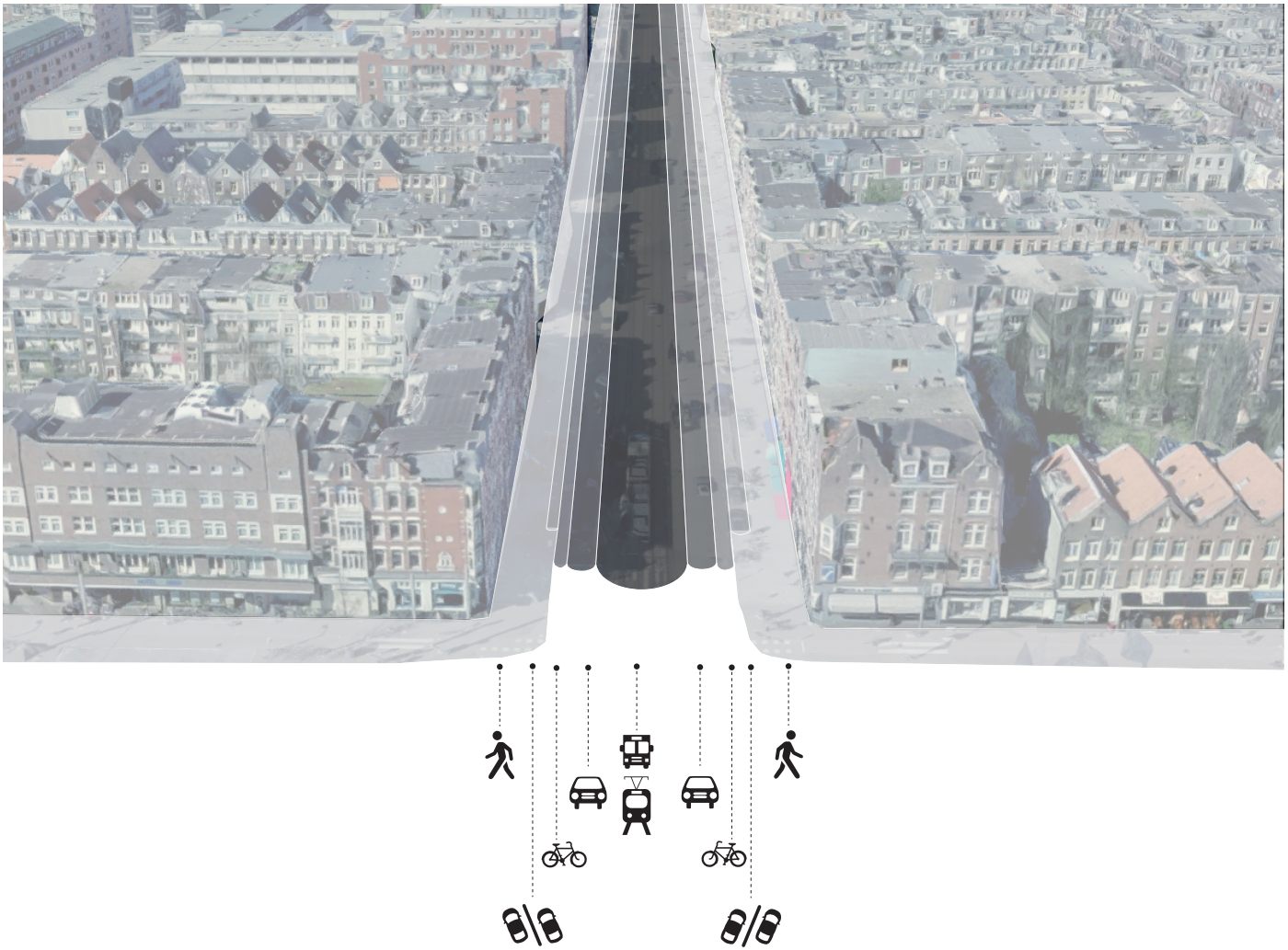
These illustration on the next page depicts Guidelines and tools which could be used to induce different kind of functions on the street.



[120] Eerste Constantijn Hugensstraat
Author



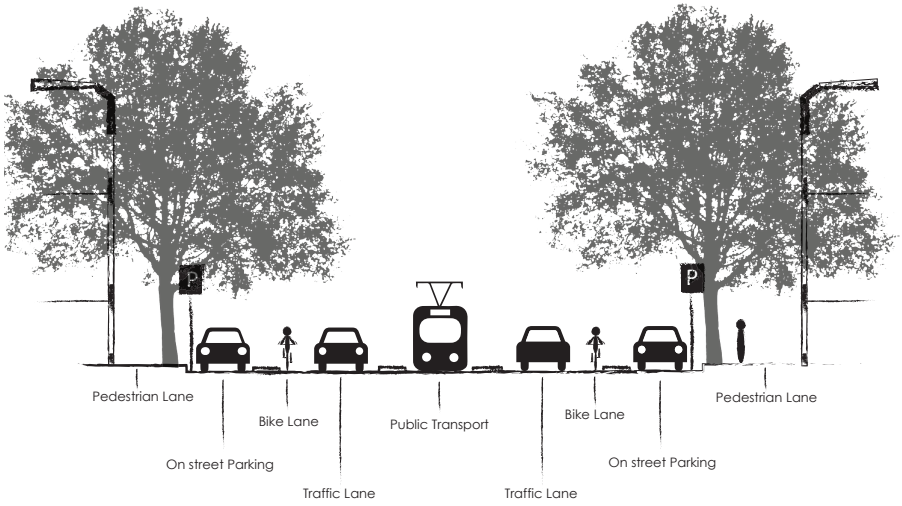
[121] Guidelines and tools for implementaton on streets
Author



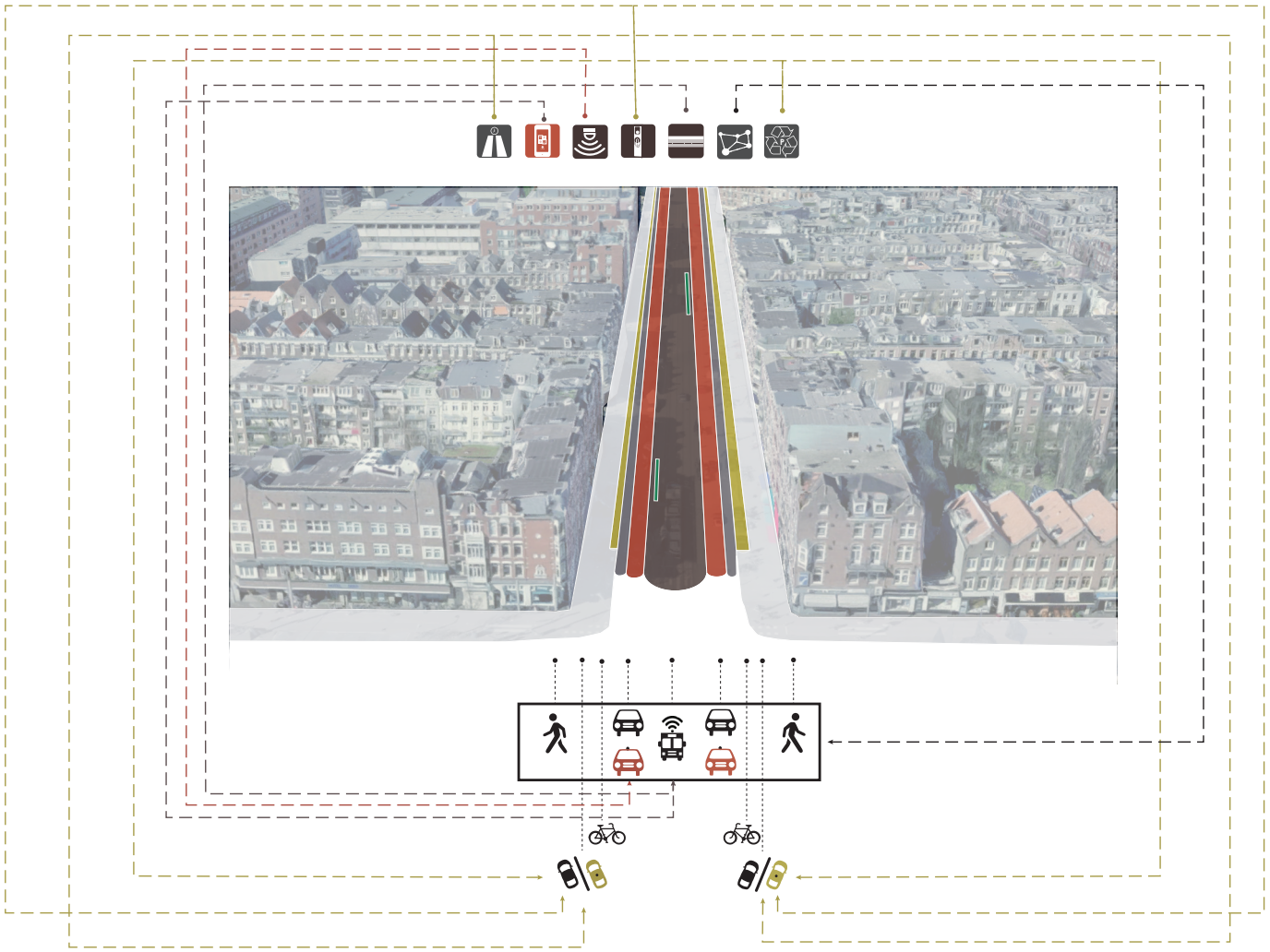
[122] Connector street visualized for the current situation
Author

The street Eerste Constantijn Hugensstraat has been chosen and is depicted as it is today.

This can be classified as a typical two way main connector street in Amsterdam consisting of a backbone lane of public transport catering to buses and trams accompanied buy bike lanes, car lanes and pedestrian lanes with on-street parking.



[123] Connector street section today
Author
131



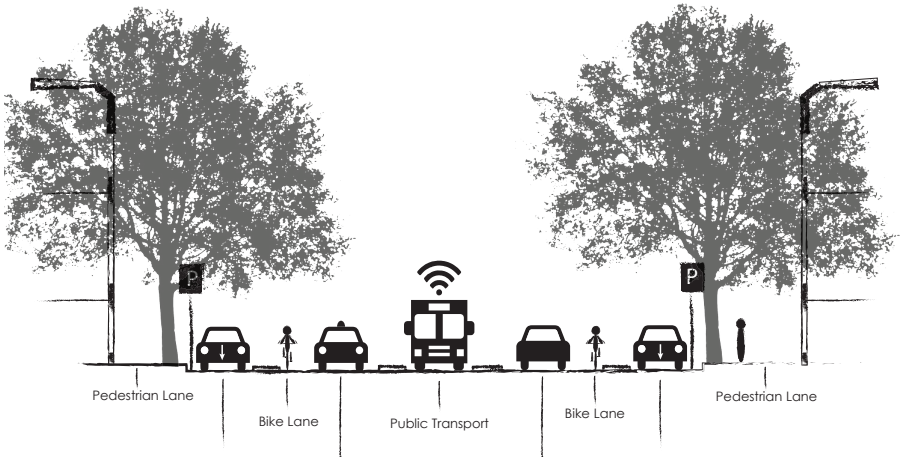
[124] Connector street visualized for the year 2025
Author

The illustration here shows the street as it would be in 2025 when autonomous multi-modal systems will be implemented.

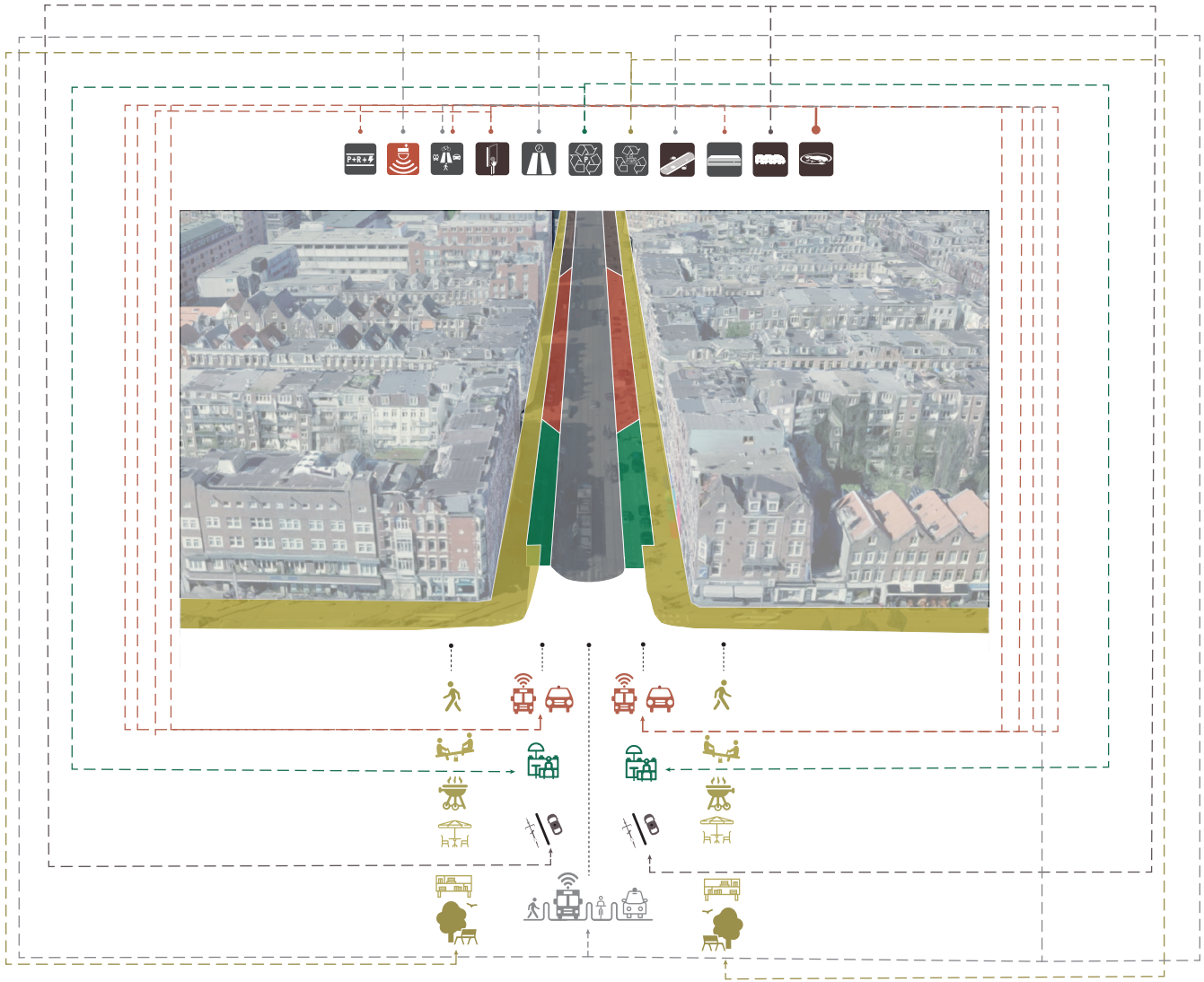
In this typical two way main connector street in Amsterdam, the major change would the elimination of the traditional public transport and instead replaced with autonomous shuttle buses. To facilitate these buses, the existing bus lane is used as the priority lane. The infrastructure receives an upgrade in terms of installation of sensors to adapt to the sensors on the vehicles and energy efficient charging stations.

Using the existing apps like 9292 with the autonomous upgrade, the public transport arrival timings can be determined by the users. The major two way car lane will be shared by both autonomous personal, shared and non autonomous vehicles at this stage and due to this some parts of the street could be freed up for the concept of shared streets.

It is important to mention here that due to the transition phase during this period of time, the onstreet parking might still prevaill.



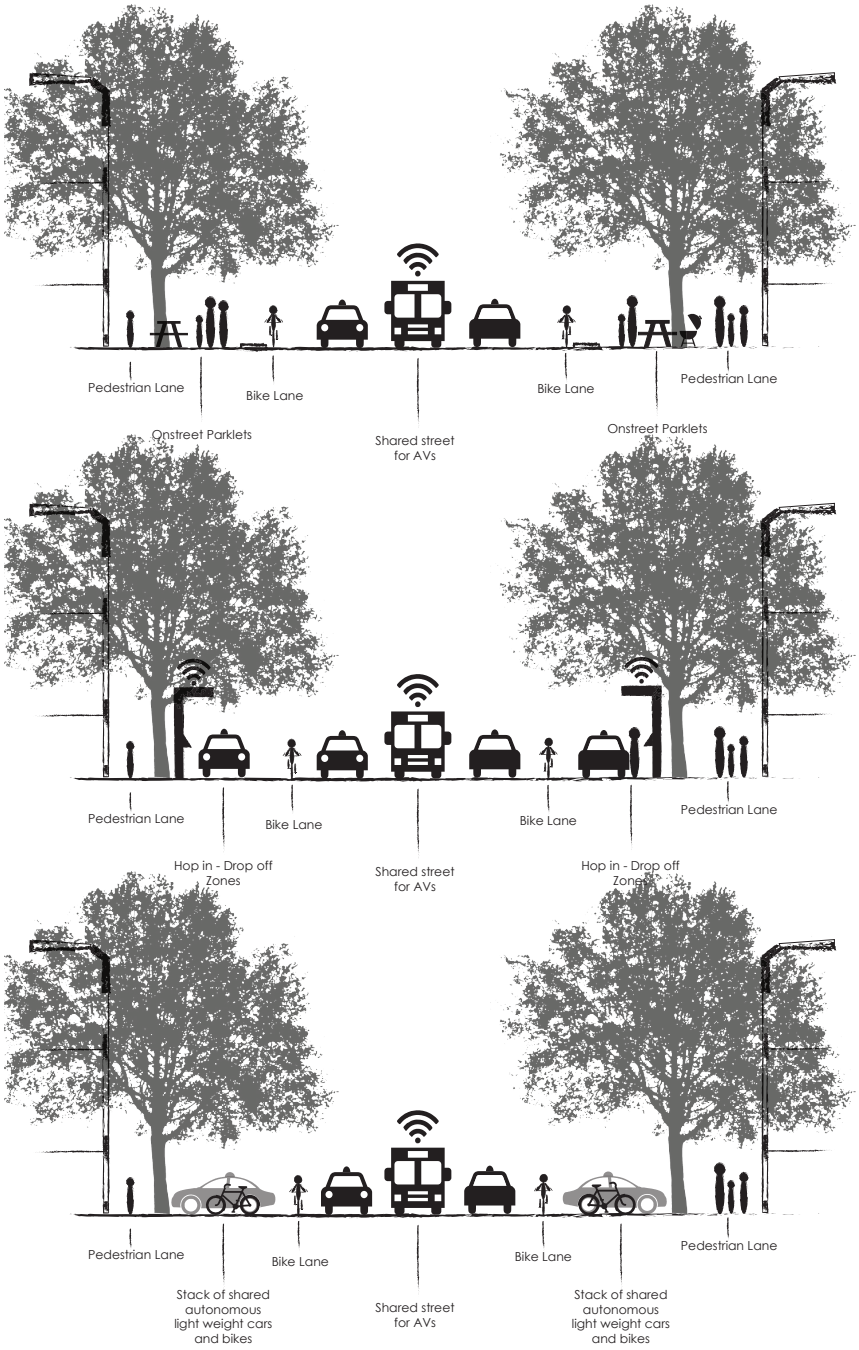
[125] Connector street section for the year 2025
Author



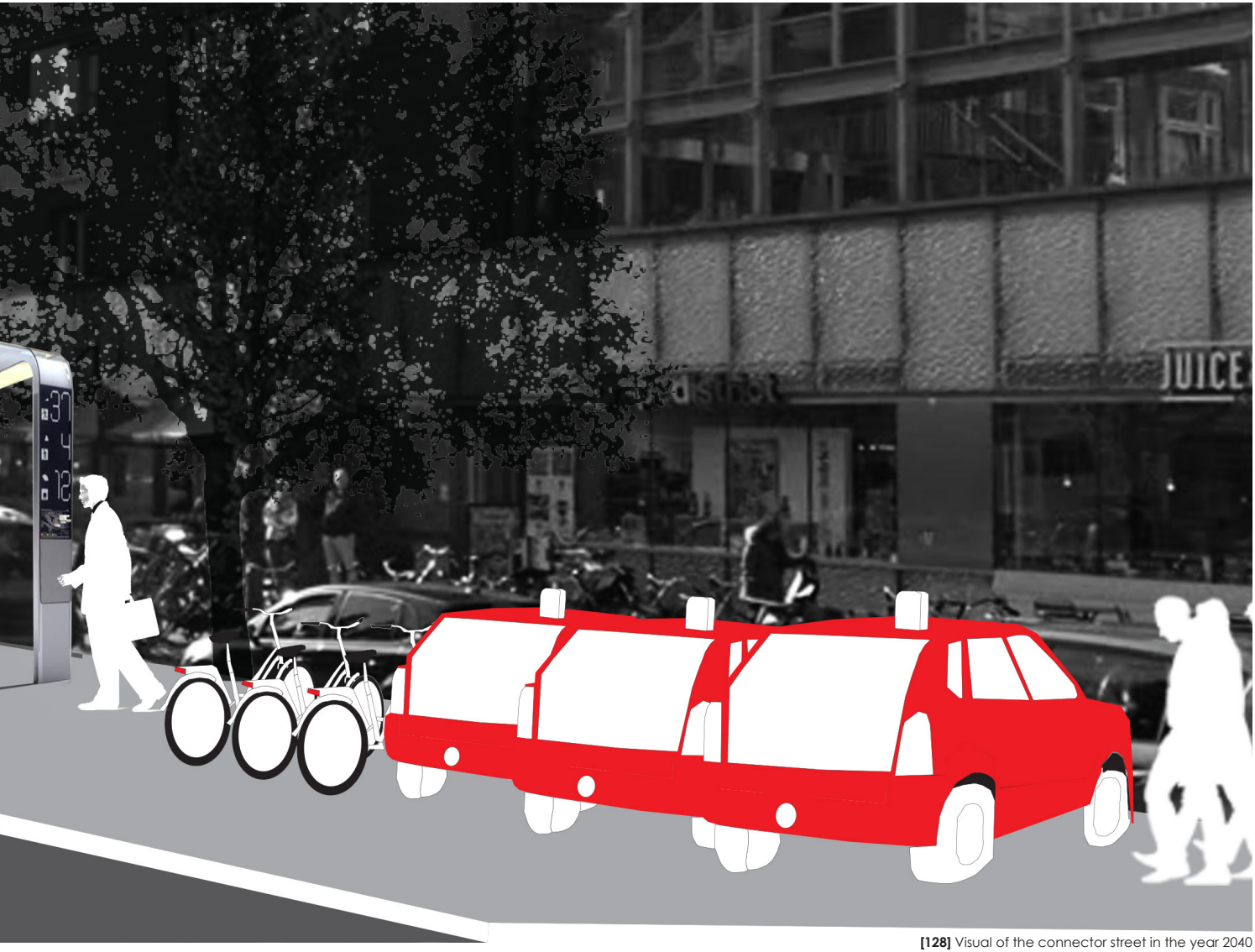
[126] Connector street visualized for the year 2040
Author

The illustration here shows the street as it would be by the year 2040. Changes in the previous sequence i.e. in 2025 will facilitate the changes in the this car on demand system for successful implementation. Many of the tools at this stage receive an upgrade and some new features are applied as follows:
1) Existing PT stops would now be transformed into Hop in drop off zones with the Park, ride and charge function and digital information displays combined along with it.
2) Due to the space freed up the idea of flexible shared streets is now applicable. The safety of this feature could be provided by digital displays on the street.
3)Centrally owned car fleet racks would closely be located to the PT stops for ease of access.
4) Due this organization of space, haphazard on-street parking is eliminated and creates space for various temporary and permanent functions such as pop up parks, cafes, libraries and pop up playgrounds.

These combination of tools could be applied in any connector street in the city to create livable streets the space could be available for various other temporary purposes such as cafe extensions, seating spaces etc.



[127] Connector street section for the year 2040
Author



[128] Visual of the connector street in the year 2040
Author

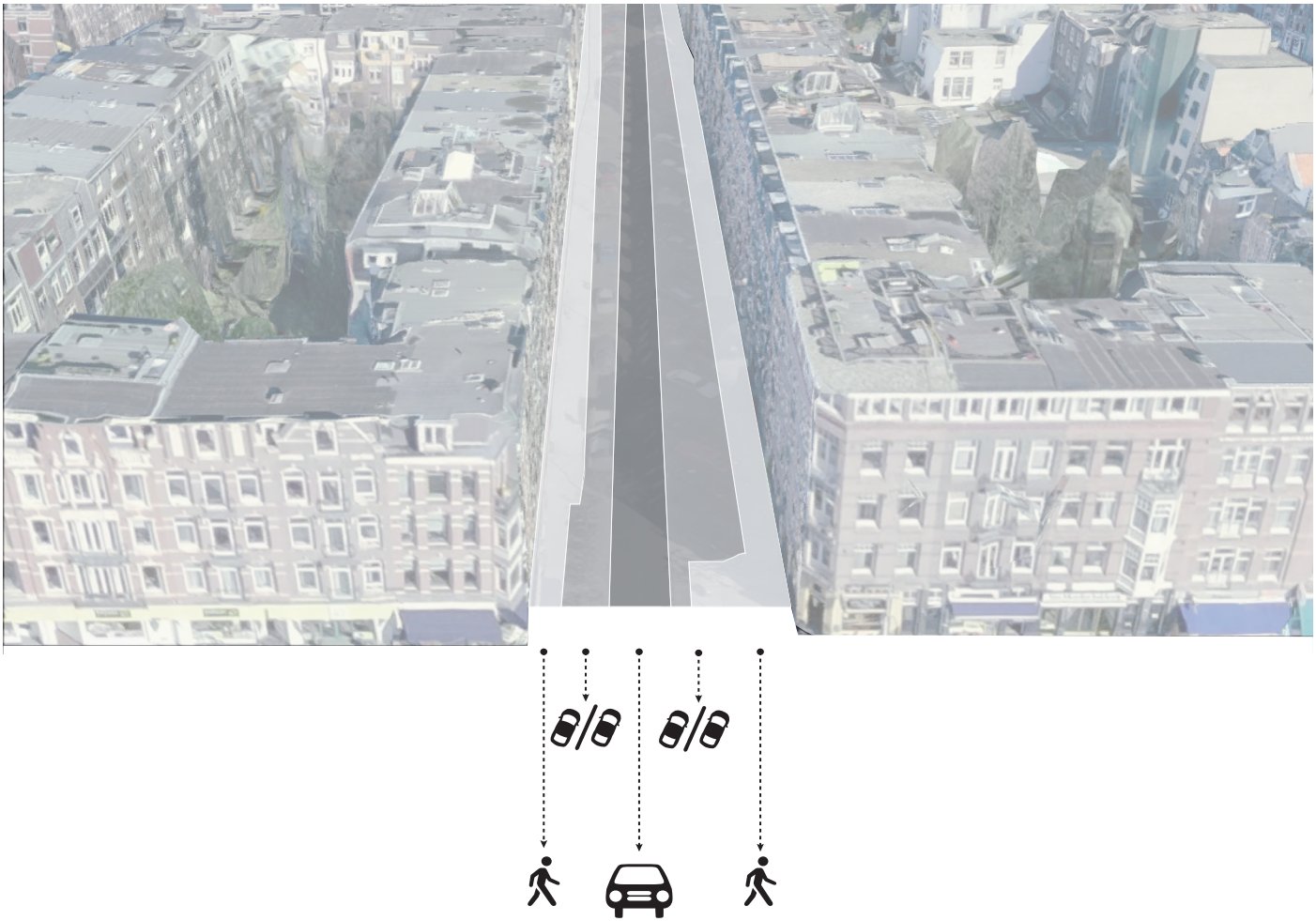
Zooming into the neighborhood streets in the block, it can be clearly stated that these are very narrow streets with most of the space occupied by cars parked on either side of the street. This leaves very small percentage of the street for moving vehicles and bikers in that area.

The idea is to show how Albertdingk Thijmstraat changes over time as the technology keeps getting upgraded i.e to the current situation, 2025 situation and 2040 situation in sequence.

The following illustrations depict guidelines and tools used to induce these functions on the street same as for the connector streets show above.

This illustration shows the street as it is today.

[129] Albertdingk Thijmstraat
Author



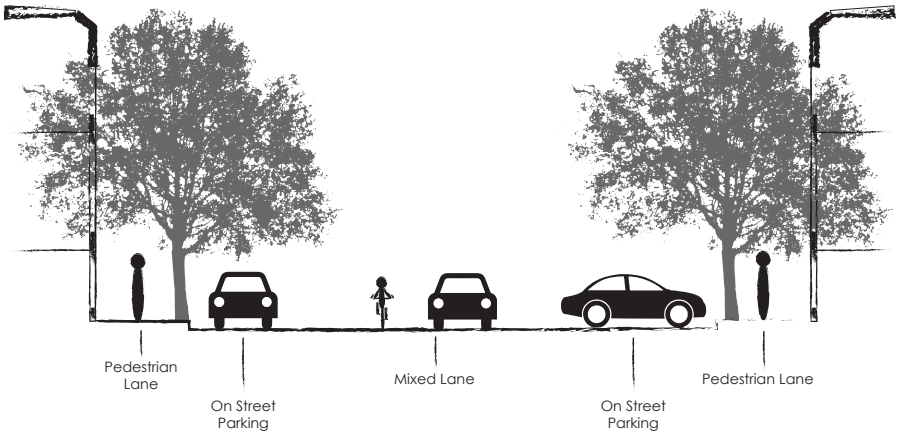
[130] Neighbourhood street visualized for the current situation
Author

At the initial stage of the development of the technology, the street will experience the following change:

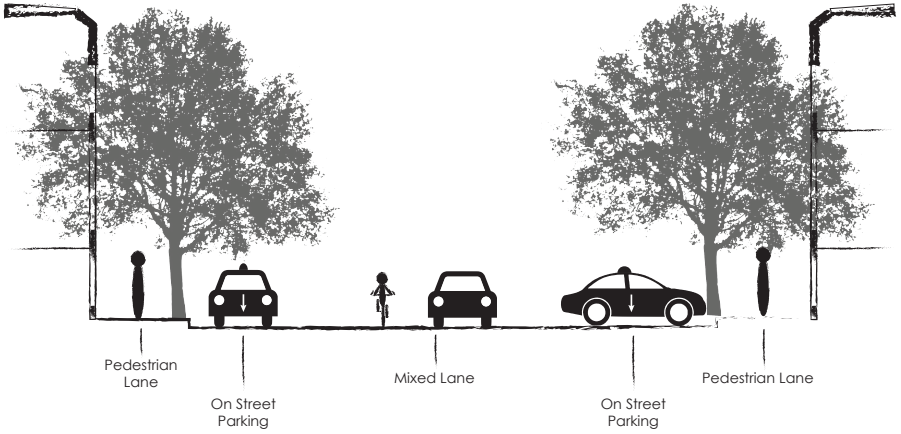
1) Charging infrastructure and sensors would be installed in these streets for better communication with the personal and shared autonomous cars operating in the street.

It is also expected that these streets might observe a slight decrease in the on street parking as some of the neighbours might opt to start using the sharing services for autonomous vehicles. The leftover space can be used by the families living in that street to come together for temporary events such as barbecue on a sunny day or play area for children during peak hours etc.

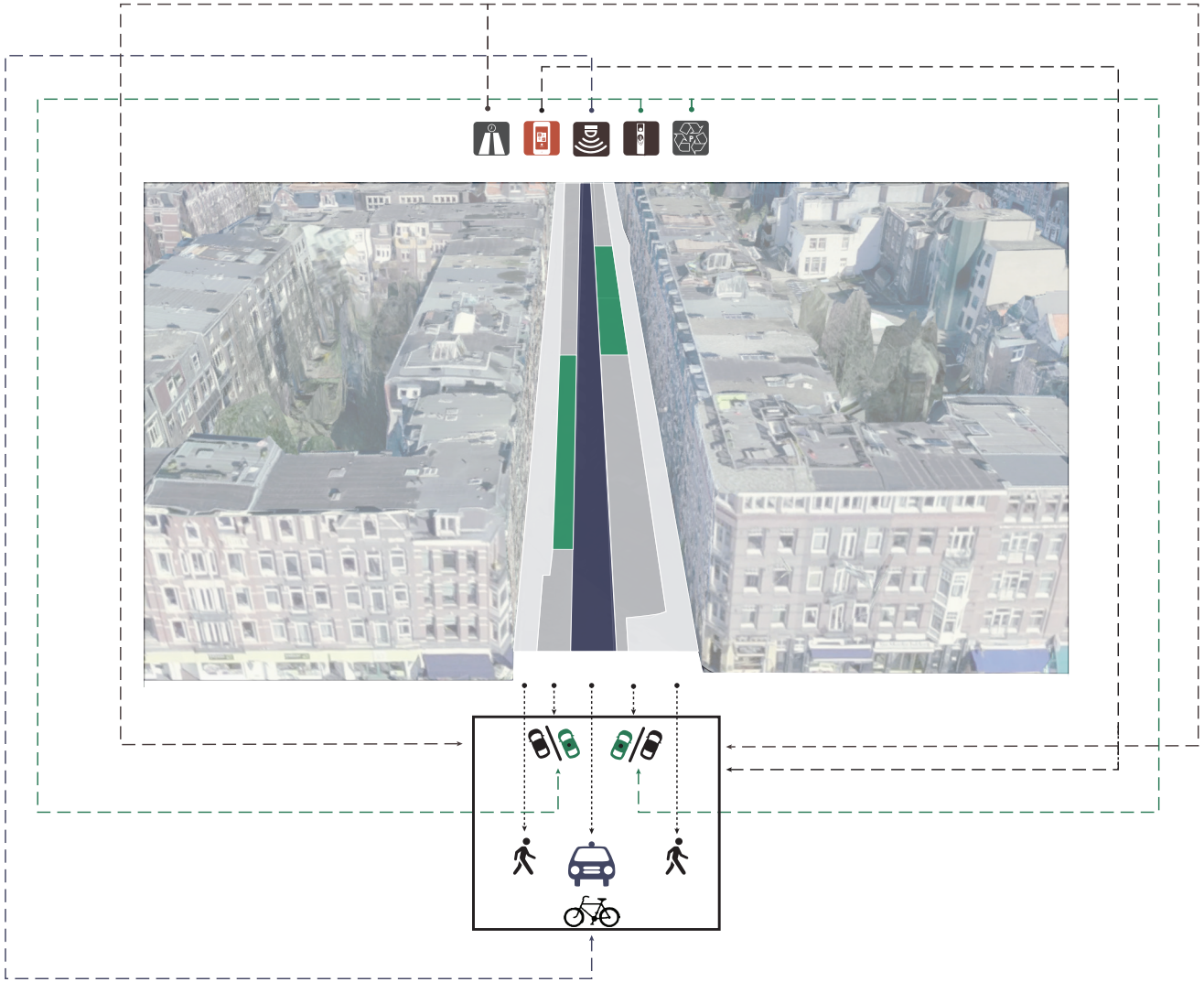
These changes will help revitalize the streets space and also help in facilitating any changes that could occur in the coming years.



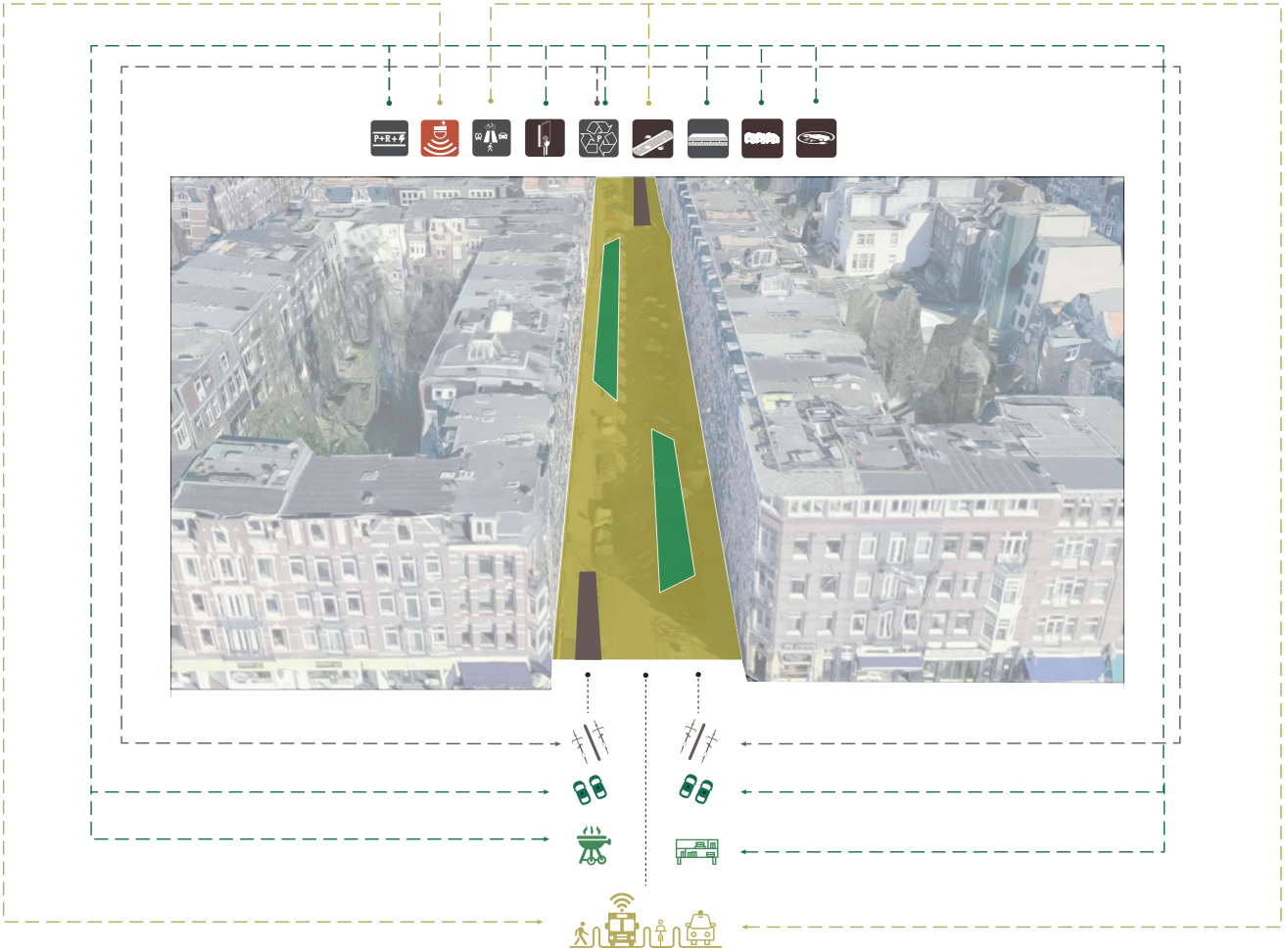
[131] Neighbourhood street section today
Author



[133] Neighbourhood street section in 2025
Author



[132] Neighbourhood street visualized for the year 2025
Author



[134] Neighbourhood street visualized in the year 2040
Author

By the time car on demand system is operational in 2040 the narrow neighborhood streets will experience the following changes:

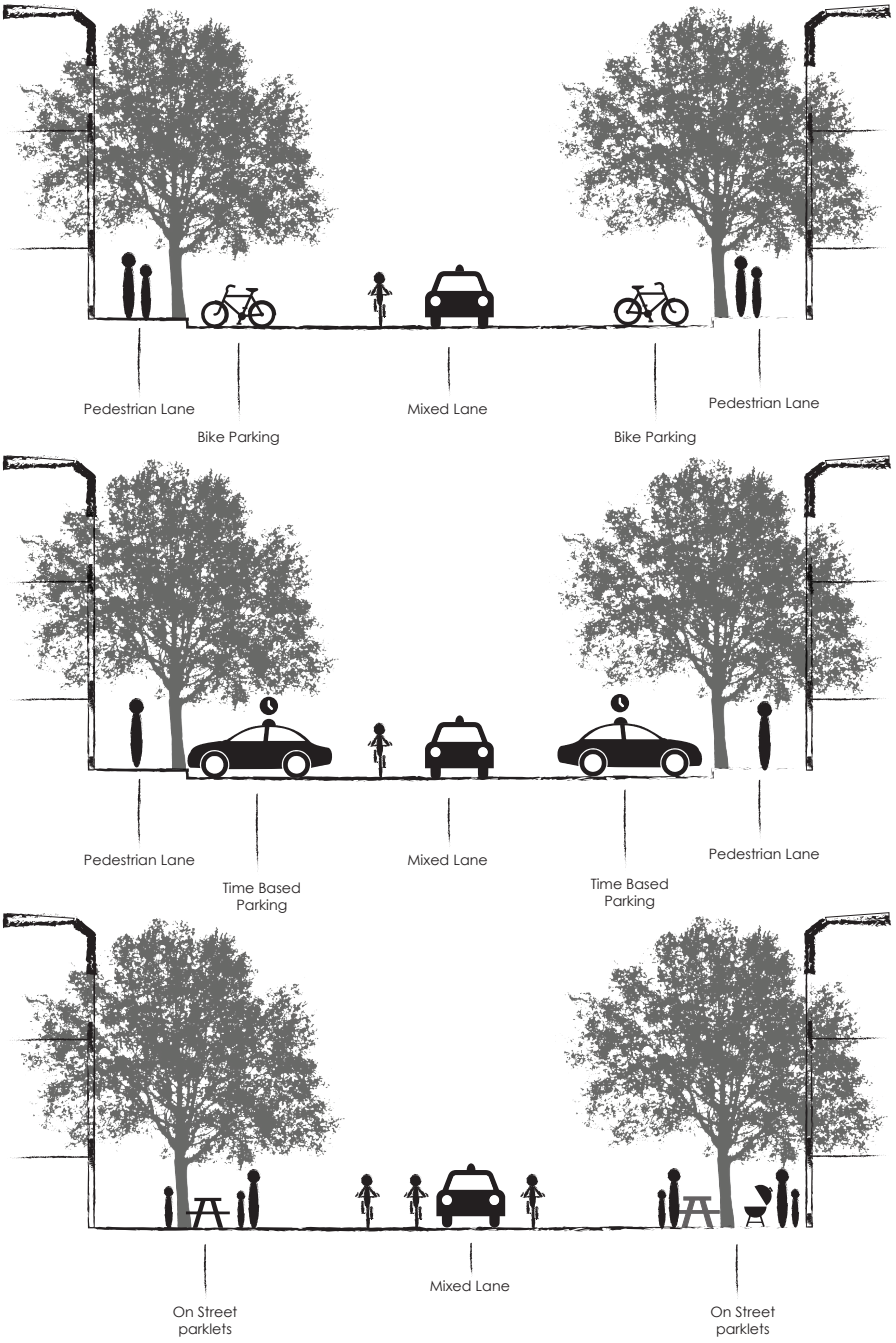
1) Due to the operation on shuttle buses and centrally owned autonomous car fleet, small scale hop in drop of zones are created by utilizing the on street parking space.

2) These zones will also be combined with small scale park , ride and charge systems with upgraded surface charging technology for the vehicles.

3) The major part of the street is now accessible not only to cars but also to the pedestrians and cyclists alike along with ample space for pop up public spaces for community gatherings, playground for children, outdoor libraries etc.

Implementation of this combination of tools at a smaller scale street such as this will create efficient space for both people and vehicles alike.

This combination could be applied to any street of this nature across the city to gain efficient results.



[135] Neighbourhood street sections in the year 2040
Author

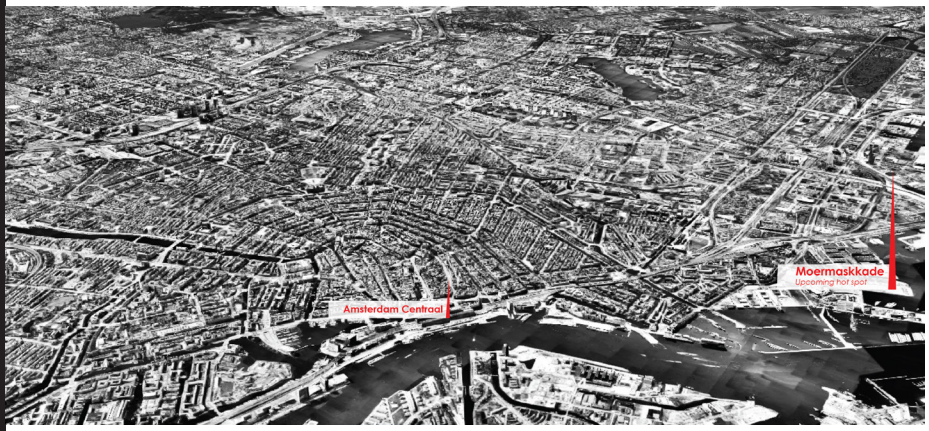
[136] Visual of the connector street in the year 2040
Author

Vacant Plots

Another aspect of the city to explore the impacts of the technology are the vacant plots in the different parts of the industrial areas of Amsterdam.

The plot chosen here is Moermaskkade which is currently an empty land with temporary commercial structures such as bar shacks. The surrounding structures around the plot are of packaging and assembling factories.

The plot and its surroundings might have a great potential to develop into water side recreational and residential neighbourhood by the year 2040.



[137] Moermaskkade
Author
146

The illustrations show how the space changes over time and the various functions it will serve in future.
During the transition period, as mentioned before, the number vehicles on road is expected to be quite high. It is safe to say that the surplus of these vehicle could be stored in this area during off peak hours when they are not being used. Due to the sensors present in the vehicles and the infrastruture they can be directed to this plot when not operated.

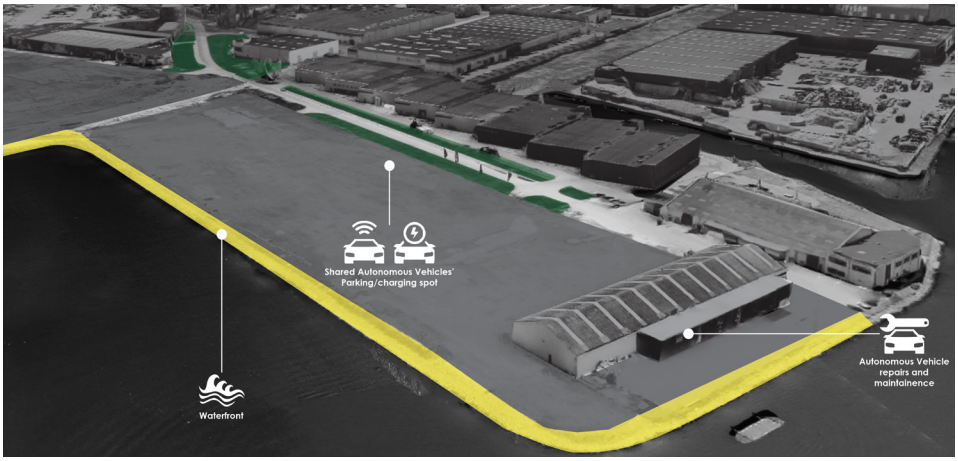
In future, this space might even hold potential to develop into various other functions like catering to housing shortage in Amsterdam, commercial and business facilities, recreational amenities etc. to develop an attract space for the citizens.

This plot will also act as a time dependent infrastructure as it can be used as a vehcile storage space during off peak hours and a public space during the peak hours. The plot has the potential to hold various activities based on different times of the day. It can either act as a football feild for children or as a market area. With its location being very close to the water, it also has a potential to develop a recreational waterfront.

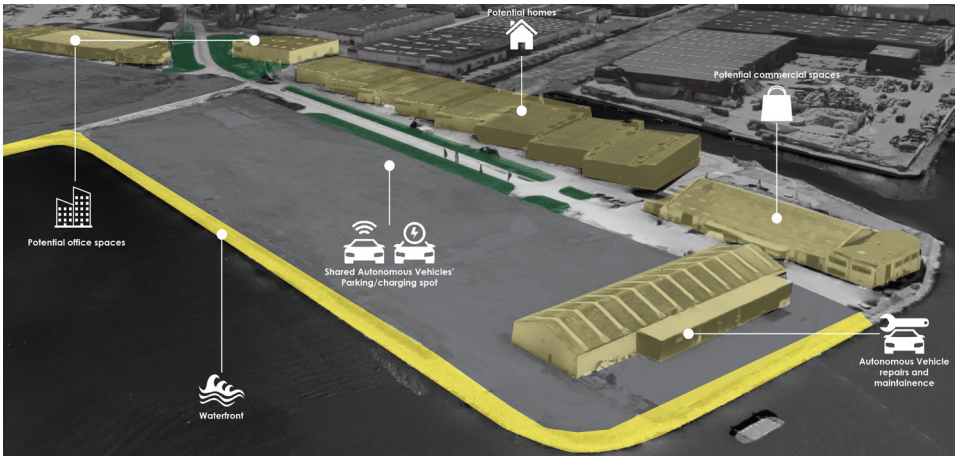
By investing in these fuctions, the space will develop into an attractive living space in line with efficient accessibility to the mobility systems in the area.

By the year 2040, it is safe to say that the number of vehicles on road might considerably decrease according to the startegy for Amsterdam. This will then add more potential to this area and the plot will eventually serve as a active vibrant multifunctional space, increasing the livability of its surroundings as the cars will be divereted to repurpose the hitech underground garages in the city.

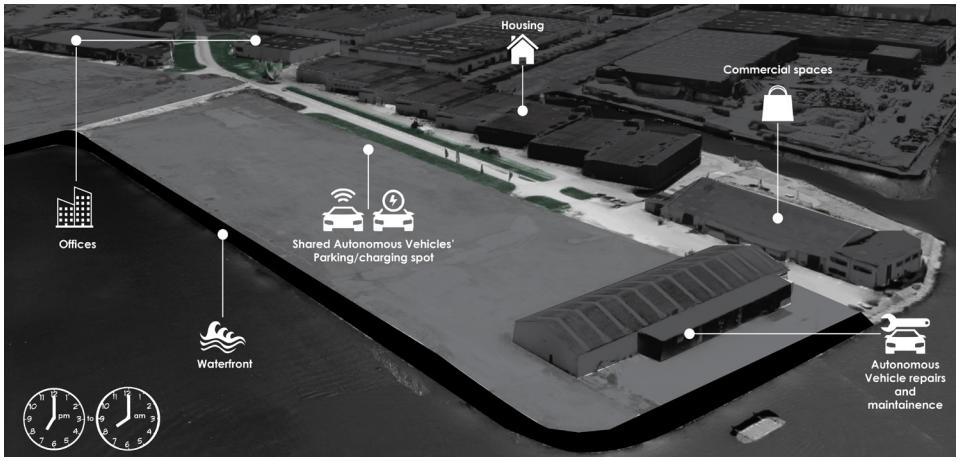
Hence giving back the space to citizens.

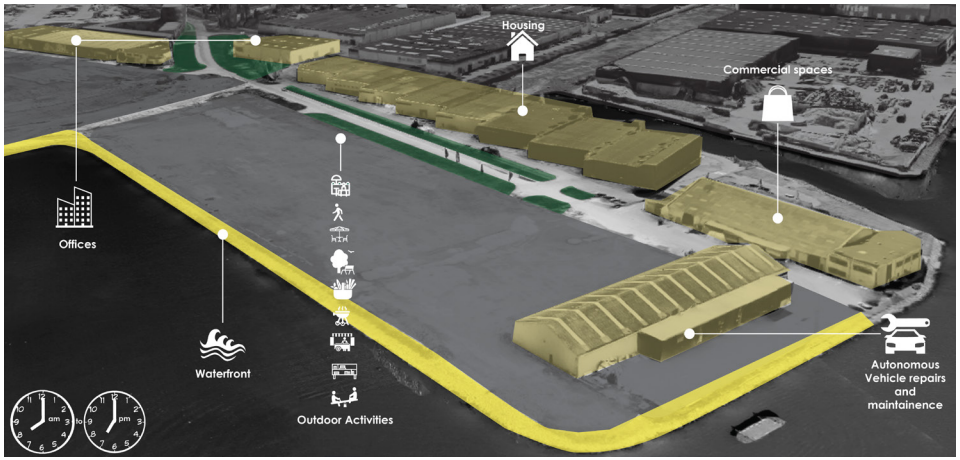


[138] The empty industrial plot during the transiton period in the year 2025
Author

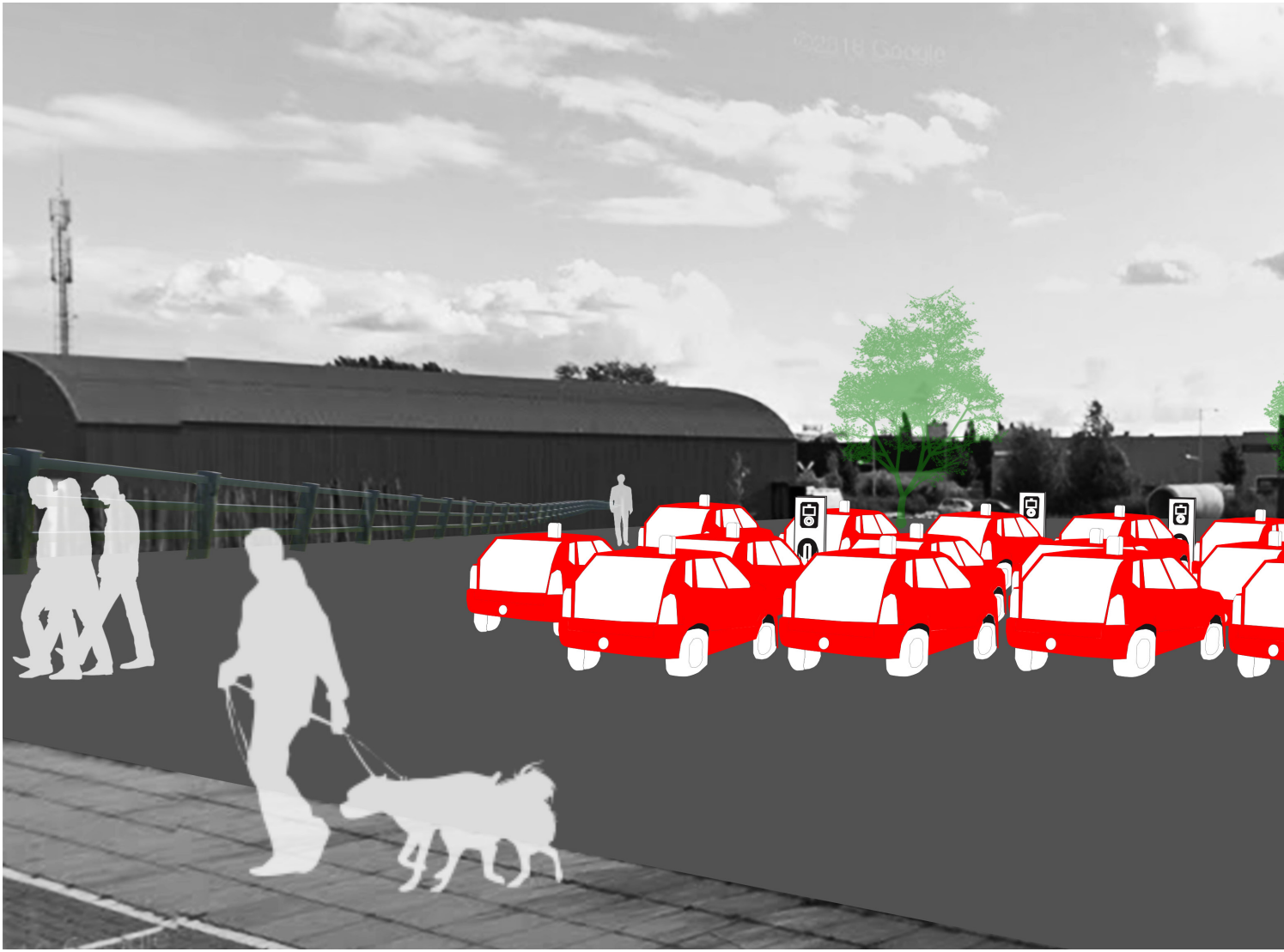


[139] The empty industrial plot during the transiton period showing potential development opportunities in the year 2025
Author





[140] The empty industrial plot operating as a flexible space during the year 2040
Author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[141] The empty industrial plot visualized during an off peak hour
Author

[142] The empty industrial plot visualized during on peak hour
Author

Daily Life in 2040

The quality of spaces along with the implementation of a proactive on demand mobility systems is expected to change the way people travel in the city. To understand that, lets look at the two types of people in Amsterdam. One a tourist and second a commuter.

Christine, 37, is a young single mother living in Amsterdam's oude west neighbourhood with her two children. She has a busy social life and she works at a business center in the south of Amsterdam.

She was highly dependent on her bike in the past but now, she is dependent on her automobile to get herself to work and drop of the kids at school.

Christine's travel log
• Drop off and pick up her kids from school.
• Get to work every weekday morning and back every weekday afternoon.
• Visits friends in the city.
• Get groceries and goods on a daily basis for her family.

Christine in 2040
Christine prebooks her on demand car the night before when she prepares to go to bed. She then gets dressed and prepares for the day for herself and her kids. They together walk to the nearest hop in drop off zone and pick up her pre- booked vehicle.

She then informs her friends that she will pick them with the ride sharing feature in her vehicle. She drops off her kids at school and makes a quick stop at Starbucks coffee as recommended by her vehicle before she picks up her collegaues and friends from work.

Because she does not have to bother finding a parking spot, never has to stop for gas, and route information is always up to date, she is quite certain of her arrival time 08.10 suggested by her vehicle.

On her way back from work she walks to the nearest hop in drop off zone to her office and shares the vehicle with her collegues and heads off to pick up her children.

As she relaxes in her car which as it glides down the priority lanes, she makes a plan to meet her friends for a cup of coffee and orders her groceries at the grocery store.

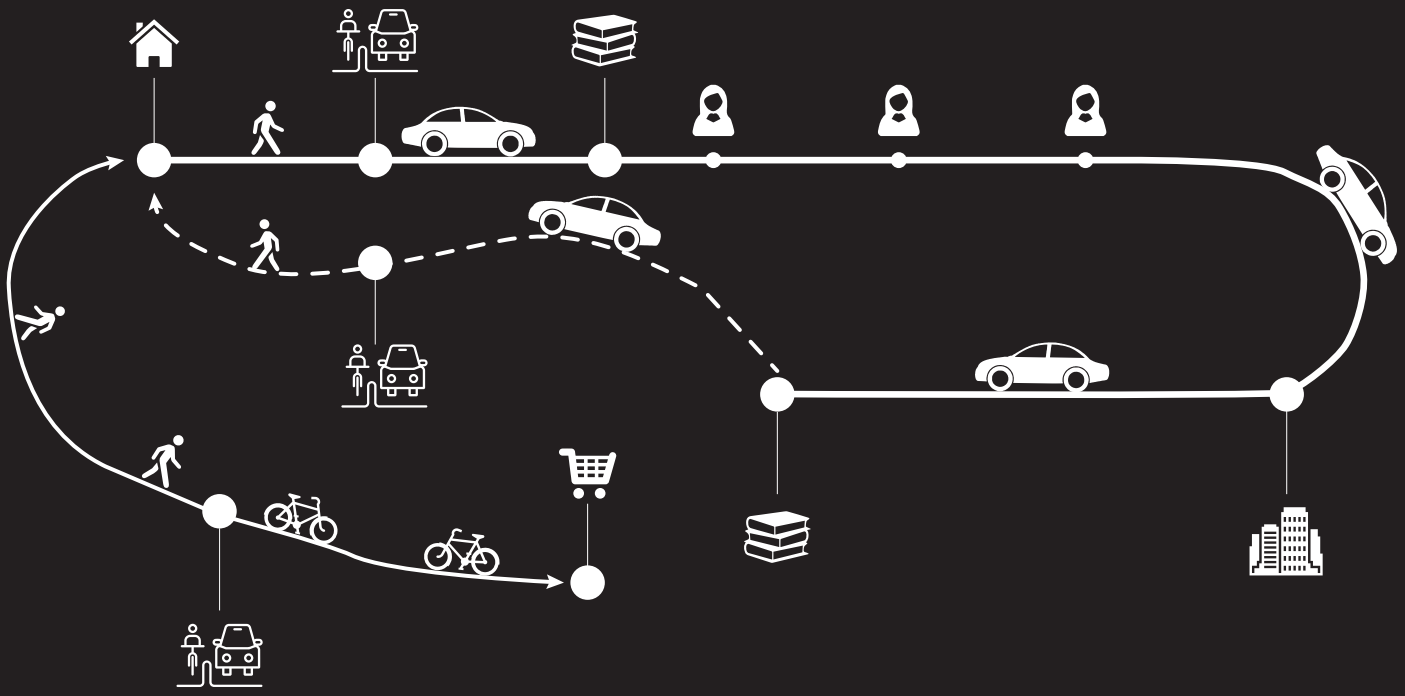
She quickly asks the vehicle to suggest cafes near her usual grocery store so she can plan her meeting accordingly.

Christine gets back home and dedicates her time to her children and helping them with thier homework.

By 5pm she walks to her nearest pick up drop off zone, she decides to use a smart bike with the help of teh bike sharing program to the cafe she planned on visiting and has a quick meeting with her friends, while her eldest child sits outside reading her favourite book from the outdoor library and her youngest plays outside with her friends in what used to be a parking space for cars years ago.

She can rest assured that her children are safe and sound since no cars are present in her interior neighbourhood street. On her way back she picks up her groceries and heads on home for a warm dinner and a good nights sleep.

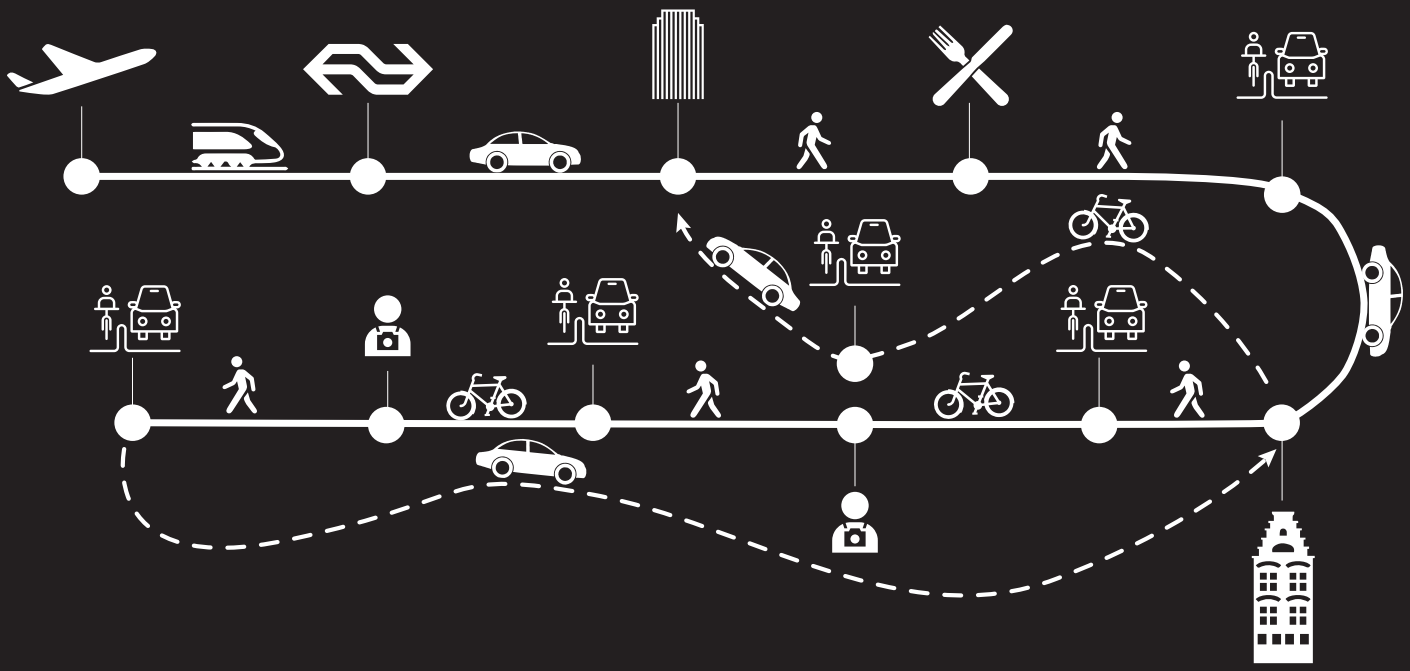
Commuter



[143] The route followed by Christine a daily commuter
Author

[144] Christine's view on her daily route
Author

Tourist



[145] The route followed by Ana, a first time visitor to Amsterdam
Author

Ana and Steve, 50 and 53 year old respectively are a married couple visiting Amsterdam for a day a before heading off to a vacation in the UK, a gift by her children for their 25th anniversary.

Amsterdam being so famous for its cycling culture, they decided to try thier hand at it while they are in the plane. As they land, they use the multimodal app to figure out how to get to the Amsterdam centraal station. They start a conversation with a dutch couple in the train and find out about bike accidents or bike riders in the city. Although they would love to travel around on the bike, they are afraid that they will run out of energy before getting a chance to visit everything.

Ana and Steve's travel log
1) Familiarize with Amsterdam's travel options.
2) Trying to expereince the city by travelling long distances by foot or by bicycle.
3) Want to visit every spot using different modes of transport

Ana and Steve in 2040
Ana along with her husband arrives at Amsterdam central station in the morning around 10 am. Upon arrival she immediately notices an interactive information screen which helps her loacte her hotel and the ways in which she can get there.

She is also instructed to download the MOOV app to check all the possible combinations she has at hand to get to her hotel. She signs up for an account and books an AV which will drop them both at the hotel at the outer ring of the city center of Amsterdam.

After shaking off the airplane smell off of them, the couple decide to walk to the nearest restautrant to grab some brunch before they set out exploring. Ana and Steve walk hand in hand on the wide pedestrian paths in the core residential streets of the city.

After brunch the couple use thier app to check thier nearest hop in drop off zone to pick up a car that drops them of at the edge of the city center as the city center is completely free of cars.

They walk around the beautiful canal streets and have a quick icecream in the Dam square before they head out to thier nearest bike sharing stand and rent out bkes to visit all the famous places in the city center.

Once they finish they return their bikes and switch to an AV to see the Anne Frank Museum , the Van Gogh museum and the Rijksmuseum. Thier vehicle suggests them to visit these spots in a certain prefereable order which will save them time and money. It also recommends them to dine at one of the well know restraunts in the city.

After dinner, they pick up an AV which drops them off at the hotel. As they return they talk about how convienent and smooth thier first time in Amsterdam was and decide to visit the city and stay in the country side this time due to the ease of access with the help of AVs and smart bikes.

They continue on to thier amazing vacation bearing fond memories of the beautiful city.

[145] Ana's day out in Amsterdam
Author
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[146] Ana's view from the Shared AV
Author

8
Reflection

This reflection aims to throw light upon the process and the outcomes of the project, its relevance to the graduation studio and the social relevance followed by exploring the challenges and weakness faced during the project.

Autonomous Shared Mobility in today's context is still at its technological development state and against the background of urban implications is still an under examined field of research which proved to be quite a challenge for this project. To predict the future development of cities hand in hand with the technology, this graduation project aims at dealing with a futuristic phenomenon with the help of scenarios.

It intends to understand the possible impact of the technology on the urban form of the city. To gain this understanding, the methodology of the project was designed to obtain a strong research and planning basis accompanied by design illustrations or spatial translations of the conclusion derived.

In order to gain the knowledge of the impact of the technology on the urban form of the city, questions were raised on why is there a need for it and what really is the technology. The first couple of months of the project were spent solely in understanding and finding answers to these questions. The second half of the project aimed at developing the different futures that could happen with the on set of these technologies and through them strategic goals and actions to reach a stage where recommendations and suggestions were given to understand the potentials space has to offer with the use of an approach guide.

The graduation research group, Complex cities aims to understand how planning and design resolves territorial urbanism by addressing poverty, extreme environmental threats, weak governance, or urban emergencies in neighborhoods, cities and regions around the world.

Their mission focuses on interdisciplinary approach/integral thinking, Internationalization/understanding differences: Institutional context/developing a critical perspective: Planning methods and tools/ manage change and the Decision-making and participation process.

For this project, it was of utmost necessity that an integral thinking approach and the concept of internationalization and understanding differences is considered and used at different stages thoroughly. Through this research group a thorough understanding of the planning process was gained for such projects.

The technology of Autonomous mobility not only impacts the change in urban form, it will have a significant impact on the citizens as well. This new technology will provide easy and quick mobility for different types of citizens and will also permit living in remote areas.

It will also play an important role in reducing the time spent looking for parking spaces in and around the city limits saving valuable time. Additional benefit is the safety factor which also provides reason to research the benefits of this technology and regulate the way it develops to reap maximum benefits in future. A considerable time was spent in the initial stage of the project dealing with the concept of scenario building.

There were three major challenges that were faced at this stage. One, for such a futuristic technology, the most suitable tool to speculate its consequences is to build the futures based on the certain factors, some constant and some varying.

This proved to be quite difficult due to the involvement of various factors with the autonomous technology and narrowing them down to three core factors was a difficult decision to take as there were greater chances of important factors being left out. After many mentoring sessions, it was understood that due to the time constraints of the project, if the factors were not concise the conclusion to the project would not be reached.

The second challenge that was faced at this stage was designing the futures which would be the best match for the city of Amsterdam. On a personal note, the best part of working on this project with Amsterdam in mind was that, it offered a wide range of opportunities in terms of projects, strategies, and initiatives to integrate with the technology and the project strategy as well.

These opportunities also played a great role in designing the futures . Research projects for the same from the Faculty of Civil Engineering and Geosciences and Ministry of Infrastructure and Environment proved to be the best inspiration at this stage.

The pitfall in the backcasting future designing process is that, the proactive approach of multi modality and mobility on demand that are chosen to formulate the strategy is quite utopian.

There are many disadvantages that come along with both these concepts. This project makes the choice of considering the advantages over the disadvantages that it can cause. One of the challenges was the acquirement of origin destination studies for the city of Amsterdam for better reasoning for the construction of scenarios. Due to the lack of this information, the scenarios lean more towards being qualitative than quantitative.

The next challenge lied in the spatial translation of the strategic vision i.e. to incorporate the actions of the vision on both large and small scale. According to the thought process, it was assumed that the spatial translation would be achieved through design which was an incorrect assumption. Coming from an urban planning background, the challenge also lies in understanding and translating the research and derived strategy into design.

During the mentoring sessions, it became clearer that a step in between must be taken in order to achieve the design stage. This intermediate stage is to formulate certain tools or an approach guide that will facilitate the actions to take place orderly.

The weakness of the project here is that due to the way the methodology was developed, the approach guide initially consisted of both tools and heavy concepts that can be achieved through more tools in a generalized manner derived from the scenarios that were developed. To solve this flaw in the approach guide, the tools were categorized into four greater concepts. During the designing process, it was realized that there are many other tools that could be used to develop the city and its urban form.

Hence, the approach guide has been under constant upgradation ever since its conception. In the designing process, the weakness lies in the way it has been illustrated.

Better quality of visual aids like real time picture renderings and collages could have been used extensively to convey their importance of the design to not only urbanists and planners but to multidisciplinary audience and citizens alike. This would also help in visualizing the strategy goal on a larger scale.

As discussed above, the scenario designing process had a major weakness. The scenarios chosen are expected to have quite a lot of disadvantages and their advantages could have been strongly proven through mathematical modelling to overcome the pitfalls and develop strong reasoning.

Overall the project has many other faucets that are yet to be researched and explored in detail to achieve better results and this is where the future scope of the project lies.

With inspiring and educational mentoring sessions and a supportive city like Amsterdam for testing, the project aims to contribute in any way possible to the larger concept of Smart Mobility in the cities of tomorrow.

9

Resources

Autonomous Shared Mobility and the cities of tomorrow

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