EXCEPT
INTEGRATED SUSTAINABILITY

SELF-DRIVING CITY
Research book

March 2017

creating the foundations for a sustainable society

‘An autonomous car (driverless car, self-driving car, robot car) is a vehicle that is capable of sensing its environment and navigating without human input.’

INDEX

Because of the complexity of the research books each chapter contains its own expanded table of contents.

FOREWORD

An English version of the Vision Book is expected to be available in Spring 2017

Self-Driving City aims to contextualize the development of automated vehicles in the scope of sustainable cities and urban society. Being part of a broader smart mobility development, autonomous cars are expected to contribute to safe, efficient traffic flows and provide equal access to mobility for all people. Integrated in smart energy grids they not only help reduce emissions, but are even part of the solution for energy transition. While scientists are in the midst of researching and validating these benefits, Self-Driving City is sketching the 'what if' perspective. If we can build this future together, what is it that planners, designers and politicians need to know to be able to anticipate for change, cooperate and challenge the current status quo on urban mobility.

This document is the result of the Self-Driving City research, initiated by Except and funded by the Dutch Creative Industries Fund. This document's purpose is to debate the insights with stakeholders from governmental organizations, knowledge institutes and industries. The research document contains the ingredients for the transition of self-driving transport systems in urban areas: the most relevant trends, precedents and data. Parallel to the Research Book, Except published a Dutch Vision Book 'De Zelfrijdende Stad'. The Vision Book takes a step beyond the facts, figures and insights towards an integrated vision on self driving transport in urban areas.

When is comes to future predicting the ultimate 'Level 5 situation' (autonomous transport without human intervention everywhere possible) there seems to be no clear, single and dedicated transition path. In countries like the US, UK, Japan, Sweden, Germany and The Netherlands seem to be taking the lead by creating legal frames for experiments in closed campus situations as well as on public roads. European coordination is intensified since the Declaration of Amsterdam was signed in April 2016. Research and development activities are worldwide increasing at impressive rates. The breakthrough moment seems to appear on the horizon.

However, in despite of political efforts and technical ability, history proves that cultural aspects and human behavior make the difference between temporary trends and major changes. And major changes haven't always lead to sustainable cities, even when we all hoped so.

In the nineteen- fifties, sixties and seventies, urban planners and architects dreamt of ideal urban structures where car traffic would dominate the organization of the city. Only a few decades later many of these areas have failed to become vibrant sustainable urban districts, while older 'organically integrated structures' have proven to better stand the test of time. The diverse patchwork of the multi-nodal 21st century city is the frame for integrated self-driving solutions from private as well as collective transport perspective. This new 'vehicle fleet' will replace the old. Not at once, like the construction of a metroline, but slowly, nearly invisible, finding it's way on existing infrastructure, adaptive and sometimes requiring physical change.

The Self-Driving City research was born out of the desire to contribute to a better cross disciplinary understanding of the effects of self-driving vehicle development and where this lies in an adaptive future urban fabric. Urban planners, policy makers, investors and operators will benefit from a stronger understanding of self-driving technology in the context of networks, infrastructure and urban development. Understanding the conditions and performances will help determine the feasibility of pilot projects and determine further research.

The Self-driving City research team initiated the research in cooperation with Rijkswaterstaat and the Metropole Region Rotterdam The Hague. Parallel to the research Except contributed to five case studies, commissioned by several municipalities in the metropole region (Schiedam, Capelle aan den IJssel, Rotterdam, The Hague) as well as Schiphol Real Estate for their share at Rotterdam The Hague Airport. These projects also contributed to the Research Book and Vision Book.

A vision from the urban perspective is needed. This Research Book is our first step. We invite you to join us to take the next.

Self-Driving City team

Stakeholder session at LEF Future Center in Utrecht, December 2016

RESEARCH STRUCTURE

THE APPROACH

We applied the Symbiosis in Development (SiD) sustainability development framework to develop the research. The SiD framework is specialized in developing multi-faceted sustainability innovations using systems-thinking, network theory, and life-cycle understanding.

SiD combines theory, method, practice, and tools in a holistic system that allows different disciplines to work together, evaluate sustainability spectrum-wide, and find high-performance integrated solutions quickly. SiD ensures a 360-degree vision, resilient outcomes, and the inclusions of aspects such as circular economies, biobased design, resilience thinking and social justice. SiD has been applied on over 500 projects worldwide, and has been under continuous development since its launch in 2001.

MOTIVATION & GOALS

Via an interactive process, we explored expectations, benefits and barriers with stakeholders from governments, businesses and knowledge institutes. The result of our research aims to contribute to further scientific research and a stronger common understanding of the motivators behind technological development.

Self-Driving City research is not scientific research, nor a feasibility study. Rather, we provide insights in decision making for urban planners, mobility experts and policy makers. Our research focus is on the effects on social equity, next economy, public infrastructure and health. The engineers and scientists from our project partners supported with technological and legal knowledge. Working side by side with municipalities and private partners in the cases provided the context of the 'real world'.

Our results provide the insights that planners, engineers, designers and politicians need to contribute to a meaningful transition that is both promising and inevitable. We aim to inspire actors to initiate future pilot projects as well as provide support for their implementation.

AMBITION

The Netherlands to become one of the world leaders in research and development (R&D) related to autonomous transport, expressed by the Minister of Transport.

PROJECT GOAL

Accelerate resilient development of the urban environment with equal opportunities for the entire society.

SPATIAL BOUNDARIES

The research combines global insights with knowledge from the Netherlands and practices within the borders of the Metropolitan Region Den Haag and Rotterdam (MRDH).

TIME BOUNDARIES

- » The perspective of AV development is set for 25-50 years.
- » The perspective of the case results is set for the next 3-25 years.

CONTEXTUAL BOUNDARIES

Our research team allowed stakeholders to determine sustainability and mobility goals for themselves. Our research focus is on the effects on the urban mobility, public infrastructure and health.

NETWORK INDICATORS
With the deliverables of the project, we want to contribute to:

- » **Awareness:** Promote awareness amongst a specialist public
- » **Connectivity:** Connect more people and institutions to the development of self-driving solutions
- » **Efficiency:** Transition paths to shorten time for decision-making for planners, politicians and designers
- » **Diversity:** Enlarge the spectrum of solutions.

PLANNING
February 2016: kick off initial partners
March 2016: working session I with stakeholders
April-May 2016: creative team sessions
June 2016: public debates in The Hague and Amsterdam
June 2016: advisory board session I
July 2016: first draft research book and quality control
September-October 2016: creative team sessions
November 2016: working session II with stakeholders
November 2016: advisory board session II
December 2016 -January 2017: Concept Research Book and Vision Book
February 2017: quality control
March 2017: publishing and public presentation.

ENERGY & MATERIALS

- » True energy positive operations;
- » Reduce the use of fossil fuels;
- » Improve total cost of ownership for autonomous driving vehicles;
- » Optimal sources and uses of energy for ventilation, heating, cooling, appliances, and lighting;;
- » Any energy sourced from certified local renewables
- » Any construction materials shall be from 100% recyclable sources, designed for easy disassembly, and where possible locally sourced low LCA impact materials.

CULTURE & ECONOMY

- » Boost area's economic performance by encouraging a new symbiotic program for Clean Tech
- » Sustainable urban development
- » Increase cultural diversity of each location, appealing to a wide range of organizations, professionals, inhabitants and visitors
- » Improve people's willingness and open-mindedness to new methods of saving time
- » Improve mobility
- » Entrepreneurship: Increase connectivity with varied professional groups such as entrepreneurs, network generators, flex workers, incubators
- » Connect to education system

ECOSYSTEM & SPECIES

- » Encourage the growth of biotopes for a wide variety of beneficial species that coexist with transport function
- » Make use of productive ecosystems that provide vital services for climate management, water management and purification, heating/cooling, energy production, insulation, water retention, etc.
- » Minimize Soil Replacement
- » Prepare for more extreme weather conditions ie. Climate-adaptive rather than climate-reactive

HEALTH & HAPPINESS

- » Clean air
- » Accident reduction
- » Inspiring locations that increases productivity, attracts more visitors and stimulates interaction
- » Stress free traveling
- » Inspiring, exemplary, stimulating, and enticing

READING GUIDE

The research book presents all the selected, processed and summarized information, structured in the SiD logics of trend analysis, precedent research, stakeholder involvement and data collection. Each of these chapters contains a concluding paragraph that sketches the foundations of the last chapter: 'Self-driving City'. This part contains integrated answers in relation to the research purpose: to provide insights in decision making for urban planners, mobility experts and policy makers

TREND ANALYSIS
The trend analysis scans for long term societal dynamics that influence the project in the long run. The trends are used to place self-driving technology in perspective. It brings awareness to the different forces that determine the direction of urban society and transport.

If we understand the context, a clear framework can be built that sets the future requirements that society needs from self-driving systems in relation to other transport means.

PRECEDENT RESEARCH
The primary reason for the precedent research stage is to prevent reinventing the wheel. Precedent reporting about self-driving systems helps by under-standing different technologies, typologies, user experiences and stakeholders.

The research also captures precedents of research and policies strongly related to the interaction of urban planning and transport innovation. This part of the research helps to build foundations for integrated transport planning.

Sharing economy evolving: car sharing in the Netherlands

Google testing its autonomous vehicles on the roads in California, USA

STAKEHOLDER INVOLVEMENT

Symbiosis in Development (SiD) involves stakeholders as soon as possible in the process. Stakeholders include those directly related to the project, such as governments and knowledge institutions, as well as business in the transport and real estate sector.

Stakeholders were involved in different ways:

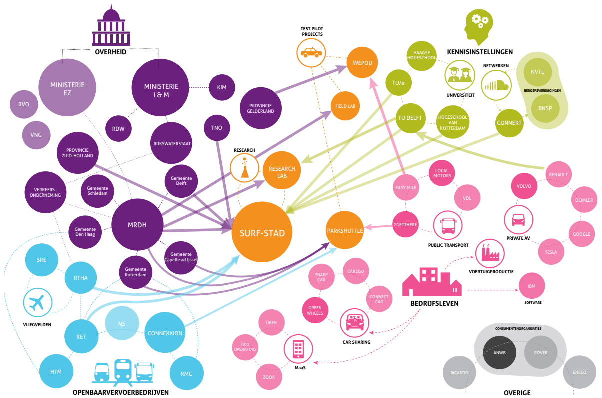
» Integrated design and back casting sessions
» Last mile working sessions
» Online survey
» Advisory board

DATA COLLECTION

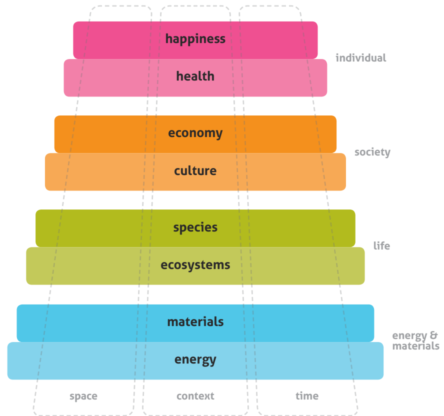
The data collection element ensures the necessary data on all sustainability related aspects (see diagram below) is present and can be integrated. It uses SiD's ELSIA categorization system to determine relevant data elements, which are researched and documented by the team prior to the SiD sessions in accessible system maps. The overall dataset validates the arguments of the Vision Book.

SELF-DRIVING CITY

This part of the research is the team's summary and integration of insights and arguments. It builds the foundations for the Vision Book and relates the trends, precedents, data and stakeholder perspectives to the original research questions.



Stakeholder Map - connections between the stakeholders in the Netherlands



SiD ELSIA Data collection framework - SiD Book, 2014

Driver-less concept of BIG architects for the Audi Future Initiative

TREND ANALYSIS


FUTURE
ANALYSIS
INTERNATIONAL
SHARES
IDEA
INTEGRATED
SALES
CONNECT
STOCK MARKET
COOPERATION
GLOBAL
WORLD
DATA
DATA CONCEPTS
SOLUTION
BUSINESS
IDEA
INVESTMENT
EXPERTISE
CONNECT
IDEA FUTURE
VISION
SHARES
TRENDS
CONCEPTS
RESEARCH
PRODUCTIVITY
PEOPLE
COOPERATION
SUCCESS
PLANS
GLOBAL
VISION
DEVELOPMENT
TEAMWORK
CONNECT
SHARES
VISION
MARKET
SALES
PLANS
ADVICE
SOCIAL
ADVICE
NEGOTIATION
COMMUNICATION
MARKETING
IDEAS
IDEA
MARKET
DATA
TEAM
STOCKMARKET
TEAMWORK
GLOBAL
PEOPLE
PEOPLE
SALES
CONNECT

INTRODUCTION

There are many topics that can be discussed in relation to transport shifts in the urban context. This chapter provides a brief overview of the most influential such as, urbanization, population changes and migration. Environmental aspects like circular and biobased economy and energy transition.

Some of these trends are a push factor to self driving technology, some show strong parallels (like electric driving or Mobility as a Service), others are more contextual (like the silver society).

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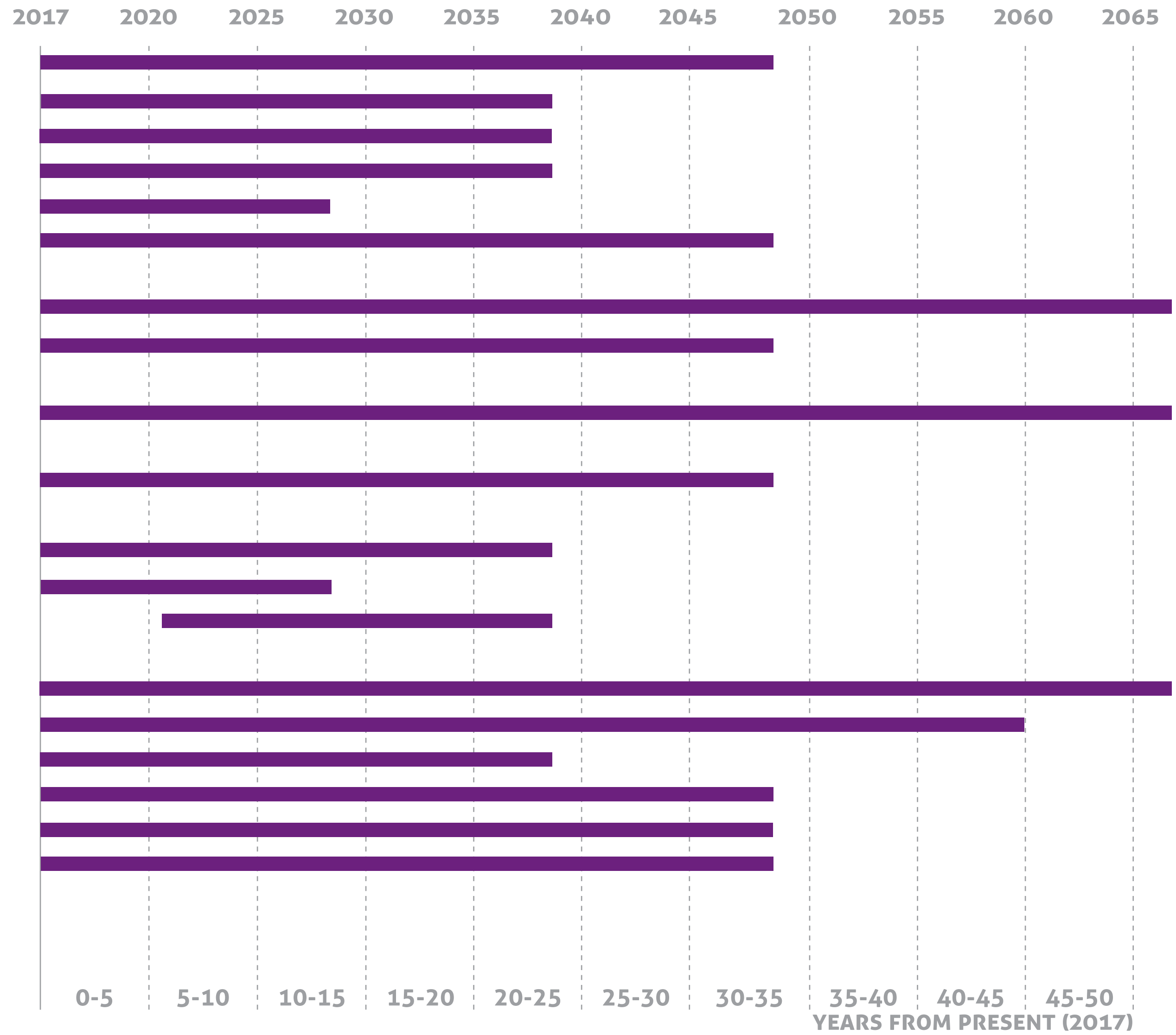
TIMEFRAME



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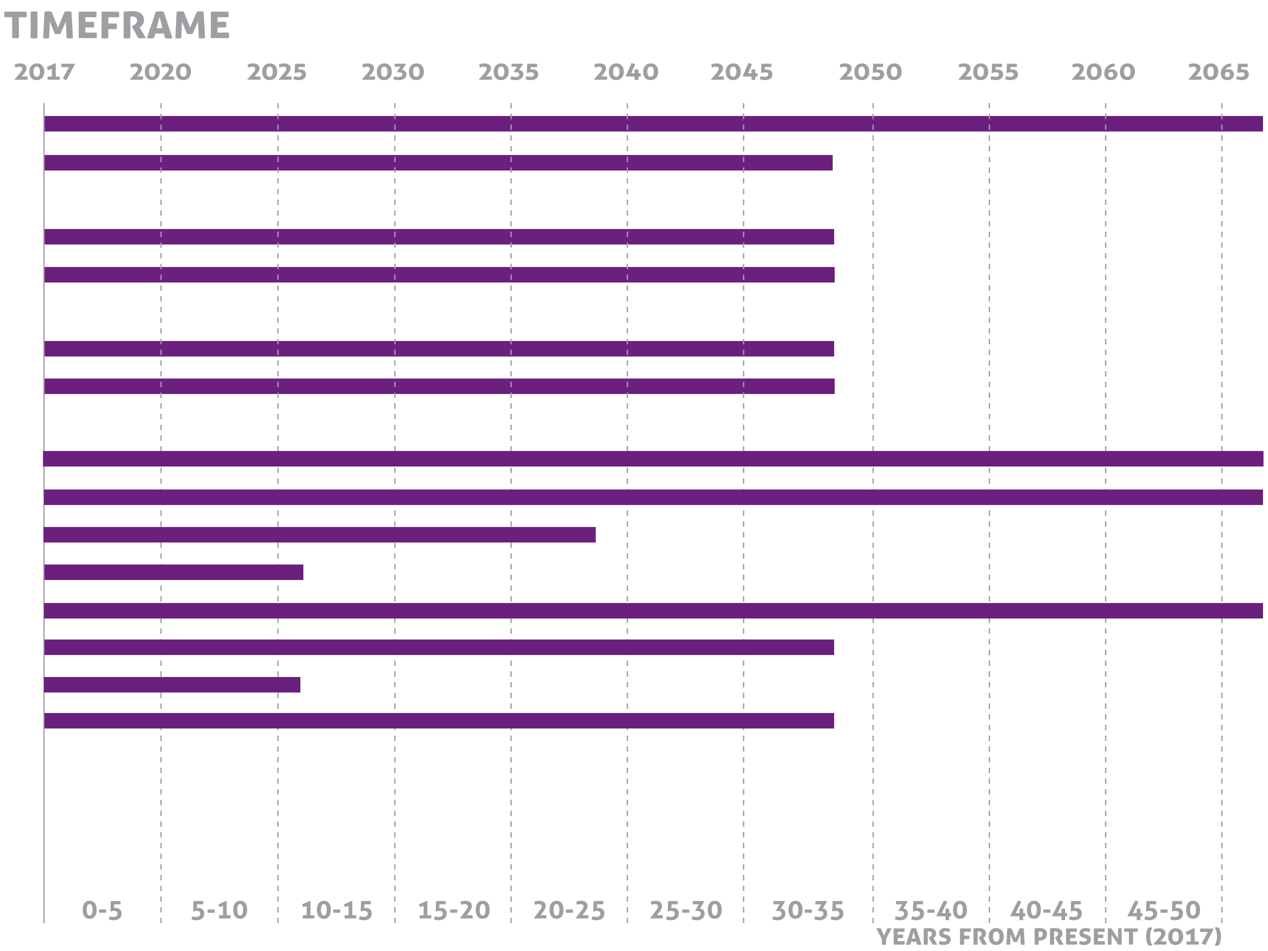

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DECENTRALIZATION

0-30 YEARS

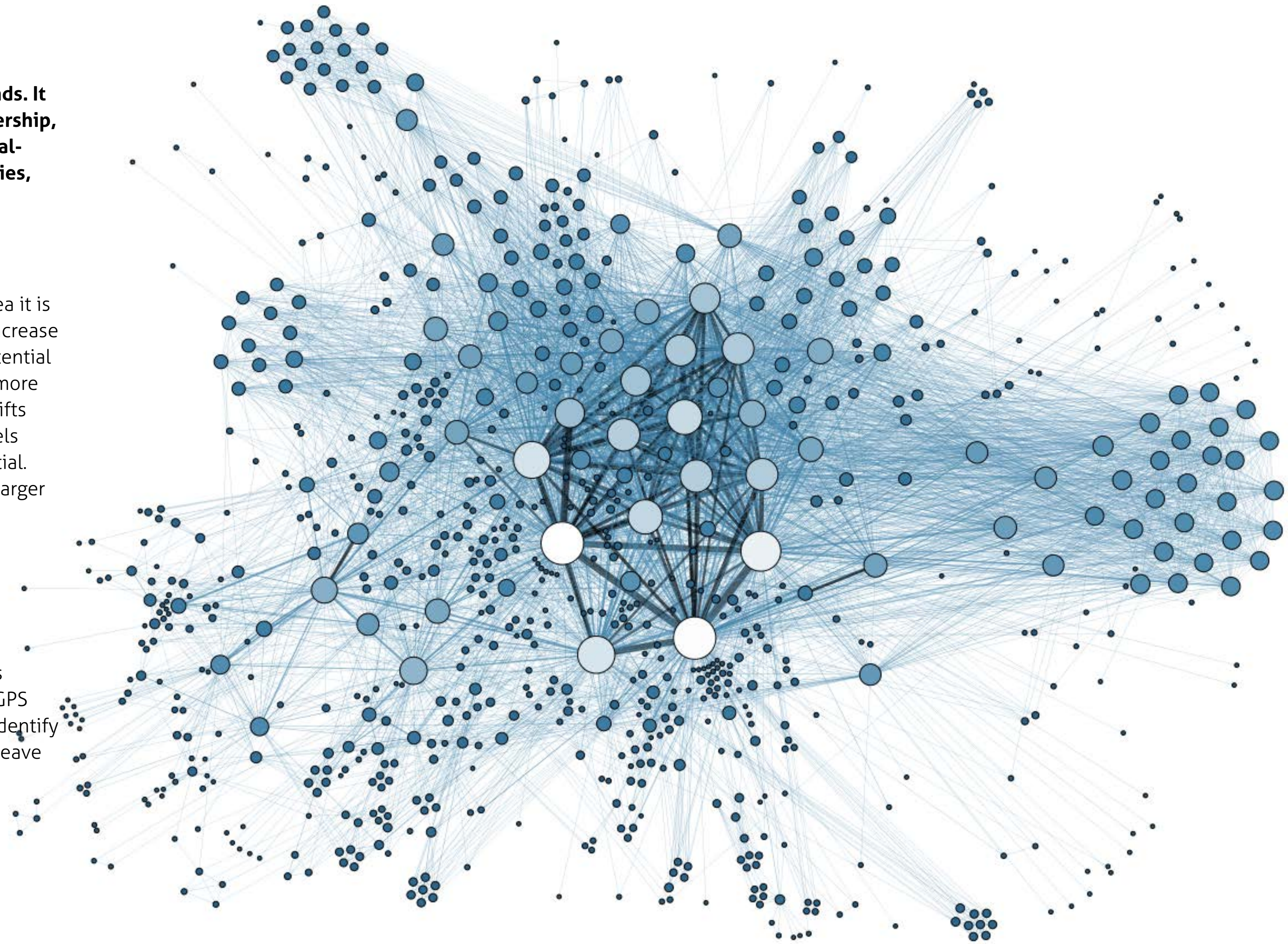
Decentralization is one of the major global trends. It is present in most sectors and areas. From ownership, production, services and management, decentralization is everywhere. Restoring local autonomies, it stimulates the increase in diversity and local adaptation.

Effects

The effects of decentralization differ from the area it is applied. It leads to local adaptive solutions, an increase of autonomy, redundancy, and flexibility. The potential for greater efficiency, lower transport loads and more adaptive services and systems are all positive shifts from decentralization. Changes in business models towards product- service systems are also essential. This global trend is key to working as a part of a larger whole.

Effects on Mobility

The viability of both technology and economics improves on a daily basis due to advances in computing and networking technologies. Today's technology uses GPS to recognize where the cars are on the road. Cameras, lasers, and radar help GPS systems keep car distance from each other and identify objects like pedestrians. Super-fast processors weave all the inputs together, allowing cars to react.



INTERNET OF THINGS

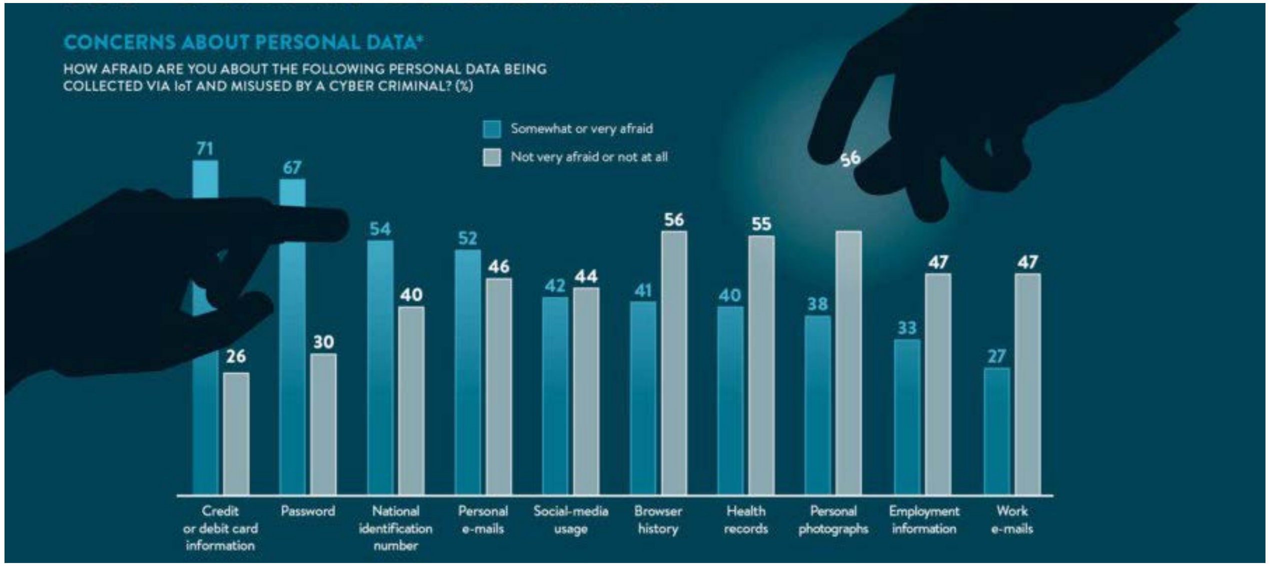
0-20 YEARS

The Internet of Things (IoT) is a decentralized control network where everything in our life is connected and in communication with one another. From cell phones, coffee makers, washing machines, headphones, lamps, cars to wearable devices. Objects adapt themselves in the context of other aware products as well as their environment and usage patterns and adapt to the needs of a person.

IoT opens the door to many opportunities but also to many challenges. When everything is connected, we have more control over our environment (but less on our privacy).

Effects
IoT prepares our society for things like advanced robotics and higher autonomy for devices to adapt to our lives through a myriad of sensors and adjustments. On a broader scale, the IoT applied to transportation networks and "smart cities" can help us in reducing waste and improving efficiency for things such as energy use. It can help us understand and improve how we work and live.

The downside is that things become hard to repair and service and that our privacy is out in the open. Another dangerous effects, besides the vulnerability to hacking, are technical errors that have the potential to erase all information stored in the cloud.



LEGAL TRANSITIONS

0-20 YEARS

The legal marketplace is changing; lawyers no longer have a monopoly on the law and clients can seek legal assistance from a growing number of "non-lawyer" professionals, including virtual assistants and offshore legal vendors. Law data is now mostly open source electronically stored information (ESI).

If we take a look at the technology development sector, the changes in regulation models towards are essential. Unfortunately, so far regulators were not fast enough for the deployment of self-driving vehicles.

Effects
Transparency in legal issues will play a major role, as a society actively takes action to understand their rights and ways they can benefit from the law. E-transactions and e-signing are already popular in many developed economies.

Effects on AV development
Due to the slow policy changes within mobility sector, the private companies as Google, Uber, Lyft, Ford, and Volvo are moving on their own and creating a lobby group to further autonomous vehicles. The five companies have as a primary goal to *"work with civic organizations, munici-palities, and businesses to bring the vision of self-driving vehicles to America's roads and highways."*

SERVITIZATION

0-20 YEARS

The decentralization of the societal functions is leading to 'servitization' where the services are increasingly replacing the goods and products. These are usually associated with tailor made business models and tie in with aspects such as the circular economy and supply chain management.

Effects
More complex business models, better control over products in the life cycle, more on-demand and tailored user experience.

NETHERLANDS: ON-LINE SHOPPING

0-10 YEARS

Dutch people (but also in other countries) are buying more stuff on-line. 10% increase every year in the Netherlands, leading to a 5% drop to stores. More and more we try to buy at the producer and make the supply chain as short as possible. Logistics is the big challenge here. Highly automated manufacturing is nothing new, but the level of automation is now rapidly increasing in the distribution channel.

Effects
Decreased retail space demand, lowering prices. Empty stores city centers, more drop-off points for products, higher demand for showrooms and 'embedded' product display. E-commerce is enabling the rise of new concepts and ideas within the supply chain, but also new companies are popping up to address logistical challenges.

For the logistics industry, the rise of e-commerce combined with the incoming autonomous vehicles technology is a ground-breaking change. Crowd-sourced business and autonomous driving technology are joining forces to deliver new solutions for more demanding customers.

NEW DEMOCRACY

0-30 YEARS

The relationship between government and society is changing and generating new forms of interactions. Bottom-up initiatives are booming. Many people feel a sense of commitment to their neighborhood/ city and are actively involved in it to improve the life quality. As a result, the government is adapting and taking in a greater account the initiatives in the community.

Effects
Citizens prefer a tailor-made approach and authorities that think along with them rather than simply providing standard solutions for everything. The citizens and government are devising new communication channels through social media and new ways of working together – what is often called a 'do-ocracy.' The Central government is keen to promote and support this form of democratic collaboration.

RESOURCE DEPLETION

0-50 YEARS

Infinite growth on a finite planet leads to resource shortages. The rate at which people consume natural resources is unsustainable. This has immediate effects on the global economy, most visibly in the volatility of the oil reserves and market. In addition to direct consumption, the effects of pollution and climate change endanger resources.

Effects

Volatile markets have global consequences. As the price of electronics to go up, food prices also increase. Potable water can be produced by inputting energy used for desalination, but because of this cost, it will hit the lower echelons of society the hardest. Because of this, strained political relationships between have and have-not regions with regards to technical capabilities can lead to armed conflict or even war.

ENERGY TRANSITIONS

0-30 YEARS

Worldwide governments are moving towards clean and sustainable energy sources such as solar power, wind power and other forms of renewable energy that can replace oil and fossil fuel.

As products, such as cars, and building installations, are increasingly switching to electric, the power loads on the national networks of countries are strained. In recent years, micro-grids have evolved from a growing concept to a significant source of opportunity across the electric power industry.

Effects

Increased load on electricity network and rising of electricity prices. Demand for electricity storage grows, and microgrids are becoming a global trend. The distributed generation (DG) cuts into the utility's core business of selling electricity to businesses and consumers.

Effects on Mobility

In transportation, the switch from fossil fuels to electric cars will reduce C02 emissions and pollution. However, to get the full environmental benefit, we need to supply the grid with more renewable energy.

BIO-BASED ECONOMY

0-50 YEARS

One of the largest global trends concerns itself with the question of how to move away from our finite economic cycles that include a regenerative use of natural resources. This includes the Natural Capital movement and movements focusing on embedding ecosystem services into all processes of our society.

One of the more challenging of the global trends, the bio-based economy concerns rebuilding the foundations of most of our production and value chains from the ground up. Some less-developed countries are in an advantageous position because they have not entrenched themselves in the older, linear and non-bio-based economy.

Effects
On a material level, we will see more bio-based material enter supply chains and into common use. On a societal level, we will see more ecosystem services performing tasks machines used to do for us. On a building level, we will see a combination of those two, supported with new ideas about biophilic design and access to nature. Within the mobility sector, the research towards bio-based fuels. Financial solutions embedding Natural Capital are already in use and will continue to spread.

CIRCULAR ECONOMY

0-30 YEARS

As a direct response to resource depletion, the circular economy is the evolution of the concept of recycling. It is about connecting resource flows across value and production chains to increase resource efficiency and lower environmental impact. It is a re-branding of a variety of development, from the recycling trend in the 60's to the 90's, and the short-lived commercial Cradle to Cradle trend in the early 2000's. Circular Economy is gaining traction around the world as the new name for these 'closing the loop' projects.

Effects
The circular economy could greatly benefit the environment and boost competitiveness and resilience. With its system-wide perspective, the circular economy has the potential to help us make better decisions about resource use, design out waste, provide added value for business, and proceed along a secure route to society-wide prosperity. Under the right rules, the circular economy can shift the economic mix to increase the number of jobs at the same time.

Effects on Mobility
Applied to the transportation, a circular mobility system would offer more choices and be shared, electrified, autonomous, multimodal, and looped. Together with MaaS, these changes can lead to fewer, better-utilized cars and less congestion, less land use and less pollution.

SHARING ECONOMY

0-20 YEARS

As a response to resource depletion and increased socialization of urban communities, combined with a lower societal drive for ownership as status, the sharing economy is now a growing trend in more developed economies. New business models have emerged that include sharing everything from unused electric drill to cars and even houses. Often arranged through Online platforms, the sharing economy has the potential to work within the context of society individualization and the service economy making more resources available to individuals on demand.

Effects
Ownership and the status associated with it are waning for status related to use on demand. Supporting product service systems that increase sharing, Internet-driven models, leasing, renting and social sharing all have trickle-down economic effects. They tie in with new technologies as larger investments become shared giving rise to decentralized financing.

"Peer-to-peer transportation will remain the largest sharing economy sector across Europe through 2025, accounting for over 40% of total revenues within the five sectors we've analysed. It could also present the most disruptive force to traditional organisations, as car-sharing models start to rival the size of the car rental industry, and the two concepts start to converge with ridesharing around an "on-demand" model."

Pwc

NL: SHARING ECONOMY IN STARTUP PHASE

0-10 YEARS

In the Netherlands, the sharing economy is well in its start-up phase. Services such as Uber and WeGo are up and running, new services such as Peerby are operating globally. However, it is still on trial. Airbnb is successful, but how 'peer to peer' are professional full time real estate rental agents? Uber drivers are facing a very competitive market with low rates. The sharing economy is not always as fair or transparent as it seems, or funded in a way that it will be resilient in the future.

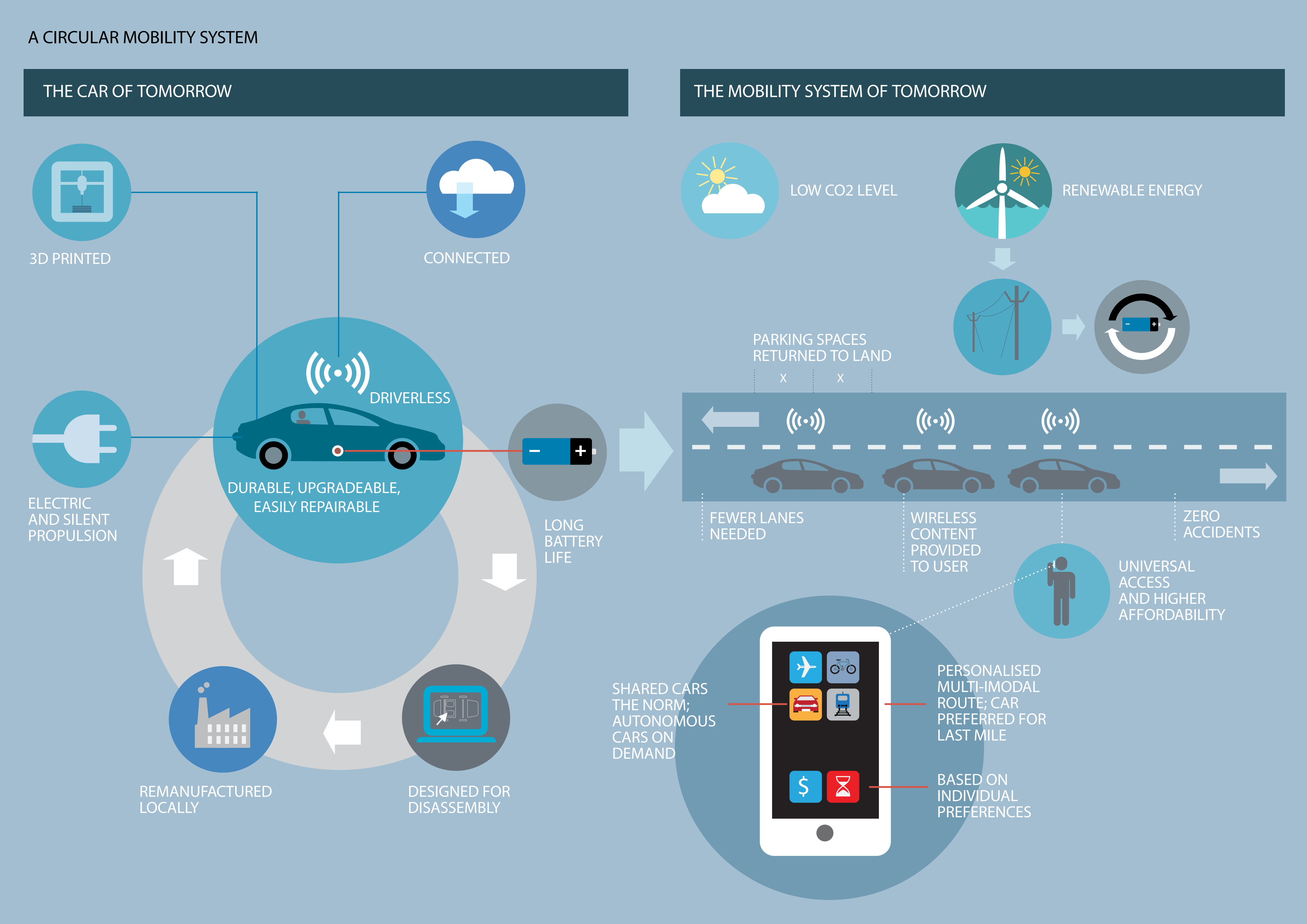
Effects
More sharing economy services will pop up, but it is a start-up and volatile market that is yet to prove itself in the long run.

NL: CAR SHARING

0-20 YEARS

Car sharing is growing steadily in the Netherlands. This trend is pushed by several factors. The cultural attitude of new generations shows a mindshift from car possession as the main purpose to affordable and flexible transport. Rising real estate prices force a personal budget decision whether total cost of ownership of the private car is worth the investment versus other priorities like housing and lifestyle. And obviously: where shared vehicles are widely available, it's easier to use them.

Effects
Car sharing is evolving all over Europe, varying from rental services to peer to peer sharing. Effects are already visible in the streets. Where cars are shared, others are disappearing from the streetscapes, resulting in some urban areas is a shift from parking shortage to parking surplus.


A CIRCULAR MOBILITY SYSTEM
THE CAR OF TOMORROW
3D PRINTED
CONNECTED
DRIVERLESS
ELECTRIC AND SILENT PROPULSION
DURABLE, UPGRADEABLE, EASILY REPAIRABLE
LONG BATTERY LIFE
REMANUFACTURED LOCALLY
DESIGNED FOR DISASSEMBLY
THE MOBILITY SYSTEM OF TOMORROW
LOW CO2 LEVEL
RENEWABLE ENERGY
PARKING SPACES RETURNED TO LAND
X
X
FEWER LANES NEEDED
WIRELESS CONTENT PROVIDED TO USER
ZERO ACCIDENTS
UNIVERSAL ACCESS AND HIGHER AFFORDABILITY
SHARED CARS THE NORM; AUTONOMOUS CARS ON DEMAND
PERSONALISED MULTI-IMODAL ROUTE; CAR PREFERRED FOR LAST MILE
$
BASED ON INDIVIDUAL PREFERENCES

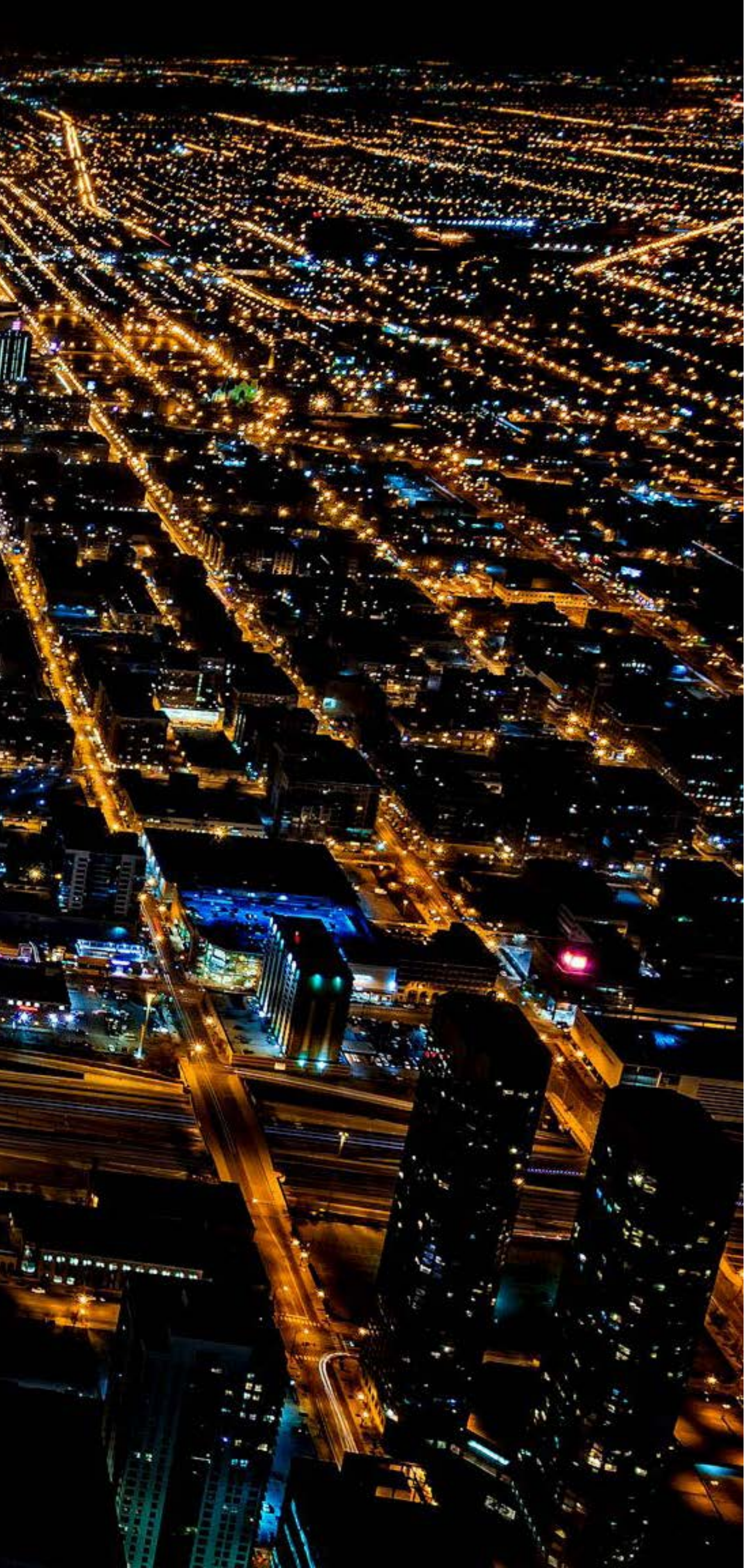
POPULATION GROWTH

0-50 YEARS

The world's expected growth is up to 9 Billion in 2050, mostly outside of Europe and North America. Population growth is a primary societal cause for all exponential effects related to human operations, such as food demand, water demand, CO2 emissions, land use.

Effects

"Demand for food, water, and energy will grow by approximately 35, 40, and 50 percent respectively owing to an increase in the global population and the consumption patterns of an expanding middle class"



URBANIZATION

0-40 YEARS

The end of 2008 marked the turning point where more people lived in cities rather than outside of them. This trend keeps increasing. By 2030, the world's urban population is expected to rise to 60% and by 2050 to 70%. Due to the economic opportunities present in the city, and rural production increasingly under pressure from upscaling and industrialization, marginalized rural populations flock to the city around the world, where there is inevitably a lack of employment opportunities for them.

Effects
The massive growth of urban areas, but not of high quality. With smarter technology systems in transport and parking combined with car-sharing could readjust the use of public space and greenery in cities.

CONGESTION IN THE URBAN AREAS

0-20 YEARS

Car ownership has determined or even dominated infrastructure and urban planning in the 20th century. Suburbs grew by push factors (expensive or dangerous urban cores) and pull factors (green space, affordable transport and land). The suburbs lead to a causal loop of new roads, more congestion, more road capacity, etc.

Effects
Congestion is a serious challenge in many urban areas. The damage associated with congestion, right from wasted fuel costs to loss of productive time, and air pollution, are estimated to cost economies anywhere between 2% to 4% of their GDP today.

Less of the current infrastructure will be needed with the introduction of AVs. Spaces like parking areas, some road times and even fixed EV charging points may become obsolete.

SILVER SOCIETY

0-30 YEARS

The global average population is getting older. In 2006, almost 500 million people worldwide were 65 and older. By 2030, that total is projected to increase to 1 billion. It is significant that the most rapid increases in the population of those 65 and over are occurring in less-developed countries. The number of physically-challenged people is also increasing, due to illness or genetics. This fragile society tends to feel like outcasts and not integrated into today's cities and rapid technological developments.

Effects

Aging countries will continue to face an uphill battle in maintaining their living standards. Demand for both skilled and unskilled labor will spur global migration. New patterns of technology adaptation might have to be considered to deal with the more fragile society as a whole.

Effects on the AV development

The automotive industry is moving forward by taking the elderly more and more into consideration when it comes to the product development, as the self-driving cars may just be the answer to the autonomy issues of the aging population.

"For the first time in history, older people are going to be the lifestyle leaders of a new technology. Younger people may have had smartphones in their hands first, but it's the 50-plus consumers who will be first with smart cars."

Joseph Coughlin

WALKABLE URBANISM: CREATING PEOPLE-ORI-ENTED-CITIES

0-30 YEARS

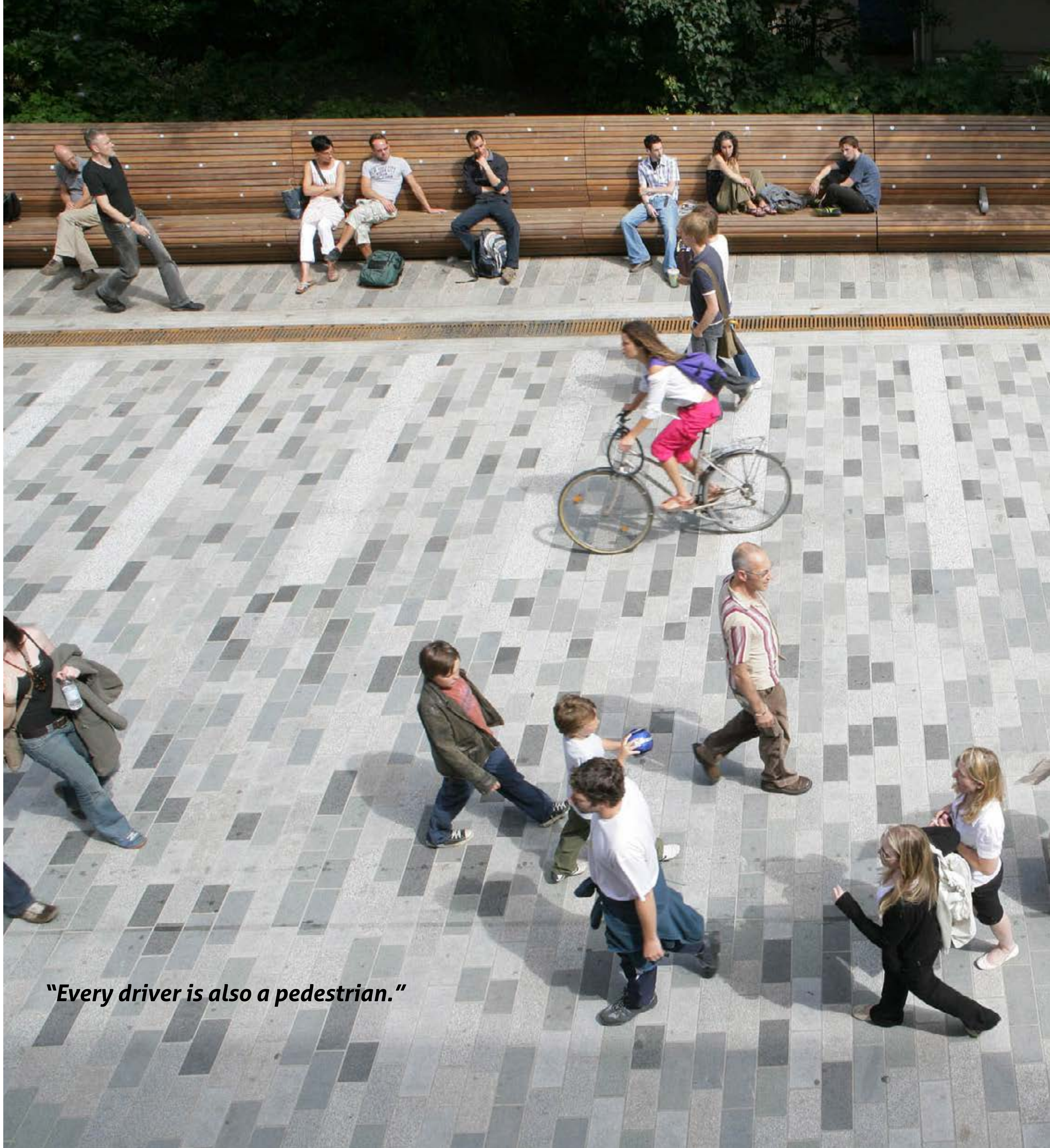
In cities around the world, urban residents want to live healthy, with access to jobs, education, healthcare and public space. However, the rising number of cars, air and sound pollution in the cities create an unsafe, unpleasant and dangerous place for its residents. As a result, many cities are advocating walkable streets, positive public space, integrated civic and commercial centers, transit orientation and accessible open space.

Effects

The effects vary from environmental, economical to social and health benefits. The pressure will be on the public transport to deliver efficient and accessible services to the residents.

More open space for interaction among community members, opportunities for the climate adaptation strategies, lower environmental impact due to less CO_2 exhaustion and new business opportunities for the local communities.

"Human-scale neighborhoods encourage different activities and social interaction, recreating the streets and sidewalks as viable public spaces."



HEALTH & HAPPINESS FOCUS

0-30 YEARS

We are increasing our global focus on human health and wellbeing, as well as social justice, improved user experiences, happiness, satisfaction, and empowerment. The public health trend in consumer services boomed in the last years and continues to grow thanks to developments in the medical, leisure and political arenas.

There is an overall tendency in Western countries towards a decrease in air pollution as a result of better technology and stricter regulations. People make wiser choices about their preferred methods of transport and usage. The usage of the electric car as a healthier transport option is experiencing a boom.

Effects
Shifts in consumer-facing industries at first, with the new advertisement and individual-oriented service levels. Acceptance of the importance of biodiversity and its healing effects is increasing while more emphasis is on surrounding ourselves with healthy materials, filtration of substances and better maintenance.

New business models are emerging where the delivery of fresh air is as an 'ecosystem' service, and the incremental decreasing of sick days is as currency. A wide range of new support industries for marginalized individuals, from the aging and handicapped to special preference and educationally or socially challenged. Fast revolution in thinking, the slow revolution in execution.

**Note that happiness and wellbeing are not analogous to comfort and luxury. Because of the trend in dematerialization of status, happiness and wellbeing are increasingly about being stimulated, challenged, and access to opportunity. It is not growing into increased focus on individual ownership or status.*

CLIMATE ADAPTATION

0-50 YEARS

The message got through. Governments and organizations are uneasily shifting in their seats to start working on climate adaptation with some seriousness. In some cities and countries, the challenge is severely picked up, in others, it is still an in-name-only operation.

In Europe, with the support of the European union's 2020 program, new research is developing quickly. The action is trailing due to lackluster political interest on a national level.

Effects
Sea level rise and increased precipitation, changing weather patterns, warmer summers, more temperate winters predicted in the Netherlands. Increased infrastructural support in all the main areas such as dikes, sewers, and rainwater runoff systems, as well as mediation interventions such as carbon capture, and interventions on urban heat island effects.

NL: ADDING VALUE

0-30 YEARS

The focus in the Netherlands is on water management, air quality, CO2 and shifting weather patterns. From water square that combines water storage with the improvement of the quality of urban public space to large air purification installation that cleans the smog from the cities and SolaRoad path for cyclists which harvests the power of the sun, the focus extends to the added value projects can generate both for the environment and the society.

Effects
Affects all energy-related areas, including building systems, transport, and different usage patterns. More government initiated projects and regulation, as well as subsidies to support the European Horizon 2020 program.

AUTOMATIZATION

0-30 YEARS

Each day we are more aware of the evolution of artificial intelligence. Global trends are leading towards industrial automation defined as the art of using machines to reduce employee workload while maintaining or even improving productivity and quality. In a world of cognitive artificial intelligence, machines will be able to make their decisions simply because there will be more insightful real-time data; this will give them the context to make sense of it and react just like a human would.

Effects
Introducing automated systems can reduce daily operation costs including overhead and wages. These systems can do simple, tedious tasks allowing the workers to focus their energies on more complex and productive tasks, further increasing workplace efficiency. On the other hand, the advancement in technology is leading to the displacement of jobs over the coming decades – with potentially profound implications for both workers and society as a whole.

Effects on AV development
In future, cars will be cognitive; not only will they recognize voices and be able to optimize the journey; they will also incorporate other cognitive technologies of AI such as computer vision and machine learning. This will change the future of cars, challenge traditional business models and create immense potential for innovation.

EMPLOYMENT SHIFT

0-30 YEARS

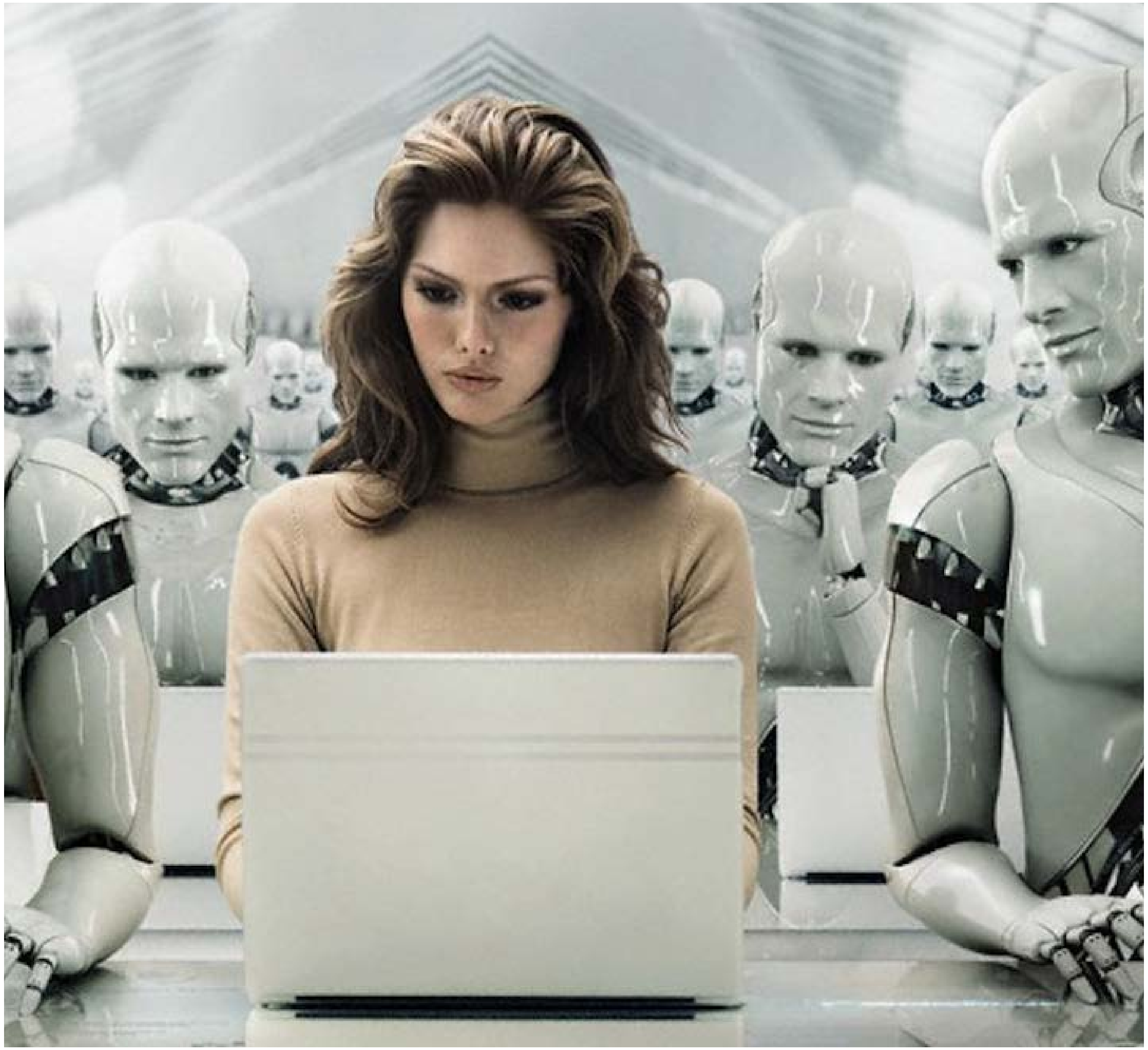
We are at the beginning of a Fourth Industrial Revolution. Developments in artificial intelligence and machine learning, robotics, nanotechnology, 3D printing and genetics and biotechnology are all building on and amplifying one another. Smart systems—homes, factories, farms, grids or entire cities—will help tackle problems ranging from supply chain management to climate change. Concurrent to this technological revolution are a set of broader socio- economic, geopolitical and demographic developments, with nearly similar impact to the technological factors.

Effects

The upcoming technological advances will cause the disappearances of certain jobs but will also create new jobs. Most new jobs will be in more specialized areas such as computing, mathematics, architecture and engineering. Which will leave the manual and clerical workers out of work are unlikely to have the required skills to compete for the new roles. To avoid the crisis, the governments and employers in every sector will have to retrain and re-skill workers.

"Without urgent and targeted action today, to manage the near-term transition and build a workforce with future-proof skills, governments will have to cope with ever-growing unemployment and inequality, and businesses with a shrinking consumer base."

Klaus Schwab,
Founder and Executive Chairman of the
World Economic Forum.

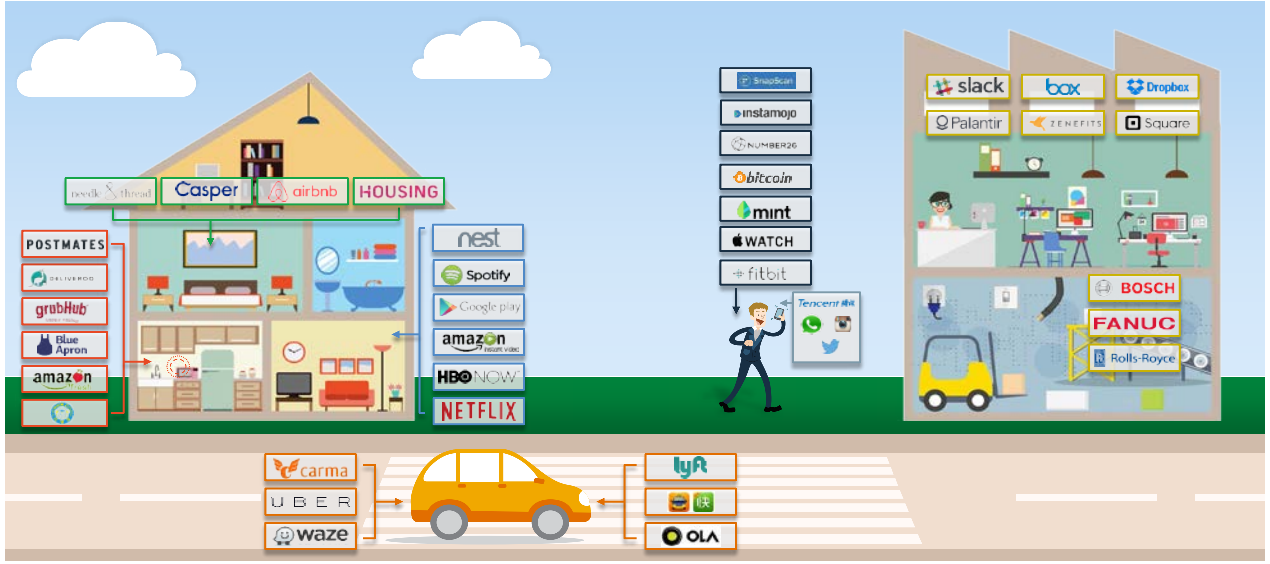


DIGITALIZATION

0-30 YEARS

Parallelly to the automatization, the phenomenon of digitization is reaching an inflection point. The effects of an increasingly digitized world are reaching into every corner of our lives: computers, the Internet, mobile phones, texting and social networking is already transforming the way we work, communicate and consume.

Effects
By the year 2020, an entire generation, Generation C (for "connected"), will grow up in a primarily digital world.



SMART CITY: IMPROVING THE QUALITY OF LIFE WITH ICT

0-30 YEARS

Building up on the new technologies and the digitalization trend, the cities around the world are developing new urban strategies that integrate various ICT (Information and Communication Technology) solutions to manage the city assets.

The main goal is to enhance the management of urban flows towards real-time actions and challenges. The City of Amsterdam started its Smart City Initiative in 2009 and already has 79 contrib-uting projects.

Effects
Real-time sensors and systems will collect data from citizens and other objects to enhance quality, perfor-mance, and interactivity of urban services, to reduce costs, resource consumption, and to improve contact between citizens and government by ICT.

Effects on Mobility
The interconnection of mobility and transport is essential for a town to function properly. Traveling in smart cities will be problem free and easily accessible. To reach this goal, the system has to be efficient, safe, multi-modal and comfortable. It also has to be linked to the Intelligent Transport System (ITS).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TRANSPORT SHIFT

0-50 YEARS

Transport is the lifeblood of society and is changing as rapidly as all other sectors. Patterns in time and space are shifting the perception of transport as a driving element of the economy. Rather than simply a trend, there is increasing direct attention paid to user experience, leisure, and on-demand services.

TRANSPORT SEEN AS A DRIVER OF ECONOMY

0-50 YEARS

There's increasing recognition that transport promotes and initiates economic development. Transport authorities in some places such as Singapore are taking this shift to the next level, by turning transport hub development into business development. Transport-oriented development was already a thing, but transport supported economic development is the new thing.

Effects
New understanding of how transport can drive economic development rather than follow it. Opens up more opportunities for a varied program that was previously thought impossible.

LEISURE AND USER EXPERIENCE FOCUS

0-20 YEARS

The focus on user experiences, in general, extends into the transport sector. We want our journeys not to be just a movement from A to B but to add quality of life. Moreover, we want to spend as little time as possible in transport hubs and gas stations. Increased understanding that sitting in a traffic jam is a terrible way to spend life and public transportation offers increasing comfort, entertainment, and support services.

Effects
Support services around transport hubs diversify, increase product quality and level of services. More onboard entertainment.

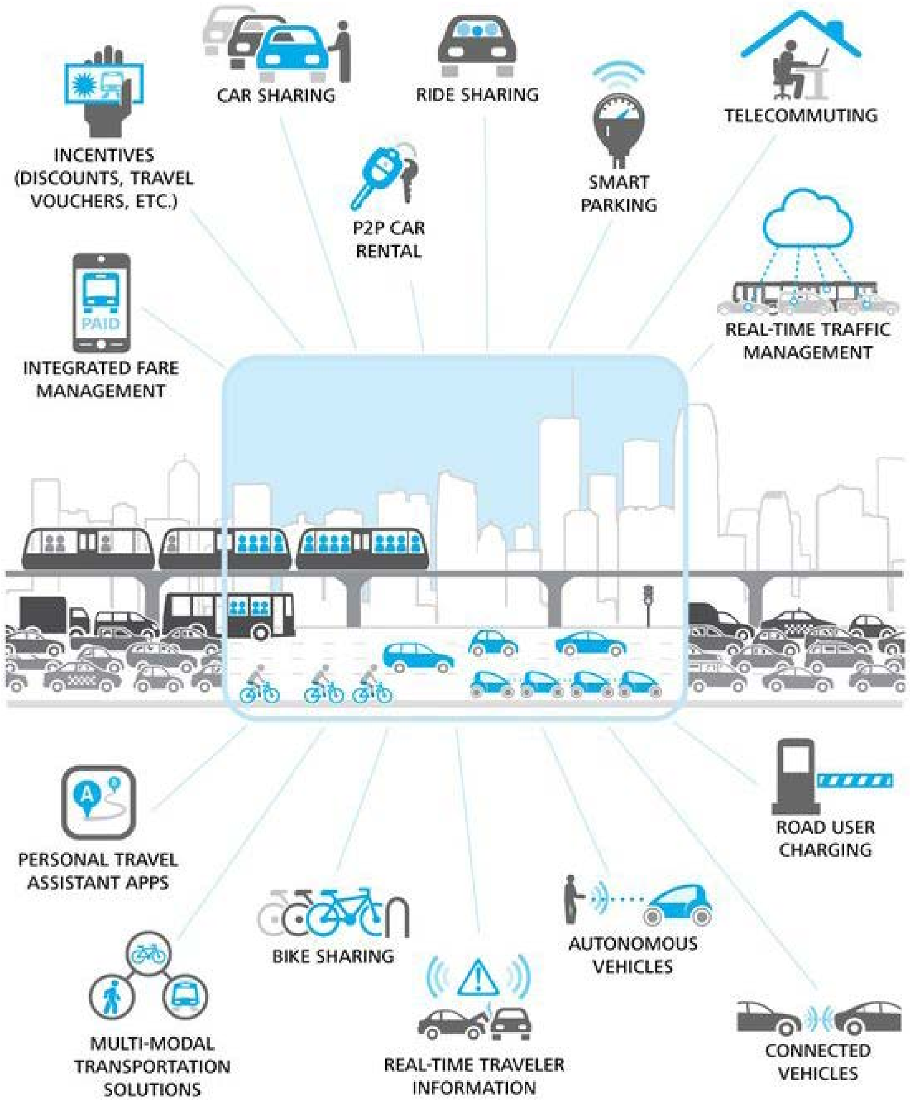
TOWARDS SERVITIZATION OF MOBILITY: MAAS

0-10 YEARS

Servitization and digitalization are current trends that are influencing many areas, including mobility and transport sectors. The growth of sharing the economy with companies as Airbnb and Uber bring these changes into public knowledge. These trends facilitate and drive mobility services into more multimodal and digitalized era and turn mobility into service by combining several transport modes into one package.

Effect
Significant advantages can be a hassle-free transport, high transport network efficiency, lower transport costs for each of the users, reduced congestion and in general a great comfort.

On the long term, MaaS may lead to a decline in car ownership, which would reduce overall gas emissions, less environmental pollution, and resource use. More efficient network coupled with new technology such as autonomous vehicles can significantly lower the cost of public transit.



PATTERNS SHIFTING IN SPACE AND TIME

0-50 YEARS

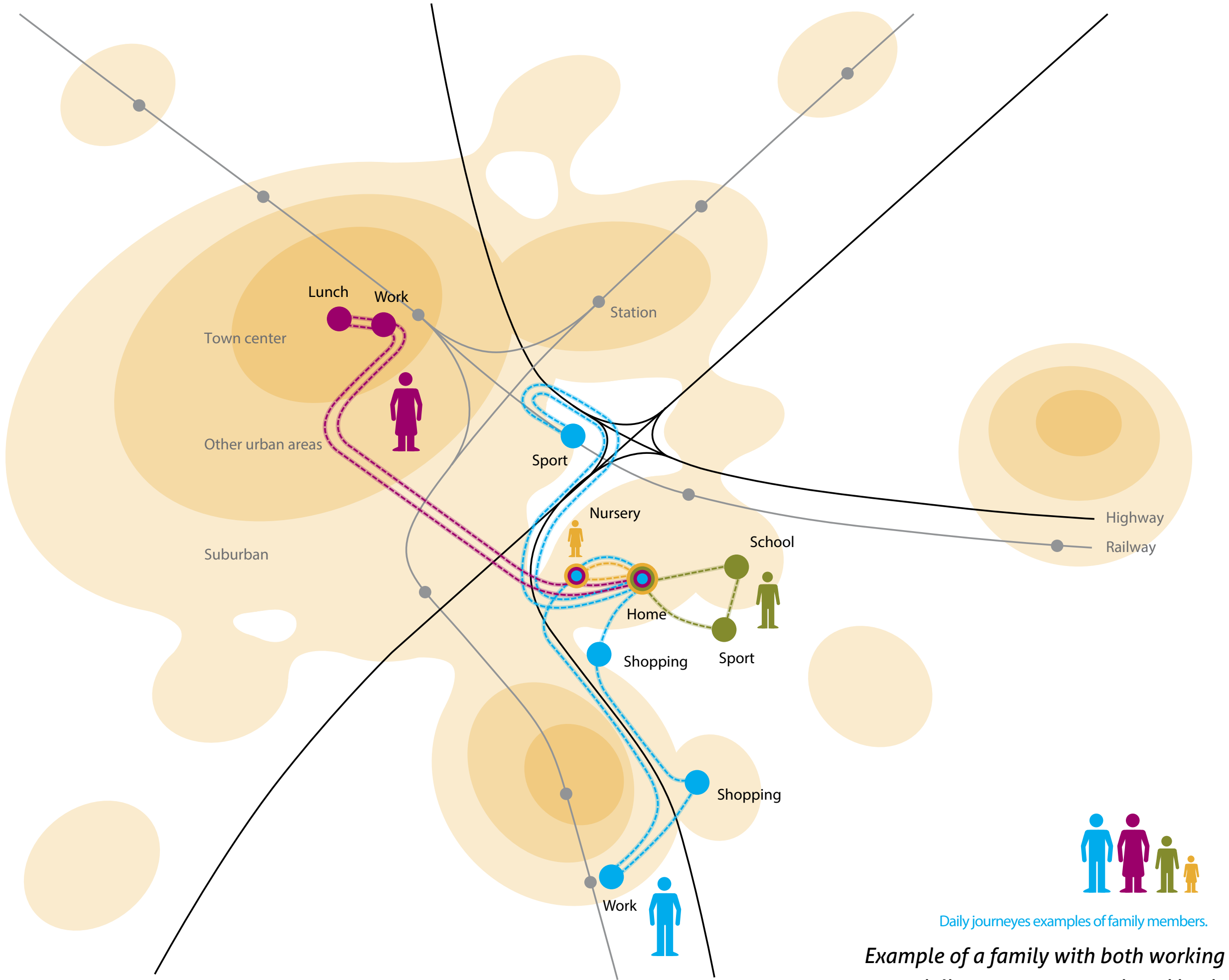
Patterns in society are shifting faster than before due to exponential growth trends. Mobility patterns in urban areas have become more complex compared to the past. Not only activities and destinations have changed, but also the types of transport, demographic alteration, and distances traveled.

More people work from home. There are less 9-5 and more flex workers, more and more widespread tourism, and more 24-hour economies. All of these amount to a diversification of travel times and places, and renewed demand for previously unsustainable modes of transport as well as the development of new ones.

Effects

The convenience of any desired transport gives room for a vast variety of activities. Many citizens want to travel to the closest urban area to go shopping or engage in other activities. Daily reasons for trips include work, recreation, education, shopping, and family related activities.

Influence on all transport-related areas, from timetables to business models.



Example of a family with both working parents.: daily commute to work and back, almost doubles the trips and distance covered.

MOVING BEYOND OWNERSHIP: CAAS

0-30 YEARS

By 2025, 50 % of the global working populations will be made of Millennials. Various researchers show that this demographic group is less interested in owning a car and instead more interested in the environmental implications.

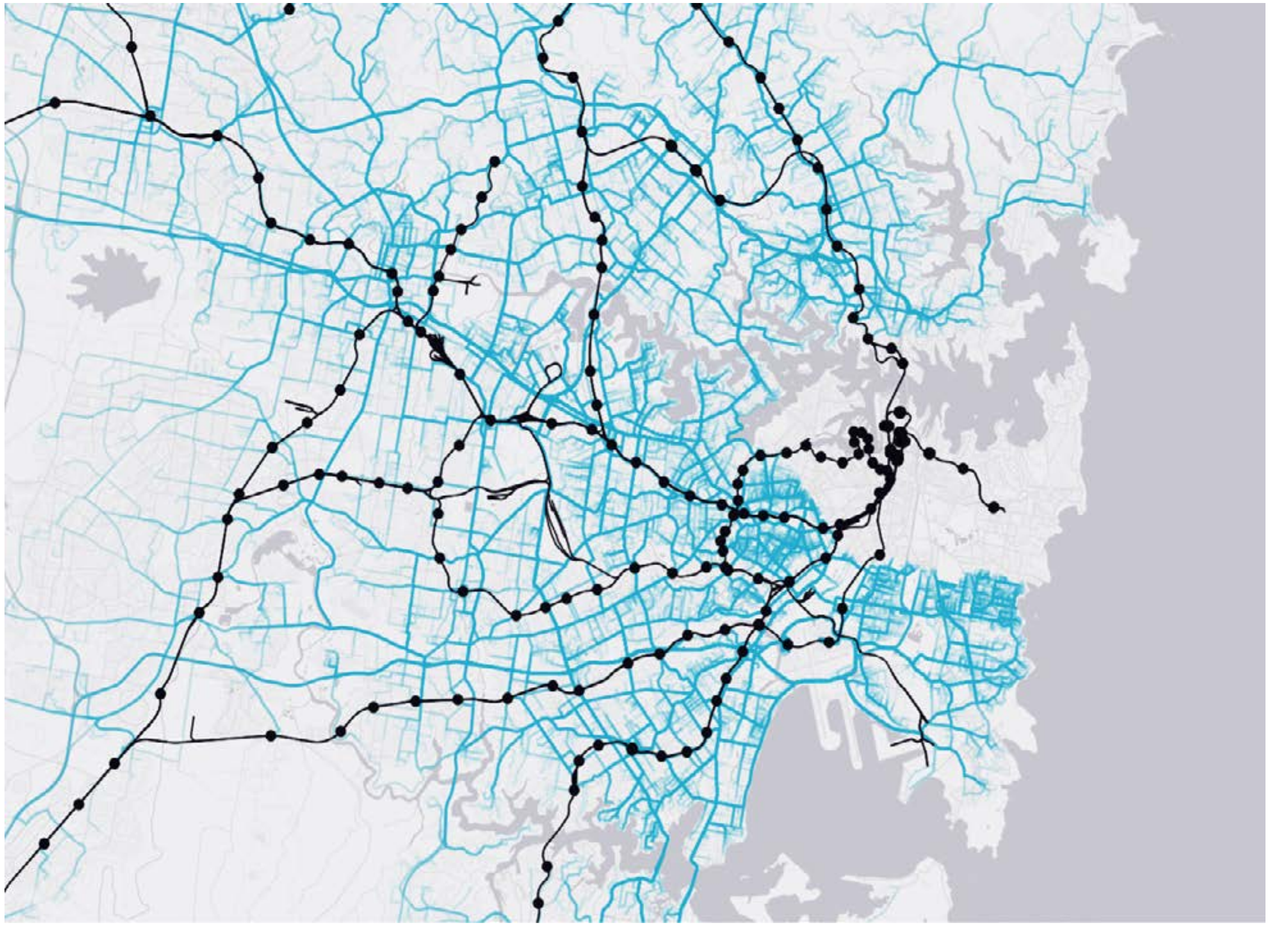
The consumers that prefer services over products (e.g. Spotify and Netflix) can use a car-as-a-service (CaaS). The 'buying' decision concentrates on the flexibility of the services that can meet a variety of demands.

Effects
The changing attitudes will drive the growth of shared mobility business models as well as greater utilization of existing infrastructure in cities.

Effects on Mobility
Over the coming years, the automotive industry is expected to change drastically. From the user experience to the supply chain, the sector is starting to see the value of embracing the modern consumer's lifestyle and connective expectations to influence and in turn re-invent the core values of the automotive industry.

"Cars are no longer the mechanical marvels of the industrial age, but a utility to the life we'd like to lead. In order for the industry to fulfill its utilitarian need and provide a service reflective of the new role cars now play in our day to day life and become the hosts of information, which is what consumers are looking for."

Dr. Martyn Jeffries and David Rigler



Uber rides pattern map - Sidney

SELF-DRIVING VEHICLES

0-10 YEARS

The self-driving car exists and needs about ten more years to come to adulthood on an influential scale. The technology is complete and improving, while it waits for legal and regulatory frameworks to deal with inevitable questions of responsibility and accountability.

Effects
Analysis forecasts that 8 million semi and highly automated vehicles will enter the market in the next ten years. Once the commercialisation of autonomous driving kicks in, it will have far-reaching impacts. The entire landscape, as well as the future of cities, will change as a result of this technology shift.

Related areas such as parking, road design and thus the urban landscape will be heavily impacted. The shift in parking places, a reduction of parking areas due to automatic compacting combined with the servitization and reduction of desire for ownership, new sharing and on-demand models will overtake current family ownership and control of cars, as well as replace lease models for businesses.

NL: BICYCLE & THE CITY

0-30 YEARS

In Dutch Cities, as well as a few other European such as Copenhagen, the bicycle has never been away from the spotlights, but shows significant gain of importance. Either pushed by the lack of space for other transport means (Amsterdam) or driven by healthy lifestyle and new markets for fashionably and fast bikes like the speed pedelec.

Effects

- Increased pressure on cycling infrastructure such as crowded bike lanes and bike parking on sidewalks.
- Need for parking and charging facilities.
- Healthy lifestyle and social interaction
- Reduction of air pollution.

CONCLUSIONS

When it comes to the relation between self-driving technology and urbanization, let's first look at urbanization in itself. Global urbanization is an unstoppable process. Since the 1960s, suburban structures catalyze the ownership of private cars and all the problems that came along with it: congestion, spatial barriers, air pollution and traffic accidents. Planners and politicians still haven't been able to break the cyclical pattern of more traffic leading to more roads leading in turn to more traffic.

At the same time, we witness the trends of reurbanization, gentrification and urban transformation. These are forces that work against sprawl as a result of the growing attractiveness of dense and vibrant urban districts. In these areas, cars compete for space and are equated as a factor equal to other needs such as affordable housing and urban green space. This type of environment is fertile ground for car sharing operators and services like Uber. Even the 'good old bike' is being reinvented.

It seems only a matter of time before apps are available that deliver completely integrated door to door mobility solutions; this being a combination of train, metro, tram, taxi, shared car or bike. It is more than likely that AVs will capture a significant market share in these integrated chains. The mixed urban zone, somewhere between the pedestrianized urban core and the low density residential and business parks will be the true testing ground voor collective self-driving solutions. The sooner and better these solutions are integrated in user interfaces and other transport means, the more likely the are to succeed.

The automated private car is developing in conjunction with the speed of electrification and in the current legal context rather than a replacement for driving seen as an additional. The market for luxury electric or hybrid cars will pave the way for a transition towards fully automated transport solutions. Liability aspects are crucial. Where human drivers will always fail, vehicle manufacturers could potentially claim a practically zero failure rate. This trend will cause shifts in legal and insurance practicalities.

New generations will easily adapt to new transport modes like AV. Seniors despite being more hesitant towards innovation will reap the benefits of access to more places and individuals despite physical limitations.

Possible spatial impacts of transport shifts are in close relation to other spatial needs such as climate adaptation. The green-blue healthy city movement is gaining strength and will set new requirements for transport design.

PRECEDENT RESEARCH

INTRODUCTION

Precedents are important for the purpose of learning from other products, projects and researches. A thorough understanding of precedents helps in system understanding and improve solutions. The selected precedents are structured in three categories: Urban Mobility Strategies, Research Papers and Technology Development & Application. The 4th category 'Fake or Real' takes us on a preview to Hyperloops, human-carrying drones and flying water taxi's.

THE STRUCTURE

The precedent research is divided into four different categories relevant for this phase of the Self-driving City project:

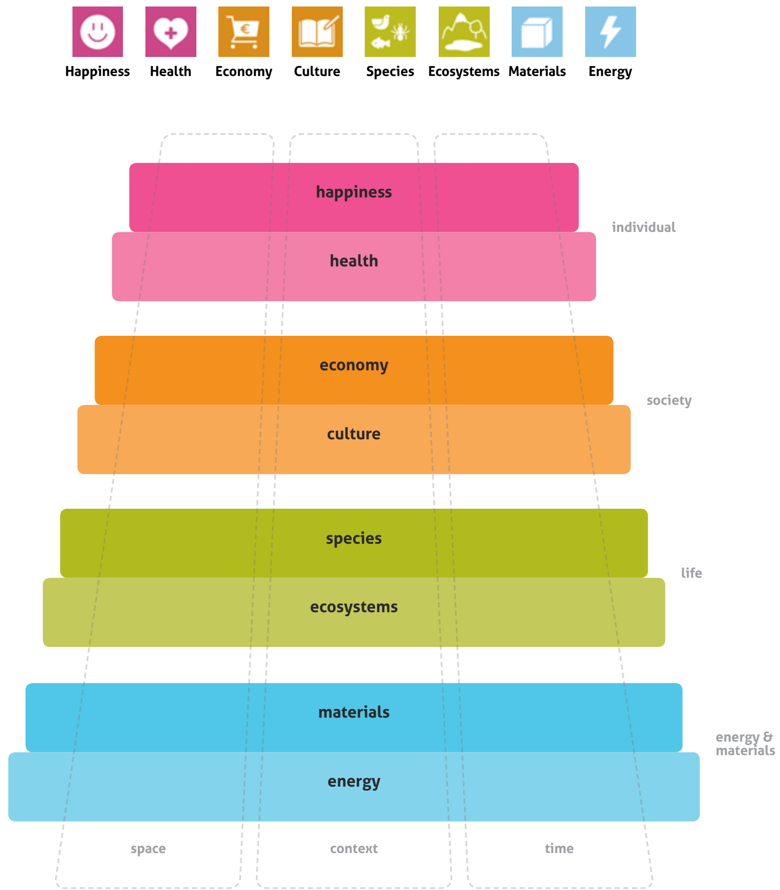
1. Urban mobility strategies,

2. Research papers,

3. Technology development & applications,
» Operational public transport,
» Private AV development,
» Testing environments,
» Logistics,
» Smart Mobility,
» MaaS,

4. Fake or real.

CATEGORIES FOCUS
These four categories have a subset of focus areas which look at distinct and interrelated aspects of sustainability applying ELSIA indicators. The sustainability aspects specific for each precedent are indicated by icons in the colors:
» **blue** (energy & materials),
» **green** (ecosystems & species),
» **orange** (culture & economy)
» **pink** (health & happiness).



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URBAN MOBILITY STRATEGIES

"Curitiba was the first to include the essential elements necessary for a BRT system to function effectively,"
Andrés Fingeret

When faced with high ridership problems due to a conventional boarding systems, Lerner created revamped glass tube stations that enabled faster boarding through multiple doors, where passengers pay fares before entering the station. The new "tube stations" opened in October 1991 as part of the first Ligeirinho express line. Today there are 357 tube stations throughout the city.

With this valuable addition, the city's system became the world's first bus rapid transit (BRT) network.

CURITIBA RTB SYSTEM

Location
Curitiba, Brazil

Year
1974

Implemented in 1974, Curitiba RTB system is known as one of the first and most successful examples of transit-oriented development. In the 60's Curitiba was dealing with fast population growth and traffic issues. Urban planners called for the creation of subway lines and widened streets for cars which construction would be costly and could take decades to complete. Instead, architect and Major, Jaime Lerner saw an opportunity in the one form of transport that many considered a lost cause: the bus.

Lerner created integrated dedicated bus lanes along the city's main arteries allowing the buses to run at a higher speed while reducing the cost. Furthermore, he created a pedestrian mall in the city center and dammed the small streams to create parks, which would close during floods transforming Curitiba in one of the most innovative cities in the world.

Relevance
The first rapid bus lanes of Curitiba ended up costing 50 times less than rail as Lerner made a bargain with private bus operators who paid for the new infrastructure, while the city provided the vehicles in exchange.

CITY CENTER AS 'URBAN LIVING ROOM'

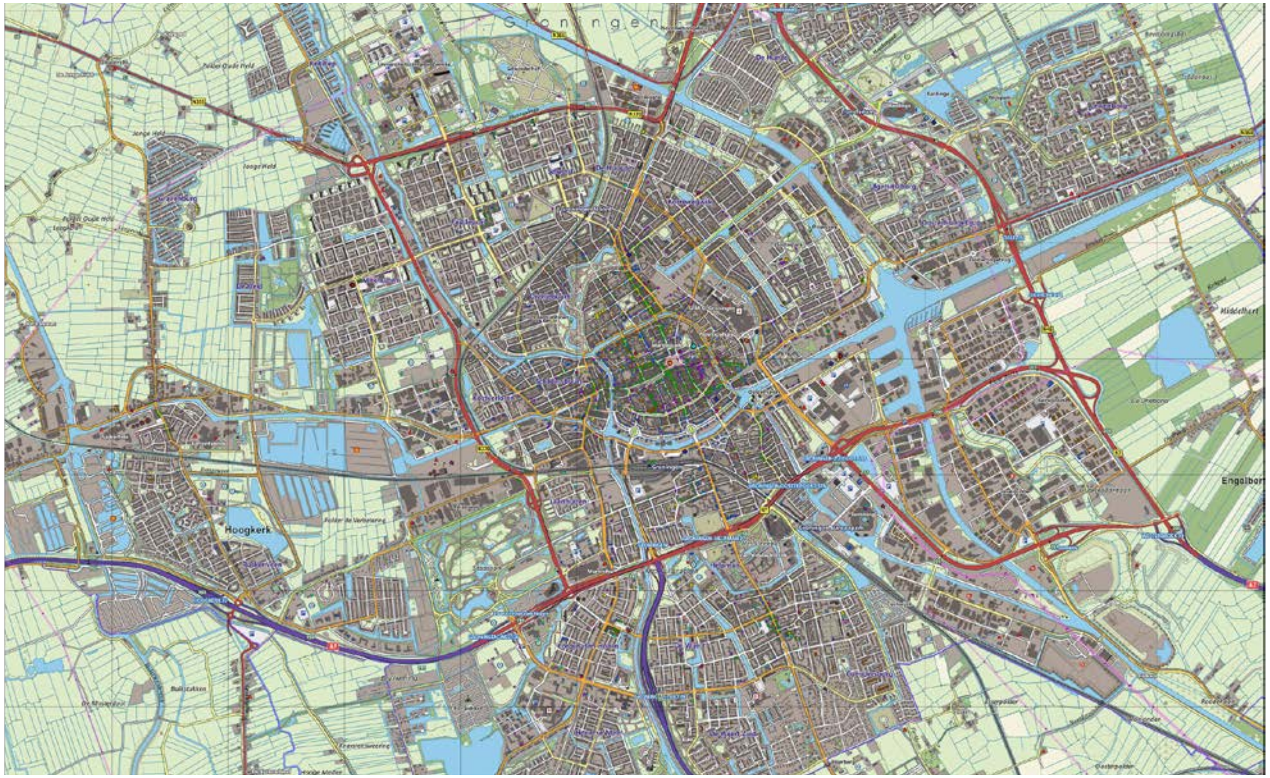
Location
City of Groningen, The Netherlands

Year
1970 - 1980

Project description
Groningen is known for implementing new transportation strategies and infrastructure, all for the health and well-being of the city. In 1972 a new local government shifted the emphasis from cars to bicycles. The city introduced a parking circulation system consisting of zones and one-way traffic lanes, no longer allowing cars to cross the heart of the city transforming it into urban 'living room'. Today, Groningen plans to reroute the city buses to continue the process of pedestrianization.

Relevance
In the 80's Groningen was one of the first cities to give priority to pedestrians over cars. Groningen's achievement came from policy to exclude cars from the center of the city (a form of segregation without cycle paths) and to provide high quality and mostly traffic-free cycling routes from the outskirts to the center. The strategy became a tremendous success and only after a strong debate was finally embraced by the vast majority of entrepreneurs and citizens.

The emergence of the autonomous vehicle is jet a new chapter for the city to prepare for.



"Residents finally don't feel isolated anymore! The tram has enormously improved Bordeaux's image."
Michèle Delaunay, a Socialist politician

THE RENAISSANCE OF THE TRAMWAY

Location
various cities in France

Year
1980's

Project description
After almost entirely disappearing in the first half of the 20th century, trams have made their way into French cities since 1985. Initially, they were perceived only as a means of public transportation. However, they gradually became an important urban tool and a catalyst for the thorough restructuring of public spaces serving as an antidote to traffic jams and gridlock.

Today, tram lines in France are a symbol of a modern approach and an expression of pro-environmental ambitions of French cities.

Relevance
It is not only about the revitalization of transport systems. Bringing back the tram to the French cities had a significant impact on the social development within.

"Can Trams Transform Society?"
In Mulhouse and Montpellier, for example, the tram connected neighborhoods that were once isolated - both geographically and socially - from the cities' centers. In different cities tram allowed its residents access to the city's downtown, where they can hang out, work or go to the movies.

BOGOTÀ MOBILITY STRATEGY

Location
Bogotà, Colombia

Year
2000

Project description
In 2000 the city of Bogotà declared war to the cars. To decrease the ownership and use of automobiles, the government implemented a complex New Mobility strategy which prioritizes walking, cycling, and public transportation, while discouraging private vehicle use. Inspired by Curitiba's Rede Integrada de Transporte, the largest restructuration of Bogotá's transportation system took place in the form of the city's public bus system TransMilenio.

The system is characterized by large capacity buses, dedicated lanes and raised stations that enable fast boarding and pre-board ticketing. The system operates as a public-private partnership.

Relevance
The Transmilenio system had big environmental and social impacts on the city. The level of carbon emissions from the transport decreased, new jobs were created, and the quality of the access and mobility across the city improved. This strategy is a relevant part of a wider urban development instead that an alone and small-impact implementation.

The introduction of the BRT system was part of a wider urban development project which aims to radically altering the image of the city through the development of public spaces, pedestrianized zones and cycle paths.

SEOUL FREEWAY TRANSFORMED INTO PARK

Location
Seoul, South Korea

Year
2005

Project description
The stream running through the center of Seoul was for three decades totally buried beneath a busy downtown highway. The area under the highway was avoided by the citizens, which considered the space rife with criminal activity.

In little more than two years, the area was part of a vast urban renewal project that turned the highway into a beautiful and multi-functional linear park. The aim of the project was to restore former public space and create a waterfront in the downtown, improving the environment and restoring the historical value.

Relevance
What may have seen as a bold move and risky strategy turned out to be a winning solution for the city. In addition to the restoring a public space, Seoul also implemented transportation planning, rerouting traffic through other corridors and adding more public transportation. As a result, the number of the vehicles entering the city has decreased, and the use of the bus and subway have increased.

AREA C

Location
Milan, Italy

Year
2012

Project description
The city of Milan has one of the highest European rates of car ownership and one of the highest concentrations of particulate matter among large European cities. For these reasons, the City of Milan launched several measures to address air pollution and traffic congestion. One of them is an innovative road pricing scheme called Area C.

Area C is a congestion charge aimed at reducing traffic pollution in the city of Milan and, consequently, improving the quality of life for citizens and visitors alike. It is a limited traffic zone (LTZ) with the access limited to four days a week from 7.30am to 7.30 pm. Besides this Milan is finalizing its Sustainable Urban Mobility Plan, which outlines the possibility of extending Area C to the Cerchia Filoviaria, and introducing a Low Emission Zone. Similar measures have been taken in other Italian cities, like Florence and Rome.

Relevance
The Area C project provides great benefits to the city: less congestion, traffic, pollution, noise, and more space for walking and cycling. The reduction of cars circulating in the city center enabled public space once reserved for parking to be reclaimed by pedestrians. Moreover, thanks to the reduction in traffic from Area C, the city's whole transport system has benefited.

SINGAPORE TRANSPORTATION MASTER PLAN

Location
Singapore

Year
2013

Project description
The Singapore Land Transport Authority ("LTA") is updated and improved version of the previous Master Plan published in 2008. Due to changes in increased demand for transport, an increased expectations of a better quality of life and tighter land constraints the new strategy was needed.

The vision is that by 2030, Singapore will be a city where 8 in 10 households are living within a 10-minute walk from a train station, 85% of public transport journeys is completed within 60 minutes and 75% of all journeys in peak hours are undertaken on public transport.

Relevance
The Master Plan goal is to create a more people-centred land transport system with the emphasis to commuters needs and offer diverse and quality service. The new system will give more consideration to the well-being of the Singapore diverse community and enhance the livability of the environment of the city.

To achieve this goal Singapore is introducing driverless vehicles piloting an electric car-sharing scheme and creating more car-free zones in the city to give space to public activities.

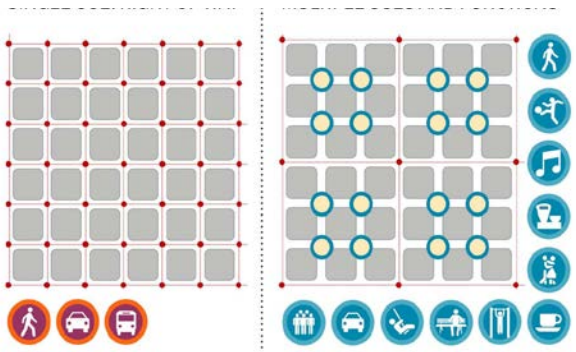
COPENHAGEN BIKE PLAN

Location
Copenhagen, Denmark

Year
2014

Project description
Copenhagen is one of the top cycling cities in the world. By widening the cycle tracks, planning contraflow cycling and building more connections (bridges and paths) the Danish capital implemented a cycling infrastructure which allows 45% of its population to cycle to work and back home. The rates are increasing each year steadily with surprising success. In 2016 the number of bicycles officially was superior to the number of the cars within the city.

Relevance
Integrated sustainable planning can be successful by giving bikers and pedestrians priority. Many western cities are also improving their urban cycling visions, and developing countries are at the forefront of some of these adoptions as well.



'SUPERILLES' - TAKING BACK THE STREETS

Location
Barcelona , Spain

Year
2016

Project description
Faced with excessive pollution and noise levels, Barcelona faced the challenge with an ambitious plan that will reduce traffic by 21% and will free up nearly 60% of streets currently used by cars transforming them into so-called 'citizen spaces'. The plan is based on the idea of 'superilles' (superblocks) – car-free areas designed to maximize the public space.

Each 'superilles' combines nine city blocks in one pedestrian-friendly mini grid, forcing the drivers to pass thru and circle. Car, scooter, lorry and bus traffic is restricted to the roads on the superblock perimeters, and are allowed only in the streets in between if they are residents or providing local businesses. The speed is drastically reduced to 10km/h (typically the speed limit across the city is 50km/h, and 30km/h in specific areas) creating safer streetscapes.

Relevance
The application of the 'Superilles' will significantly improve urban quality while reducing the environmental impacts of vehicles. It will also increase the quality of life of residents and visitors, enhancing social cohesion and increasing economic activity within the area.

SOMERVILLE ASSEMBLY ROW: INTELLIGENT PARKING

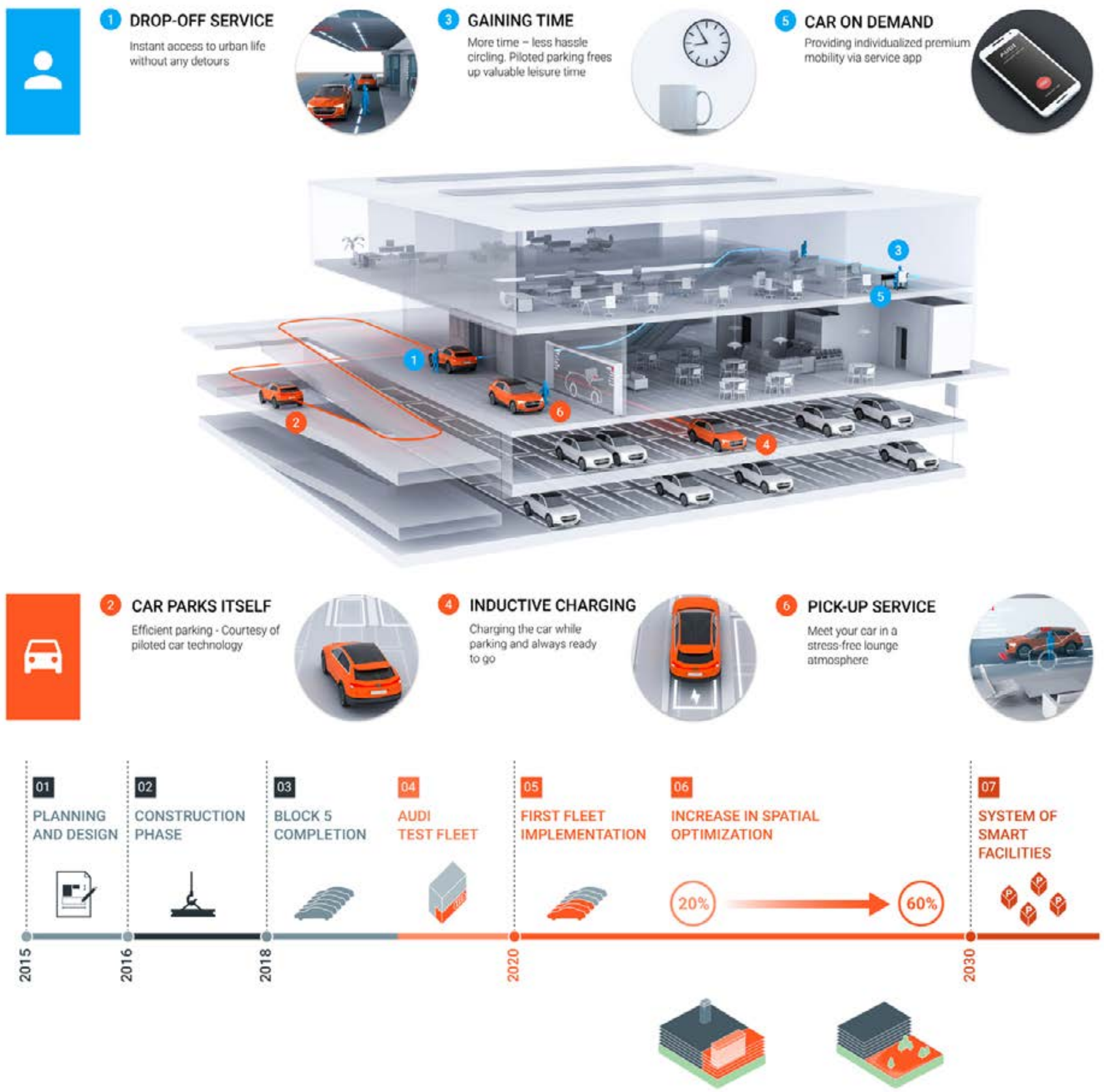
Location
Somerville, Boston, USA

Year
2018 - aimed 2025

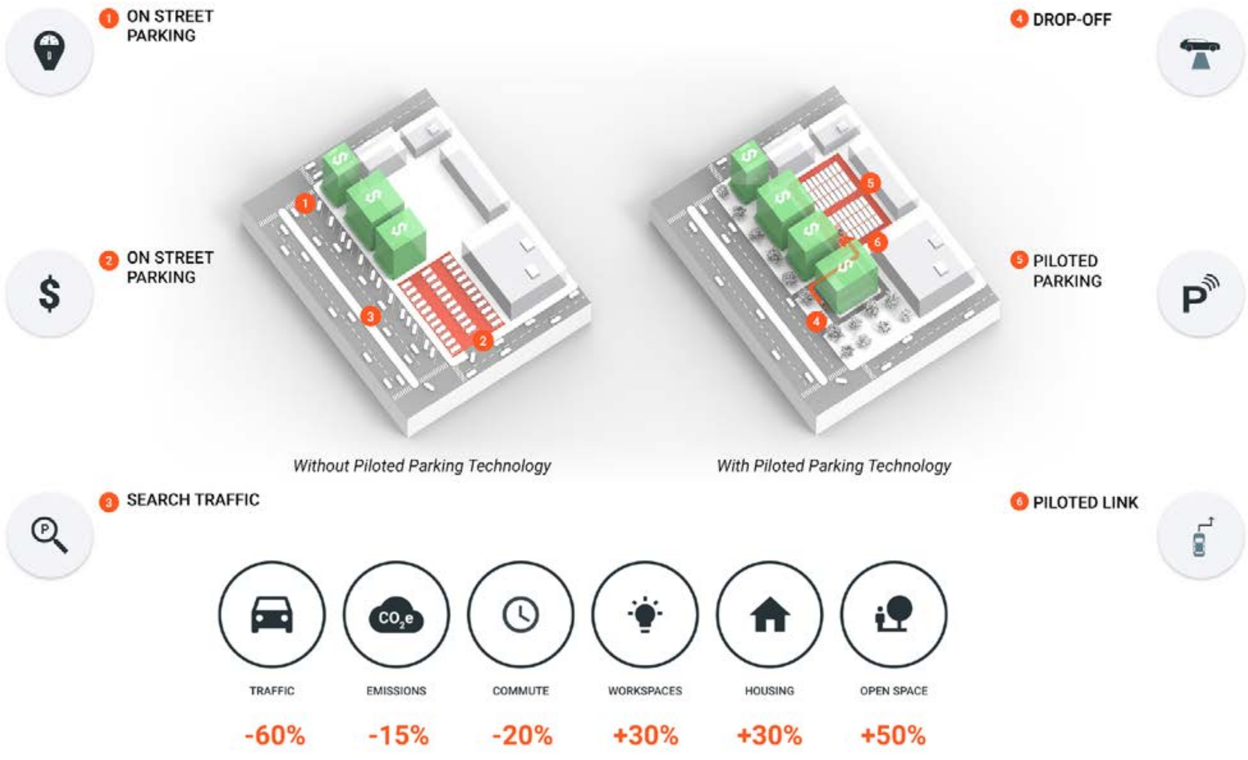
Project description
Somerville is the fastest-growing economic region in the USA after the Silicon Valley. It has a very young population prevalently formed of millennials: pioneers of the digitization and networking of society making Somerville the ideal test laboratory for the future of urban mobility.

The City of Somerville and Audi teamed up to test self-parking car technology and a traffic management system in the city. At Somerville's Assembly Row Audi will test its "intelligent" parking system. The existing mobility infrastructure will soon reach its capacity limits. Due to a dense urban structure and narrow inner roads, parking is becoming a big problem for commuting systems and fruition of the public space. Audi estimates a parking garage with a fleet of its devoted self-parking cars can reduce the area of Assembly Row dedicated to parking by about 62 percent and save about $100 million.

Relevance
This project is about the transition in parking systems and adaptation to new infrastructures. AVs can park by themselves and use less space within the urban fabric. Somerville is taking those factors into consideration and proposing a unique set of solutions for their parking problem.



EXCEPT
INTEGRATED SUSTAINABILITY



UNION SQUARE: TRAFFIC MANAGEMENT SOLUTION

Location
Somerville, Boston, USA

Year
2018 - aimed 2025

Project description
Somerville's Union Square neighborhood is currently undergoing revitalization and a testing ground for Audi's traffic management solution. With the development of Union Square its traffic and mobility challenges will increase. According to Audi about 30 percent of traffic volume at peak times is caused by drivers looking for a parking space.

To help manage the added volume of vehicles and pedestrians, Audi will implement its "traffic-light information online" system, allowing Audi's connected vehicles to network with the city's traffic lights.

Relevance
The company predicts this effort could improve the flow of traffic by 20 to 50 percent by reducing the number of cars looking for parking spaces and showing drivers the ideal speed to reach a green light in time. Eventually, Audi also believes about 20 percent of Somerville's roads could be reduced in size or dedicated strictly to pedestrian, bicycle, or public transportation use.

RESEARCH MATERIALS

THE PATHWAY TO DRIVERLESS CARS

Author
Department for Transport, UK

Year of publication
2015

Research description
The report explores the impacts of the self-driving car in larger western cities with more complex systems and dense urban areas. With one of the most challenging, and diverse traffic roads and weather conditions in Europe and London, UK is the ideal location for testing and developing these technologies.

It gives insight into how the existing legislation supports the development of AV technologies and sets out a plan of action to ensure that the UK continues to develop its place as a leading automotive nation attracting investment from across the globe.

Relevance
The Government established a Code of Practice which facilitates long distance and large area public road testing of these technologies. It sets the standards for manufacturers and testing organizations and their test drivers in the unusual circumstances of carrying out testing on AVs.

"It is envisaged that national legislation can be amended by 2017 and there should be an aim to finalize amendments to international regulations by the end of 2018."

THE NEXT REVOLUTION

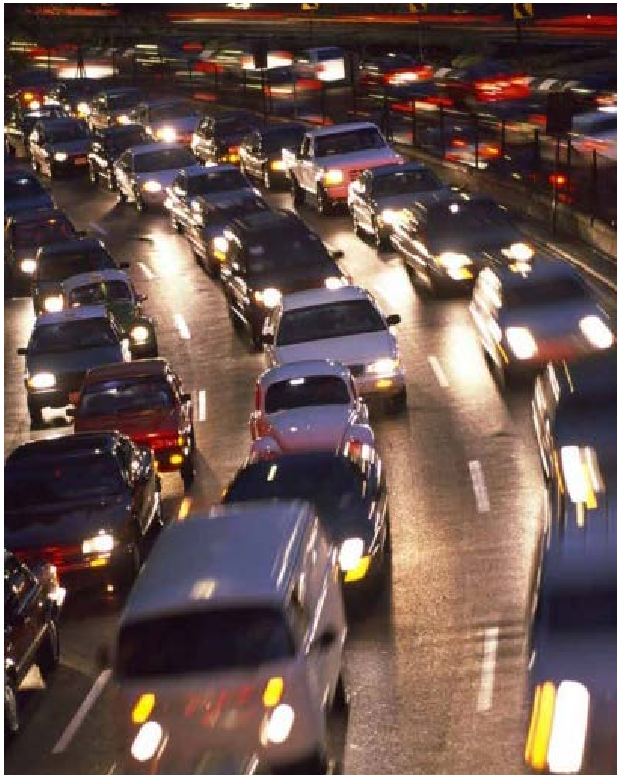
Author
KPMG LLP and the Center for Automotive Research

Year of publication
xxxxx

Research description
KPMG LLP and the Center for Automotive Research (CAR) joined forces in examining the forces of change, the current and emerging technologies, the path to bring these innovations to market, the acceptance of the consumers, and their potential impact on the automotive ecosystem.

The research is divided into main four sections:

- Market dynamics examines the market dynamics and the social, economic, and environmental forces that are making change inevitable.
- Convergence discusses the ongoing convergence of the key enabling technologies.
- Adoption focuses on the path to widespread adoption of advanced automated driving solutions.
- Implications for investment addresses the social, political, and economic implications of self-driven automobiles and their impact on the entire automotive ecosystem.



Relevance
The auto industry is currently developing sensor-based solutions to increase vehicle safety. These systems, known as Advanced Driver Assist Systems (ADAS), use a combination of advanced sensors, such as stereo cameras and long- and short-range RADAR, combined with actuators, control units, and integrating software, to enable cars to monitor and respond to their surroundings. Some ADAS solutions, such as lane-keeping and warning systems, adaptive cruise control, backup alerts, and parking assistance, are available now. Many others are in the pipeline.

SELF-DRIVING VEHICLES IMPACT ON LOGISTICS

Author
DHL

Year of publication
2014

Research description
DHL report "Self-Driving Vehicles in Logistics" developed a comprehensive analysis of the impact of AV technology to the logistics and supply chain industry:

Warehousing Operations: With a solid indoor navigation and situational systems, AVs can optimize warehouse management.

Autonomous Loading and Transport: AVs within the warehouse can both transport the goods and combine other process steps as loading and unloading increasing the efficiency of the entire process.

Outdoor Logistics Operations: AVs could provide a great solution by executing all types of yard logistics. This would reduce congestion and improve safety in the yards.

Last-Mile Delivery: The most unpredictable part of the entire logistics journey: *"The environment is likely to be both complex and dynamic, particularly in congested urban areas. This presents an advantage for self-driving technology because speeds are lower and vehicles have more time to react and to 'think' about route alternatives, and finally fulfill with on-time delivery".*

SHARED MOBILITY SOLUTION IN STOCKHOLM

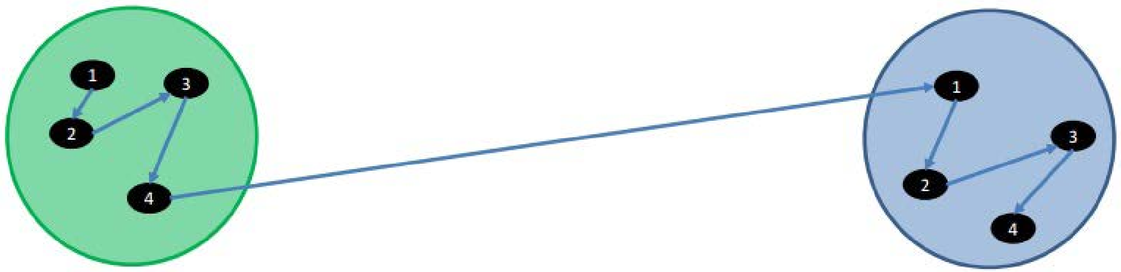
Author
Royal Institute of Technology

Year of publication
2014

Research description
The KTH study aims to show what can happen if cities build on the growing interest in car-share programs, indicating that self-driving technology could be a game-changer. According to researchers at Sweden's KTH Royal Institute of Technology, a fleet of shared self-driving cars in Stockholm could reduce rush hour traffic volumes by 14 cars for every shared vehicle.

The study explores the possibility of introducing a fleet of 9,700 Shared Autonomous Vehicles to the Stockholm metropolitan region, which would hopefully replace the estimated 136,000 automobiles that are in daily circulation in the Swedish capital.

Relevance
This research report shows that shared self-driving cars in Stockholm are an appealing solution since it makes obsolete most of the parking places releasing a considerable amount of valuable space in cities. A space that could be used for cycling or public transportation infrastructure, which are difficult to squeeze in today's city road network.



KIM: CAR SHARING

Author
Kennisinstituut voor Mobiliteitsbeleid (KiM)

Year of publication
2015

Research description
Research published by KIM discusses the car sharing trend in The Netherlands. There are already about 90,000 people sharing their vehicles and 14,000 shared cars. Less than 1 percent of citizens above age 18 are participating in this trend. Primarily it is well-educated young adults with children subscribing to this trend. This report shows the importance of car sharing. The content is about flows, trends, and effects of the shared vehicle.

Relevance
While exploring the current trends and data related to the growth of the sharing economy within the Netherlands, it focuses on the car-sharing and its effect on the society today. Connected to the AV development, it shows the importance of the sharing economy for the future of our cities and most importantly mobility. AVs could be part of the shared system instead of private ownership helping in solving the congestion and pollution issues.

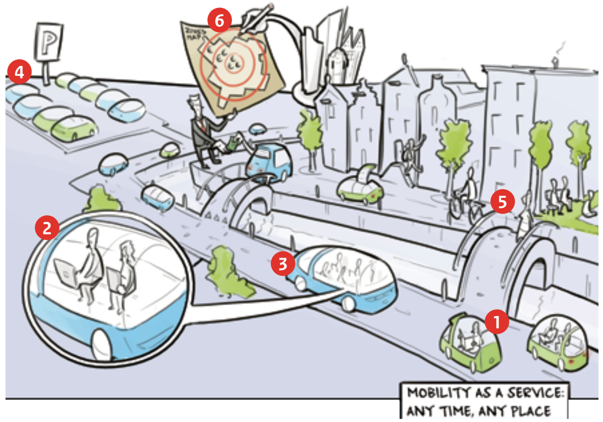
KIM: 4 SCENARIOS

Author
Kennisinstituut voor Mobiliteitsbeleid (KiM)

Year of publication
2015

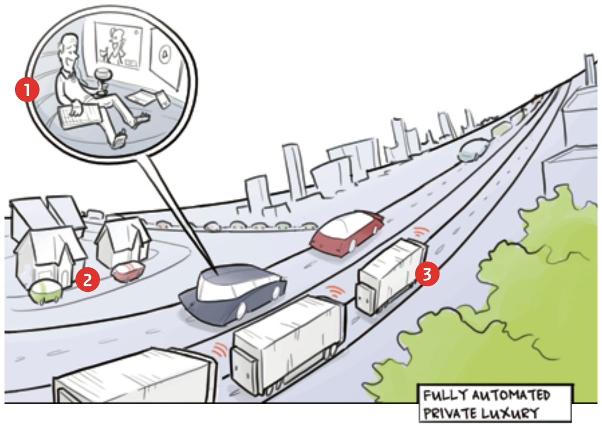
Research description
KiM (Kennisinstituut voor Mobiliteitsbeleid) published the report "chauffeur aan het stuur" (driver at the wheel) with four scenarios predicting the possible impact of the self-driving vehicles. The study shows the AVANZAMENTO of self-driving cars technology and the acceptance of car sharing within the society. The scenarios are based on the developments of levels 1 until 5, the last being the most advanced level of full automatization.

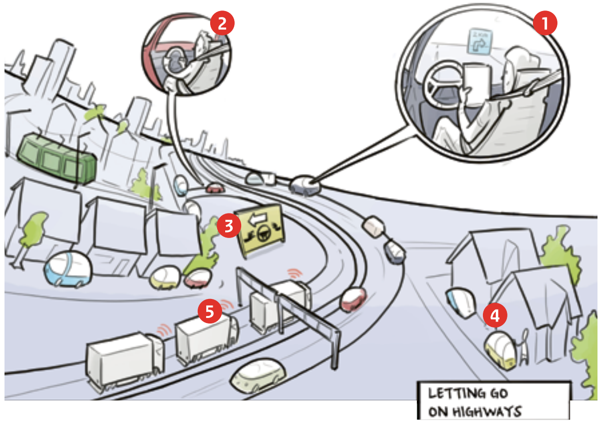
Relevance
Self-driving cars are no longer a part of a distance future. The Dutch ministry of infrastructure and environment suggests four pathways towards an automated future.

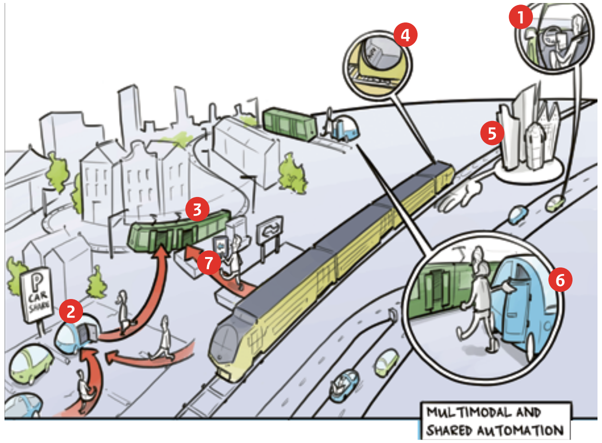


1. MOBILITY AS A SERVICE - ANYTIME, ANY PLACE

This scenario presumes a very high technological level. Vehicle users show a clear willingness to share their transport device. Automated cars are an everywhere available service. The whole transport system gets complemented by a maximum usage of bicycles and travel by foot. Public transport in the traditional sense will not exist any more. Instead, mobility users will utilize automated vehicles of various sizes together. Car sharing will experience significant growth and follows thereby current trends. Only a few people will possess an own car. Not all locations will be reached, however, the last and the first mile can be covered by bicycle or by foot.







2. FULLY AUTOMATED PRIVATE LUXURY

This scenario gives car possession an important role as a status symbol. The technology is on an advanced level. The car will be used for own, and family transport only and no sharing will be present. The population of the Netherlands loves car automation and wants it to be accessible for the whole family. Thereby, the willingness to share a vehicle is very low because it is seen as an unnecessary annoyance. Fully automated luxury driving offers the possibility to use travel time for recreation. Due to affordability reasons, public transport will still exist. The use of bicycles or walking by foot will be less and urban land use will prioritize automated "second homes". Travel distances will not matter anymore, so more kilometers will be covered, and fewer accidents will occur and it gives a great opportunity to the car industry because families want to own more than one vehicle.

3. LETTING GO ON HIGHWAYS

The third scenario has a less advanced technology. Car drivers must steer their vehicles in urban areas but will be able to let go to the automatized system on highways. A few car owners show willingness to share the vehicle with other people. Most of the people want to own a car. Citizens do not fully trust the automated system and want to be able to steer themselves whenever they like. The little interest leads to insufficient investments in the car industry to fully develop automated vehicles. So, automated driving is far from being feasible in busy urban areas. A wide variety of partially automated systems in available to support the car driver in the city. Public transport has still an important role in urban areas. The situation is comparable to the present, but fewer accidents and a rising number of car possession.

4. MULTI MODAL AND SHARED AUTOMATION

Car sharing has a significant role in the last scenario. Full automation is not developed enough, and its basis is too weak. The situation is comparable to "letting go on highways" but with a distinct use of car sharing and better prospects for a more advanced technology. Car sharing is flourishing and is seen as a solid component of everyday life. The quality of life increases and the environmental impact decreases gradually due to more efficient technology and the sharing culture. The shared transportation is in direct cooperation with public transport. Key is a multimodal transport system which supports the choice of the most favorable transportation system with ICT. The transport of choice is the most efficient one. Benefits are fewer traffic accidents and more green due to less cars.

THE IMPACT OF AUTOMATIZATION ON JOBS

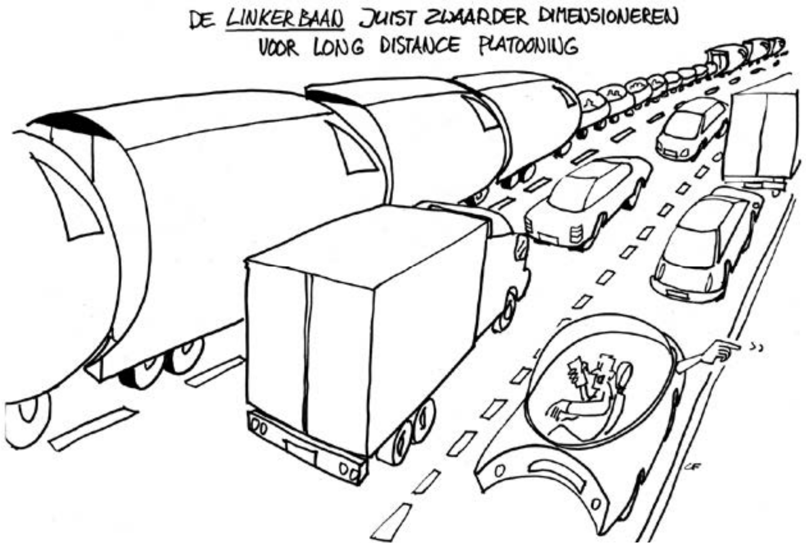
Author
Oxford University

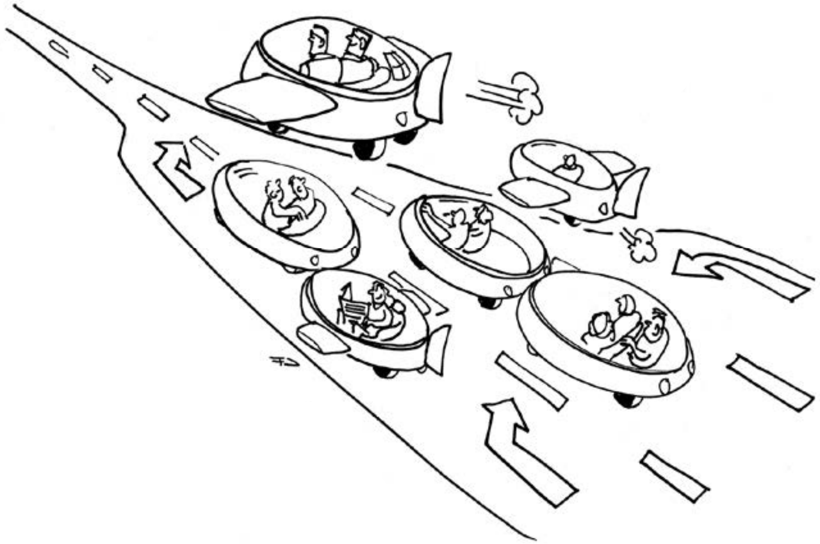
Year of publication
2015

Research description
The report "The Future Is Not What It Used to Be", produced by the Oxford Martin School and Citi, provides in-depth analysis of the vulnerabilities of countries and cities to job automation. It explores what automation will mean for traditional models of economic growth, and considers how governments can prepare for the potentially disruptive impacts of job automation on society.

The research shows that countries and cities will experience very different impacts – both negative and positive - from increasing automation. To avoid to be displaced by the new wave of automation, workers will need to develop new skills to take on very different kinds of jobs, possibly in different industries. Presently, most governments dedicate resources towards helping low-skilled workers secure better jobs through training and education. This shift will affect workers across the employment spectrum.

Relevance
This research is relevant because it shows the magnitude of the challenge. This challenge needs to be recognized to minimize the negative effect of automation on workers. And it is crucial that this recognition starts now.





IMPLICATIONS FOR THE ROAD DESIGNS

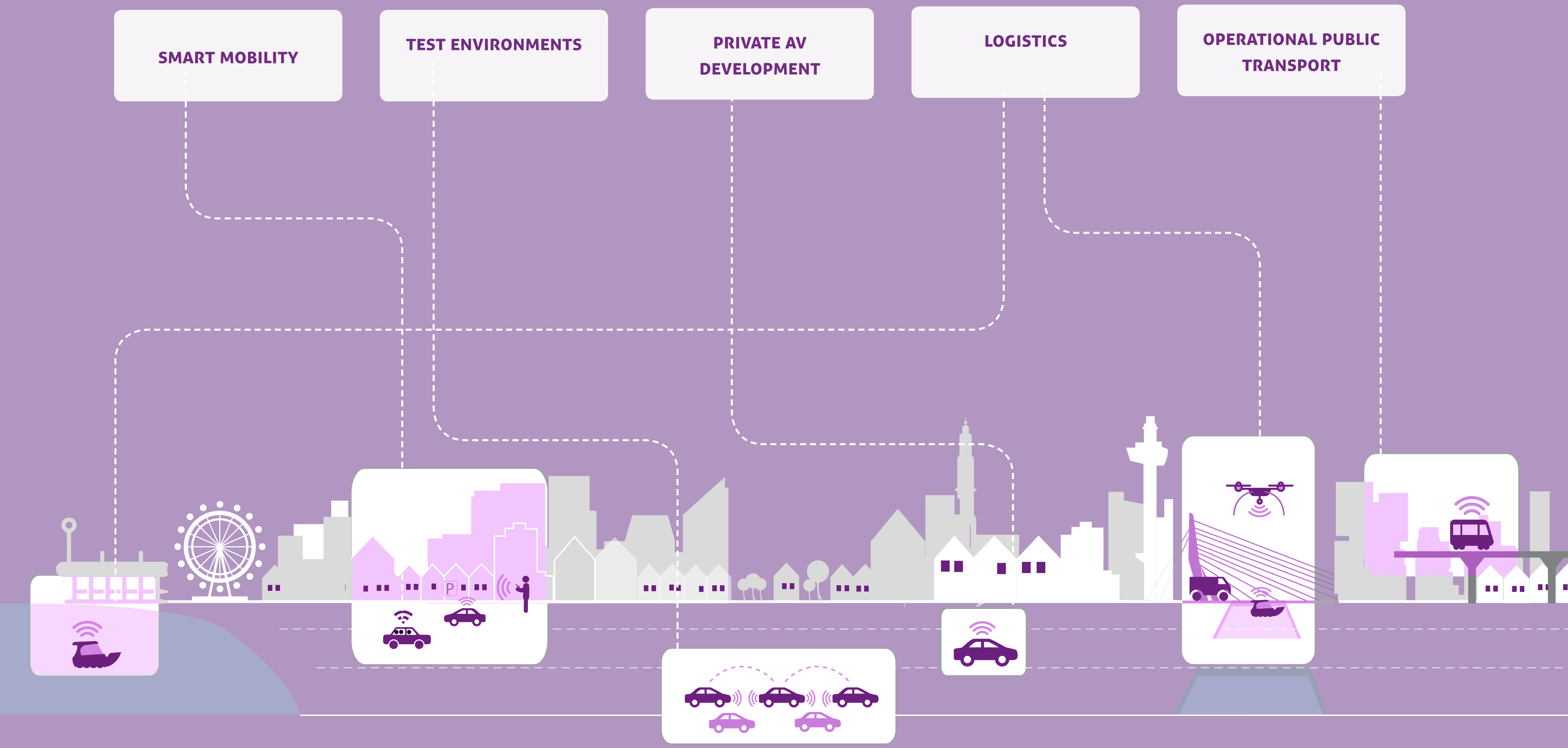
Author
TNO

Year of publication
2016

Research description
Concentrating more on the spatial impacts, TNO provides an insight into the design and the layout of roads. The report shows that many modifications may be necessary for road design in the longer term when there will be just the Level 5 of automation on the cars. There is a limited implication on the road design as long as there is still mixed traffic, with a mix of various levels of automation vehicles. The aim of this report is to draft a development agenda indicating the steps that road authorities can now take to facilitate the further development of self-driving cars.

Relevance
This report underlines the importance that smart road infrastructure will play in the development of different autonomous vehicle levels. In fact, to make an autonomous future happen it requires an ecosystem that works together. The report defines the ecosystem as the union of the vehicle, human and infrastructure.

TECHNOLOGY DEVELOPMENT & APPLICATIONS


SMART MOBILITY
TEST ENVIRONMENTS
PRIVATE AV DEVELOPMENT
LOGISTICS
OPERATIONAL PUBLIC TRANSPORT


OPERATIONAL PUBLIC TRANSPORT
P

CABINTAXI

Location
Germany

Provider
MBB and Demag

Year of completion
1970 - 2012

Maximum speed
36 km/h

Client
German Government

Line position
Dedicated line

Project description
Cabintaxi was developed and tested in 1970 as a personal rapid transit (PRT) technology in Germany. It is the first "true" PRT technology that was built and operated successfully in the western world. This particular
example includes only a test track as the public service part of this is no longer operational. A similar version of this technology is currently running in Hagen, called the Cabinlift. Another similar technology (H-Bahn) has now been constructed at the Dusseldorf International Airport. The testing program for Raytheon's PRT 2000 technology was completed successfully, but in 1999, Raytheon announced that it would end project.

Relevance
The Cabintaxi shows the implementation of German technology with computerized and automated public transport services. This project has been running since 1970, and the current working example is located in Dusseldorf. Like the Netherlands, Germany also aims towards implementing more examples of AV within both the private and public domain into their urban systems.

CVS OSAKA

Location
Osaka, Japan

Provider
Toyo Kogyo Co,Ltd

Year of completion
1970

Maximum speed
80 km/h

Client
Ministry of International Trade and Industry, Japan

Line position
Dedicated line

Project description
The Ministry of International Trade and Industry (MITI) sponsored the development of a very sophisticated PRT system, called The CVS (Computer-controlled Vehicle System). It was one of the first automated vehicles developed in the early 1970's. Planning for the CVS PRT system development work began in Japan in 1968. At that time preparations were made for a "traffic game" to be demonstrated at the Osaka World Exposition, which was held from March to September 1970. The demonstration in the Automobile Industries Pavilion consisted of more than ten specially designed electric vehicles operating individually under computer control on a checkerboard-like guideway network with intersections every five meters. The two-seat vehicles communicated with the central computer through an underground communication channel.

Relevance
This is one of the first projects to demonstrate the technology of a computerized and automated transport system in conjunction. It was a widely accepted project and Japan showed once again their advances in technology. Although this project was built temporarily for the World Exposition, Japan continues to develop top advanced technology in automation systems.

PARKSHUTTLE

Location
Capelle aan den Ijssel

Year of completion
1995- 2005

Client
Local government

Provider
Connexxion and 2getthere

Maximum speed
28km/hr

Line position
Dedicated line

Project description
The PARKSHUTTLE is an autonomous vehicle connecting the Rotterdam metro station Kralingse Zoom with the Rivium business park in the neighboring new town of Capelle aan den Ijssel. The goal of the pilot was to demonstrate that with the same budget, the service can improve and offer higher frequency transport making public transportation more attractive for car owners. This initial agreement was implemented back in 1995, and in December 2005, the Dutch Prime Minister Balkenende, opened the second generation of the project, featuring six rapid transit vehicles with an extended range of two kilometers and five additional stops.

Relevance
The PARKSHUTTLE was one of the first steps towards the autonomous vehicle. The difference with other publicly implemented forms of AV is that the PARKSHUTTLE does not drive on public roads. With the assistance of magnets embedded in the ground, it drives the same road every time by itself.

PERUGIA MINI METRO

Location
Perugia, Italy

Provider
Poma/Leitner Group

Year of completion
2008-ongoing

Maximum speed
25 km/h

Client
Municipality of Perugia

Line position
Dedicated line

Project description
MiniMetro is a cable propelled automated people mover systems built by Poma/Leitner Group in Perugia. It opened in February 2008 and is long 3.2-kilometre with seven stations. It consists of more than 25 vehicles, 5 m each, with the interval between successive vehicles around 1.5 minutes. It can carry up to 25 passengers with speed of up to 25 kilometers per hour. In 2013 the system carried 10,000 passengers per day.

Relevance
The aim of the project was to relieve the inner city of car traffic and create strategical connections between the city center and the periferic area. The biggest success of the project was to connect the city center to the major parking space of the city. This allows a great reduction of parking problem in the historical center of Perugia. It was part of Municipality initiative 'Alter-native mobility'.

Relevance
The on-demand vehicles improve passengers' experience of the airport and help reduce emissions by replacing a fleet of shuttle buses. They also represent a novel way to travel to and from the terminal, without waiting times and queuing. Heathrow Pods are powered by batteries which removed 30% from the cost of the guideway infrastructure and offered more flexible operation at the same time. On that regard, pods are also more sustainable because they use stored energy and they eliminated bus journeys.

HEATHROW PERSONAL RAPID TRANSIT SYSTEM

Location
Heathrow Airport, London

Provider
Text here

Year of completion
2011

Maximum speed
40km/h

Client
BAA Heathrow Airport

Line position
Dedicated

Project description
Heathrow PRT stands for the personal rapid transit system in Heathrow airport, which are in a shape of pods. The pods are lightweight, low-energy, driverless vehicles that can carry up to 4 passengers and their luggage on a guideway reaching the speeds of up to 40 km/h (25 mph). The system was designed to link Terminal 5 (T5) with the terminal 5 business car park and involves the fleet of 21 pods, 3,8 km of the one-way guideway and three stations which serve around 900 passengers a day. The separate guideway is mainly elevated therefore enabling a fully automated system and greater capacity.

The Heathrow Pod does not need heavy infrastructure and does not stop during the journey. The project is also an example of good design, that dealt with tight constraints of the airport infrastructure and security codes.

MASDAR CITY AV PLAN

Location
Masdar, Abu Dhabi

Provider
2getthere

Year of completion
2012-ongoing

Maximum speed
36km/hr

Client
Masdar City

Line position
Dedicated track

Project description
The Masdar City Master Plan plays a central role in enabling the city's success in achieving its sustainability goals. The initial aim of the Masterplan was to have a large vehicle-free pedestrian zone at street level. Ultimately, the high cost of building the entire city on top of a platform to accommodate the podcar system was too costly. The plan involved using the same dedicated tracks to run two-pallet flat-bed vehicles as part of a Freight Rapid Transport program.

The entire system was designed to run up to 5,000 trips per day. Today the 13 initial pod-cars in the prototype continue to shuttle students along with an 800-meter stretch between the station moreover, the Masdar Institute of Science and Technology.

Relevance
Masdar City implemented the AV as pod-cars for the students of Masdar Institute of Science and Technology. This example is notable for its ambition in the urban transformation of public space.

THE LAST MILE

Location
Singapore

Provider
EZ-10 of EasyMile

Year of completion
2015-ongoing

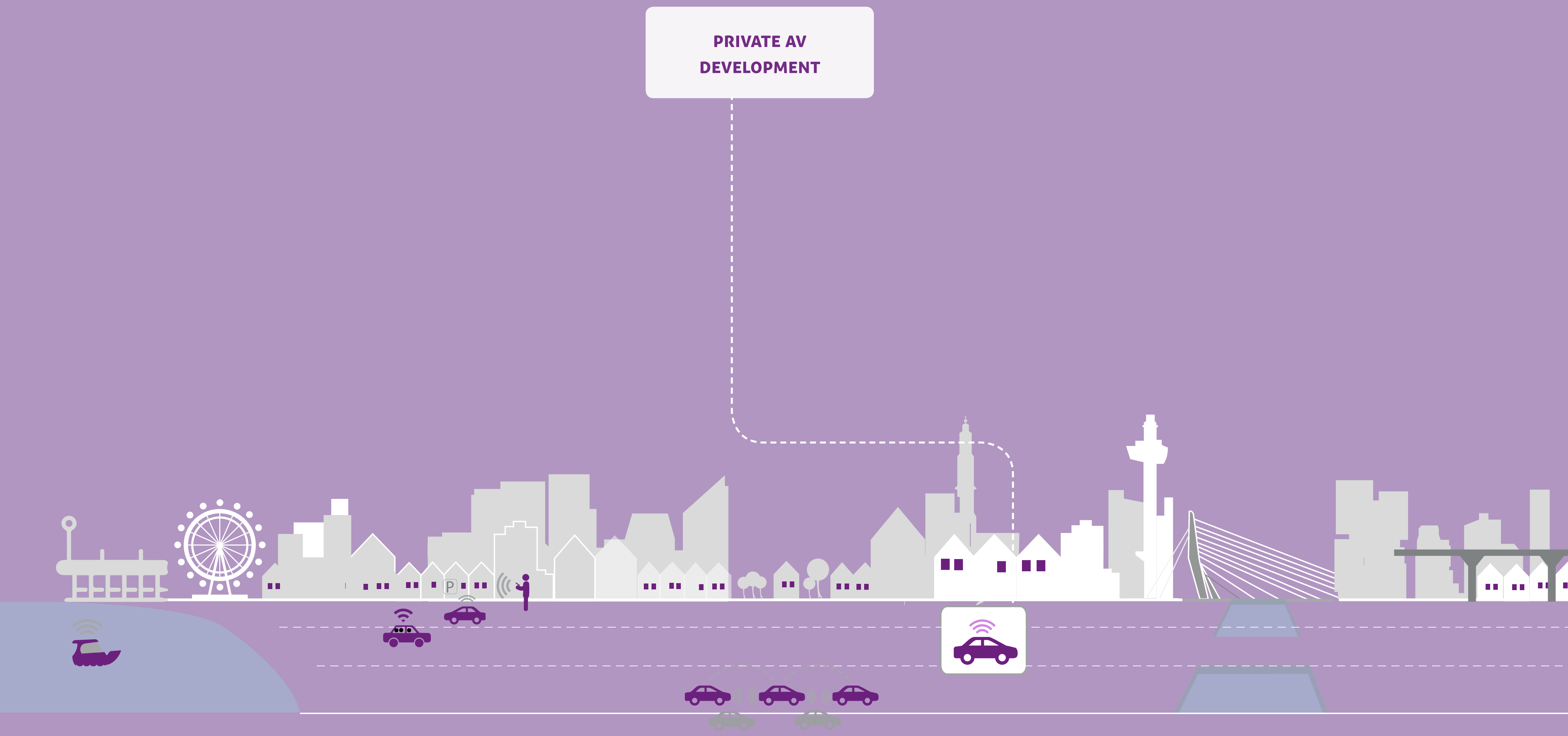
Maximum speed
20km/hr

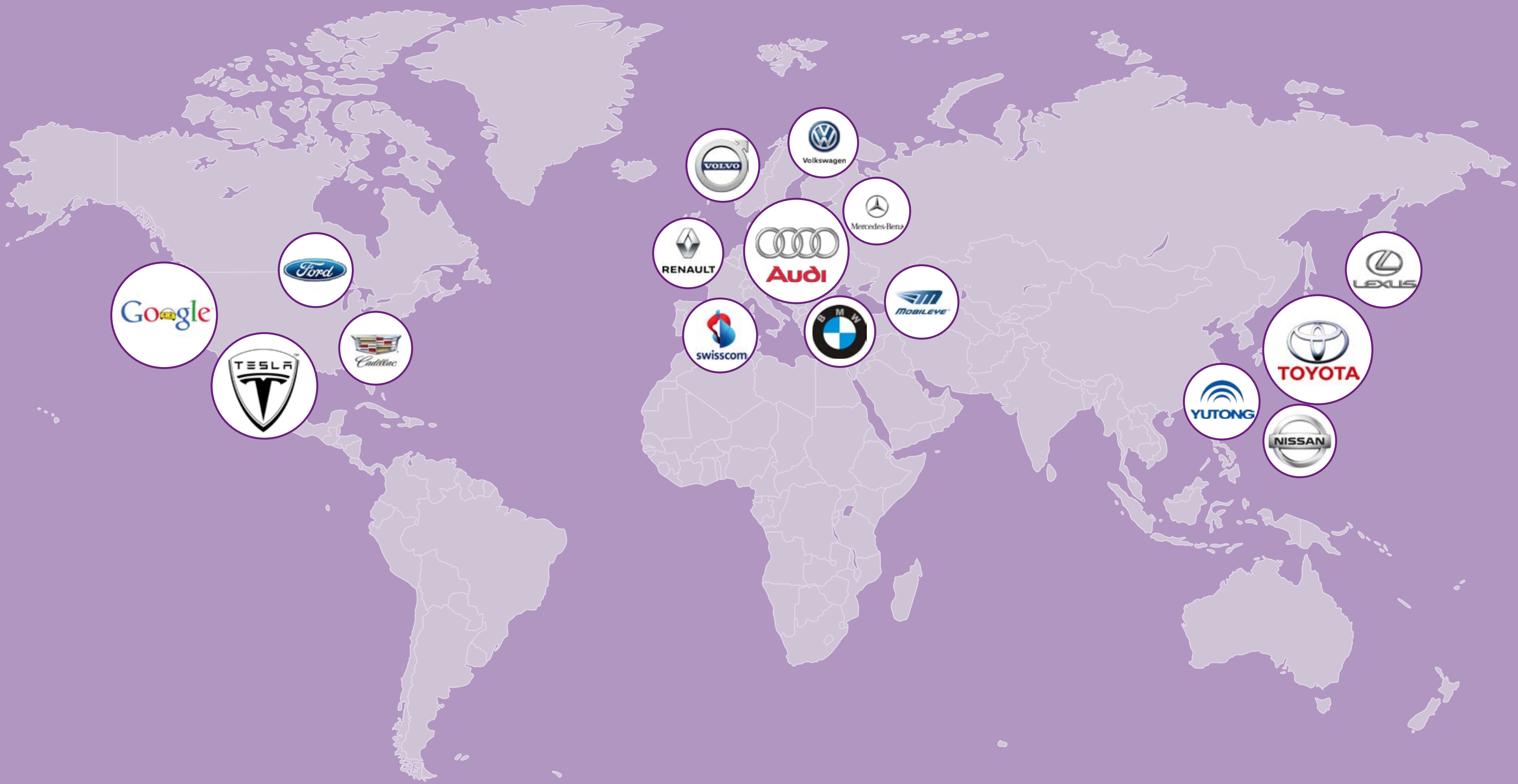
Client
Gardens by the Bay, ST Engineering

Line position
Public pedestrian road

Project description
This project is a collaboration between Gardens by the Bay, ST Engineering, and Robosoft. The EasyMile driverless shuttle began its public trial in December 2015 and is targeting full-scale deployment for mid-2016. This project is co-funded by the Ministry of National Development and National Research Foundation, with technical advice from A*STAR's Institute for Infocomm Research (I2R). Each vehicle has a capacity of 10 people, comprising seats for six passengers and standing room for four. Fully enclosed and air-conditioned, passengers are taken around the gardens in comfort. This service aims to strengthen the connectivity within the gardens and enhance mobility for the elderly and physically challenged people.

Relevance
The Last Mile is a progressive step for Singapore's Garden by the Bay as it enhances the experience for tourists and improves productivity. The investors aim to engage more organizations that follow this example in employing self-driving technology to transform their operations around Singapore.


PRIVATE AV
DEVELOPMENT



Overview of the main manufactures worldwide.

GOOGLE CAR
In the mid 2000s, the Defense Advanced Research Projects Agency (DARPA) organized the Grand Challenges where teams gathered to compete with AVs. In 2009, Google started the self-driving car project with a Toyota Prius on freeways in California. They create a vision of how the future could be. The design of the Google car also sets high standards in marketing, since it is designed only for riding, not for driving.

Relevance
Google aims to reach more vulnerable members of society such as the elderly and physically challenged people as potential users and make them feel included in the rapidly developing field of technology and mobility. In February 2016 the Google car suffered a minor crash when it collided with a bus, causing alarm bells to go off for legal and security issues.

TESLA MOTORS
Premium vehicles company Tesla Motors is one of the front runners in the development of technology related to autonomous vehicles. They have several projects running including the Supercharger and Powerwall. The Supercharger is a charging pole that fills the battery of the Model S Tesla car in minutes instead of hours. The Powerwall is a charging point located at privately owned homes.

Relevance
Tesla Motors smart car is one the first private AVs on the market, which contains not only advanced technology but is also designed as a luxury product. Tesla's development demonstrates a large interest within society in the replacement of conventional cars with automated vehicles.

AUDI
Currently, each federal state in Germany has the ability to grant permission for lifting technical requirements of the German Road Traffic Licensing Regulations. This enables a vehicle to operate autonomously on public roads, with the assumption there is a driver who has full legal responsibility for the safe operation of the vehicle. There are a number of vehicles tested on German roads with different levels of automation. In January 2015, it was announced that the A9 highway between Munich and Nuremberg meets the requirements with technology to allow driverless cars developed by Audi.

Relevance
Germany with its ambition to be an early adopter of many new technologies, is likely to be one of the first countries that allow fully automated vehicles on its highways.

Audi is the first automaker that has successfully launched a vehicle-to infrastructure (V2I) communication channel. V2I refers to any time a structure in a city, like a traffic light, relays data to a car.

TOYOTA

Toyota branded this project as the "guardian angel" of autonomous driving. Their car developments are based on hybrid use, meaning the driver is always in control unless the system detects as possible incident and the car takes over. Toyota will continue working on traditional, fully autonomous vehicles as well, but assisted driving has more promise for the near future because of the challenge of switching quickly from fully autonomous back to driver-control. Even a 10-second switchover might be nine seconds too long if the car can't handle a dangerous situation

Relevance

Toyota is the largest automaker in the world, but it is not feasible yet for them to move directly to the highest level of self-driving

FORD

Ford's plan is to be a leader in autonomous vehicles, as well as in connectivity, mobility, the customer experience, and data and analytics. To achieve this goal Ford announces its plan to launch a fully autonomous vehicle in 2021, in a ride-hailing or ride-sharing service. The company also announced that it would be several years after 2021 before individuals can buy it; instead it hopes to find customers in ride-hailing companies.

Relevance

Thanks to Ford the concept of autonomous vehicles for ride-sharing service will raise awareness and will be a bridge to ownership.

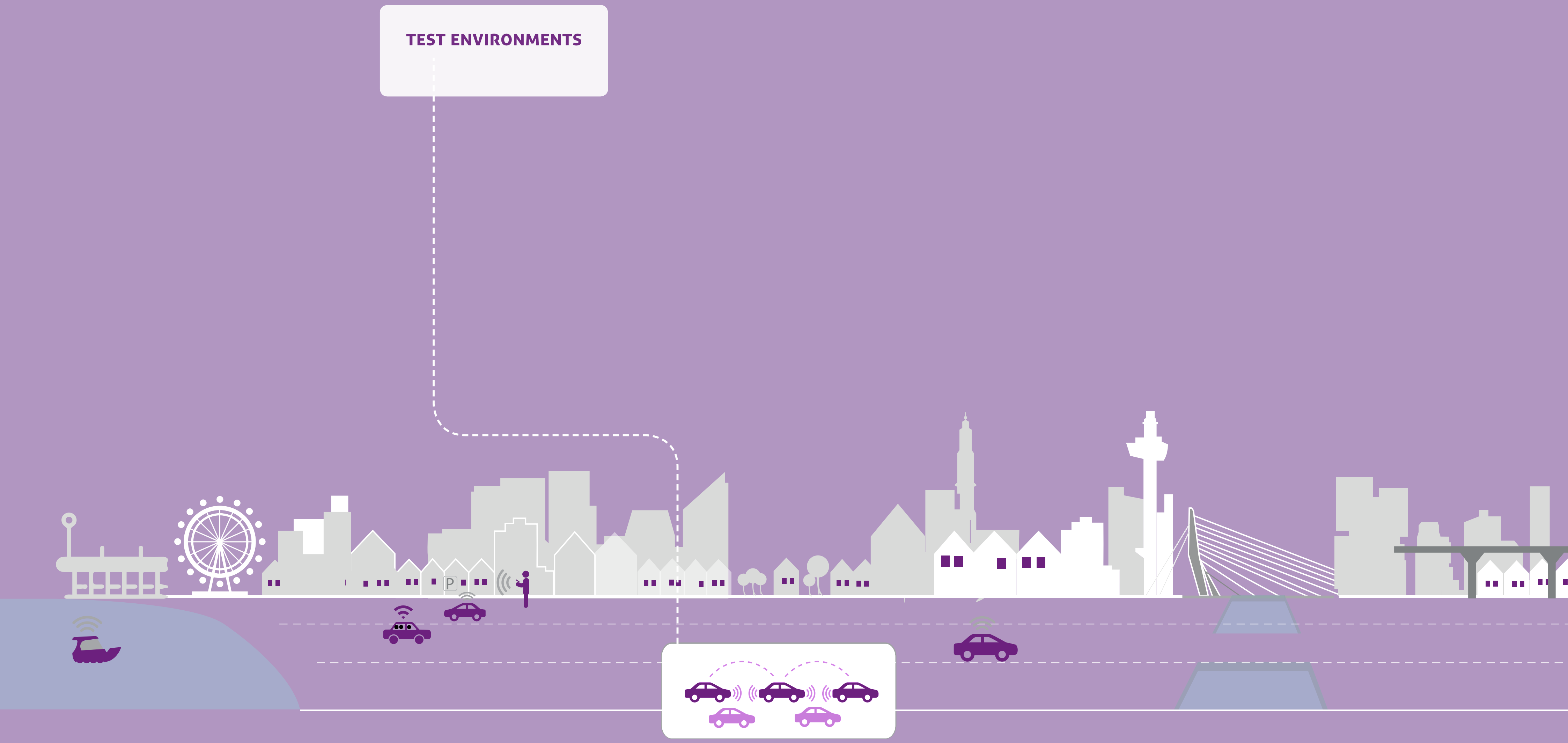
BOOK
BY CADILLAC

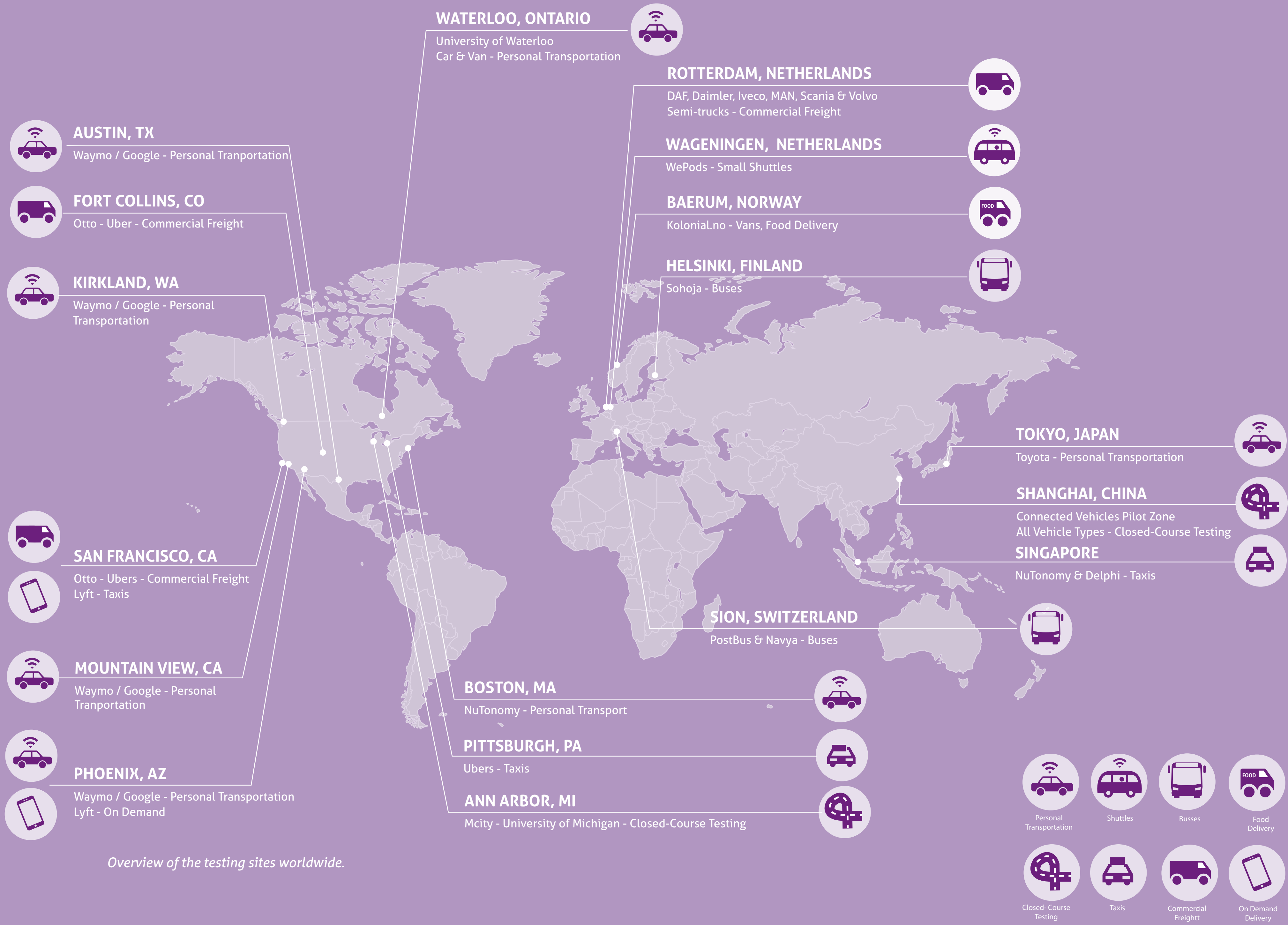
CADILLAC'S BOOK

The Cadillac's book is an innovative subscription service targeted at a growing class of luxury drivers searching for access to various cars over time. This new service gives members access to popular Cadillac vehicles without the commitment of leasing, financing or buying. The members can make reservations through a smartphone app, and the vehicles will be delivered via "white-glove"concierge to members' requested locations. The service has the price of $1,500 per month and there's no set term for the service, so you can cancel at any time.

Relevance

This innovative service might've invented a new business model for the auto industry. The main benefit is that this model eliminates the hassles of car ownership without compromise the business of car industries.


TEST ENVIRONMENTS



Overview of the testing sites worldwide.

TRUCK PLATOONING, NL

Location
Zwolle, The Netherlands

Year of completion
2015

Client
Local government

Provider
Scania

Maximum speed
Adapting speed

Line position
Public line

Project description
Zwolle is the first trial with partly self-propelled vehicles launched on Dutch road, a technique called platooning. They are self-propelled vehicles made by the Swedish manufacturer Scania. The trucks brake automatically and adapt their speed to match the other vehicles in the line. When a truck joins the line, the following distance is automatically increased; when the truck turns off from the road, the following vehicle pulls up automatically. Steering is still done by a chauffeur, but perhaps in time, the vehicles can be completely self-driven.

Relevance
The goal of truck platooning is ultimately to avoid congestion and provide a safer road environment on highways. In five years time the technology will likely be used widely in transport in the Netherlands.
At the same time, the Dutch Government aims to play a leading role in the development of similar technologies and aims to finance more testing for easier and potentially faster services. Concerns must be considered in terms of reliability, security and privacy.

WE POD, NL

Location
Wageningen, NL

Provider
EZ-10 of EasyMile

Year of completion
2015

Maximum speed
25km/h

Client
Province of Gelderland

Line position
Public line

Project description
WEPOD is the second AV transport shuttle in The Netherlands.
The province of Gelderland, together with its partners, are exploring the social impacts and functions of this particular AV and its trajectory between station Ede/Wageningen and Wageningen University & Research Centre (WUR). The difference between the Capelle Parkshuttle is that Wepod drives on the public road. The progress and impacts of the Wepod is being monitored for further improvements in technology and society adaptation. The Provincial authorities are provided up to date research and investigations about the topic of AV and its implementation in The Netherlands.

Relevance
The WEPOD is one of the first steps towards a self-driving city. It could be an answer for the "last mile" challenge of public transport for people without a car. If people can accept the AV on this range, the range of the AV can expand until it reaches central hubs. It is the first step of a road map towards a self-driving city.

RESEARCH LAB, DELFT

Location
Delft, NL

Provider
Renault

Year of completion
2016

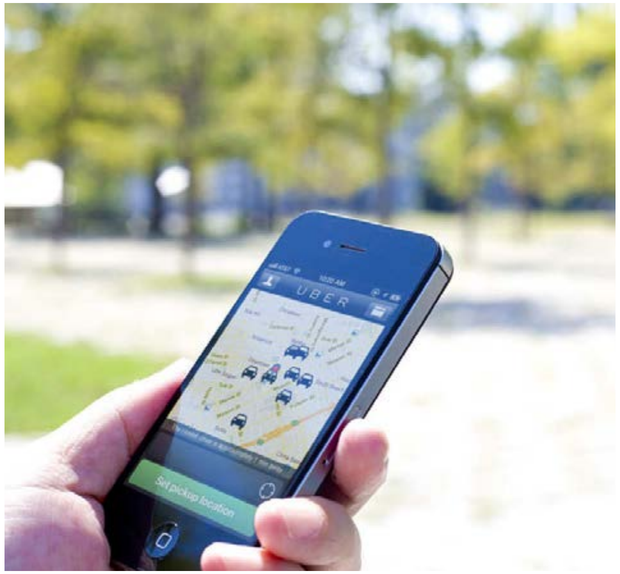
Maximum speed
-

Client
Municipality of Delft

Line position
Public lane

Project description
The distance from the Delft Zuid station and the TU Delft campus is actually too big to walk comfortably, and is not well connected by public transport. ProRail, the Municipality of Delft and TU Delft are in favor of making Delft Zuid an attractive hub. For the last mile transport between public transport nodes and the campus there is really no effective public transport system available. Automated vehicles can provide a solution here, where different variants are conceivable in terms of capacity and necessary infrastructure.
One possible solution is the use of a small fleet of vehicles suitable for transporting one person. Infact now after arriving at the future Delft-Zuid railway station, you can use the electric Twizy to travel to your final destination. After arrival, the Twizy safely and independently finds its way back along the cycle path to the next traveller or its charging station. The AD-Twizy will ride on public infrastructure, partly etspaden partly urban infrastructure. The vehicles are modified electric-powered Renault Twizy.

Relevance
The project is a pilot project, the final demand has yet to be determined, but the focus will be on serving a relatively small market with real quality transport and thus aimed at the higher end of the transport market (business traveler).



In 2017, Uber started its second pilot program in Tempe, Arizona. All trips will include two Uber engineers in the front seats as safety drivers, in the event a human needs to take over control from the vehicle's software.

Relevance

Uber is the pioneer in connecting sharing economy to self-driving cars. Uber allows its customers in downtown Pittsburgh to summon self-driving cars with their phones, crossing an important milestone that no automotive or technology company has yet achieved. None of the bigger companies in the field, as Google or Tesla, have yet brought a self-driving car-sharing service to the market. With this, Uber made a first steps in a challenge towards the cities with less traffic. Shared and autonomous will meet the goals of the future cities and will enable governments to give some much needed public space back to the city and citizens.

SELF-DRIVING UBER VEHICLES IN PITTSBURGH

Location
Pittsburgh,USA

Provider
Volvo

Year of completion
2016

Maximum speed
-

Client
Uber

Line position
Public pedestrian road

Project description

Uber identified autonomous driving technology as the springboard for the next stage of growth. Uber set up an Advanced Technologies Center in Pittsburgh, dedicated to self-driving technologies, mapping, and vehicle safety. The team mission is to make self-driving Ubers a reality. In September 2016 Uber launched its first self-driving service on the roads of Pittsburgh. The car, a hybrid Ford Fusion, collect mapping data and test its self-driving capabilities. When it's in self-driving mode, a trained driver will be in the driver's seat monitoring operations. The Uber ATC car is equipped with a variety of sensors including radars, laser scanners, and high resolution cameras to map details of the environment.

Uber's second pilot started in San Francisco in December 2016, but two weeks after, California's Department of Motor Vehicles revoked the registration of Uber's 16 self-driving cars after few reports of traffic violations and repeated legal threats from state officials.

LOCAL MOTORS: OLLI

Location
USA, Berlin

Provider
Local Motors

Year of completion
2016

Maximum speed
40 km/h

Client
Local Motors

Line position
Public pedestrian road

Project description
Olli is the electric, self-driving shuttle from Local Motors which can carry up to 12 people on a pre-set route. It is the first vehicle to utilize the cloud-based cognitive computing capability of IBM Watson Internet of Things (IoT) to analyze and learn from high volumes of transportation data, produced by more than 30 sensors embedded throughout the vehicle, therefore improving the passenger experience and allowing the interaction with the vehicle. The plan is that Olli will be able to pick up riders on demand and it will be summoned by an app or a kiosk.

Starting from late July 2016, Olli will be used on just a few local public roads, as legally it can only operate there. Because of this Local Motors are planning to market the vehicle in places like airports and university campuses. Although legally, the Olli is still limited in operating grounds, The U.S. Department of Transportation via the National Highway Traffic Safety Administration (NHTSA) recently initiated efforts at writing a regulatory rulebook for self-driving vehicles.

By the end of the year the company is planning to have vehicles in Miami-Dade County, Las Vegas and also Denmark. In Washington, DC residents can already ride the driverless shuttle bus starting from June 2016.

Relevance
Passengers will be able to vocally communicate with Olli while traveling from point A to point B, discussing topics about the vehicle design and the destination. These interactions with Olli are designed to create more pleasant, comfortable, intuitive and interactive experiences for people as they ride in autonomous vehicles. The vehicle is also very spacious and has a very relevant element of lowness to the ground which is helpful for elderly and young children when boarding.

Relevance
Self-driving buses are very promising and will be a key ingredient of future mobility. On demand-buses will be able to service the complex mobility demands of our societies much better than today's mix of scheduled buses, trains, and individual cars. They will lower the cost, resource consumption and ecological footprint of mobility. Because significantly lower costs will prompt many travelers to use buses on medium to long-distance trips instead of cars, these buses will increase the effective capacity of highways when measured in people-miles.

DRIVERLESS BUS ON ZHENGZHOU HIGHWAY, CHINA

Location
Zhengzhou, China

Provider
Yutong

Year
2014

Maximum speed
32 km/h

Client
-

Line position
Public highway

Project description
After three years of development, one of the leading Chinese bus manufacturers Yutong has sent the prototype of a self-driving city bus on a 32 km long circuit on an intercity road between Zhengzhou and Kaifeng in Henan Province. The bus drove the whole track in regular traffic without any human assistance, attained a peak speed of 68 km/h, passed 26 traffic lights and was able to change lanes and overtake autonomously. This is a significant accomplishment and clearly puts Yutong on the map for autonomous driving.

The bus is equipped with many sensors, including camera and Lidar. Two Lidar sensors are strategically placed in the middle of both sides of the car. This is the best way to monitor the adjacent lanes and mimics the approach Google has taken on their driverless pods (where the side Lidars protrude like the mirrors of conventional cars).

SELF-DRIVING BUSES ON THE ROAD IN HELSINKI

Location Helsinki, Finland	**Provider** -
Year 2017	**Maximum speed** 6-10 km/h
Client -	**Line position** Public road

Project description
The Easymile EZ-10 electric mini-buses, capable of carrying up to 12 people, will roam the open roads of Helsinki's southernly Hernesaari district in a month-long trial, negotiating traffic for the first time. Members of the public can hop on and off at pre-defined points along the route.

The buses were previously tested on closed roads in the Netherlands and in a small Finnish town just north of Helsinki. But this trial—with autonomous buses carrying riders along public urban streets—is one of the first of its kind anywhere on the globe. A supervisor able to manually take over the bus is onboard for the duration of the test.

This test project is being coordinated by Helsinki's Metropolia University of Applied Sciences with the aim of better understanding how the vehicles fare in real-world traffic. The buses are limited to traveling at an average speed of just 6 miles an hour (10 km/hour) to minimize risk as they share the open road with other cars and pedestrians for the first time.

Relevance
Finland is one of the only countries in the world that does not legally require every vehicle on public roadways to contain a driver. Because of this feature, the country is fast becoming a popular testing site for self-driving technology.

"We need to have human drivers, but the human doesn't need to be physically in the vehicle. You can remotely supervise a fleet," explained Santamala. "When this regulation was written in the 70s, there was no mention the driver has to hold the steering wheel or be in the car. So the Minister of Transportation decided with the government agency that, for testing purposes, we can allow supervised autonomous operation on the road."

VOLVO - DRIVE ME

Location
London, UK

Provider
Text here

Year of completion
2017

Maximum speed
Text here

Client
Volvo & Thatcham (UK)

Line position
Text here

Project description
Volvo is bringing its Drive Me autonomous driving research program to the United Kingdom next year. It will run alongside similar programs in Sweden and China, which will see each country have 100 XC90 SUVs put in the hands of real families to test Volvo's autonomous car technology.

"In autonomous mode, the car can handle all situations that occur. Going down a stretch of road, the car takes the responsibility for extreme events. If you don't take over, if you just want to do email, the car will take the responsibility and safely stop at the side of the road."

Relevance
The Volvos in the Drive Me UK program will be designed for autonomous use mostly in commuting situations, where Volvo is aiming to help drivers gain time for other activities by freeing them from needing to pay attention to their drive. The Swedish company calls its ultimate vision Concept 26 and believes customers will spent their commute watching television, working, or simply relaxing.

The cars will be able to run in fully "unsupervised" autonomous mode on certain, pre-approved and pre-mapped freeways around London. This means that drivers will be able to fully disengage from the driving process, instead spending time reading a book or watching a video. The car will be able to drive itself and handle any situation that might arise on the roadway.


LOGISTICS

AMAZON'S DRONE LAUNCHES DELIVERY

Location
UK

Year of completion
2016

Client
Private customer

Project description
Amazon Prime Air is a cargo airline and conceptual drone-based delivery system currently in development by Amazon. On December 2016, Prime Air delivered its first order , an Amazon Fire TV and bag of popcorn, using a highly automated drone. It took 13 minutes from customer click to package delivery at a home. The delivery involves fully autonomous flight, with no human pilot involved in the process.

Relevance
With drone delivery systems, fewer transportation carriers will be traveling on roads and polluting the atmosphere.

UBER'S SELF DRIVING TRUCK FIRST DELIVERY

Location
Colorado

Year of completion
2016

Client
-

Project description
Otto company designs new approach to modern transportation, starting with self-driving trucks. On 2016 Uber acquired autonomous truck company Otto, and the retrofitted 18-wheeler made its first delivery: 50,000 cans of Budweiser. Its technology works only on the highway, where it doesn't have to deal with tricky variables like jaywalking pedestrians, four-way stops, or kids on bicycles. The software is programmed to hand off control to the human driver when the truck needs to exit the freeway.

Relevance
This is the first time in the story that a truck completed an autonomous commercial delivery. Autonomous cars are sexy, but trucks are more practical. And they'll almost certainly be here sooner than cars, because the industry desperately needs them.

THE ROBOAT PROJECT, MIT

Location
Amsterdam, NL

Year of completion
2016

Client
Municipality of Amsterdam

Project description
The ‘roboat’ project is a research collaboration between MIT and AMS, the Amsterdam Institute for Advanced Metropolitan Solutions. The collaboration will develop and design a fleet of autonomous boats for the city of Amsterdam. seeks to design and test the world’s first fleet of autonomous boats in the city of Amsterdam. Each roboat can be used for transporting goods and people and for creating temporary floating infrastructures, such as self-assembling bridges and concert stages. Roboats can also monitor the city’s waters using new environmental sensors that provide vital insights on urban and human health.

Relevance
The relevance of the project is that how as self-driving cars can hit the road also autonomous boats can hit canals. Roboat’s findings will provide insights for many coastal cities; they will also contribute to the growing field of autonomous mobility, as it moves from roads to waterways.


SMART MOBILITY

DRIVE SMART, NEW YORK

Location
New York

Year of completion
2015

Client
New York City Department of Transportation

Project description
A new technology has been developed by the New York City Department of Transportation in order to help drivers save money, save time, and drive more safely. The technology consist in an application that provide drivers with feedback on how to drive more safely, use less gas, and avoid traffic, and also reward drivers for driving during off-peak hours or on less congested routes. With this pilot project the NYC Department will have the opportunity to provide insights into users preferences and the market response and as well the opportunity to test the Drive Smart technology in a large-scale market.

Relevance
Drive Smart is designed to encourage a good driving and also to encourage users to make fewer mistakes and on the basis of the scores achieved to gain advantages in terms of discount on insurance policies. Besides, the project will also analyze aggregated Drive Smart data providing a complete picture of the city's road network.

LIMERICK CITY, UK

Location
Limerick, Ireland

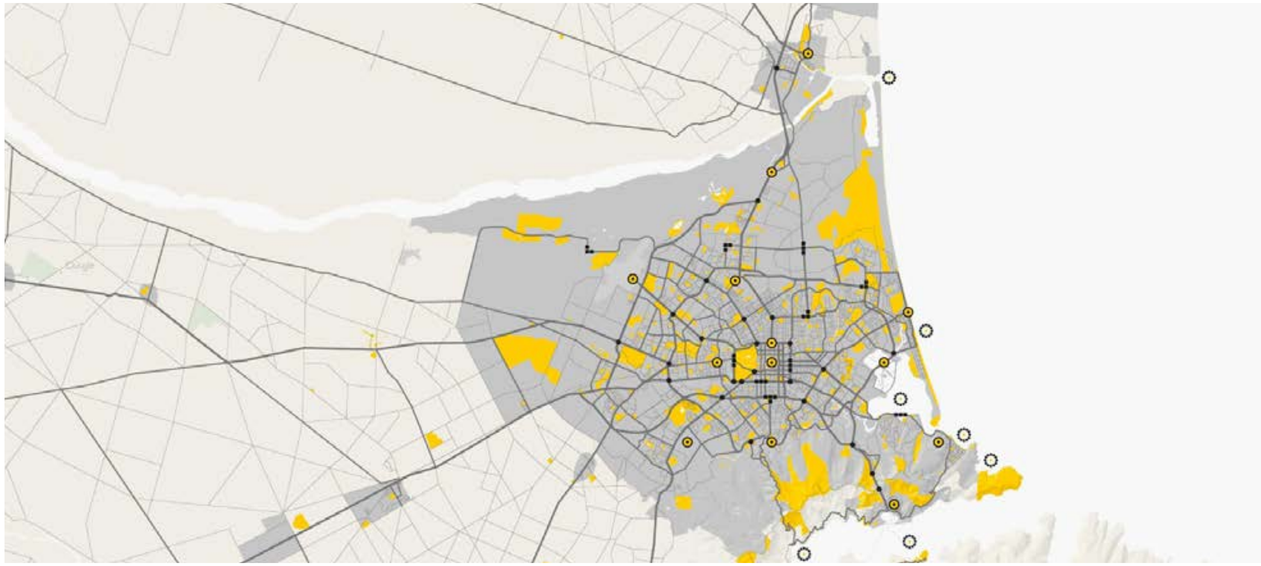
Year of completion
-

Client
Limerick City Council

Project description
Through an upgrading and modernization of the existing traffic signal system, Limerick demonstrated how technology can improve the efficiency of traffic flow and and increase connectivity and mobility.
The new signal system is characterized by the introduction of adaptive coordinated traffic control placed at strategic junctions throughout the City, by sensors in public transport system and by Electronic signs displaying real time space availability at off-street parking.

Relevance
This example demonstrate how the ITS system reduce delays to traffic at junctions and, as a result, reduce the vehicles emissions and fuel consumption. This type of smart mobility shows how the combination of intelligent transport systems as part of an integrated transport solution can lead to reduction of private car use providing a more pleasant environment.

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTING IN YOUR FUTURE
An Roinn Iompair Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport
Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union
Limerick City & County Council
University of Limerick



CHRISTCHURCH SENSING CITY

Location
Christchurch, New Zealand

Year of completion
-

Client
Infratil

Project description
Sensing City initiative aim to collect real-time information about how the city actually works, including pedestrian and vehicle traffic flow, water and air pollution in order to improve the functionality of the city. The combination and the analysis of this data have the potential to add a huge value to the local business and to the services for citizens. In fact the obtained data will drive the future decisions and the challenges of the 21st century. The next two projects that will be launched will be focused on health informatics in regards to respiratory illness and on communicating real time traffic information.

Relevance
This project encourage the development of solutions based on real-data of the city and its constituents and, in the same time, will create export opportunities and will attract internal investment.

AMSTERDAM SMART CITY

Amsterdam Smart City is an innovative platform of the Amsterdam Metropolitan Area that promotes sustainable economic growth and helps develop new markets. The platoform deeply contributes to the liveability of Amsterdam through a constant exchange between businesses, residents, the municipality and knowledge institutions in order to test innovative ideas & solutions for urban issues.

Relevance

By challenging parties to submit and execute innovative solutions to urban issues, ASC connects the right stakeholders and accelerates progress. This advances the development of new markets and profits for innovative solutions. Where possible, these solutions are replicated elsewhere in the city.

CARGOHOPPER

Stands for zero-emission intricate inner city distri-bution. It is clean, quiet, safe, friendly and universal. It helps carriers to reduce their mileage and expensive hours making them more flexible in their planning and forming a reliable and clean alternative to the generally expensive and often unprofitable last mile.

Relevance

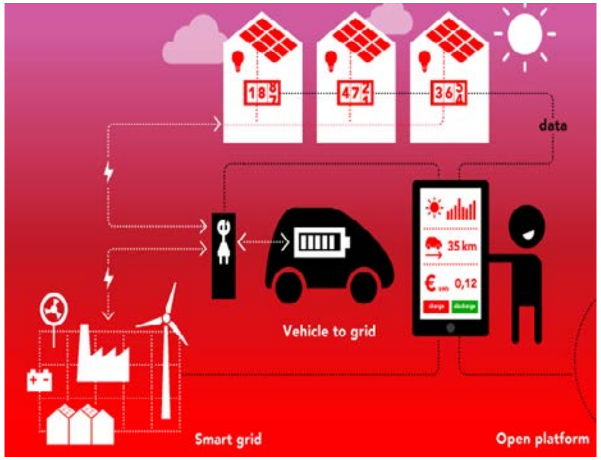
Cargohopper is about road safety, traffic flow and the quality of life in a town and helps governments in achieving their air quality goals.

MOBYPARK

A shared parking platform, makes parking easier and more efficient. Private parking lots, public parking garages, hotels, and hospitals offer their unoccupied parking spots for drivers on a platform where it's possible to see real time availability and book these parking spots ahead. Mobypark ensures that you can easily rent a parking place for several days of a private individual, hotel or another institution.

Relevance

It is relevant because as a result, drivers spend less time searching for a single spot and reduce CO_2 emissions.



VEHICLE2GRID

Vehicle2grid is a pilot project starting in Amsterdam and Lochem. It will allow to the residents to use the batteries in their electric cars to store their locally produced energy. Residents will be able to decide how to put their locally produced energy (i.e. from solar panels) to use. The energy can be transferred to the electricity grid, used immediately or stored in the battery of an electric car, to be used at some later time to drive the car or run household appliances.

Relevance

By adding technical and social flexibility, the grid is an important technology that will increase the expected raise of use of PV panels, electrical cars, all-electric households and innovative solutions of the next future.

ELECTRONIC PARKING-SIGN

Since October 2014 an electronic sign has been installed on some coach stops in Amsterdam. The sign indicates the parking time for the coach and shows the minutes that are left for it to stay there. This sign is a neighbourhood initiative in close cooperation with the district council for Amsterdam city centre to reduce the inconvenience caused by long parking coaches.

Relevance

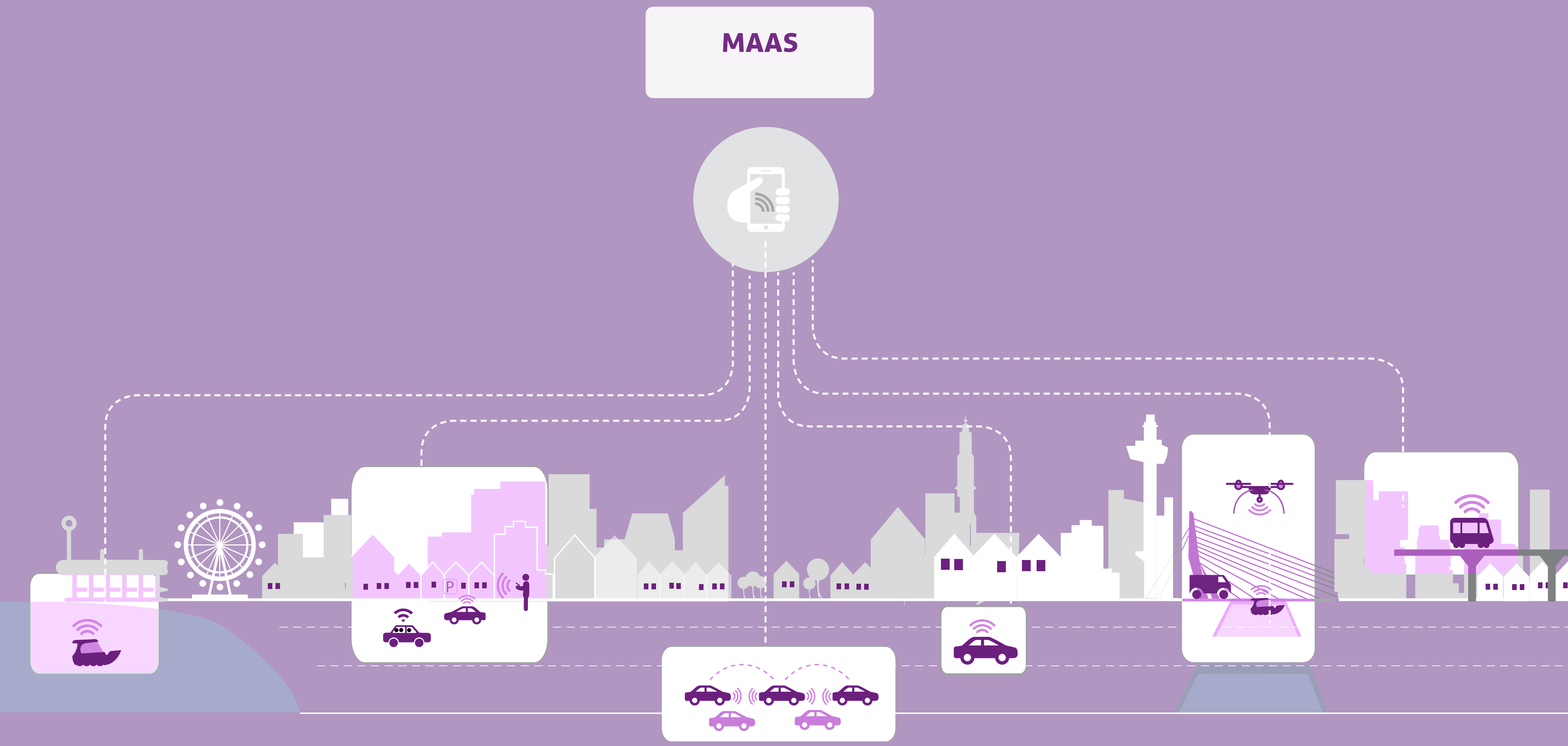
The initiative shows that improper and excessively long parking decrease installing the electronic sign. Truck or coach drivers can use this information for optimizing their route through the city. Furthermore, the author-ities will get a sign when a truck or coach is in violation, acting more efficiently.

SMART SHIPPING TRAFFIC

Vicrea Solutions with Libelium technology developed a wireless sensor network to manage canals traffic in the Netherlands by controlling the flow of boats. The goal is to predict touristic boats so bridges can open at more planned times and prevent traffic jams on roads or at waterways.

Relevance

The innovative sensor reduces costs and provides a data service to the province that can have no concern on the chain, just on the data.


MAAS

MAAS, HELSINKI

Location
Helsinki

Year of completion
2016

Client
Helsinki Regional Transport Authority (HRT)

Project description
The Finnish company MaaS Global developed the Whim app that will make life easier for everyday users of public transport. Whim gives people instant access to virtually every kind of transport, from brand new cars to taxis, buses, trains and bike share. In just one app you can find the best way to get there, to buy the ticket and to pay. Furthermore, the app syncs with the users' calendar, helping plan journeys even in advance.

Relevance
Whim will give to people the freedom to go wherever and whenever they want becoming better than their own car. It will encourage the use of public transport, which means cleaner cities with fewer traffic jams. Combining all the existing transportation services and offering personalized transport plans tailored to customers needs in one app will define a huge business potential for transport providers.

HANNOVER'S MOBILITY SHOP INITIATIVE

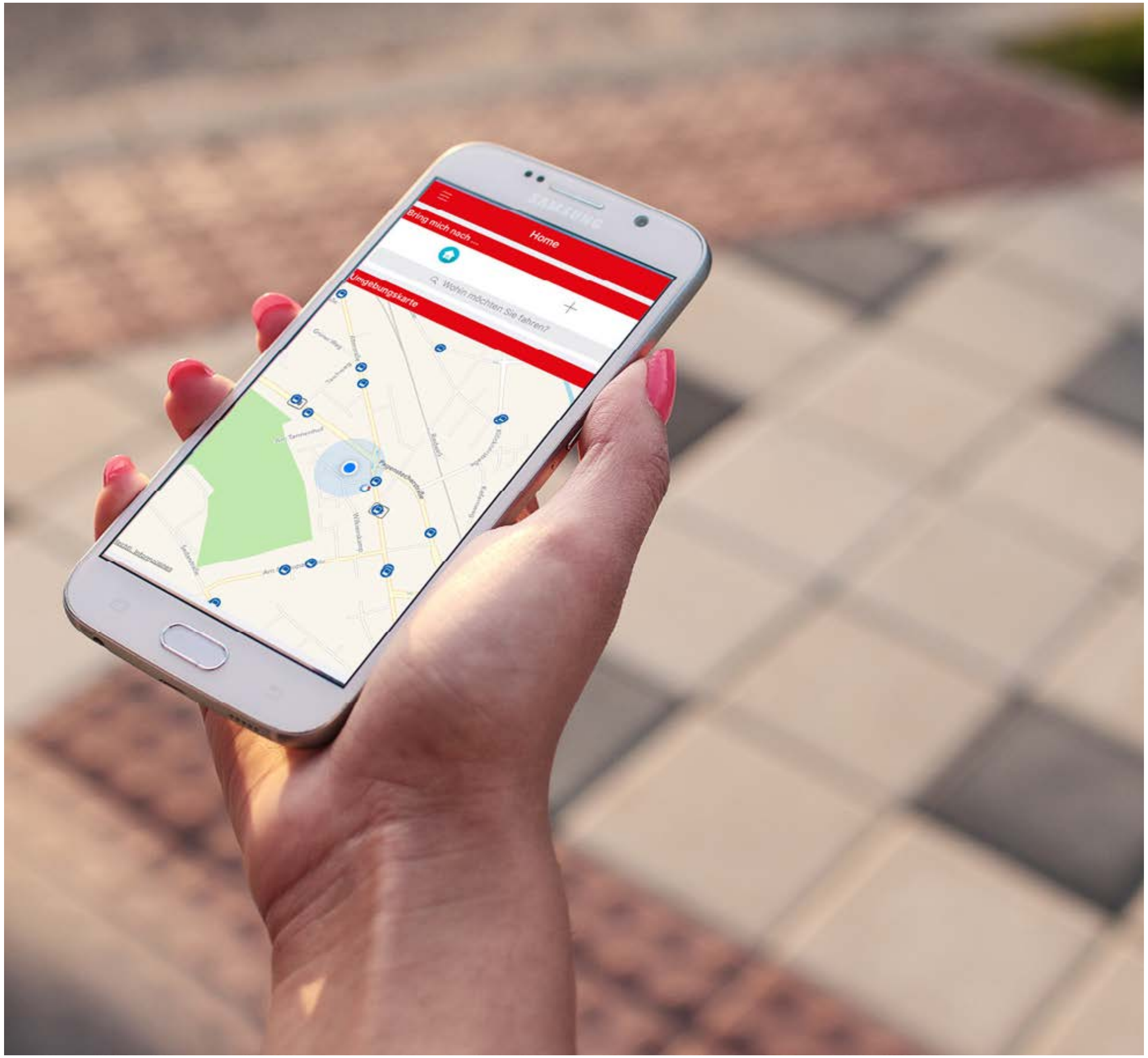
Location
Hannover, Germany

Year of completion
2016

Client
-

Project description
Hannover's Mobility Shop initiative has been short-listed for the 2016 Sustainia Award for its environmental, social and economical purpose. In fact the use of the app could helps to reduce private car traffic, could help to reduce the time and money spent on multiple transit providers and could reduce congestion in the cities. The Hannover service lets users book anything from public transport tickets to taxi rides on a mobile application, while also checking travel-times in real time. Adding a monthly fee the app will include car-sharing membership and a discounted rates for car-sharing and taxi use.

Relevance
Hannover's 'Mobility Shop' is relevant because take into account the idea of combined mobility: public transport in synergy with other service as car-sharing and bike-sharing.



VOS PILOT IN OSNABRÜCK

Location
Osnabrück, Germany

Year of completion
2015

Client
Osnabrück Municipality

Project description
To increase mobility services in the town, Osnabrück last year has launched a new scheme: flexible carsharing service. But the real novelty come from the option to use these cars spontaneously using the VOS pilot mobile app. The aim of this app is to integrates public transport and shared cars just in one app. Thanks to this app no pre-booking on internet or in the transport office is required. As long as the user has purchased a card that gives him/her access to the service, then he/she can hop in a car or in a any other transportation system by searching on a mobile app where one would be available.

Relevance
This case is relevant since is a pioneer on connecting the flexibility of an urban car sharing with the comfortable ride of the bus or of the train in a medium size city of Germany.

W O W

REAL OR FAKE?

HYPERLOOP

Where
Delft, NL

Who
SpaceX Hyperloop Pod Competition

Project description
The Delft Hyperloop team is participating to the SpaceX Hyperloop Pod Competition. The competition, organized by Elon Musk's company SpaceX and aimed at university students and independent engineering teams, entails teams designing half-size pods. In short, the Hyperloop is a conceptual high-speed ground transportation system incorporating reduced-pressure tubes in which pressurized vehicles travel. By doing this, the air resistance is so low that a vehicle can travel at almost the speed of sound while being a lot cheaper, more efficient, and more convenient than airplanes. This competition entails travelling with a half-size capsule through a low pressure tube, built by SpaceX in California.

Relevance
What if it's really possible to build a Hyperloop? Our nation's transportation infrastructure is badly flawed now, whether it's planes, trains or automobiles. Here's hoping that Elon Musk's Hyperloop can lead the U.S. into a brave new age of transportation that's cheap, fast, weatherproof, crash-proof and always on time.

HUMAN DRONES

Location
Nevada, US

Company
Nevada Institute for Autonomous Systems

Project description
Drones are everywhere these days: they are used to deliver pizza, fly over inaccessible lava lakes, and take elaborate selfies. Recently, the Chinese manufacturer HEang has unveiled a drone that is able to carry humans through the air, which would be a world-first for drone technology. The autonomous drone can carry one passenger and a prototype was shown off at the Consumer Electronics Show in Las Vegas, with the company hoping to sell the drones within a year.

Relevance
Although this sounds remarkably similar to a helicopter , and in fact, it strongly resembles one, this automated technology could be a big step through the transportation system of the future.

PARIS "FLYING" WATER TAXIS

Location
Seine, Paris

Company
-

Project description
Parisians could soon have another mode of transport to get to work in the morning. Maritime startup Sea bubbles are testing on the River Seine the "flying water taxis"at the request of the environmentally conscious Town Hall, which is always looking to be innovative.
Seabubbles is a green, maritime transportation system inspired by the hybrid/electric car movement. Each shuttle is made from a biodegradable mix of fiberglass and high-density foam, and seats up to five people. Best of all, their battery-driven propulsion systems are totally emissions-free.

Relevance
The eco-friendly, solar-powered shuttles will operate like taxi cabs, taking advantage of most cities' open waterways to reduce road and highway traffic.

UBER EXPLORES THE TECHNOLOGY OF FLYING CARS

Location
USA

Company
Uber

Project description
In 2010 Mark Moore, an advanced aircraft engineer at NASA's Langley Research Center, published a white paper outlining the feasibility of electric aircrafts that could take off and land like helicopters but were smaller and quieter. The vehicles would be capable of providing a speedy alternative to the dreary morning commute.

Moore's research inspired different companies to start their own projects, amongst which Google and Uber. Google started and financed two Silicon Valley startups, Zee Aero and Kitty Hawk, to develop the technology, Bloomberg Businessweek.

Today Moore is joining Uber Technologies Inc. and taking on a new role as director of engineering for aviation at the ride-hailing company, working on a flying car initiative known as Uber Elevate.

Uber isn't constructing a flying car yet. In its own white paper, the company laid out a radical vision for airborne commutes and identified technical challenges it said it wanted to help the nascent industry solve, like noise pollution, vehicle efficiency and limited battery life. Moore consulted on the paper and was impressed by the company's vision and potential impact.

Relevance
"Uber's vision is a seductive one, particularly for sci-fi fans. The company envisions people taking conventional Ubers from their homes to nearby "vertiports" that dot residential neighborhoods. Then they would zoom up into the air and across town to the vertiport closest to their offices."

"Uber continues to see its role as an accelerant-catalyst to the entire ecosystem, and we are excited to have Mark joining us to work with manufacturers and stakeholders as we continue to explore the use case described in our whitepaper."

Nikhil Goel,
Uber's head of product for advanced programs

STAY TUNED...

CONCLUSIONS

Several car industries are preparing to be ready, or already claiming to be ready for the fully self-driving car. Semi-automated services such as adaptive cruise control is already available. Rather than technology it will be the legal transition that sets the path for the introduction of the selfdriving car in urban areas. The Netherlands and the UK are actively supporting legal constructions that open the door for experiments. Governments and institutions of both countries are exploring scenario's and transition paths.

The first Dutch automated transport solution on a dedicated lane dates from 1999 already: Capelle's ParkShuttle. The recently opened WePod in Wageningen sets the standard for automated missing transport links from station to destination on (partially) public infrastructure. These pilots are tremendously valuable to generate experience and insights needed for the next development phase. Supported by the Metropolitan Regional Authority of Rotterdam The Hague (MRDH) more of these 'last mile' solutions are being introduced the next coming years. Meanwhile Truck Platooning pilots are paving the way for self-driving on highways.

From the perspective of the KIM scenario's, it is now time to define next steps for feasible urban AV solutions. Will different last mile solutions connect as a new Rotterdam waterfront network between metro and fast ferry? Who will be the first city or legal authority to allow Tesla drivers to leave their car at the front door and let it park itself in the garage nearby?

With so much progression on the tech side, AV pilots being introduced in different cities and national governments taking leadership, now seems the time for cities to choose position and develop strategies for AV. These strategies will need to be part of a larger goal that leads to physical and economical healthy cities. Strategies like Groningen has followed for decades to pedestrianize the inner city, constantly adapting and improving car and bus circulation. Or like Copenhagen's cycling approach where sensoring contributes to better bike circulation.

Settings
Navigation
Phone

STAKEHOLDER ENGAGEMENT

INTRODUCTION

A good understanding of the desires and wishes of (future) users and other stakeholders are key for a successful development process.

During the research, the Except design team encountered many stakeholders. Students, professors, industrial CTO's, public transport operators, civil servants and many others.

The enthusiasm for supporting the autonomous driving transition is driven by the Dutch tradition of cooperation in transport and logistics as well as the need for 'next economy' drivers for the metropolitan region of The Hague Rotterdam.

The region's economy has two faces: innovative logistics (port, Westland greenhouses) and international law and knowledge (three leading universities and institutions). In despite of having these strong economic forces, the region has fallen behind on new economic developments such as the hi-tech Brainport Eindhoven region or the dotcom start-up and financial hub of Amsterdam.

STAKEHOLDER OVERVIEW

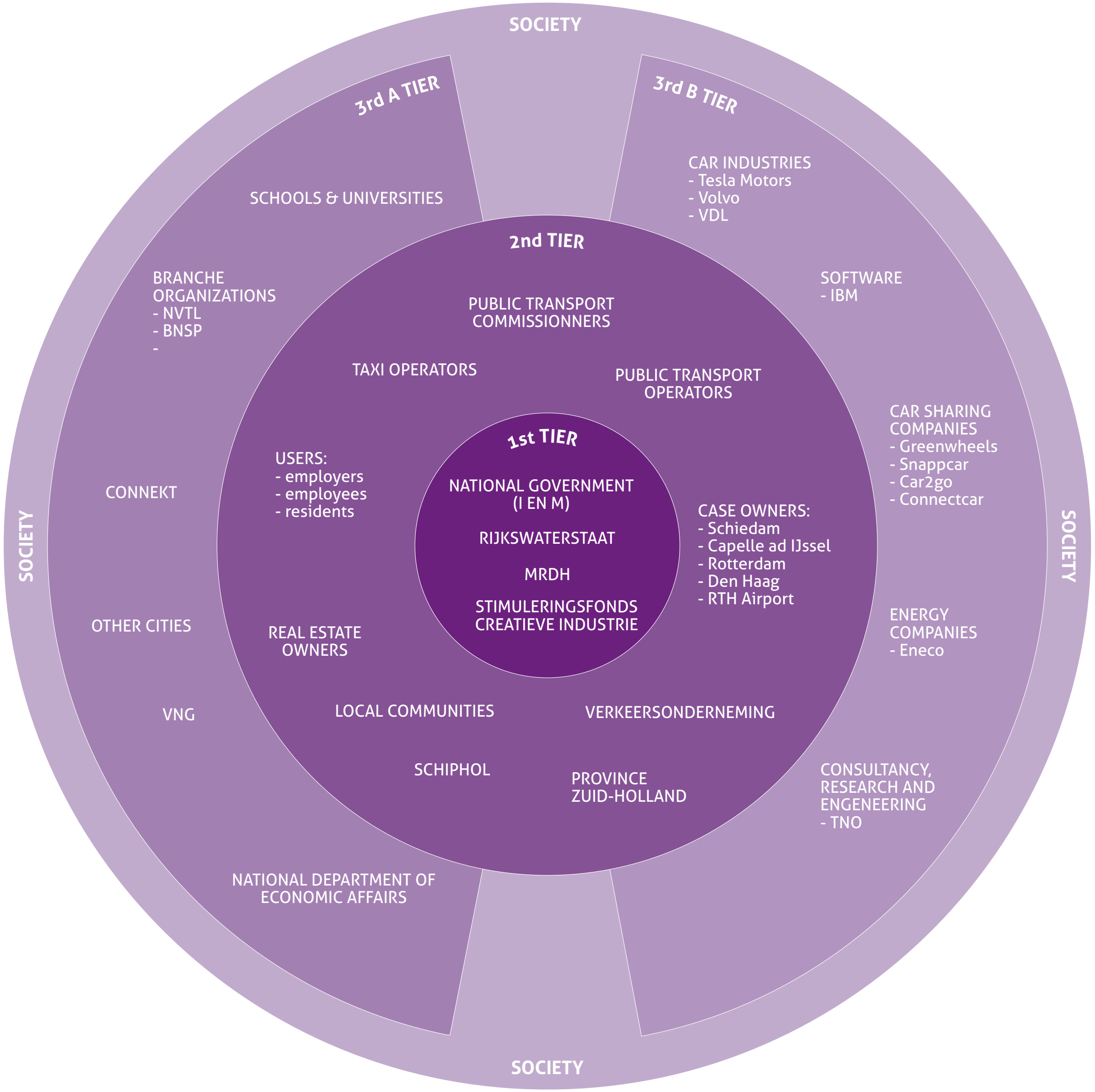
1st Tier
Commissioners and partners - national & regional

2nd Tier
Case owners & their partners

3rd A Tier
Urban planners, designers, mobility advisors, politicians

3rd B Tier
Businesses in AV development

4th Tier
Society at large



ROAD MAP NEXT ECONOMY

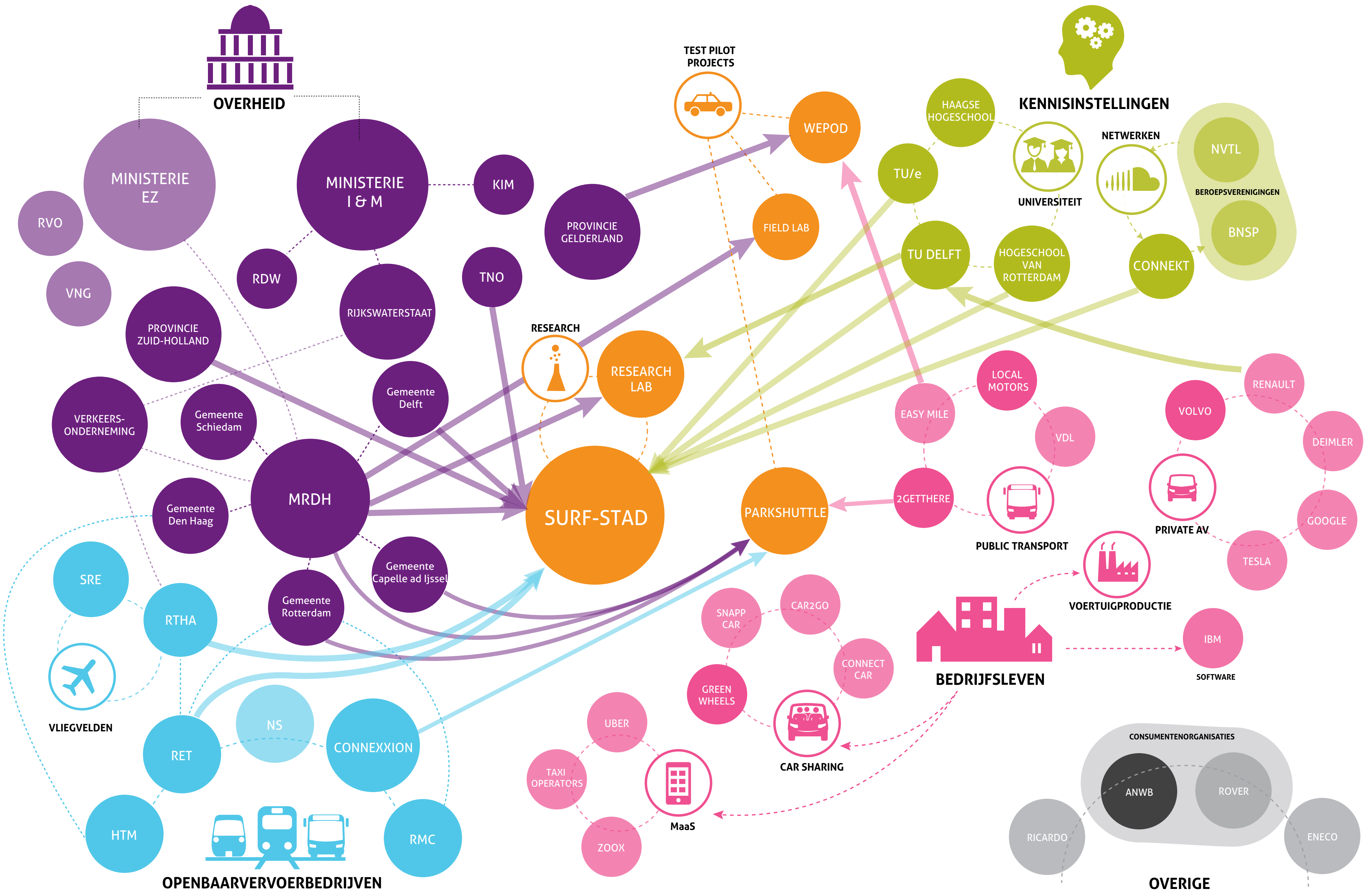
With the 'Roadmap Next Economy' signed by the end of 2015, all regional boards, supported by the Dutch national government, set the ambition of shifting gear to a new generation of economic investments.

Translated into a regional investment package, twinty five potential development areas were defined, one of them being AVLM: automated vehicles for the last mile. New autonomous shuttle services that connect regional train and metro stations to business and residential areas that normally have insufficient density to generated a financially healthy operation. Capelle Rivium's Parkshuttle shows for the 16th consecutive year that a controlled, high frequent and electric shuttle system without a driver on board is a good business modal as well as a satisfactory customer service. Needless to say, these two go together. A next generation of these last mile solutions was planned, in seven different locations. The Except team was involved in most of them, scanning market possibilities, spacial designs, stakeholder demands, project boundaries and road maps for feasibility. The big next stap for these shuttles were to leave the dedicated track structure and spread wings into the public road structure. By the end of 2016 all involved parties joined forces to merge there initiatives into a common step by step approach. A fieldlab was created (under MRDH leadership) to join forces with governments, universities, research centers and businesses.

DECLARATION OF AMSTERDAM

On international level, just a bit up north from Rotterdam and The Hague to Amsterdam, EU member states joined in April 2016 at the summit about international transport innovation and cooperation. The transport ministers signed the 'Declaration of Amsterdam' to set future steps for a common legal reformation. The declaration will result in legislation that will allow the self-driving car on all European roads within uniform regulations.

The Except team invited the ministry of Infrastructure and Environment and the Dutch Road Authority (RDW) to cooperate in our research. This resulted in information exchange (mostly by the KIM institute) and the participation of RDW in many case workshops as well as the SiD session at LEF-future Center, November 18th 2016



OVERHEID
MINISTERIE EZ
MINISTERIE I & M
KIM
RVO
VNG
RDW
RIJKSWATERSTAAT
TNO
PROVINCIE GELDERLAND
PROVINCIE ZUID-HOLLAND
VERKEERS-ONDERNEMING
Gemeente Schiedam
Gemeente Delft
Gemeente Den Haag
MRDH
Gemeente Capelle ad Ijssel
Gemeente Rotterdam
TEST PILOT PROJECTS
WEPOD
FIELD LAB
RESEARCH
RESEARCH LAB
SURF-STAD
PARKSHUTTLE
KENNISINSTELLINGEN
HAAGSE HOGESCHOOL
TU/e
UNIVERSITEIT
TU DELFT
HOGESCHOOL VAN ROTTERDAM
NETWERKEN
CONNEKT
NVTL
BEROEPSVERENIGINGEN
BNSP
LOCAL MOTORS
EASY MILE
VDL
2GETTHERE
PUBLIC TRANSPORT
RENAULT
VOLVO
DEIMLER
PRIVATE AV
GOOGLE
TESLA
VOERTUIGPRODUCTIE
BEDRIJFSLEVEN
IBM
SOFTWARE
SNAPP CAR
CAR2GO
CONNECT CAR
GREEN WHEELS
CAR SHARING
UBER
TAXI OPERATORS
ZOOX
MaaS
CONSUMENTENORGANISATIES
ANWB
ROVER
RICARDO
ENECO
OVERIGE
SRE
RTHA
VLIEGVELDEN
NS
RET
CONNEXXION
HTM
RMC
OPENBAARVERVOERBEDRIJVEN

GOVERNMENT - NATIONAL LEVEL

The Dutch Ministery of Infrastructure and Environment and the Driver and Vehicle Licensing Agency (RDW) support the development of autonomous driving by adapting legislation, international cooperation, knowledge development and authorizing pilot projects. RDW has contributed to most case studies as well as the research sessions. The ministery's ambition is to be one of the global leaders in autonomous driving.

GOVERNMENT - REGIONAL LEVEL

Metropole Region Rotterdam The Hague (MRDH) supports research and development, specifically on operational last mile solutions (AVLM). MRDH supported this research by connecting research and case studies. The province of South Holland supports research (SURF-STAD).

UNIVERSITY & KNOWLEDGE INSTITUTIONS

Delft University of Technology, Rotterdam University of Applied Sciences, The Hague University of Applied Sciences have several research and development programs and participated in most case studies as well as the research sessions. Their ambition is to be international leaders in knowledge development as well as applied technology.

TNO contributed to the research as well as the Rotterdam case study

MUNICIPALITIES

Four municipalities (Capelle aan den IJssel, Rotterdam, Schiedam, The Hague) were connected to this research with case studies. Most of them are interested in last mile public transport solutions. Larger cities like Rotterdam are interested in long term effects and strategies for sustainable implementation. Other incentives are solutions for urban distribution systems and car sharing.

PUBLIC (AND SEMI-PRIVATE) TRANSPORT OPERATORS

Connexxion and RMC are convinced that autonous driving will be one of the main gamechangers for their future business models. They participated in several case studies as well as research sessions. Connexxion (that is part of Transdev Group) operates the Parkshuttle, that demonstrates high rates in customer satisfaction as well as a health financial operation.

IT, INTERNET AND SOFTWARE

Global companies such as Google, Apple, Uber as well as startup ZOOX are investing largely in R&D for autonomous driving. These companies were not connected to our research, except IBM that is allied to Local Motors. Digital solutions and mobility services are giant potential markets in autonomous driving.

REAL ESTATE & AIRPORT OPERATION

Rotterdam The Hague Airport and Schiphol Real Estate are interested in last mile connectivity terminal – parking – public transport as well as autonomous parking and automated valet parking.

CAR SHARING - GREENWHEELS

Greenwheels participated in the Rotterdam Oude Noorden Case to learn about effects and operational benefits. Greenwheels' long term strategy is related to their owners (PON holding) interest to explore future business models for car sale, lease and share.

AUTOMOTIVE INDUSTRY ENTERPRISES

Out of all the leading world car brands, Volvo joined the SDC Amsterdam debate. Volvo's brand image is largely depending on safety and Volvo considers autonomous driving to have a major impact on car safety. 2Getthere and Local motors participated in several case studies with the perspective of providing directly operational vehicles for last mile shuttle services.

CONSUMER ORGANISATIONS - ANWB

The Royal Dutch Touring Club ANWB visions that selfdriving cars will be safer, cleaner and more comfortable. ANWB emphasizes the central position of the user in research and development and internet privacy aspects. Users should be able to decide about the access of data in relation to the purpose.

USERS

ANWB's vision to center the users perspective in R&D opens the debate on a relatively underexposed aspect. What are the people's needs, dreams, conditions and requirements? The SDC team organized a customer enquiry for the Park Shuttle Service, collected publications and published an article on user aspects in cooperation with the Delft University of Technology.

For the large audience self driving cars are a futuristic application that they will consider once it is available. From private car owners perspective the Volvo test drivers in London and Gothenburg are a very interesting group because Volvo cooperates directly within a test environment that is supported by public road authorities. Tesla obviously has a different approach providing 'autopilot' in the model S already, with a tremendously larger amount of user experience. But also facing the downside: a fatal accident in California in June 2016.

The SDC team put user perspective central in all cases, simulating for example with stakeholder role games where actual users were not (yet) available.

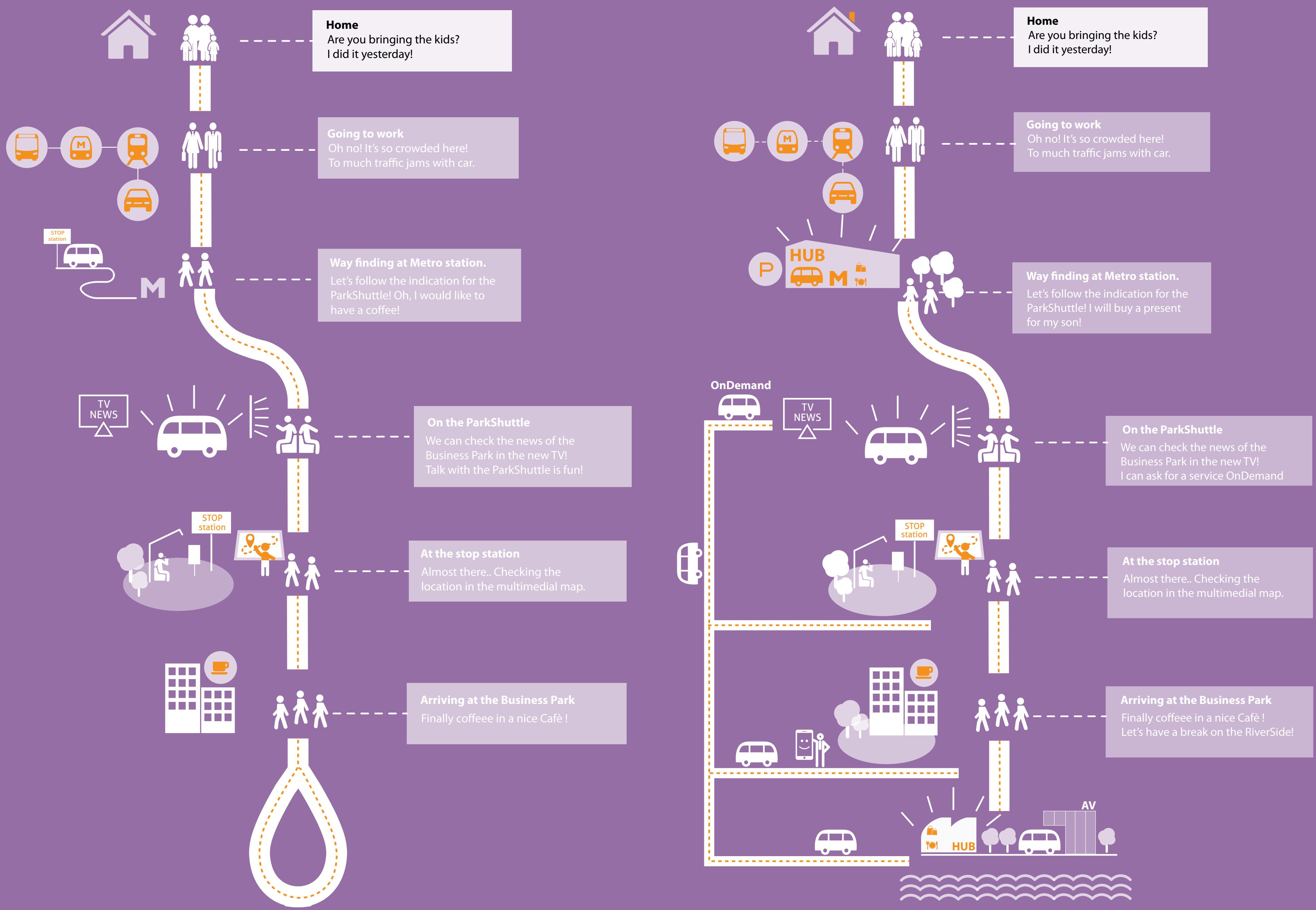
Major user aspects are:

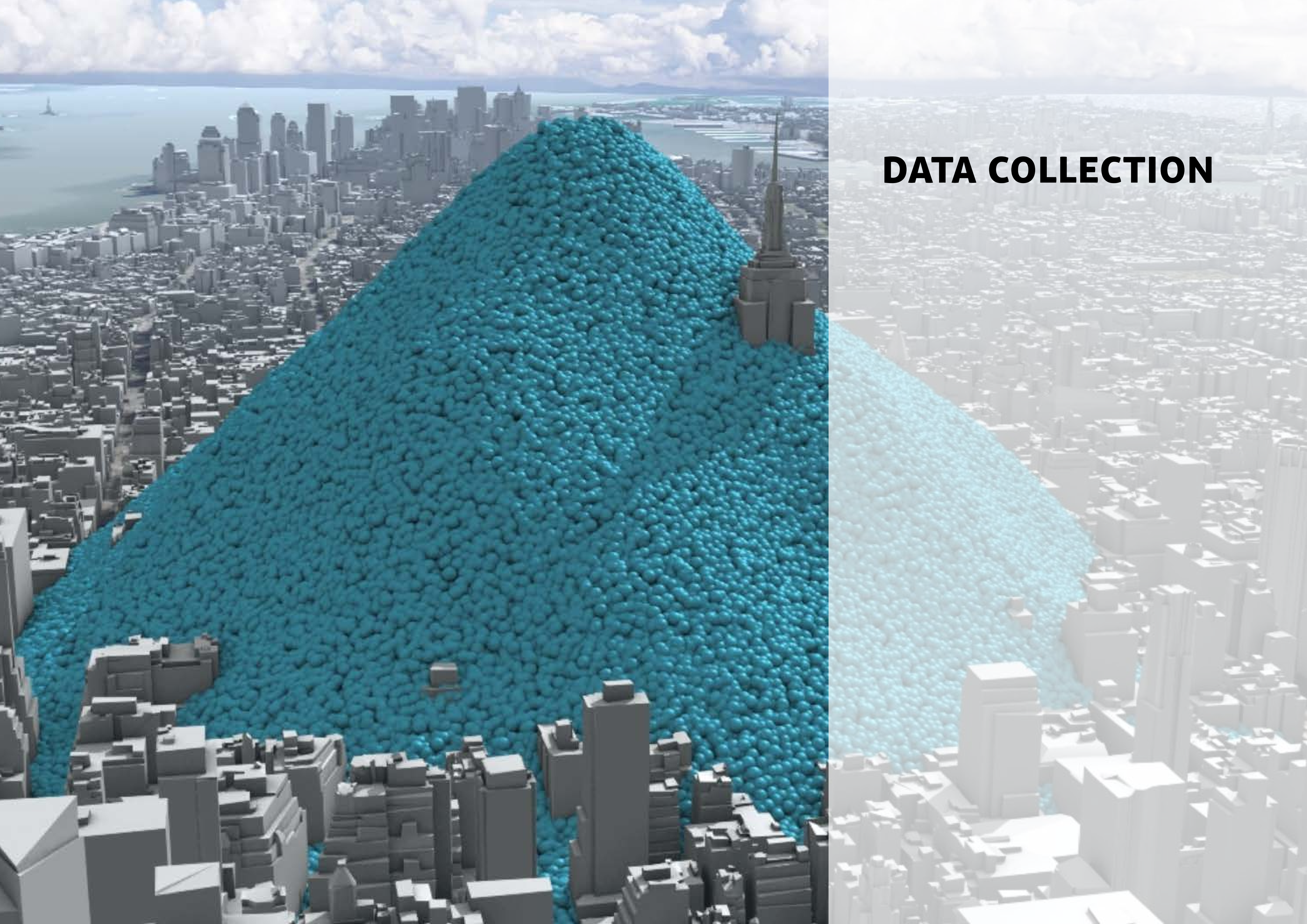
» Vehicle safety (reliability)
» Road safety (encountering an autonomous car)
» Vehicle comfort (vehicle behaviour)
» Social safety (in shared rides and public transport)
» Internet privacy (sharing private data)
» Internet safety (against vehicle hacking)
» Transparency and systems knowledge (working of the vehicle in traffic streams)
» Overall mobility finances (ownership, rides, taxes, insurance)

Inside the Parkshuttle

Station points

"ParkShuttle supports the needs of users of office park Rivium (Capelle aan den IJssel)"





DATA COLLECTION

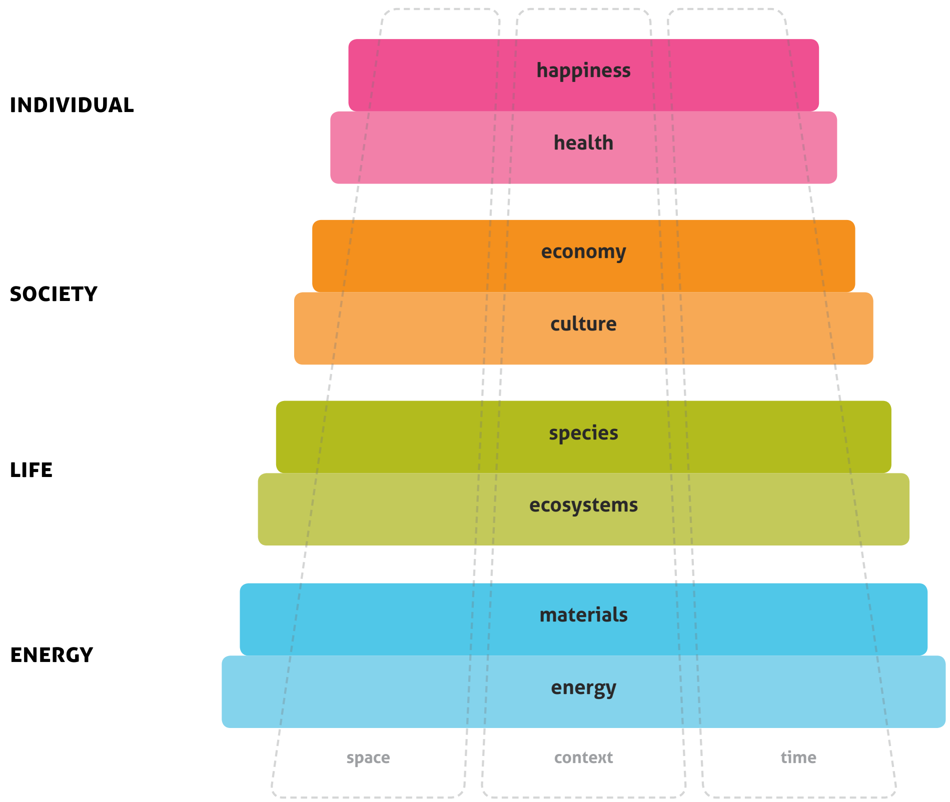
INTRODUCTION

Self-driving vehicles have long been predicted and are a typical part of science fiction literature. One way or the other, the future transport sector will be completely re-envisioned by automated driving, as evidenced by the precedents and tends discussed in the previous chapter. The only question is exactly how and to what extent this change will show itself.

This chapter is concerned with the relevant data to ease decision-making related to the introduction of self-driving vehicles. The present state of automation technologies will be described and an idea of how these technologies might be employed in the future will be given. Primarily, this section encompasses a full iteration of the ELSIA framework and gives insights into several categories of future developments.

ELSIA INDICATORS
To create a general awareness on full-spectrum sustainability we used the ELSIA indicators. It is a categorization tool for object level performance indicators which helps to form an overview of all the object-related aspects of a system and their causal relationships.

As an object-categorization system it helps to map the larger set of relationships between objects, and it's one of the core components of Except's Symbiosis in Development framework.



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Individual

Society

Life

Energy

ENERGY & MATERIALS

"Energy is one of the building blocks of society. The path towards the sustainable energy sources will be long. We cannot resist this transition, we must lead it."

ENERGY CONSUMPTION

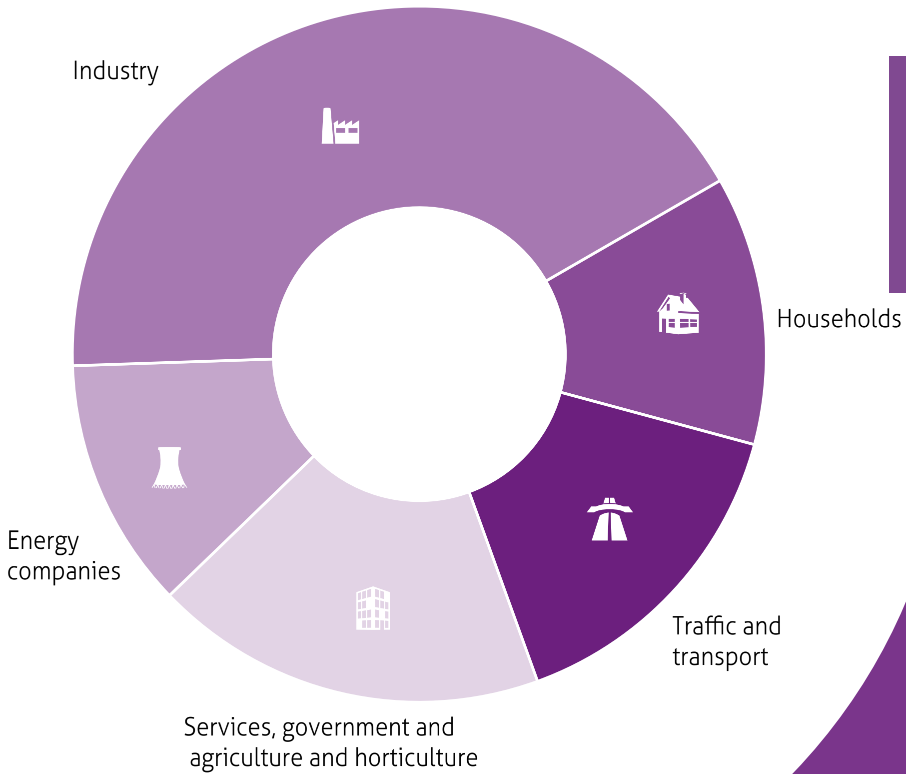
TRANSPORT SECTOR

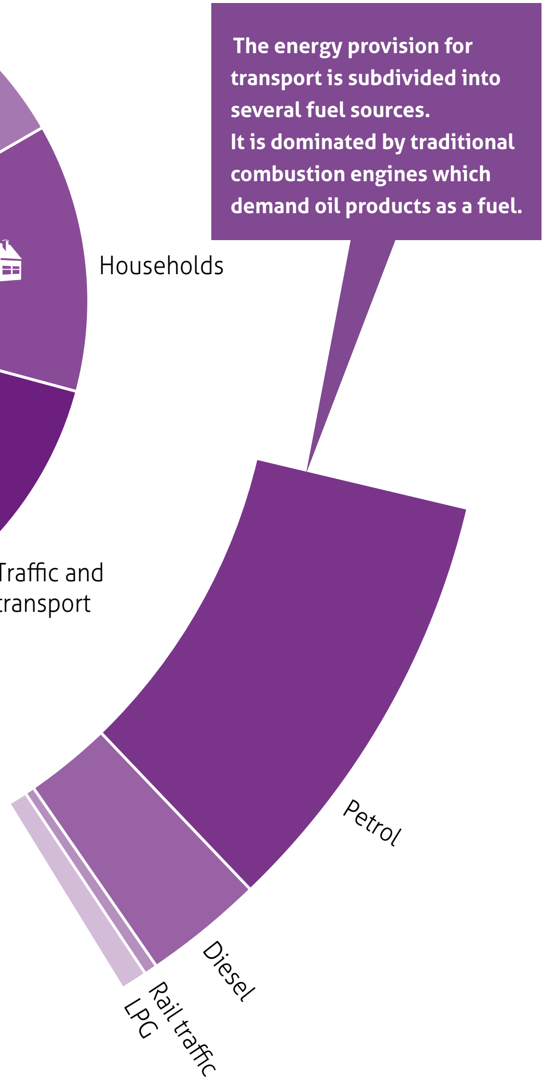
The energy mix in the Netherlands is illustrated by the amount of primary energy used to cover the total energy demand. Energy provision is achieved by employing different energy sources. Fossil resources play a major role in the Netherlands even though renewable energy forms have gained significant traction over the past few years. It is expected that renewable energy sources (RES) will play a more and more important role in the Dutch economy. A problematic factor is thereby the land demand for RES. Gas demand in the Netherlands is of special note. This is mainly due to a widespread use of gas for hot water supply and cooking appliances.

The energy demand for transport is large. The Netherlands uses a high percentage of non-fossil fuel in transport due to the high use of public transport.

The total energy use in the transport sector increased by 19% from 1990 until 2014. Currently, about 47% of the whole energy consumption is due to fuel consumption of personal cars. The share of company vehicles accounts for 25%. A small dip in energy use could be observed during the financial crisis, but currently demand is still rising continuously.

The share of public transport is relatively small in relation to the dominant personal vehicle sector.





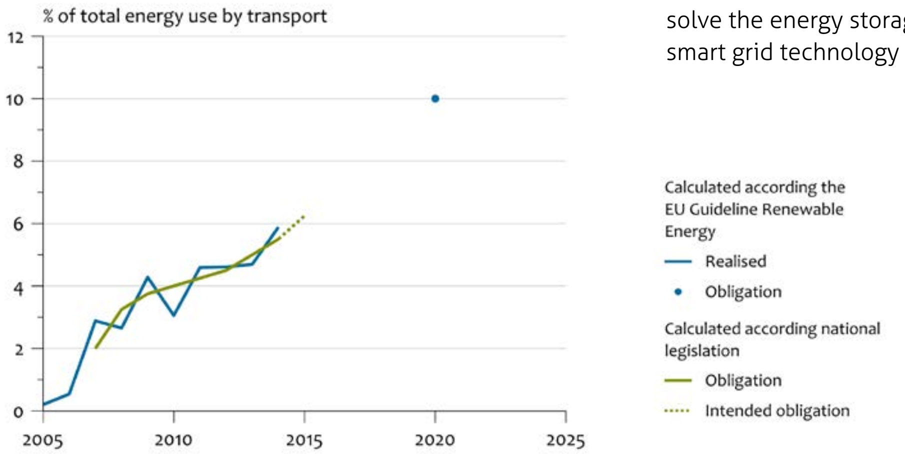
The distribution of energy in the Netherlands is dependent on a variety of sources. Most of the resources are
imported as a result of natural resource scarcity in the Netherlands.

TOWARDS ZERO-EMISSION TRAFFIC

USE OF RENEWABLE ENERGY FOR TRANSPORT

It is laid down in Dutch law that part of total use of petrol and diesel for transport must be renewable energy. This share increased form 2% in 2007 to 5.5% in 2014 (IenM, 2011) and to 10% in 2020 (IenM, 2014). In 2014, the actual share of renewable energy amounted to 5.8%.

The obligation is based upon the EU Guideline Renewable Energy. In 2020, member states are obliged to use a share of renewable energy for transport which corresponds to 10% of the total use of fuels and electricity for transport.



> Share renewable energy for transport, NL [26]

ELECTRIFICATION OF THE MOBILITY

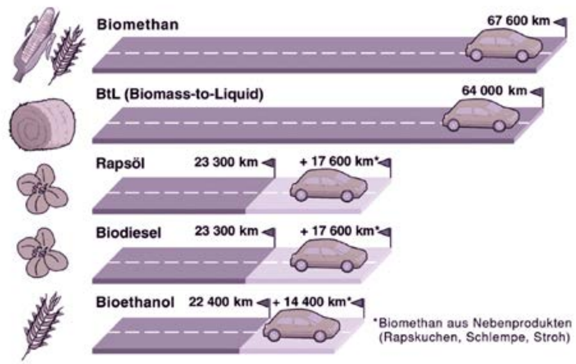
Eighty percent of the energy demand in the Netherlands is dependent on fossil fuels. This dependency is likely to continue into the future. To achieve a really sustainable transportation sector, new fuels such as electric/hybrid vehicles and biofuels need to be promoted and further subsidized in order for EV technologies to become competitive.

A massive shift to electric cars is expected to happen in the next decade. Electric engines are superior in almost all categories compared to conventional combustion engines. Important points are the lower overall environmental impacts, efficiency, comfort and lower noise pollution levels. Electric cars are also expected to become very cheap, consume less energy and with their increasing range they may be able to solve the energy storage problem with the help of smart grid technology to ensure supply.

BIOFUELS

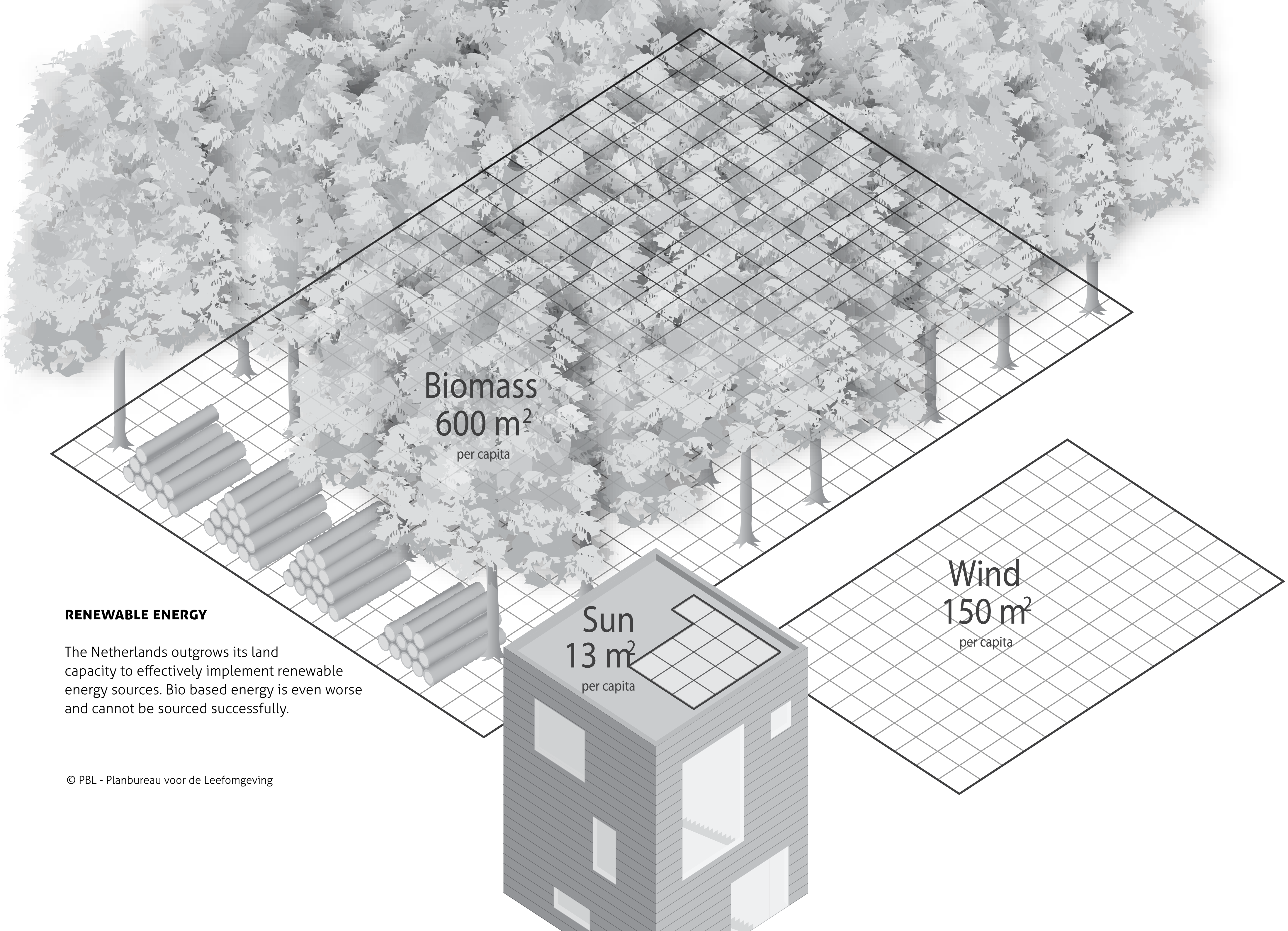
State of the art second-generation biofuels are made from agricultural waste, for instance straw. A future research goal is to cutout the very inefficient photosynthesis stage and to produce biofuels directly from sunlight. The core technology for fuel development is catalysis, which increases the rate of chemical reaction and lowers the activation energy.

Other research tracks are about optimizing engines and gas turbines to increase efficiency and to match the fuels with existing engine technology. A large issue for application in the Netherlands is the low availability of arable land resources to grow the biomass required for fuels. Consequently, the basic resources must currently still be imported.



> Reach of different biofuel types per 1 hectare [4]

EXCEPT
INTEGRATED SUSTAINABILITY



RENEWABLE ENERGY

The Netherlands outgrows its land capacity to effectively implement renewable energy sources. Bio based energy is even worse and cannot be sourced successfully.

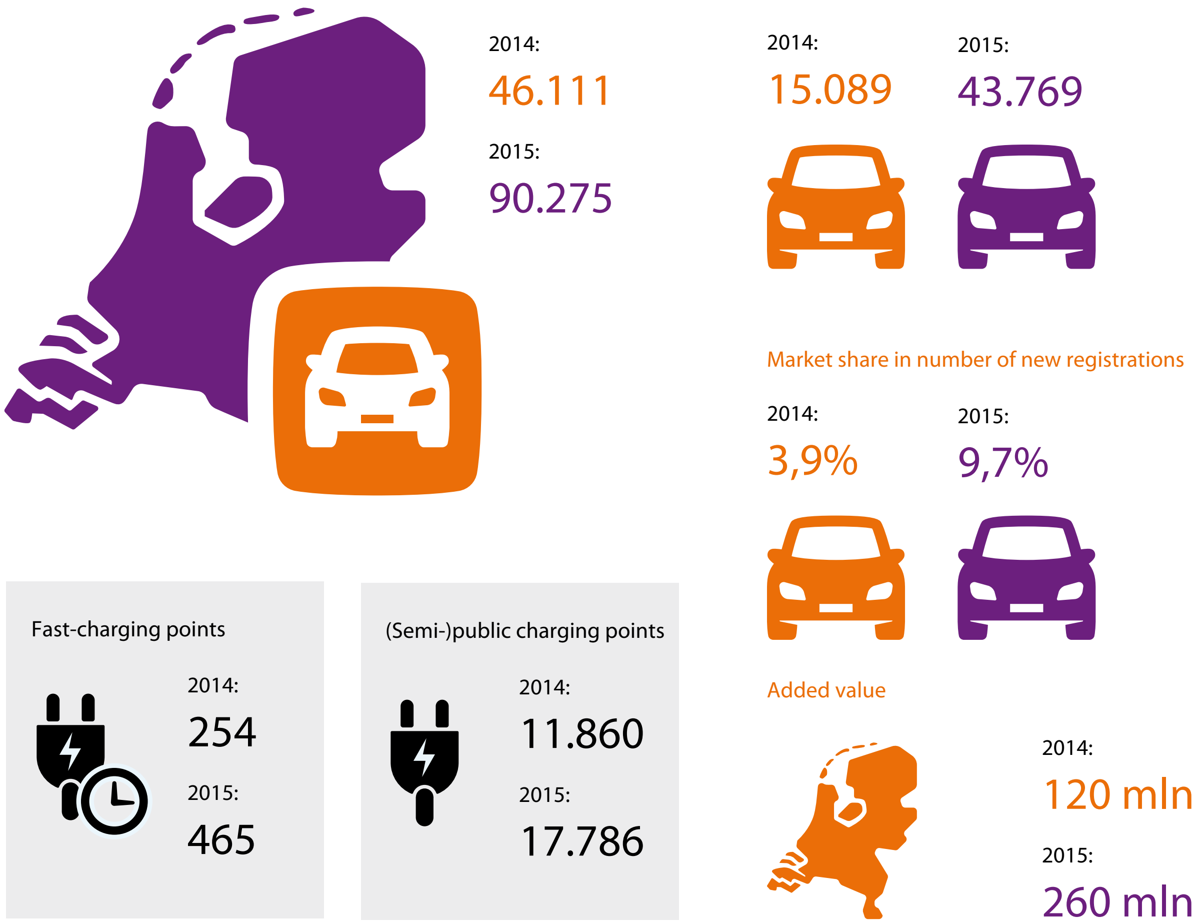
PASSENGER CARS IN NL

STEADY PATH OR ANOTHER A TREND?
The distribution of personal car fuel types is diverse in the Netherlands. The dominant type is petrol with more than 75%, followed by diesel with about 18% and other fuel types, including electricity, hybrid, and LPG.

Electric/hybrid vehicles are on the rise. Globally there are currently about 400.000 plug-in electric vehicles in use. The Netherlands is the second largest market after Norway with more than 40.000 new registrations in 2015 alone. Between 2012 and 2013 the Netherlands achieved the highest growth rates globally with 338%. Vehicle registrations for EV's account for roughly 10% of the total 400.000 vehicle registrations.

The significant share and the upward trend can be explained by the Dutch Government incentives over the last years. Until the 1st of January 2016 electric and hybrid vehicles were completely excluded from registration fees and road taxes. Since then electric vehicles pay 4% and hybrid vehicles 7% of the full registration fee. The purchase of a new vehicle is subsidized up to €3000 and €5000 in Amsterdam, Rotterdam, Utrecht, Den Haag and the Arnhem-Nijmegen metropolitan area.

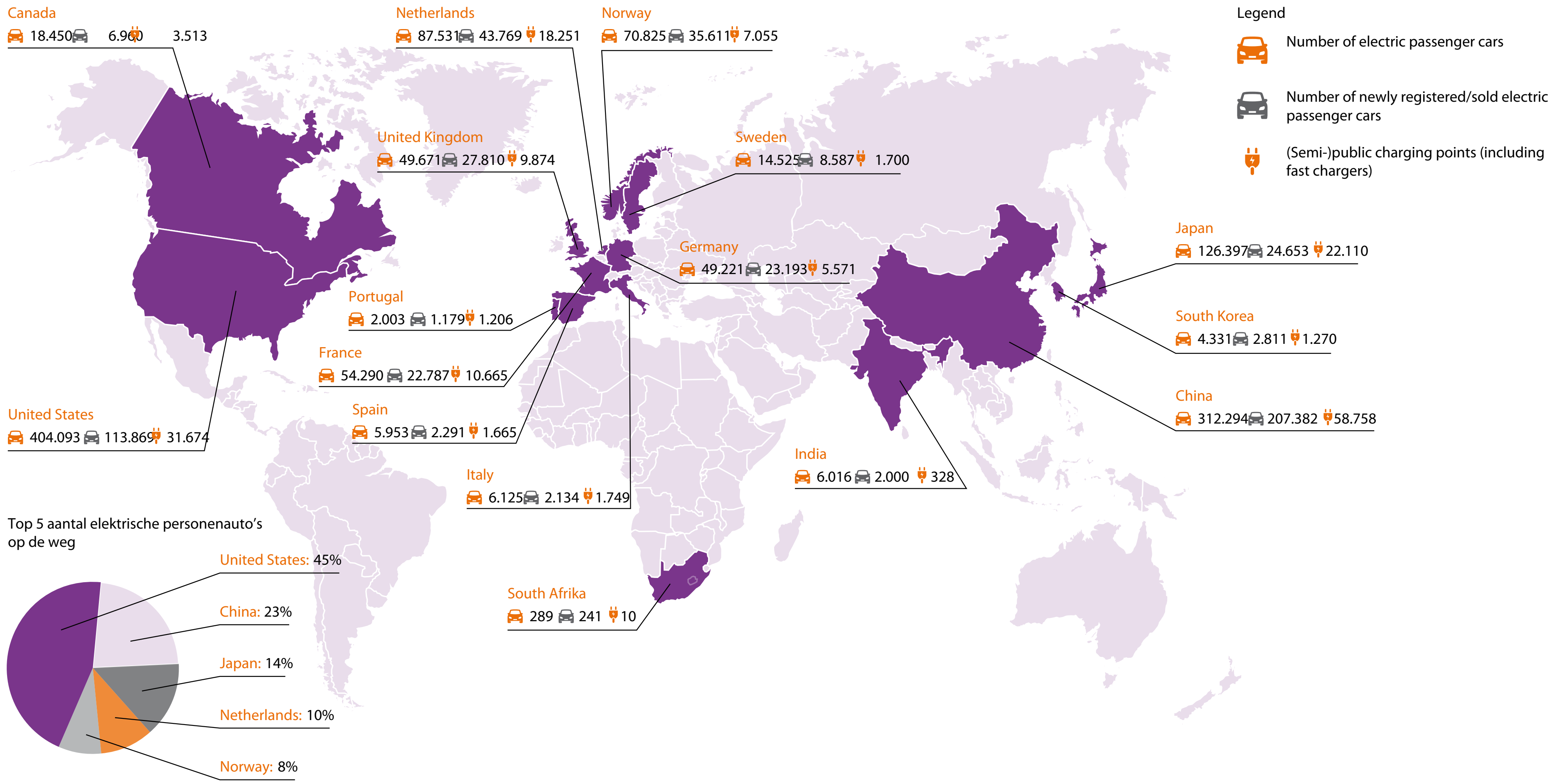
Electric vehicles are highly competitive compared to conventional vehicles. The initial costs are much larger but costs per kilometer are significantly lower.



(source: CBS, RDW, Oplaadpunten.nl; edited by RVO.nl)

The year 2015 in pictures and figures

Electromobility: Dutch achievements in an international context



(source: Global EVI Outlook 2016, IEA)

EXCEPT
INTEGRATED SUSTAINABILITY

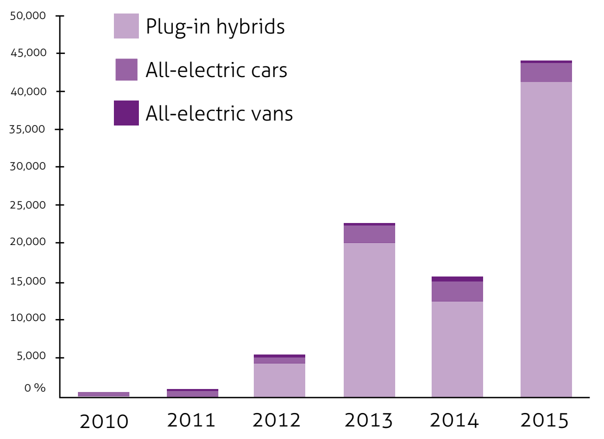
SMART GRID

ENABLING EV & INFORMATION FLOW

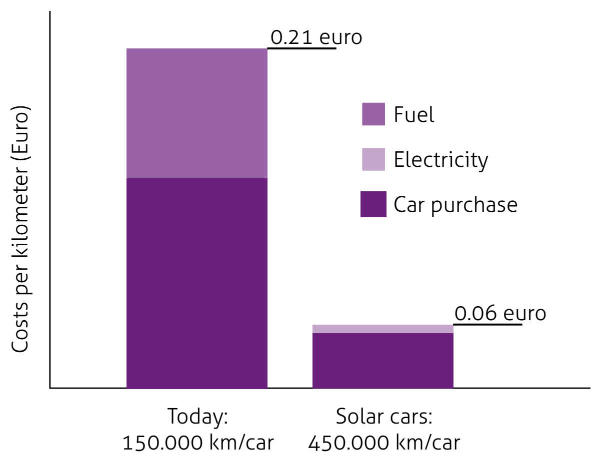
Smart grids make it possible to enable electric vehicle charges during off peak hours. Thereby the daily load curve is flattened and the utilization of the electrical grid gets reduced significantly compared to a system without a smart grid. Advanced electric equipment represents essential components to enable the flow of information from grid to vehicle and to provide a utilization of real time data to make intelligent charging of electric vehicles achievable.

Due to technical limitations, the maximum penetration level for electric vehicles in medium sized European cities is limited currently to 18%. The main limitation is the electricity buffer due to fluctuating daily and seasonal production for wind and solar electricity production.

This issue of buffering, as the International Transport Forum[31] suggests, can be solved by an application of batteries in cars which provide additional electrical capacity to the grid and can be interconnected to other energy sources on demand. As a consequence, technical improvements and economic feasibility need to be enhanced.



> Registrations of plug-in electric vehicles in the Netherlands per year [51]



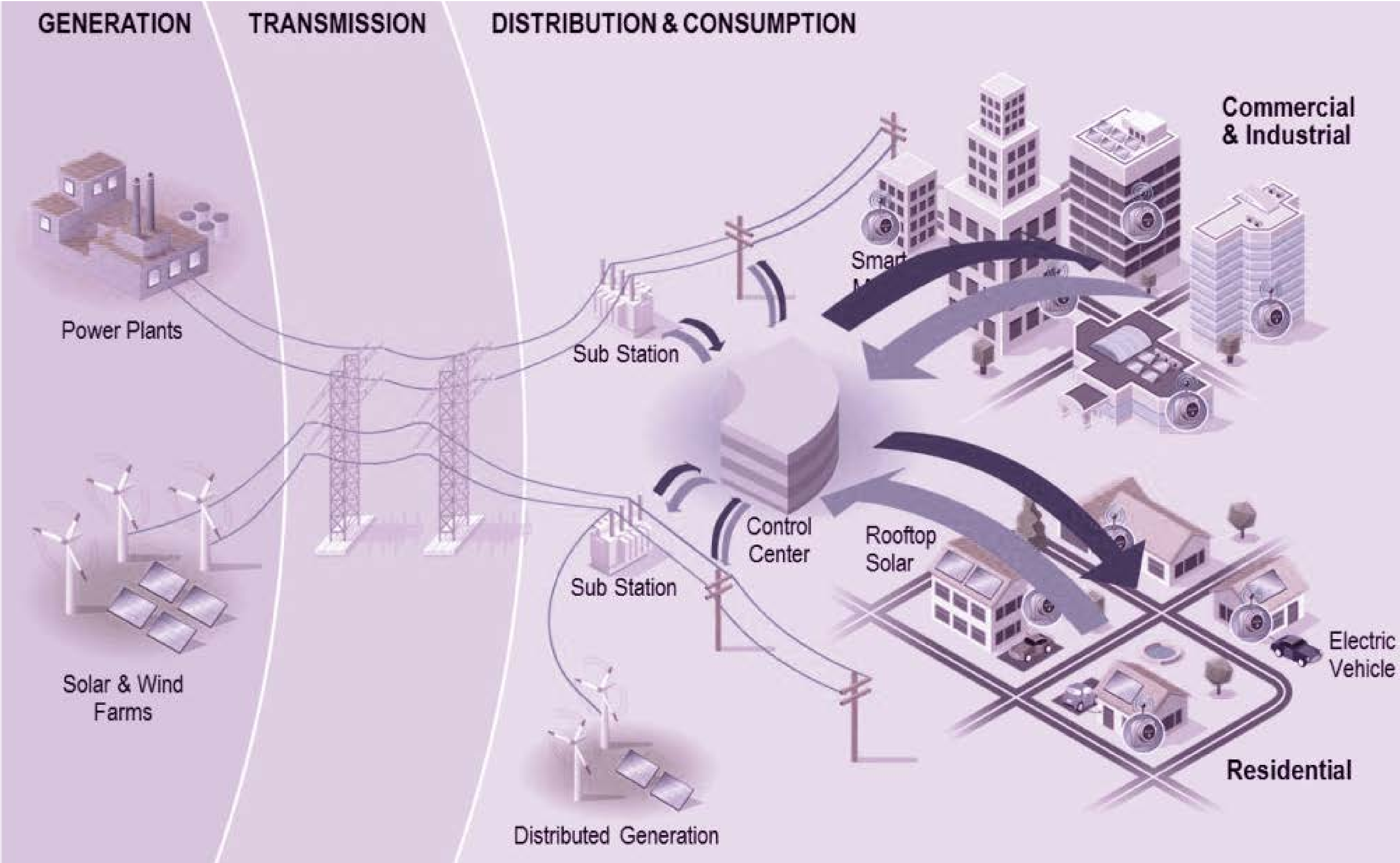
> Cost comparison between conventional- and electric vehicles [15]

ELECTRIC VEHICLE NETWORK

The purpose of an electric vehicle network is to provide charging stations and battery swap stations for the public to give opportunities to recharge electric vehicles. In 2013, Estonia managed to become the first country to apply a nationwide charging network. Agreements between the government, technology providers, and network providers were necessary to make this possible. Two frontrunner projects are:

» Since 2009 Tesla works together with government-affiliated partners to set up battery charging stations. The first ones were established in 2012. At the moment are 317 supercharger stations worldwide and the network is expected to grow continuously.

» The "Formula E Team" of 2010 is collaboration endorsed by the Dutch government. The work group unites local governments, research facilities and private stakeholders. The Dutch government also supports an initiative called "E-laad" with investments, which aims to build a charging network of 10,000 stations.


GENERATION
TRANSMISSION
DISTRIBUTION & CONSUMPTION
Power Plants
Solar & Wind
Farms
Sub Station
Sub Station
Control
Center
Rooftop
Solar
Commercial
& Industrial
Electric
Vehicle
Residential
Distributed Generation

ENVIRONMENTAL IMPACT

EMISSIONS IN EUROPE

Greenhouse gas emissions and air pollutants are very important aspects to consider with regards to the impact on environment and society. They are emitted by both anthropogenic and natural sources, and are either emitted into or formed in the atmosphere which has direct effects on climate, ecosystems, and human health. The main sources in the transport sector are fuel combustion, vehicle and road wear, and energy and resource demand by the transport industry.

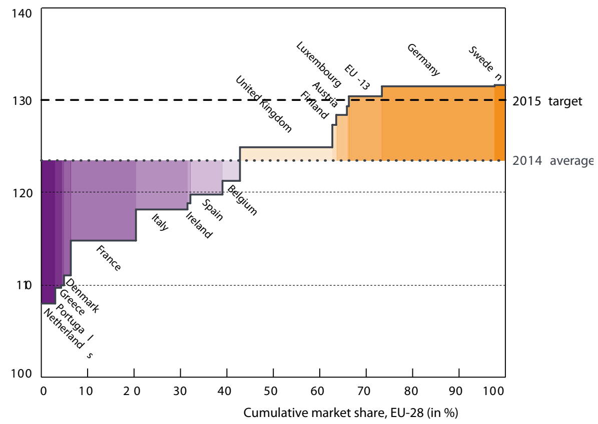
Air pollution emissions in transport accounted for between 13% and 15% in 2013 for PM2,5 and PM10 and 46% for NOX for total primary emissions in 2013.

ROAD TRAFFIC

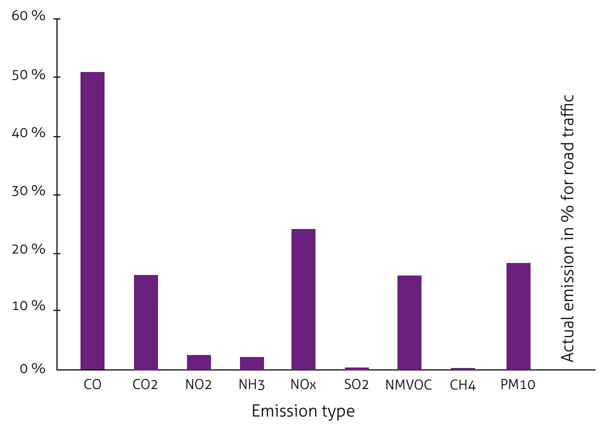
Road traffic represents one of the most important sources of greenhouse gas emissions and air pollutant emissions in the Netherlands.

The following emission sources are included in the overview below:

» Combustion emissions (via the exhaust)
» Evaporative emissions (from the fuel system of petrol cars)
» Emissions caused by wear processes (tires, brakes and the road surface)
» Others (leakage of engine oil, heavy metals due to fossil fuel consumption)



> CO2 emission in Europe [26]



> Type of air pollutant emission in the Netherlands [26]

BATTERY IMPACT OF THE EV

The production stage of electric vehicles is substantially more intensive from an environmental perspective.

The cradle to grave analysis shows potential for improvement in global warming trends and fossil resource demands if appropriate energy sources are chosen. Nevertheless, other categories like particulate matter formation and mineral resource depletion, show a significant impact on battery production.

The electronics and metal industry sectors must jointly work together to tackle these issues to make EV's part of the solution to mitigate pollution both in urban areas and at the location where they are produced. The risk is that otherwise the Netherlands is at risk of exporting their environmental impact to countries where batteries are manufactured.

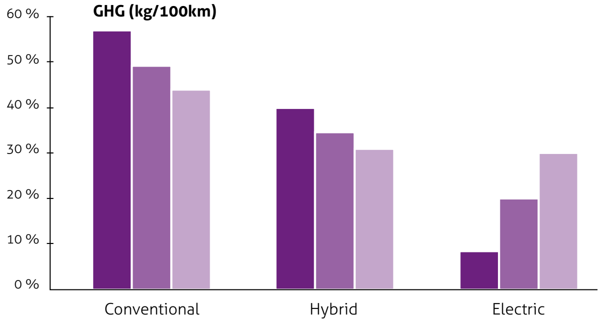
VEHICLE RECYCLING IN NL

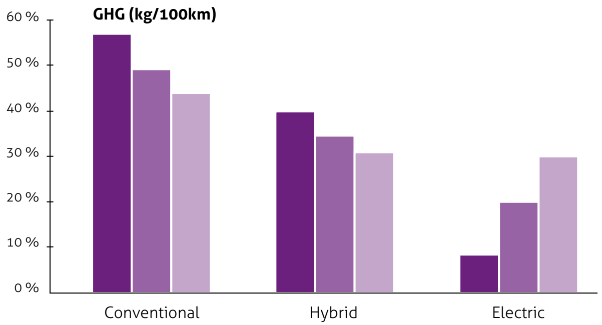
3 SCENARIOS

Hybrid and electric vehicles are the most promising technologies to reduce air pollution and carbon emissions. The direct comparison of these two vehicle types with conventional combustion engines shows that it is counterproductive to promote electric vehicles in regions where electricity is produced from oil, coal, or lignite combustion.

The figures show the total percentage of GHG emissions and air pollutant emissions for each vehicle type.

- Scenario A represents a low carbon scenario wherein energy is sourced from predominantly renewable energy sources (RES) and or coal with carbon capture and storage.
- Scenario B is a medium carbon solution. 50% of the energy demand gets covered by RES and the other half by coal with a conversion efficiency of 40%.
- Scenario C is the high intensity carbon option with all energy produced by coal and an efficiency of 40%. The electrification of transport demands a high share of renewable energy and an improvement of energy distribution.



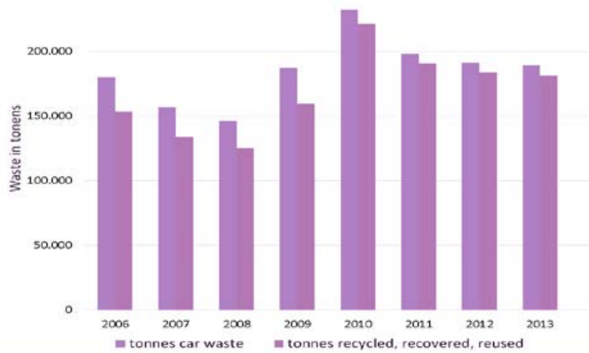


> Greenhouse gas emission and air pollutant emission for conventional, hybrid, and electric vehicles [32]

SUCCESSFUL END-OF-LIFE STRATEGY

Every year vehicle waste generates between 8 and 9 million tonnes in Europe. The goal should be to reuse, recover, and recycle as much as possible, as is required in the EU End-of-life Directive of 2000. Less hazardous substances should be used in vehicle production as well.

The Netherlands performs very well in end-of-life treatment of cars. Rates for recycling, reuse, and recovery are increasing yearly to a rate of 96% in 2013 of a total amount of 190.000 tons of car waste. The rates have reached almost 100% and were rising continuously over the last few years.



> Total tones of car waste and recycling volumes in the Netherlands [3]

EXCEPT
INTEGRATED SUSTAINABILITY

AUTOMATION

CONTEXT

Drivers around the world are getting used to the increasing amount of digital technology in their cars. Many of the normal features of the car as monitors of performance data like speed, fuel efficiency, and gas tank levels; heating and air conditioning; and the audio system — all have been digitized in hopes of providing the driver with easier operation and better information.

The car now reaches out to the surrounding world for music streamed from the cloud, real-time traffic information, and personalized roadside assistance. Recent innovations allow automobiles to monitor and adjust their position on the highway, alerting drivers if they are drifting out of their lane, and slowing down if they get too close to the car in front of them. All in all, the car of today is a technological marvel.
And there's much more to come.

LEVELS OF AUTOMATION 8

Automated driving systems can take shape in a variety of forms. Full automation implies that the driver is fully independent of the vehicle. At this stage the vehicle would be able to fully rely on its internal systems to drive and solve any problems that may arise while driving. A gradual shift towards full automation means a shift from monitoring of the environment by the driver, to a monitoring by the car of the environment.

Most automated vehicles are conditional, which implies that the driving systems can drive independently but require supervision. This indicates that the driver stays responsible even if he/she is no longer driving. The following gives an overview about the present conditions of automated driving systems and describes how far automation has come. The following describes the two main distinctions between automation.

CURRENT SITUATION

Most vehicle manufacturers focus on low levels of automation. Driving assistance systems are already well developed and can perform a variety of tasks. Examples are:

» Adaptive cruise control
» Staying in lane assistance
» Parking assistance

Many new solutions are under development to improve the ease of use of vehicles even more. Partial or full automation is still in the research phase.

AV MARKET

Important parties like Google and Tesla push development towards higher automation. Obstacles like legislation and technical limitations are in constant reform. Research facilities all over the world serve as a scientific basis to initiate more advanced systems. Fully automated vehicles are expected to be available between 2025 and 2040.

NOTE: Source mainly from precedent collection.

AUTOMATED DRIVING SYSTEMS MONITOR THE ENVIRONMENT

CONDITIONAL DRIVING
At the level of conditional driving, the automated vehicle is able to cover all driving tasks. Only the human driver needs to be able to intervene and react if the automated system fails or makes mistakes.

HIGH AUTOMATION
The car is completely able to make its own decisions and can take appropriate measures to deal with flaws. The only exception are some driving tasks which the car is not able to perform, so the driver has to take over control.

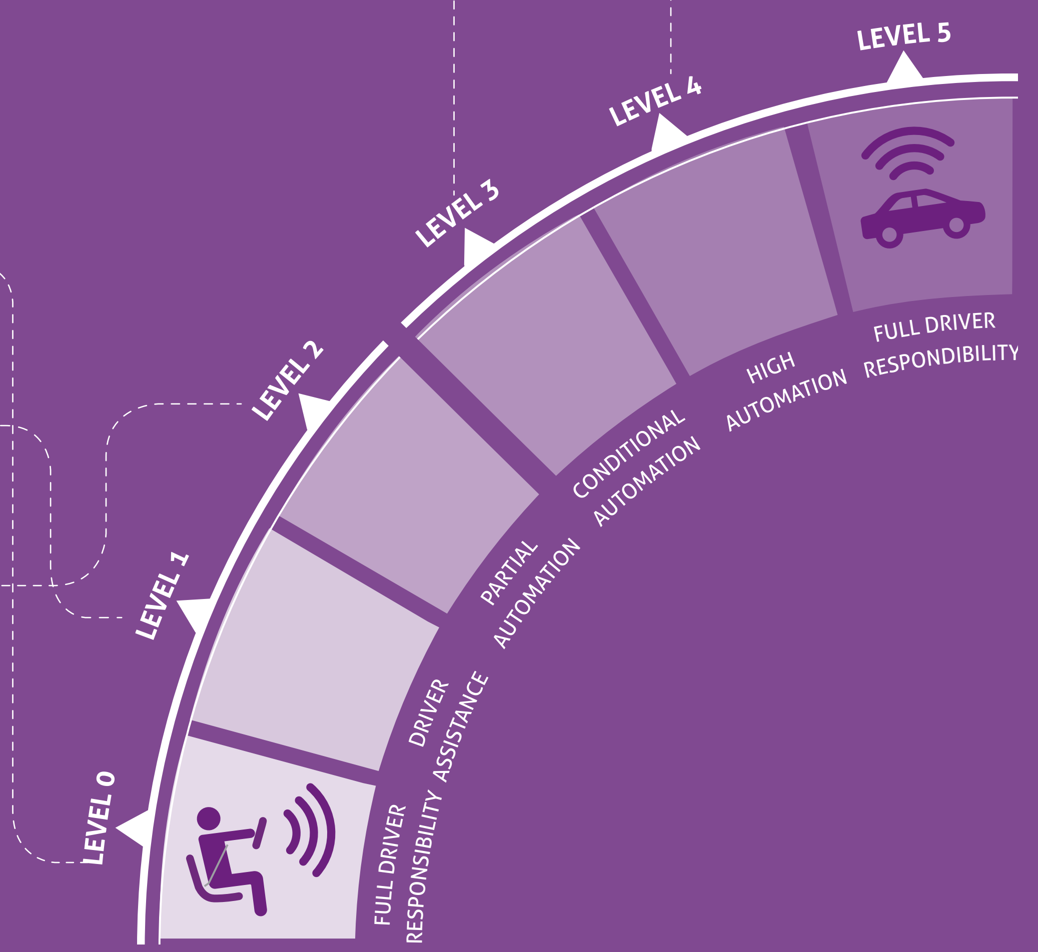
FULL AUTOMATION
The highest form of automation is full automation. Here the car is completely aware of the environment and is able to fully control the driving processes of all driving tasks.

HUMAN DRIVERS MONITOR THE ENVRONMENT

NO AUTOMATION
At these levels the human driver stays fully responsible and is in control of the driving process. There is still no automation in place, even by installation of special warning or enhancement systems.

DRIVER ASSISTANCE
Systems can cope with a variety of tasks. Mainly they are limited to steering processes like acceleration and deceleration. The system is aware of the driving environment but does not perform decisions by itself.

PARTIAL AUTOMATION
As before, the car processes information about the environment and the driver makes the decisions, but the system is able to automatically steer, accelerate or decelerate if the river wishes. Again, the driver is fully responsible and in control.



ONE SYSTEM, THREE COMPONENTS

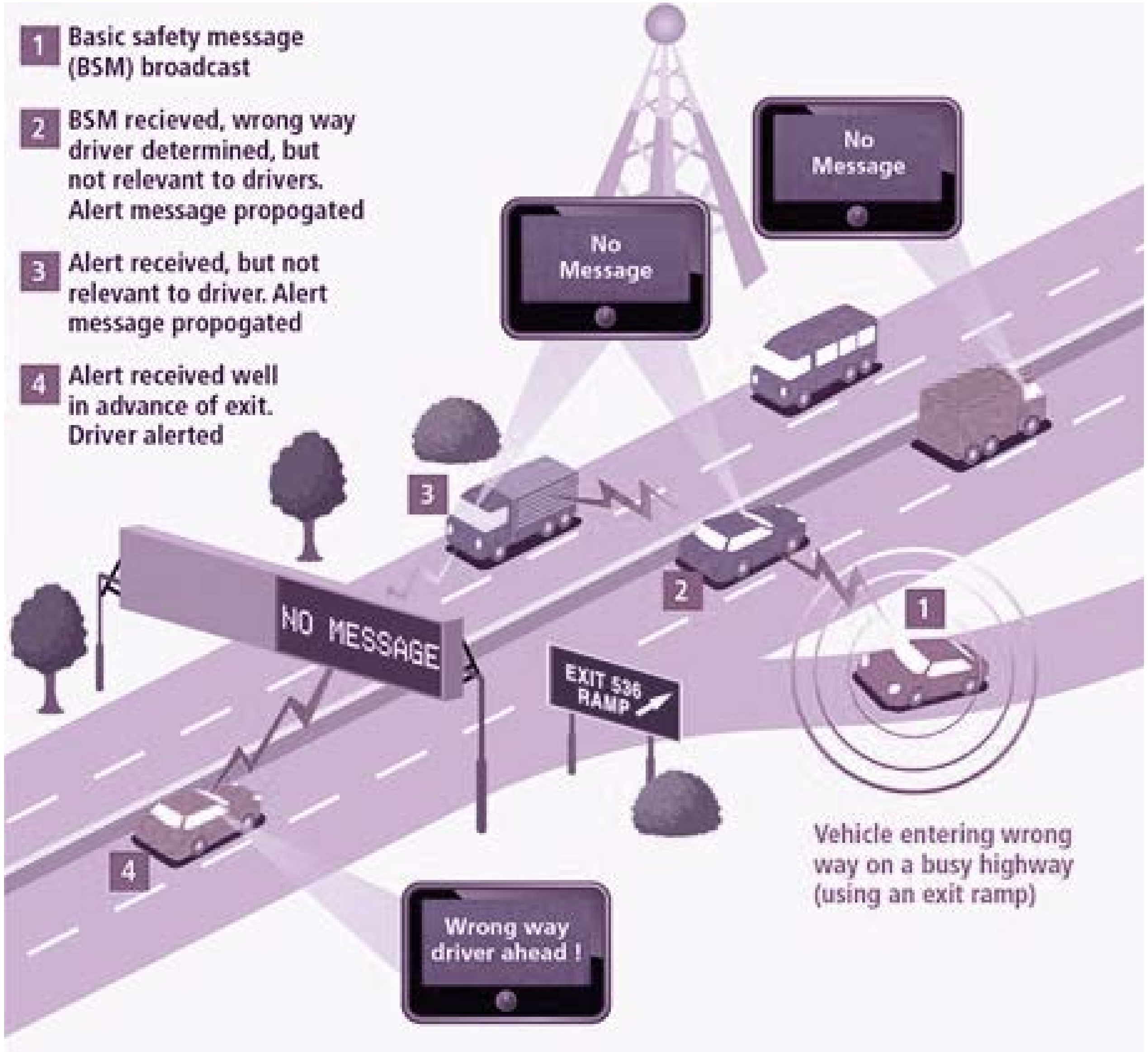
A self-propelled or autonomous car is much more complex than an autonomous lawn mower or vacuum cleaner. The main difference is in the connection of the vehicle in its surrounding area.

ITS - INTELLIGENT TRANSPORT SYSTEM

Intelligent transportation systems (ITS) are advanced applications which provide more coordinated, and 'smarter' use of transport networks. With innovative services relating to different modes of transport and traffic management they enable various users to be better informed and travel safer. They are considered a part of the Internet of things.

Several intelligent transport systems (ITS) are existing. Basic management systems are for instance car navigation, traffic signal control systems, variable message signs, weather information and speed cameras. ITS are dependent on persistent, stable and reliable communication service.

ITS play a crucial role for the implementation of the self-driving cars allowing them to directly commu-nicate with each other and the infrastructure. The communication occurs either **vehicle-to-infrastructure** or **vehicle-to-vehicle**, ensures necessary safety, and awareness of the environment. These systems have a variety of advantages. Most importantly are benefits for road safety and an increased efficiency of road transport.



VEHICLE-TO-INFRASTRUCTURE COMMUNICATION (V2I)
Vehicle-to-infrastructure (V2I) systems are networks in which vehicles and roadside units are in direct communication, providing each other with information, such as safety warnings and traffic information. They can be effective in avoiding accidents and traffic congestion.

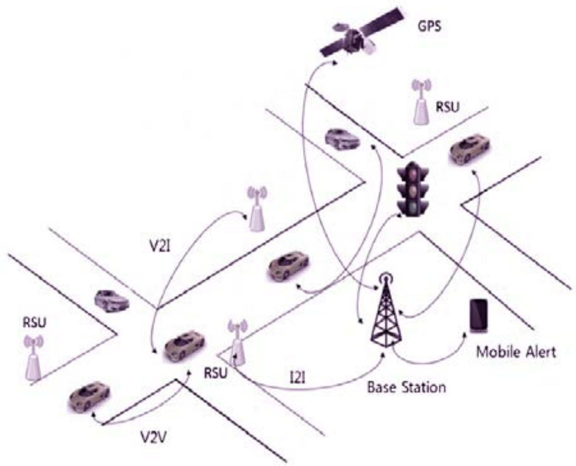
The environment in which the self-propelled vehicle is in motion should deliver fast and reliable Internet, for example, by WiFi beacons along or under the roads and / or by a network 5G. The vehicle navigates through the combination of digital maps and their own observations (see previous section). The digital maps are updated to changed circumstances, such as a slippery road, an accident or work continuously known on board.

VEHICLE-TO-VEHICLE COMMUNICATION (V2C)
Vehicle-to-vehicle (V2V) is a technology designed to allow cars to "talk" to each other. The vehicle must be able to anticipate behavior of other road users. In this situation, the vehicles are connect over the internet and can exchange the data.

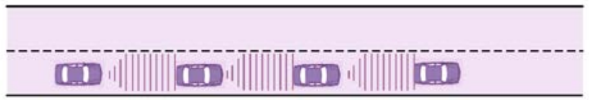
Cooperative Adaptive Cruise Control (CACC)
CACC is an improvement to adaptive cruise control and part of advanced driver assistance systems. An automated adaptive cruise control uses radar to measure the environment and to support the driver by automatically adjusting the speed without a manual interference. The next level of this system is a cooperation between more vehicles in the infrastructure flow.

The system is able to give a boost to vehicle-to-vehicle communication by being fully aware of the surroundings with the input of extra information from other vehicles. Other advantages may include less congestion, less noise, more comfort and convenience and positive effects on traffic capacity. Still issues of usability, legality, policy, and financial risks must be accounted for.

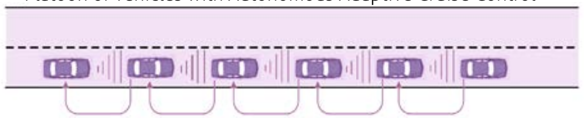
> The figure shows the net benefits for a C-ITS option wherein a vehicle to environment system is applied across all vehicle types and all roads. This option reaches the highest possible economic outcome. A positive impact will start roughly around 2022. [22]



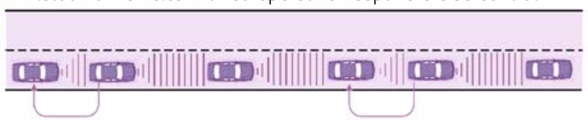
> Cooperative vehicular communication [17]



> Platoon of vehicles with Autonomous Adaptive Cruise Control



> Platoon of vehicles with Co-operative Adaptive Cruise Control



> Platoon of vehicles with & without Co-operative Adaptive Cruise Control [40]

AV TECHNOLOGY

A self-driving car is capable of sensing its environment and navigating through it without human input. Each vehicle is equipped with a GPS unit, an inertial navigation system, and a range of sensors for obstacle avoidance.

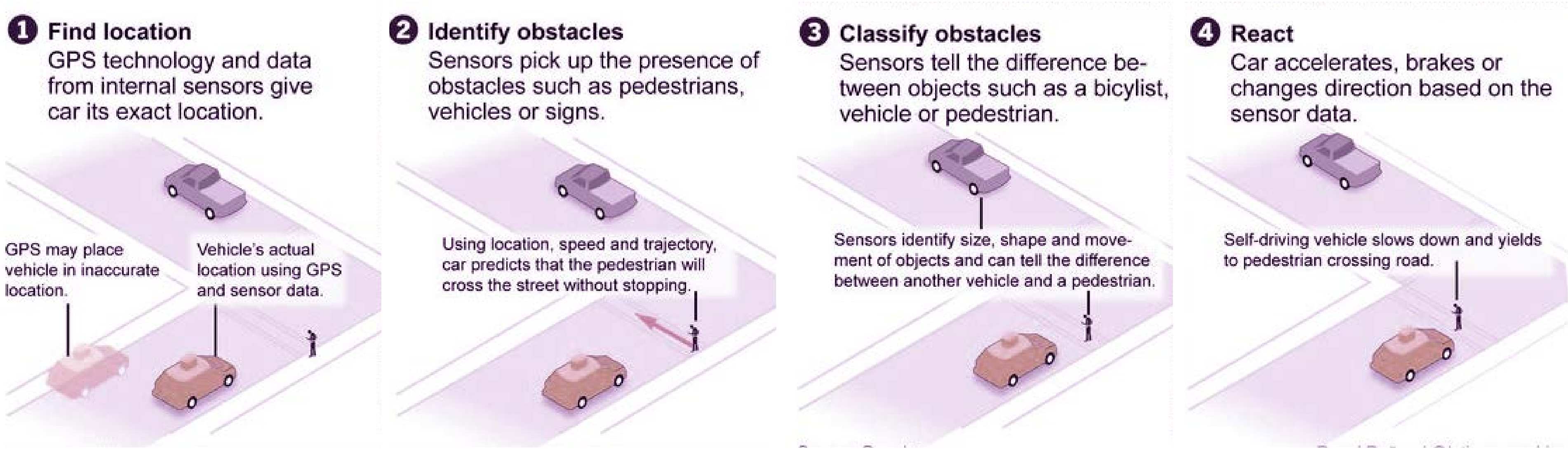
Essential technologies:

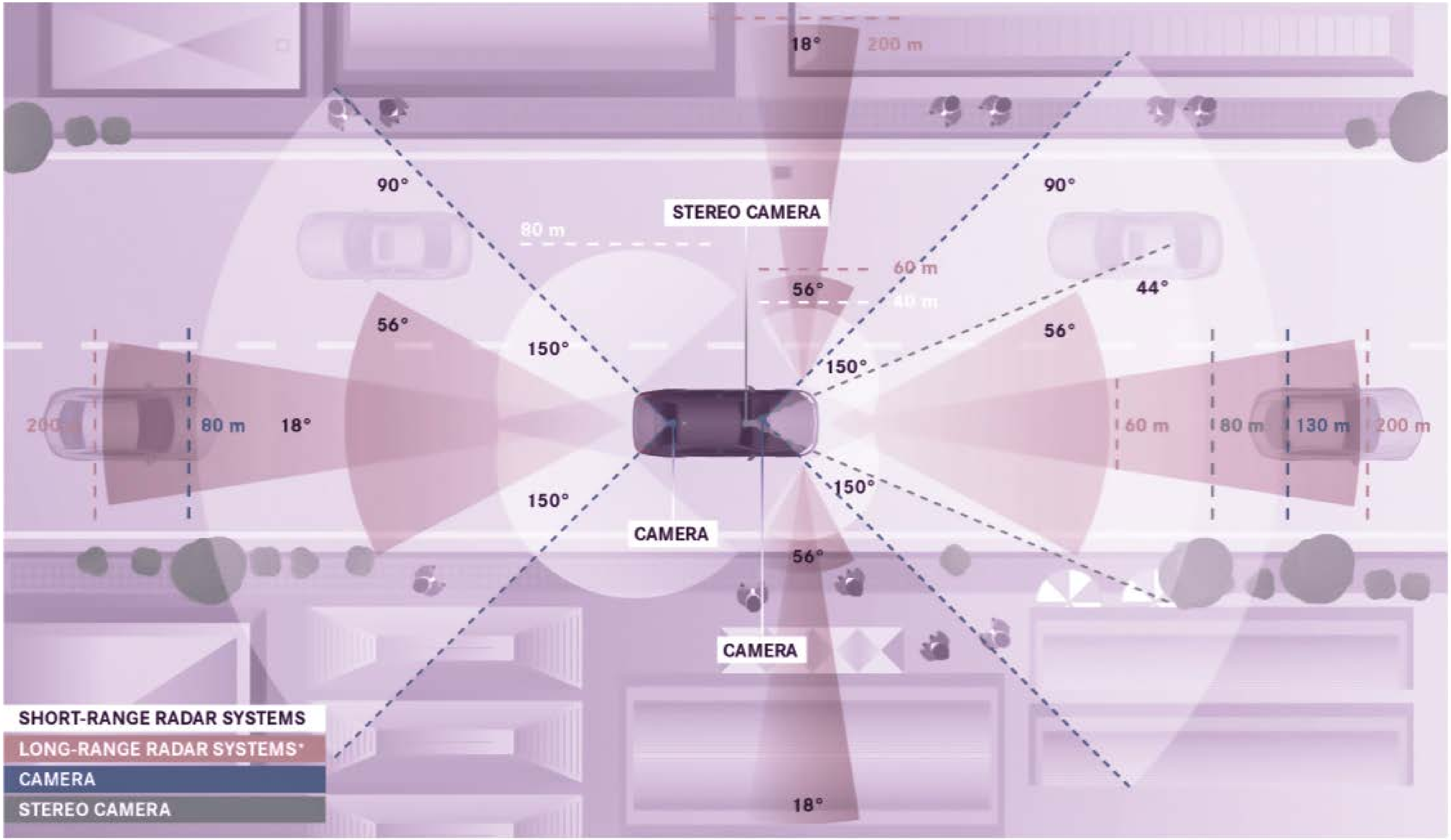
- » GPS (navigation and localization)
- » Lidar
- » Radar
- » Camera
- » Ultrasound

The vehicle uses positional information from the GPS and inertial navigation system to localize itself and sensor data to refine its position estimate as well as to build a three-dimensional image of its environment.

Data from each sensor is filtered to remove noise and often fused with other data sources to augment the original image. How the vehicle subsequently uses this data to make navigation decisions is determined by its control system.

This process of localization, mapping, obstacle avoidance and path planning is repeated multiple times each second on powerful on-board processors until the vehicle reaches its destination.





18°
200 m
90°
90°
STEREO CAMERA
80 m
60 m
56°
40 m
44°
56°
56°
150°
150°
200 m
80 m
18°
60 m
80 m
130 m
200 m
150°
150°
CAMERA
56°
CAMERA
18°
SHORT-RANGE RADAR SYSTEMS
LONG-RANGE RADAR SYSTEMS*
CAMERA
STEREO CAMERA

INDIVIDUAL

SOCIETY

LIFE

ENERGY

ECOSYSTEM & SPECIES

"Automated vehicles have the potential to strengthen ecosystem services due to the possibility of a lower land take compared to conventional vehicles. Life on earth and biodiversity might be able to flourish and to enhance provided services."

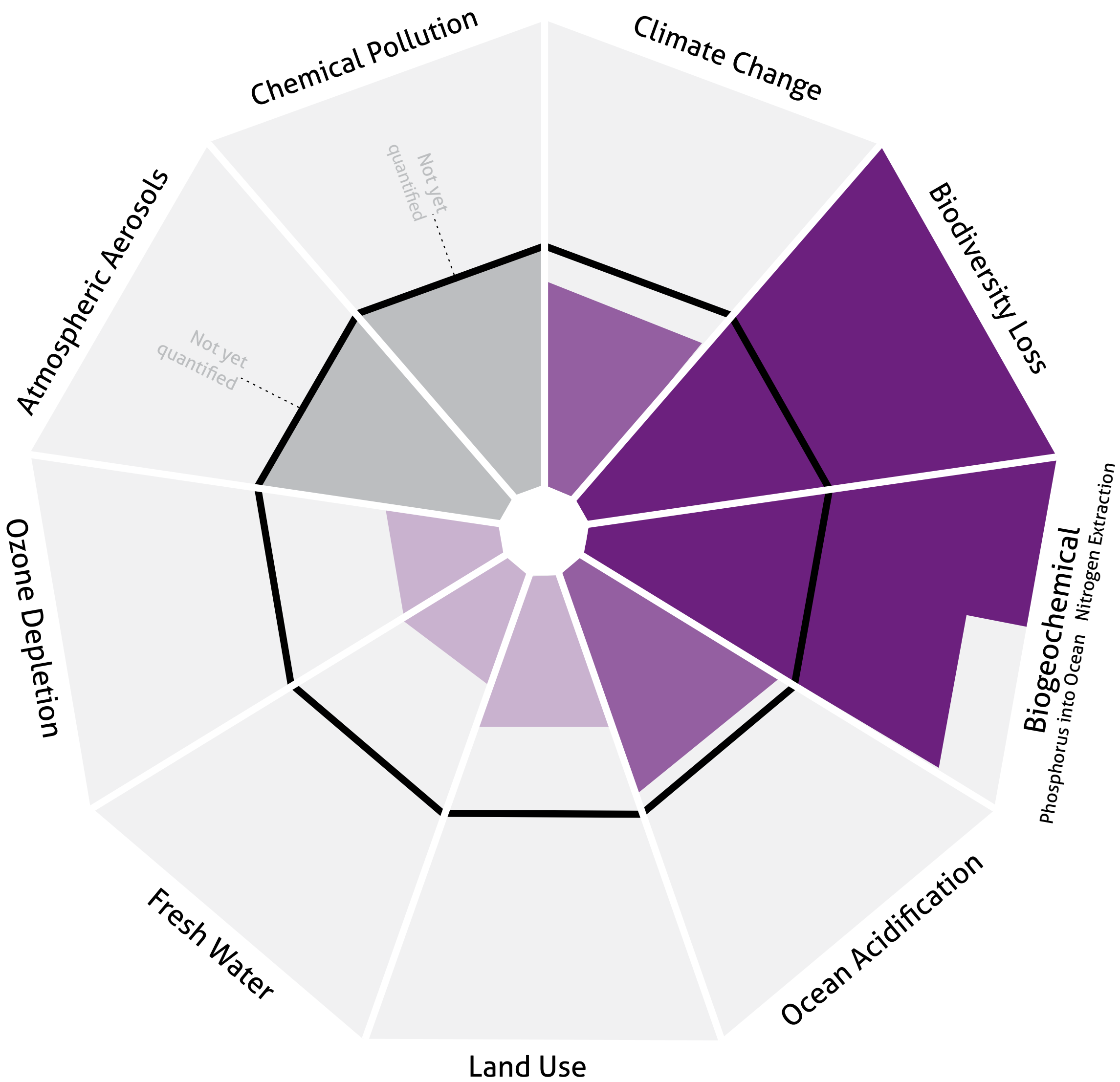
CLIMATE CHANGE

PLANETARY BOUNDARIES [37]

The Intergovernmental Panel on Climate Change projections show an almost guaranteed increase in environmental impacts due to a rise in greenhouse gas emissions and other anthropogenic causes.

The concept of planetary boundaries shows a transgression in at least two categories. The genetic biodiversity and biochemical flows have been greatly exceeded. Other categories are within the boundaries but are close to exceeding their limits and this has the potential to severely disturb the earth's systems and thus creates a substantial risk for humanity.

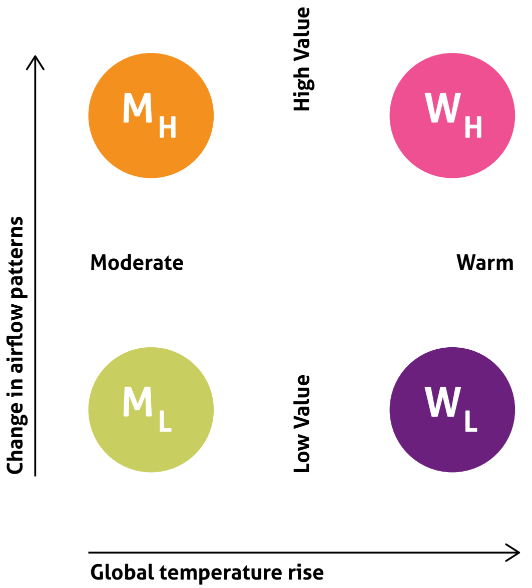
The prevalent anthropogenic environmental degradation consists of depletion of resources, acidification, eutrophication, desertification, and the most protruding of all: climate change and global warming with its included consequences.



- High Risk
- Increasing Risk
- Safe
- Boundary not yet quantified

KNMI '14 CLIMATE SCENARIO'S [27]

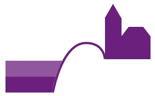
KNMI presents four scenarios for future climate change in the Netherlands. The KNMI'14 scenarios are four combinations of two divergent values for global warming, "Moderate" and "Warm" and two possible changes of the air flow pattern, "Low value" and "High value".
Each scenario presents a coherent picture of changes in twelve climate variables, including temperature, precipitation, sea and wind. The changes apply to the climate around 2050 and 2085 compared to the climate in the reference period from 1981 to 2010, published in the Climate Atlas of the KNMI. Together they describe the vertices in which climate change in the Netherlands itself, according to the latest findings, will likely occur.



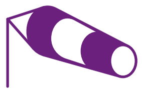
General changes

- The temperature continues to rise
- Mild winters and hot summers are more common

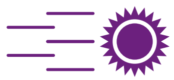
- In winter precipitation and extreme rainfall increases
- Intensity of extreme rainfall in the summer increases
- Hail and thunderstorms intensity increases



- Sea level continues to rise
- The rate of sea level rise increases



- The changes in wind speed are small



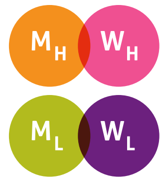
- The number of days with fog decrease and visibility will further improve
- The amount of solar radiation close to the earth's surface increases slightly

Scenario differences and natural variations

- Temperature changes are different for the four scenarios
- Changes in 2050 and 2085 are greater than the natural variations on the 30-year time scale

- More dry summers in two (MH and WH) out of the four scenarios
- Natural variations in precipitation are relatively large, so that the scenario's differ less from each other

- The rate of sea level rise depends strongly on global warming



- During winter more West winds in two (MH and WH) of the four scenarios
- The wind and storm climate shows great natural variations

- Natural variations are different for the different climate variables

EXCEPT
INTEGRATED SUSTAINABILITY

CLIMATE MANAGEMENT

CLIMATE ADAPTATION STRATEGIES

The climate is changing. Climate scenarios predict more extreme weather events, such as drought, heavy rainstorms, and heat waves. The Netherlands take measures like state-of-the-art dikes and sand motors which enforce the coastline against erosion. The goal of these measures is to make the country a robust system and to ensure a safe and dry environment.

Policies are in place on all political levels, from international to regional, to make transport cleaner and to increase fuel-efficiency. Rush-hour lanes, extra bus lanes or other additional roads, an abolishment of road taxes and adjustable speed limits are only a few examples of how to cope with an increasing demand for transport.

Rotterdam, for instance, offers trade-in prices for old vehicles to replace them with more environmentally friendly types. Other policies stimulate the use of bicycles and the extensive use of public transport to cope with potential gridlock during rush hour.

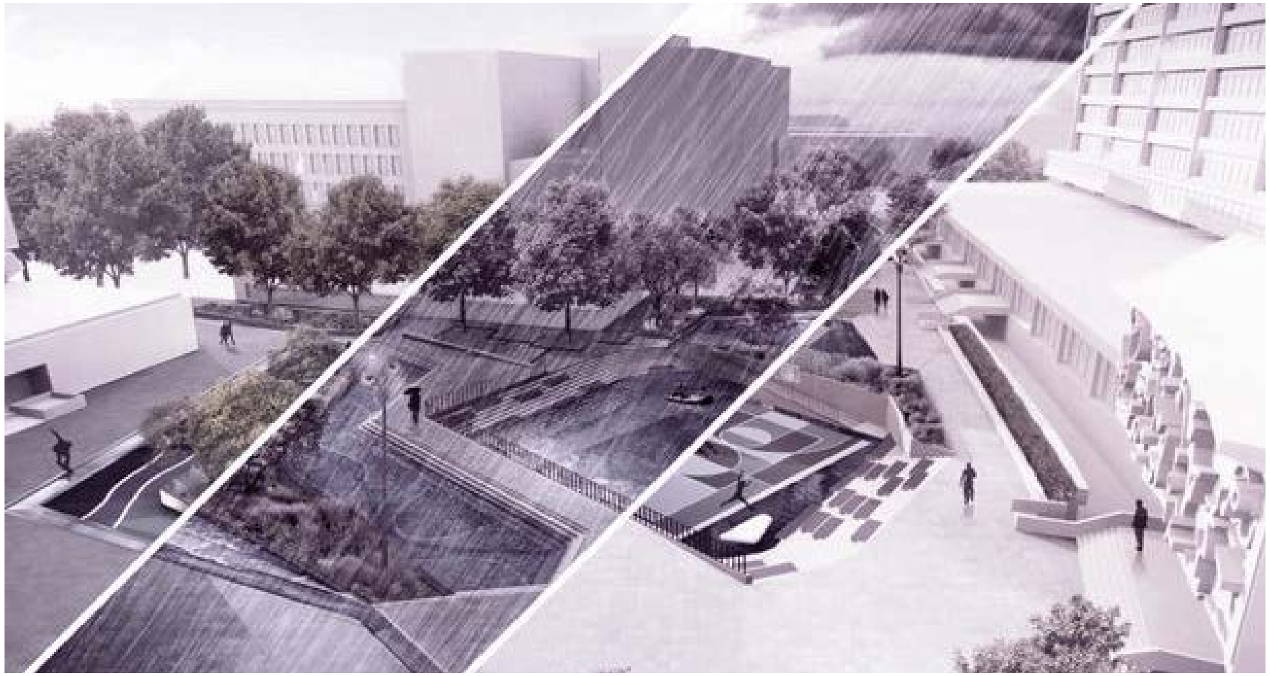
The Dutch government is not the only driving force. Other participating forces are businesses or increasingly public organizations (for instance the Smart City initiative in Amsterdam), which enforce a cumulative initiation of positive developments. Examples are a variety of products like applications which provide travel information, or electric vehicle, and bicycle sharing companies and initiatives.

URBAN ADAPTATION STRATEGIES

A successful adaptation strategy makes the urban environment resilient. Measures can be both small and large scale.

Some examples of such measures are:

» green roofs,
» storm water barriers and dikes,
» state of the art sewage systems, etc.



DIRECT DEPENDENCY OF HUMANITY

Humanity is dependent on and benefits directly from a variety of ecosystem-services. The understanding of well-being is directly linked to functioning ecosystem surroundings. The intensive human impacts worldwide demand better recognition of how ecosystems are affected and to what extent its services are restricted.

BIODIVERISTY IN CITIES

ECOSYSTEM SERVICES

Dutch society uses a variety of ecosystem services. The problem is that the current state of the ecosystem is not able to keep up with demand. It is doubtful that this will change in the future due to the small size of the country and the population density. There has been a negative for the last 25 years because nature simply cannot keep up with this demand.

Things might change if society were to become aware of the diversity of services offered. Unfortunately, in the current climate they go mostly unnoticed. Some very relevant examples of how the Netherlands is dependent on ecosystem services are: Flood protection by dunes, filtration of water and pollination of crops.

Automated vehicles have the potential to strengthen ecosystem services due to the possibility of a lower land-use compared to conventional vehicles.

Highways may gain a higher carrying capacity and a space devoted to parking in urban areas might diminish. As a consequence, life on earth and biodiversity might be able to flourish and to enhance provided services.

LAND USE IN THE NETHERLANDS

Land use for transport infrastructure is enormous in the Netherlands. This includes traffic lanes with bus lanes and verges, but excludes roundabouts, major traffic intersections, acceleration/deceleration and turning lanes, and bus-stops.

URBAN LAND TAKE DOMINATED BY PARKING

The land take for parking spaces should not be underestimated. A large and expensive space is needed which could be used for other purposes.

In suburban areas the land take amounts to 5-10%. In commercial and industrial areas, as well as in the city centers, the demand for streets is about 10-30%, for parking lots and access streets it is 30-50%. Usually a parking lot demands on average 13-20m2.

Land take of Dutch road infrastructure in km2	**Urban**	**Rural**
Metalled roads	356.7	682.9
Unmetalled roads	3.3	65.1
Parking space	119.9	n.a.
TOTAL	**479.1**	**763.8**

AUTOMATED VEHICLES TO SUPPORT BIODIVERSITY

Biodiversity in cities is of great importance. It describes the variety of living beings within the considered system boundaries.

The provided services are:

- air filtration of air pollutants which improves health,
- natural climate control due to cooling and shading of trees and other vegetation,
- enjoyable pathways for citizens,
- community cohesion through neighborhood greening; Carbon storage to mitigate climate change,
- urban farming for local food provision.

Automated vehicles support these advantages. It is very likely that land take will decrease, which is directly beneficial for most biodiversity categories. Improved propulsion technology in the form of electric- or hybrid engines have also the capability of improving the air quality significantly.

INDIVIDUAL

SOCIETY

LIFE

ENERGY

CULTURE & ECONOMY

"If we do nothing, the sheer number of people and cars in urban areas will mean global gridlock. Now is the time for all of us to be looking at vehicles the same way we look at smartphones, laptops and tablets: as pieces of a much bigger, richer network."

Bill Ford,
executive chairman, Ford Motor Company

TRANSPORT FLOWS

TRANSPORTATION DEMAND

A Dutch citizen travels on average approximately 11,000km per year. In total this results in 184 billion km for the whole Netherlands. Almost 75% of the distance traveled is by personal car drivers and their passengers, 8% for both train and bicycle.

Of special note is thereby the correlation between kilometers traveled and the actual trip numbers. Although, distances covered by foot and bicycle are low, they account for almost 50% of trip numbers.

Almost one third of trips are made with a personal vehicle. The use of a vehicle is therefore the most important factor. About 15 percent of all trips happen as a co-driver, which decreased compared to 2004. Bicycles are usually used for trips within short reach. Only two percent of the total trips are travels by public transport.

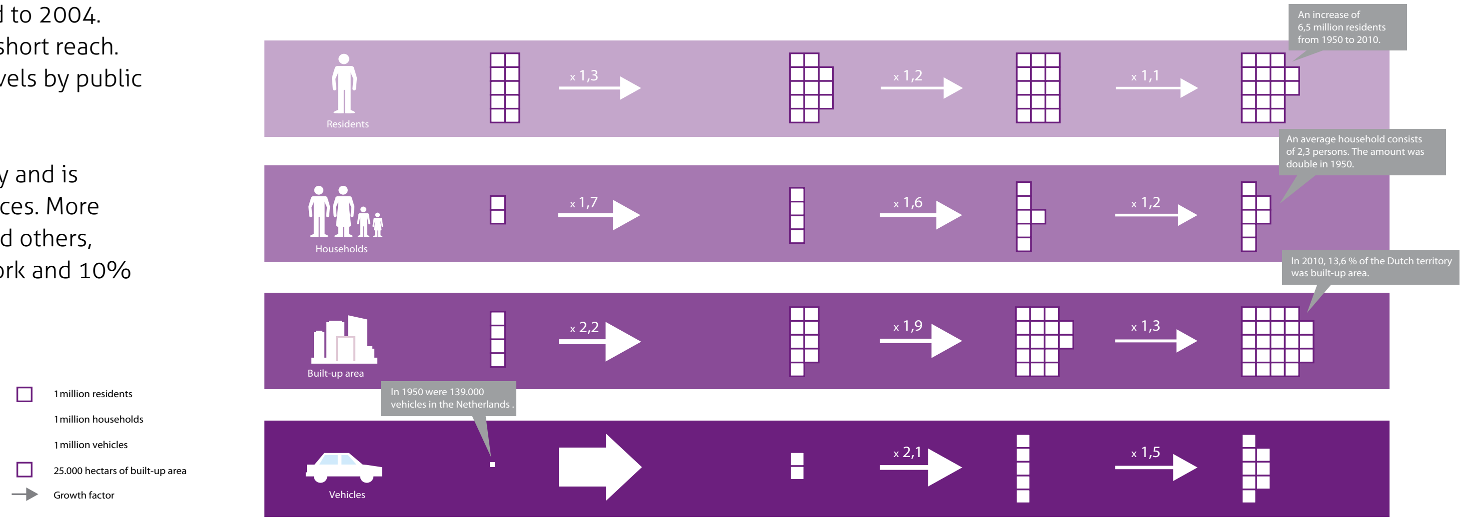
This amount has since increased gradually and is mainly used to cover medium long distances. More than half of the trips are for recreation and others, 20% for shopping, 18% for the trip to work and 10% for education.

ACCESSIBILITY

The journey to and from public transport is always multi-modal. Several modes of transport are in use. Trains are the main source for public transport with approximately 67%, followed by bus with ~16,4% and tram/metro with ~6,9%. The access to public transport happens in different ways. The used access and egress modes are walking, cycling, car use and bus/tram/metro. Walking and cycling are at the top.

A crucial innovation is that automated vehicles might be able to solve connection problems to public transport in medium density urban areas. This can lead to a quantity enhancement of public transport users.

> The Netherlands between 1950's and 2010.
The number of cars has risen from 139,000 in 1950 to about 8 million now more than 50 times.
Over 70 percent of households have at least one car and nearly a quarter over two or more cars.



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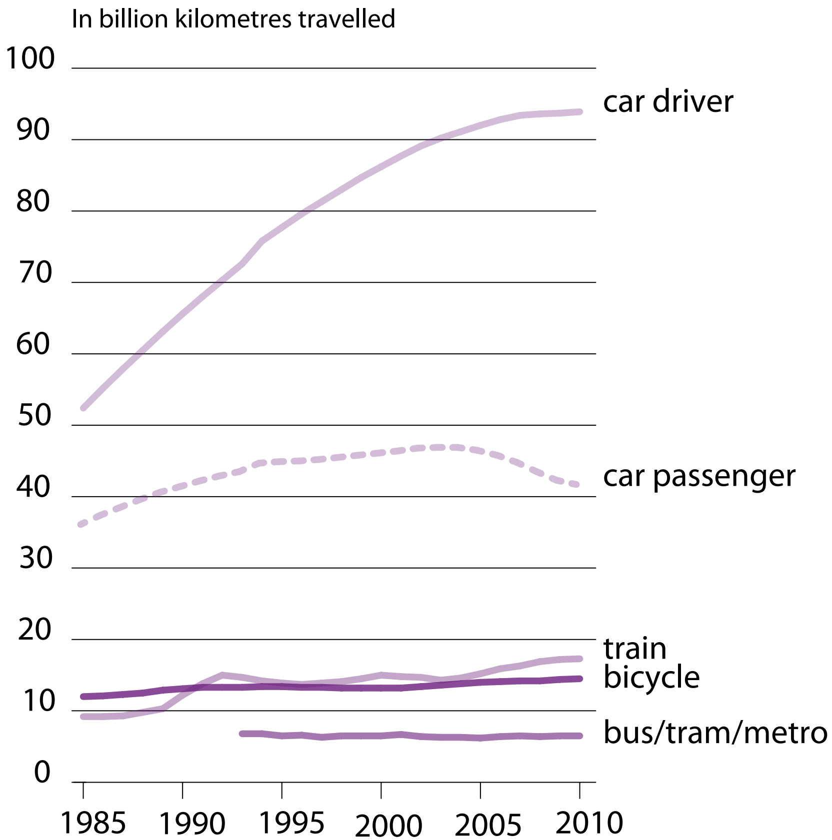
EXCEPT
INTEGRATED SUSTAINABILITY

The Dutch travel mostly by car ...

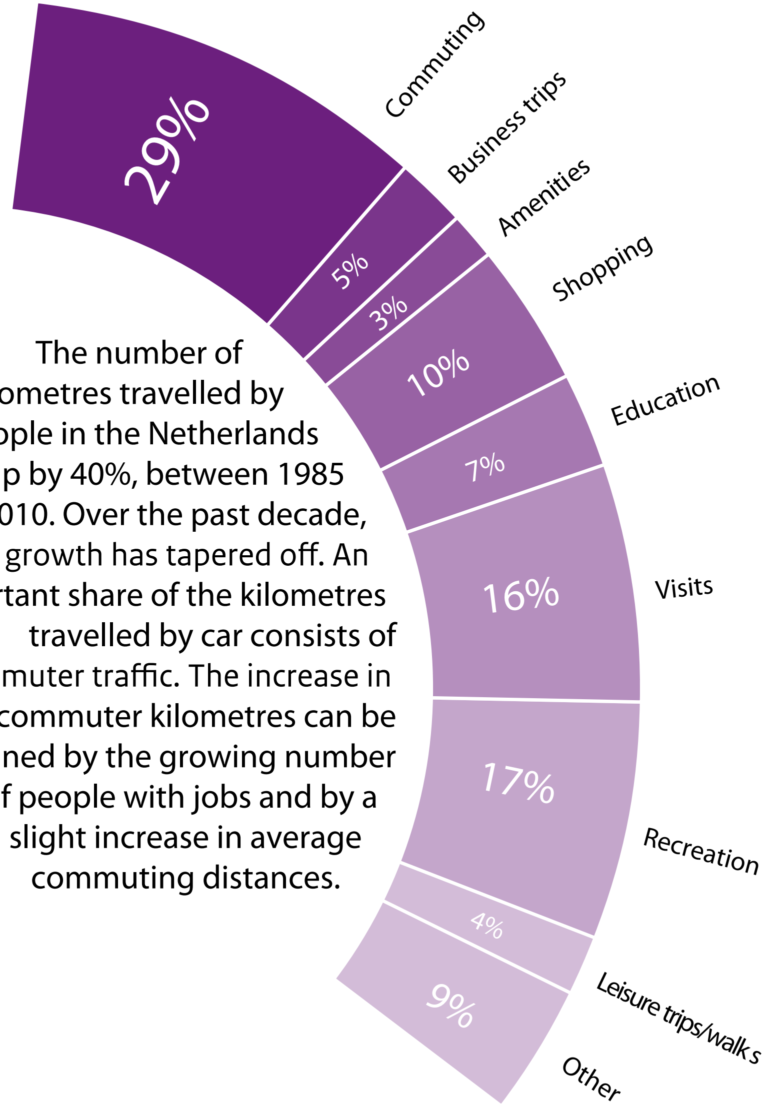
Kilometres travelled in 2010

... but the strong growth in car transportation seems to have **tapered off**



183,000,000,000 km

Where do Dutch people travel to?



The number of kilometres travelled by people in the Netherlands shot up by 40%, between 1985 and 2010. Over the past decade, this growth has tapered off. An important share of the kilometres travelled by car consists of commuter traffic. The increase in commuter kilometres can be explained by the growing number of people with jobs and by a slight increase in average commuting distances.

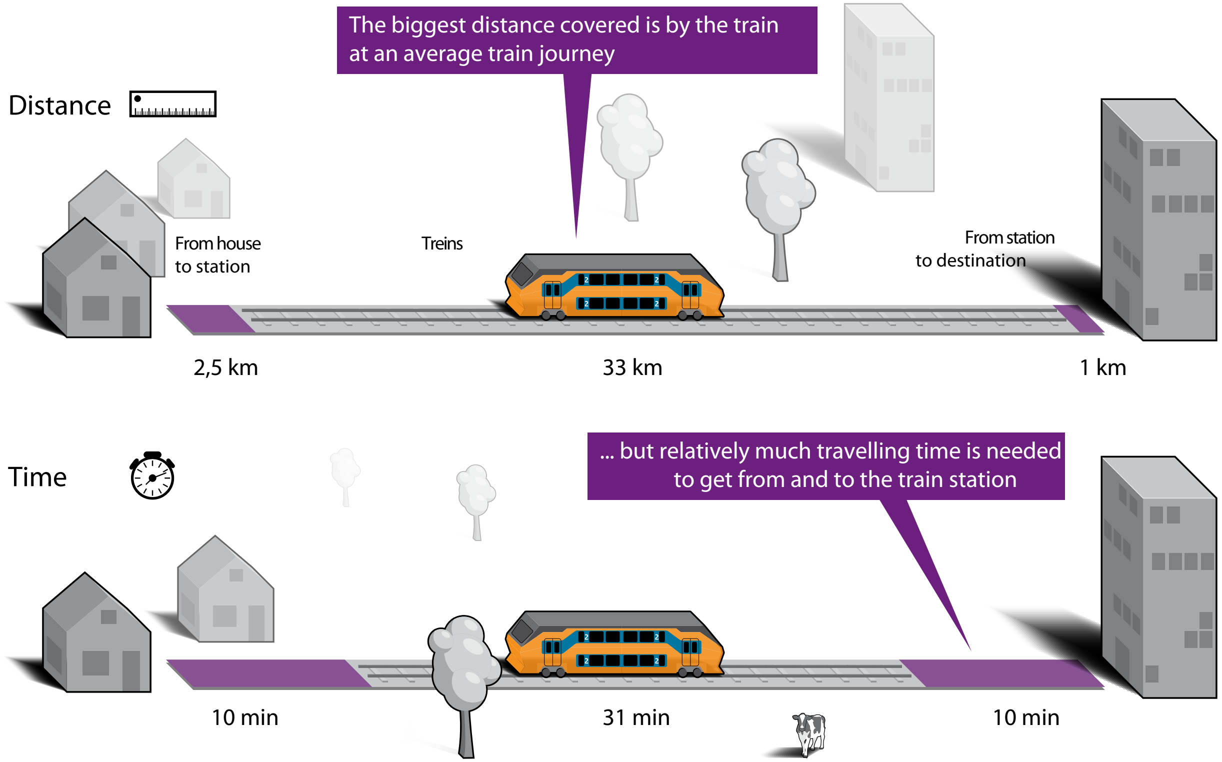
LAST MILE

CHALLENGES FOR TRANSPORTATION PLANNING AND SUPPLY CHAIN MANAGEMENT

The last mile phenomenon is a common problem in supply chain management. The most efficient and cost effective ways to deliver goods are per freight rail networks, or container ships. However, the connection from container hub to destination is by far less efficient and deteriorates the efficiency of the whole delivery.

The same problem can be observed in personal transport. Both the last mile and the first mile, which describes the access to a transportation hub, are large challenges. The most common hubs are railway stations. If the target is not accessible by foot other transportation forms need to be used. One option are own or shared bicycles, or car sharing. The most promising solutions to interconnect different transport options are automated driving solutions. This can be both personal or shared options.

Usually, journeys with large distances can be covered relatively quick, but the last mile claims a proportionally large share of the total time spent. The most common options to travel the remaining distance are by foot or bicycles. These need to be connected better to ensure quicker interactions of transport system and an overall quicker traveling time.



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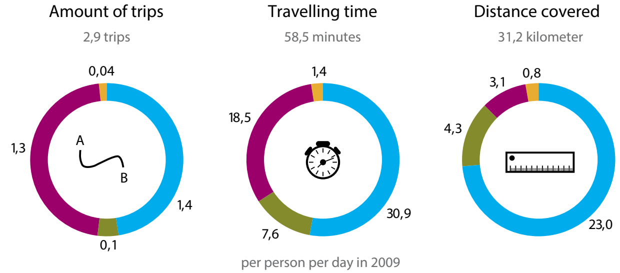
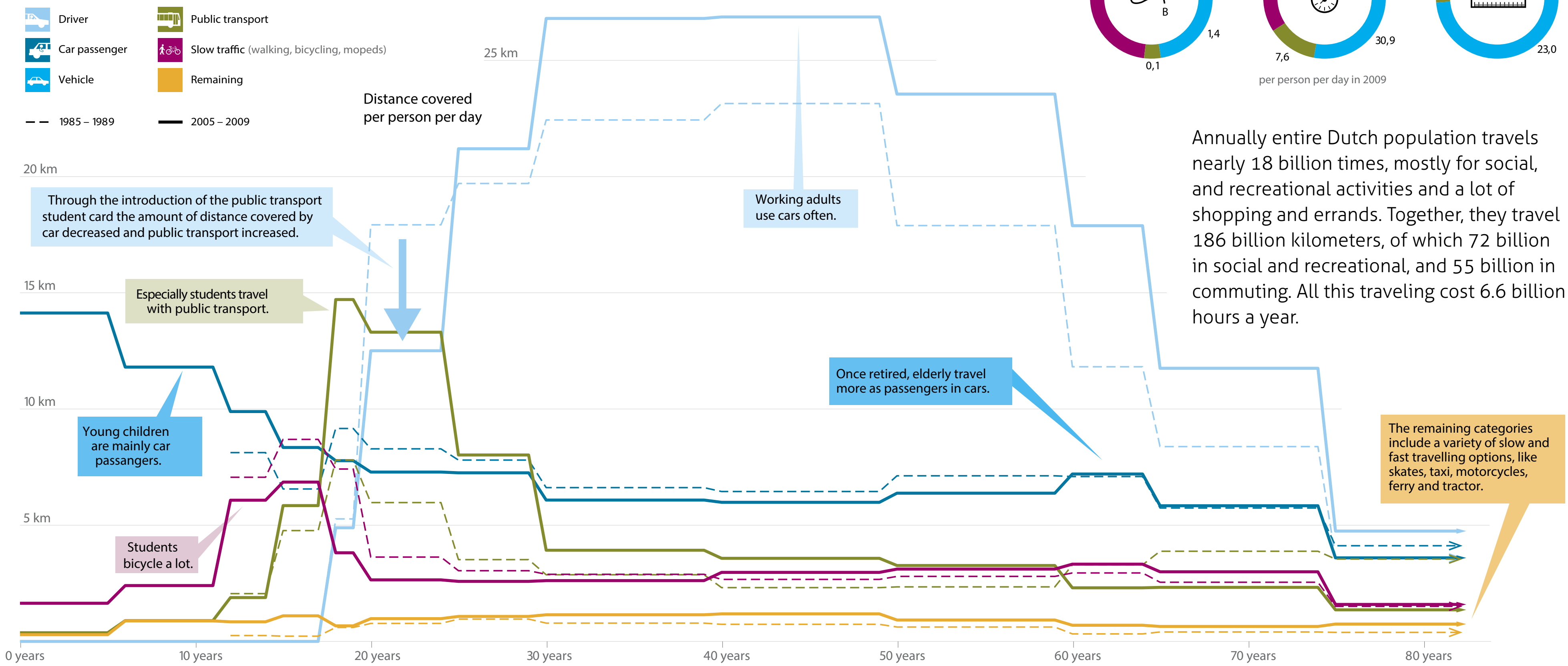
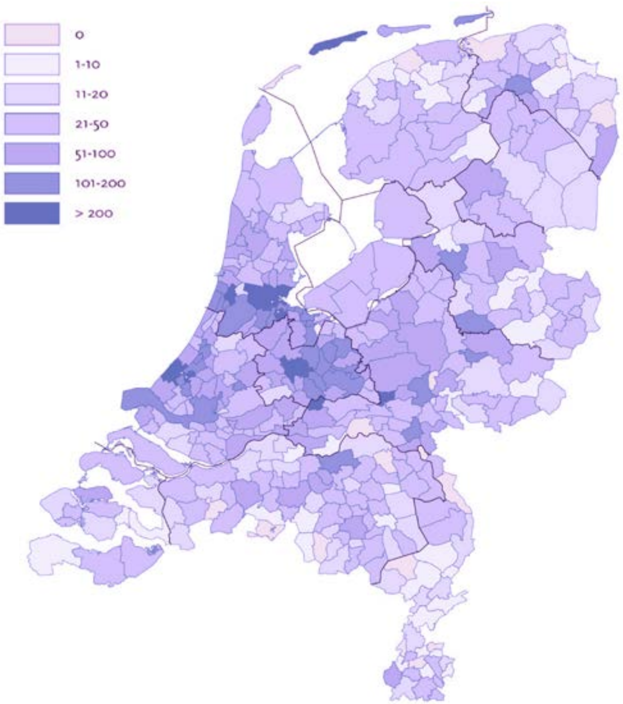




Annually entire Dutch population travels nearly 18 billion times, mostly for social, and recreational activities and a lot of shopping and errands. Together, they travel 186 billion kilometers, of which 72 billion in social and recreational, and 55 billion in commuting. All this traveling cost 6.6 billion hours a year.

CAR SHARING



> Distribution of shared vehicles per district in the Netherlands

OVERVIEW IN THE NETHERLANDS

There are currently approximately 90,000 car sharers and 14,000 shared cars in the Netherlands. This represents roughly 1% of the Dutch population. They account for a total share of 0.02% in trip numbers. The demographic classification is usually represented by young citizens, single people or families with small children. These users are predominantly highly educated, live in concentrated urban areas, and do not have their own car.

The use of the shared vehicle has several positive effects: 30% less in total car possession compared to prior to the existence of car sharing; less kilometers traveled; lower emissions levels; less parking area needed (roughly 120,000m² space can be saved).

Car sharing providers in the Netherlands are:

» Connektcar,
» Greenwheels,
» MyWheels,
» Car2Go,
» SnappCar,
» WeGo,
» Alphabet,
» MobilityMixx,
» Call-a-car.

Some of them offer a variety of car-sharing options.
(Graph to the right)

CAR SHARING OPTIONS

At the moment there are various types available in the Netherlands:

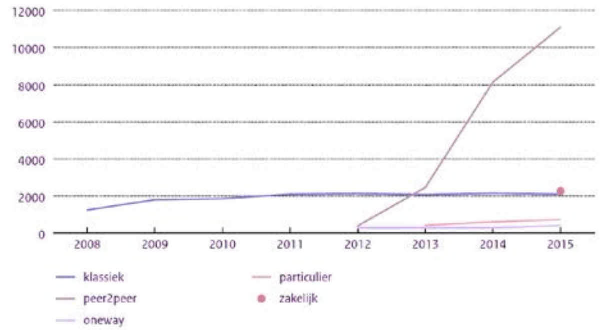
» Classical sharing is offered by a company which owns the cars and holds also the responsibility (greenwheels).

» One way option has also a own fleet, but without the fixed parking spots. So, the car can be used for single journeys, too.

» Peer2peer is rising significantly in the last years. Here private car owners rent their vehicles for use.

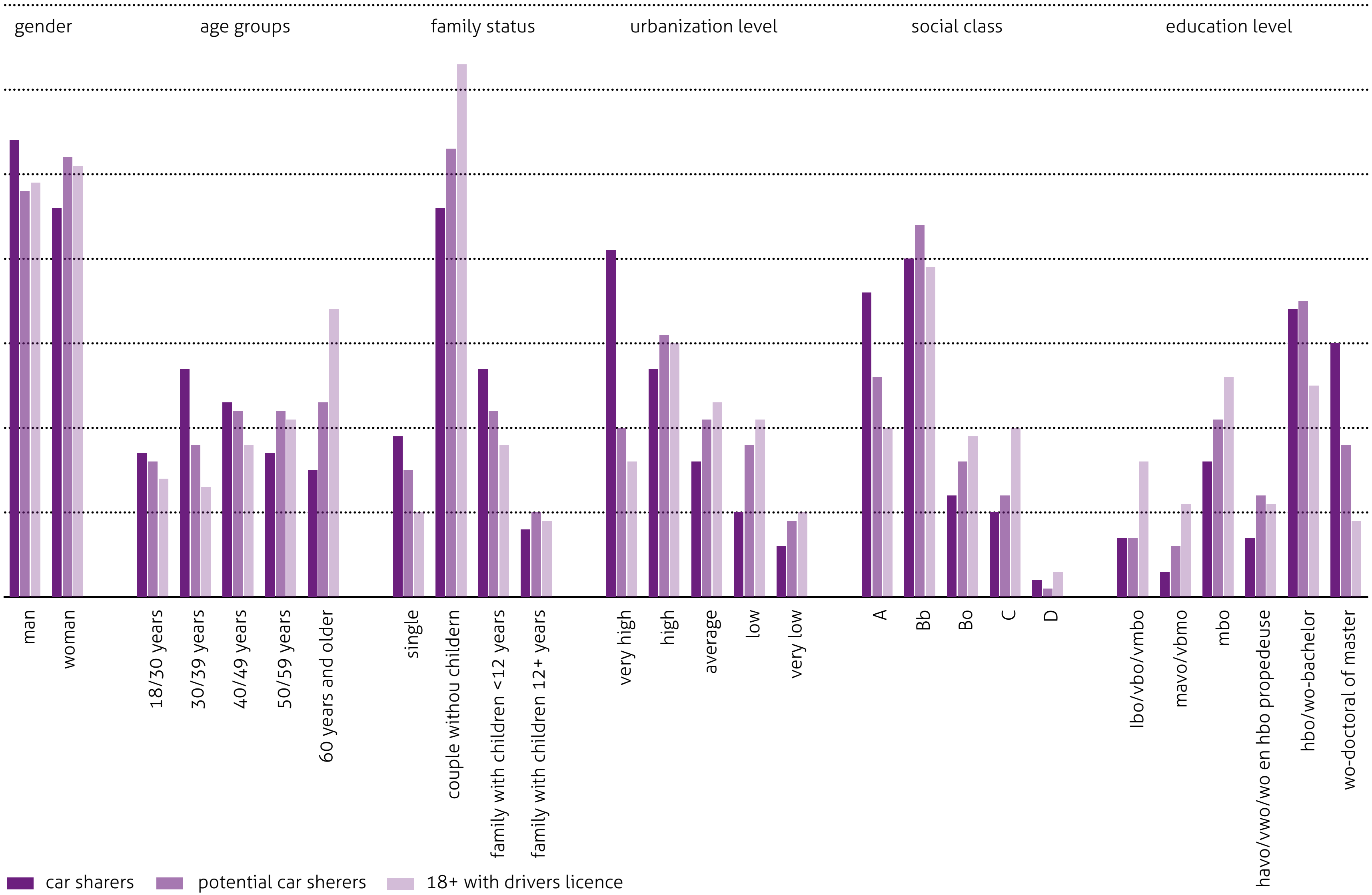
» Private sharing is the oldest form. The car is used within a small circle of family, friends, etc. and no profit needs to be made.

» Business car sharing is also an option.



> Types and amounts of shared vehicles

> Car shearers and potential car shearers divided by the background



Success factors	
Support from politicians and government officials	• support from politicians and government officials (urgency) • providing and administering parking permits • providing charging infrastructure for electric vehicles • ensuring linkage with public transport • providing public information on carsharing and marketing activities • high parking charges
Scale and diversity of vehicle offer	• number and variety of vehicles on offer • urban design (high building densities), although the Swiss case shows that carsharing can also be profitable in rural areas (to supplement or replace public transport).
Convenience and flexibility	• easier access to the carsharing service • easy processing of user and parking charges • availability of a free-floating system
Linkage with public transport	• presence of high quality public transport systems to complement carsharing services
Marketing and promotion	• promotion as a social enterprise (cooperative) • targeting specific user groups • visibility in the street

Environmental impact	kg CO_2
Change in car kilometres travelled	-250
Change in transport mode	+160
Change in car ownership	-85 to -175
Total	-175 to -265

SUCCESS AND IMPACT OF CAR SHARING

Car sharing has impacts on car ownership, car use, the environment, use of public space and economic welfare. In 2015, Dutch car sharers owned at least 30% fewer cars than before car sharing. They travel by car about 20% less kilometres which resulted an 8–13% reduction in CO2 emissions per person per year. Shared cars also occupy less space because they need fewer parking places, saving about 120,000 m2.

An important success factor for car sharing is the support from the local authority with policies that providing parking permits for shared cars and indirectly discourage car ownership and the use of private cars. A large and diverse vehicle offer is also important. Relatively large number of shared cars in Amsterdam, for example, not only improves the accessibility of car sharing services but also links it to public transport. For example, in Switzerland there are special carsharing bays at railways stations and public transport stops. A final success factor are the promotion schemes of the car sharing, for example thru target group marketing.

DEMOGRAPHIC SHIFT

GENERATION Y

'Generation Y' plays a major role in accelerating the emergence of a new, digital world. Generation Y's expectations are being formed by the technologies they surround themselves with. They are networked, collaborative and highly social.

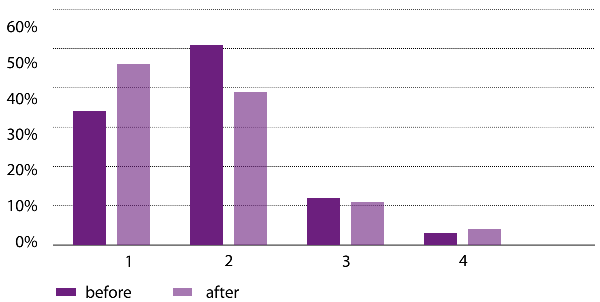
The same generation is inventing the disruptive business models that challenge the status quo of existing organizations with invention as Facebook, Uber, Airbnb, Blabla car. They are determining the way digital communication technologies are being used, and are initiating social behaviors that are transmitted to other generations.

By the year 2020, an entire generation will have grown up in a primarily digital world. Computers, the Internet, mobile phones, texting, social networking — all are second nature to them. Their familiarity and reliance on technology will transform how we work, travel and how we consume.

CAR OWNERSHIP DECREASES

In the Netherlands, car ownership among young adults is slowly decreasing in recent decades. Urbanization level and household composition are essential factors influencing car ownership. The influence of urbanization level on car ownership is much stronger for young couples than for young families or singles.

Various research results imply that increasing urbanization and postponement of parenthood could reduce future car ownership among young adults in general. However, the increasing number of young families moving to more urbanized areas could increase future car ownership in cities. While trends as sharing economy and flexibilization of work might lead to decrease in car ownership.



> Since respondents started car sharing, their level of car ownership fell from an average of 0.85 cars per household to 0.72 cars per household (Figure to the left). This decline was caused mainly by a reduction in car ownership among the traditional car sharers.

CHALLENGE FOR THE FUTURE

The speed of adoption of a new technology proceeds along an S-curve and is influenced by multiple activities and forces including consumer engagement and its willingness to change. Studies show that only one in every five consumers is interested in a fully autonomous vehicle. Most of the concerns are based on a lack of trust in technology. By introducing self-driving capabilities gradually, the consumer will learn and begin to trust the technology within a specific period of time.

The willingness to embrace autonomous driving also depends on the certain segments of the population, meaning that for every generation and group a specific strategy needs to be emphasized.

Demographic	Population	Percentage of Total
Digital Natives (0–14 years)	49 million	16%
Gen Now (15–34 years)	84 million	28%
Gen X (35–44 years)	43 million	14%
Baby Boomers (45–65 years)	80 million	26%
Older Adults (66+ years)	47 million	16%

> Demographic breakdown [36]

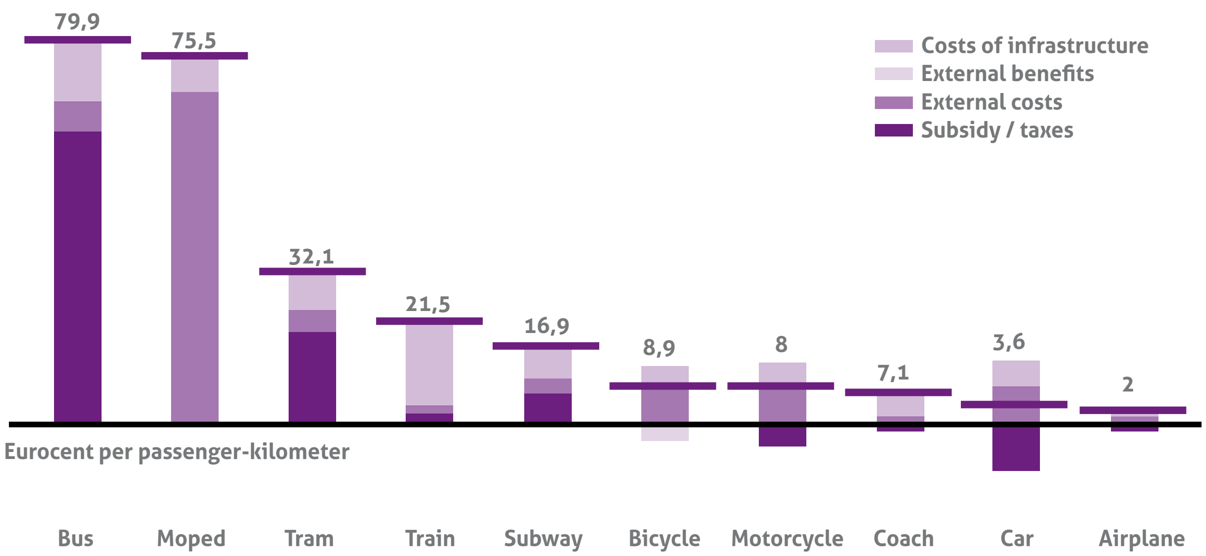
COSTS

TOTAL CONSTRUCTION AND CONGESTION COSTS

The overview shows an allocation of total costs in the Netherlands across vehicle categories (full overview in the table on the page 109).

The total costs for parking accounts for 1,937 million € and 1,326 million € for construction in 2002. These costs are mainly limited to urban areas and do not occur to that extent in rural spaces.

In the image bellow, total cost for transport in the Netherlands in 2010.



TRAFFIC CONGESTION

Traffic congestion imposes the economic costs by wasting people’s time and by slowing the delivery of the goods and services.

Higher levels of road congestion are initially associated with faster economic growth. But, above a certain threshold, congestion starts to become a drag on growth.

People in Europe and the US currently waste on average 111 hours annually in gridlock. This actually does much more than test our patience. It’s a significant drain on our wallets as well as our economies. The environmental damage caused by traffic jams is also increasing by burning fuel at a higher rate than the smooth rate of travel allows on the open highway.

This increase in fuel consumption costs commuters additional money for fuel and it also contributes to the net emissions released by vehicles worldwide. These emissions create air pollution which is one of the causes affecting climate change.

Broad adoption of Intelligent Transportation Systems (ITS), could lead to significant reduction in congestion and an even greater reduction in the costs associated with it. This system might lead to an increase vehicle travel, they could also support higher vehicle rates on existing roads and to be able to travel safely at higher speeds.

Transportation	Infrastructure costs	External costs (within transport sector)	External costs (rest of the society)	External data	User charges	Taxes	Subsidies
Passenger services in Dutch territory in min EU							
Personal car gasoline	4.006 (3.604 - 4.493)	4.585 (2.928 - 6.330)	3.629 (1.339 - 5.974)	23 (12 - 34)	306	7714	-427 1.218
Personal care diesel	1.613 (1.426 - 1.835)	1.994 (1.361 - 2.660)	1.676 (639 - 2.865)	23 (12 - 34)	147	4.281	-865 - 621
Personal car LPG	203 (179 - 231)	233 (157 - 314)	171 (62 - 283)	2 (1- 3)	18	314	-19 - 56
Auto bus	447 (369 - 542)	90 (61 - 121)	135 (41 - 220)	3 (2 - 5)	0	57	2.228 2.289
Tour car	485 (399 - 579)	54 (38 - 70)	88 (30 - 150)	3 (1 -4)	0	55	0
Motorcycle	60 (52 - 70)	124 (90 - 160)	192 (50 - 285)	1 (1 -2)	0	154	0 - 18
Moped	75 (67 - 85)	478 (285 - 685)	211 (70 - 293)	0,3 (0,2 - 0,5)	0	12	0 - 6
Passenger train electric	2.886 (2.534 - 3.173)	25 (18 - 33)	208 (80 - 371)	0	280	10	558 - 863
Passenger train diesel	251 (228 - 281)	4 (3 -5)	26 (11 - 46)	1 (0 - 1)	23	4	27 - 42
Tram	76 (70 - 84)	24 (20 - 29)	17 (5 -28)	0	0	1	176 - 192
Metro	66 (63 - 69)	9 (7 -13)	17 (5 -26)	0	0	1	55 -70
Bicycle	533 (470 - 658)	806 (611 - 1.031)	360 (322 - 393)	535	0	0	0 -84
Transportation	Infrastructure costs	External costs (within transport sector)	External costs (rest of the society)	External data	User charges	Taxes	Subsidies
Passenger services in Dutch territory in min EU							
Vans	1.045 (921 - 1.192)	1.236 (867 - 1.628)	1.307 (492 - 2.239)	20 (10 - 29)	81	1.188	41
Lorry	2.576 (2.134 - 3.021)	1.330 (1.074 - 1.596)	1.905 (677 - 3.322)	73 (37 - 108)	0	1.345	0
Cargo train electric	413 (344 - 420)	1,2 (0,8 - 1,6)	22 (8 - 38)	0	17	2	0
Cargo train diesel	188 (160 - 201)	1,1 (0,8 - 1,4)	46 (19 - 85)	2 (1 -3)	9	8	0
Cargo ships	1.113 (962 - 1.332)	14 (12 - 17)	550 (221 - 1.068)	31 (16 - 46)	20	0	0

EXCEPT
INTEGRATED SUSTAINABILITY

SOCIAL COSTS

The social costs of transport include car accidents, air pollution, health problems caused by inactivity, time taken from family while commuting, and vulnerability to fuel prices.

The sub cost group of traffic accidents can be distinguished through four different categories:

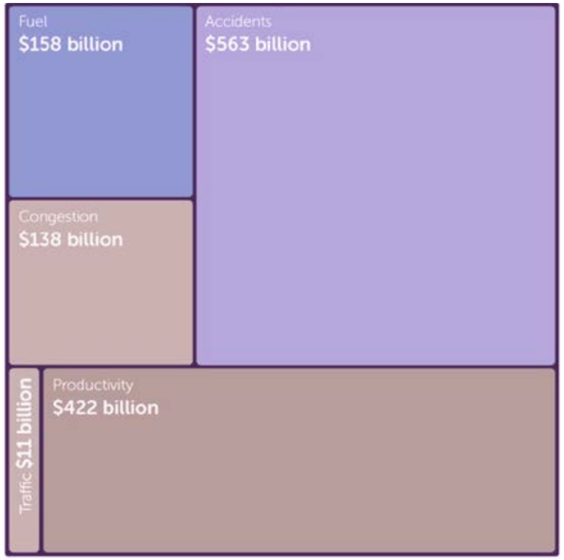
» The cost of production losses if a assigned person is not able to participate in economic production
» The costs of accident risks
» The costs of medical care
» Transaction and prevention costs

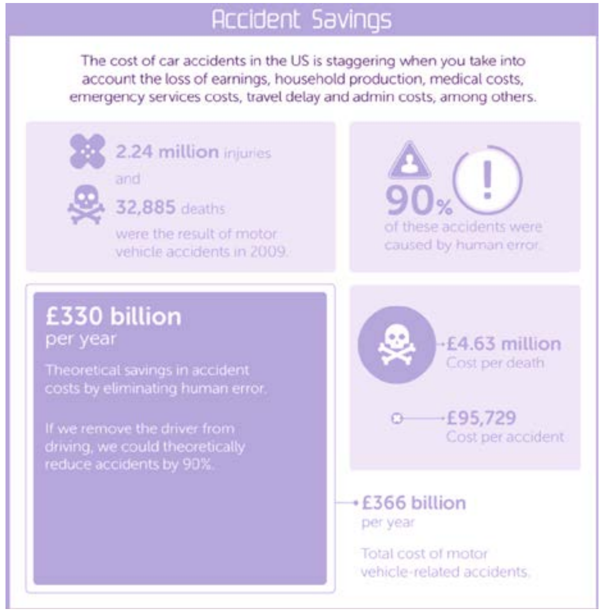
COST OF TRANSPORT-RELATED TO HEALTH

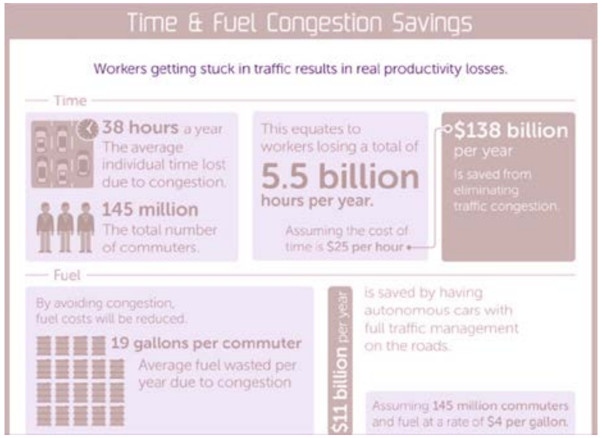
The social economic costs of traffic injuries are mainly carried by the healthcare sector. The total sum adds of to approximately 2% of the total gross domestic product in the EU, which is about €180 billion in 2004. The accident category accounts for €158 billion in Europe for 17 member states or 2,5-3,0% of GDP and is therefore the most significant part of external costs.

A regular physical activity is able to save lives. Austria has a modal share of cycling trips of 5%. Through this activity 412 lives are spared every year and €405 million could be saved in 2009. A bicycling rate increase of 10% would double these outcomes.

The costs for days of absence of work and the loss of income due to premature death were estimated between €3-12 million in England in 2002 (including costs to healthcare). Costs for physical inactivity, obesity, and overweight accounts for €9.6–10.8 billion per year. On the bottom line, physical inactivity is estimated to cost €150-300 per citizen per year.







How much money will AV ultimately save?
According to Morgan Stanley report from 2013, the automated vehicles could save the US economy a total of 1.3 trillion dollars per year.

EXCEPT
INTEGRATED SUSTAINABILITY

LEGISLATION

GLOBAL OVERVIEW

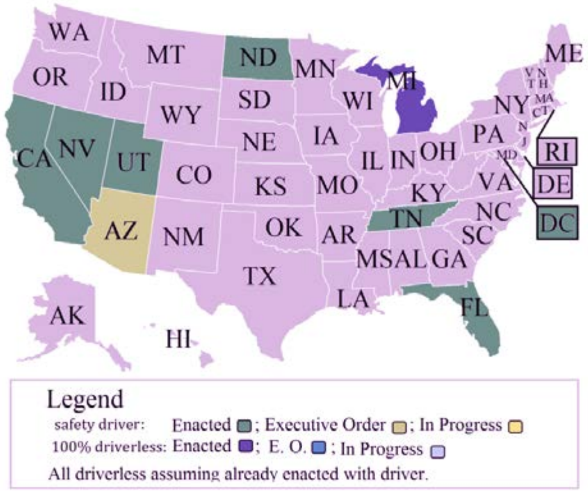
The international Vienna Convention on Road traffic of 1968 demands full control over the vehicle by the driver at any time.

The fast development of automated vehicles makes it necessary to address the potential impacts of these vehicles on the road and to adjust the legislative regulations. So far the manufacturers of self-driving cars have operated in uncharted waters, with regulations varying from state to state.

The United States of America are a front-runner in newly introduced legislation for AVs. At the end of 2016, the Federal government of USA released its first rulebook governing the manufacture and sale of self-driving cars. Everything from nearly autonomous Tesla to Google cars without steering wheels or foot pedals.

California is notable for its draft of regulations for the public use of autonomous vehicles. These regulations are divided into two sections covering testing and deployment, with the regulations for testing already instituted as of September 2014. Those for deployment still under review. The current draft of California regulations covers level 3 autonomous vehicles but not level 4.

It should also be noted that an additional condition on approval for deployment is that the autonomous vehicles must be operated by their manufacturer and only made publicly available on a leased basis. It is currently unclear whether this signals the beginning of a major change in the auto market or if it's merely a temporary measure for limiting liability.



CALIFORNIA'S AUTONOMOUS VEHICLE REGULATIONS

Ford recently became the 11th company to receive an autonomous vehicle testing permit from the California Department of Motor Vehicles.

The companies that already have licenses are:

» BMW
» Bosch
» Cruise Automation
» Delphi Automotive
» Google
» Honda
» Mercedes Benz
» Nissan
» Tesla Motors
» Volkswagen

LIABILITY

Vehicles with a low level of automatization are controlled by the driver, who is fully liable in any case of an accident. With the shift of the responsibility from humans to the technology, there is a need for existing laws and policies to evolve in order to determine who is liable in case of damage and injury.
The introduction of higher levels of autonomy (level 3&4) will lead to the increase in the insurance of commercial and product liability lines, while personal automobile insurance shrinks.

IMPOSING LIABILITY

In case of a traditional car crash the blame is either on the driver or the car manufacturer, depending on the cause of the crash. In a crash involving an autonomous car, the accuser may have four options to pursue.

1) Operator of the vehicle: the challenge is in defining who the operator is. For example, in Florida and Nevada, an operator is *"a person who causes the autonomous technology to engage, regardless of whether the person is physically in the vehicle".*

California, on the other hand, specifies that an operator as *"the person who is seated in the driver's seat, or, if there is no person in the driver's seat, causes the autonomous technology to engage."*

2) Car manufacturer: Volvo is an example of a manufacturer who has pledged to full responsibility for accidents caused by its self-driving technology.

"If we made a mistake in designing the brakes or writing the software, it is not reasonable to put the liability on the customer...we say to the customer, you can spend time on something else, we take responsibility."

3) Company that created the autonomous car technology: Companies developing the software behind the autonomous car and those manufacturing the sensor systems that allow a vehicle to detect its surrounding.

PRIVACY

As cars become more interconnected and autonomous, the risk of hacking is becoming a serious risk. For manufacturers and developers of autonomous technology, liability exposures arise from the collection and storage of data and personal information in the vehicle and in the cloud.

Broadcasting data technologies for ITS require personal information to provide appropriate functionality of the service. This raises issues with EU legislation which defines data privacy and data protection. The data can be processed if it is labelled under an "informed consent" and only used for purposes within the ITS. In any case, the driver needs to have the possibility to cut the transmission to preserve his privacy.

THE NETHERLANDS

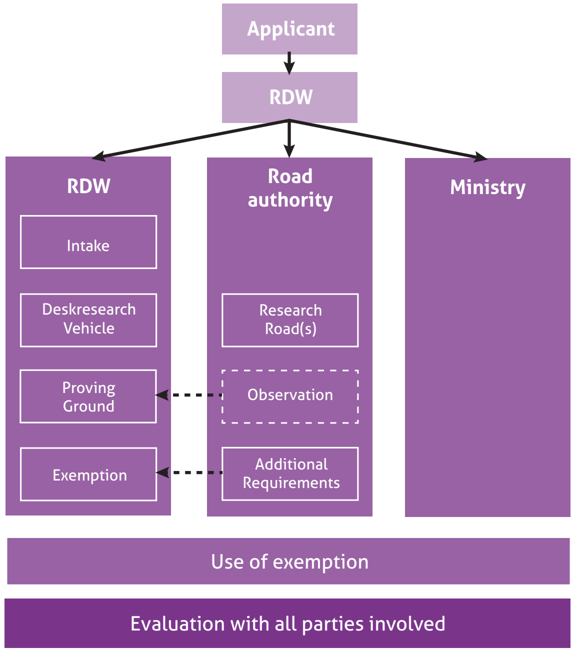
"The Netherlands firmly believes in the potential benefits for significant change in road mobility with the introduction of cooperative ITS systems. Innovations in this field should allow us to improve traffic flows on our roads in terms of safety, efficiency and environmental impact, and can be an important boost to Europe's competitive strength, jobs opportunities and growth. A coordinated approach at a European level and closer cooperation between governments and stakeholders is required to allow these innovative systems to become available on the market."

In June 2014: Announcement of the intention to allow large-scale testing of automated vehicles. The Netherlands wants to be a frontrunner in this sector. At this point small scale pilots are already running on Dutch roads.

In January 2015: An exemption proposal to widen the rules for automated vehicles on public roads is approved. The testing shall start in summer 2015 as soon as necessary changes got approved by the parliament.

In February 2015: First partially automated driving truck tests are conducted by Scania. The wish is that automated truck driving is, according to the Dutch government, advanced enough within 5 years. The following positive impacts are recognized: Reduced road space requirements; Improved safety; Lower environmental impact.

The RDW has published an exemption process, on request of the Ministry of infrastructure, to give allowance for automated driving testing.



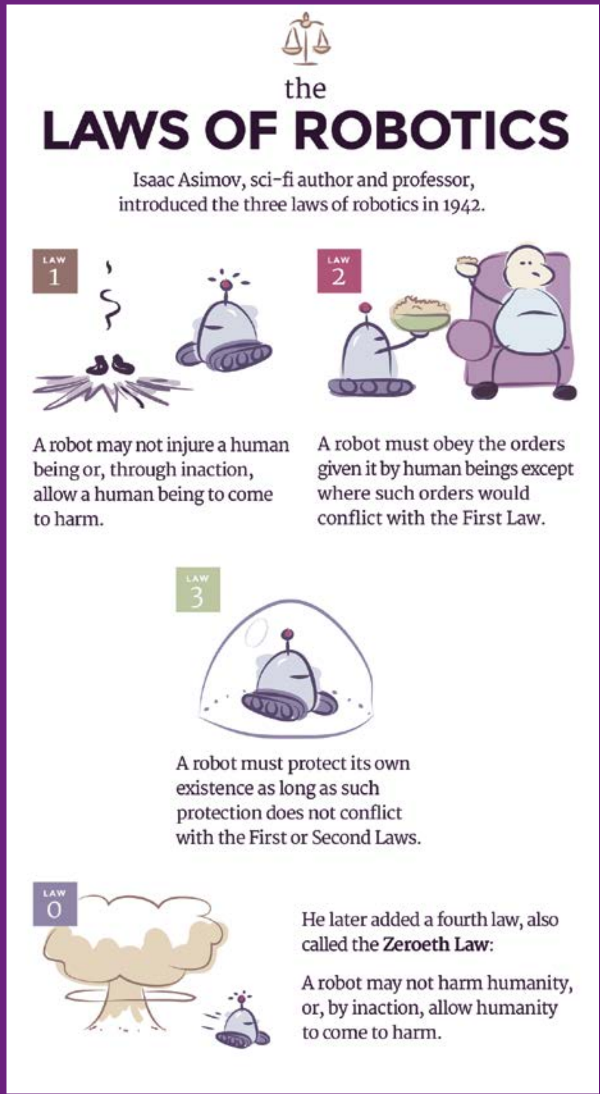
> Application procedure for automated vehicle testing in the Netherlands [50]

THE ETHICAL DILEMMA

With the emergence of autonomous cars, there are various ethical issues arising. While morally, the introduction of autonomous vehicles to the mass market seems inevitable due to a reduction of crashes by up to 90%] and their accessibility to disabled, elderly, and young passengers, there still remain some ethical issues that have not yet been fully solved.

Those include, but are not limited to:

- The moral, financial, and criminal responsibility for crashes,
- the decisions a car is to make right before a (fatal) crash,
- privacy issues,
- potential job loss.



The reference of the article: CJ Pony Parts website © 2016 CJ Pony Parts.

THE LAWS OF ROBOTICS
In 1942, Isaac Asimov, sci-phi author and professor introduced the three laws of robotics.

- The First Law states that a robot may not injure a human being or, through inaction, allow a human being to come to harm.
- The Second Law outlines that a robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- The Third Law states that a robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

He later added a Fourth Law, also called the Zeroeth Law; a robot may not harm humanity, or, by inaction, allow humanity to come to harm.

Can the clear rules-based code of a computer handle the nuances of ethical dilemmas?

Let's take a look at a few hypothetical scenarios:

THE TROLLEY PROBLEM

You are the driver of a trolley that has broken brakes. Fortunately you still have the ability to steer the train from the main track to an alternate track. You can see the two tracks right ahead of you:

» The main track has five workers
» The alternate track has one worker

Both tracks are in narrow tunnels so whichever direction you choose, anyone on that track will be killed. Which way will you go? Would you let the train continue down the main track and kill five, or will you switch it onto the alternate track to kill one?

Most people respond to the Trolley Problem by saying they would steer the train onto the alternate track because their moral intuition tells them that it's better to kill only one person rather than five.

Little modification to the hypothetical scenario
The runaway trolley is speeding down a track about to hit five people. But this time, you're on a bridge that the train is about to pass under. The only thing that could stop the trolley is a very heavy object. It just so happens that you are standing next to a very large man. Your only hope to save the five people on the tracks would be to push the large man over the bridge and onto the track.

How would you proceed?
Most people strongly oppose this version of the problem – even the ones who had previously said they would rather kill one person as opposed to five. These two scenarios reveal the complexity of moral principles.

THE TUNNEL PROBLEM

You are traveling on a single lane mountain road in a self-driving car that is quickly approaching a narrow tunnel. Right before you enter the tunnel, a child tries to run across the road but trips right in the center of the lane, blocking the entrance to the tunnel.
The char only has two options:

» To hit and kill the child
» Swerve into the wall, thus killing you

How should the car react?
Now that the age of self-driving cars have dawned upon us, this new technological innovation has given ethical dilemmas such as the tunnel and trolley problems a new relevance.

Hypothetical scenarios like the Tunnel Problem present some of the real difficulties of programming ethics into autonomous vehicles. In a survey asking how people would like their car to react in the Tunnel Problem scenario, 64% of respondents would continue straight and kill the child. 36% would swerve and kill the passenger.

But who should get to decide?

44% of those surveyed felt that the passenger should make major ethical decisions. 33% felt that lawmakers should be the ones who decide, 12% felt that the decision should lie with the manufacturers and designers. The remaining 11% responded with "other."

Ethics is a matter of sharing a world with others, so building ethics into autonomous cars is a lot more complex than just formulating the "correct" response to a set of data inputs.

Here's one last ethical scenario for driverless cars.

THE INFINITE TROLLEY PROBLEM

The Infinite Trolley Problem, introduced by autonomous vehicle advocate Mitch Turck, is where a single person is on the tracks. This person can easily be saved by simply halting the trolley, but that would inconvenience the passengers. So for this variant, the question is not "would you stop to save someone" but rather, "how many people need to be on board the trolley for their inconvenience to be valued more than a single life."

This variant points out to the fact that given the current number of vehicular fatalities, waiting for self-driving cars to be 99% (if not perfectly) safe disregards the fact that many of these accidents could be prevented once the fatality rate for self-driving vehicles merely dips below that of physically-manned vehicles, even if that is still a nonzero statistic.

THE EMPLOYMENT SHIFT

Employment worldwide is affected by different megatrends. Servitization, aging population, flexibilization of working space with more people working from home and migration rates are shaping the current market place. The advancement of the technology and automation is yet another big factor influencing the economy.

"The automation has already decimated jobs in traditional manufacturing, and the rise of artificial intelligence is likely to extend this job destruction deep into the middle classes, with only the most caring, creative or supervisory roles remaining."

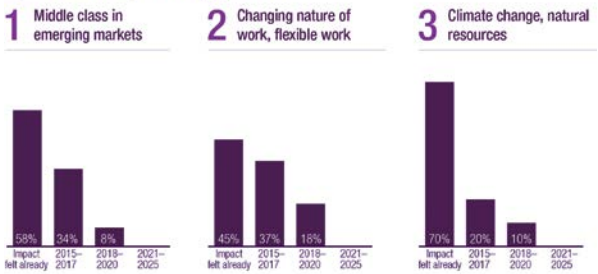
Oxford University study published in 2013, shows that automation can affect both skilled and unskilled work and both high and low-paying occupations; however, low-paid physical occupations are most at risk. The impact of computerization in most cases is not replacement of employees but automation of portions of the tasks they perform.

In the long run and for society as a whole it will lead to cheaper products, lower average work hours, and new industries forming (I.e, robotics industries, computer industries, design industries). These new industries provide many high salary skill based jobs to the economy.

Drivers of Change

Top Trends Impacting Business Models

Expected Time to Impact on Employee Skills



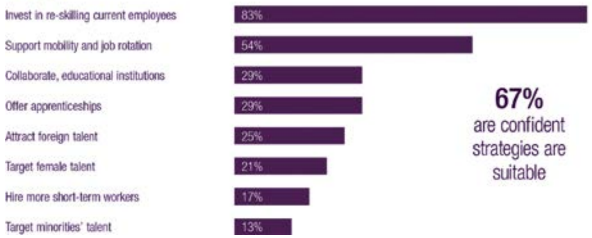
Change Management and Future Workforce Planning

Barriers

Insufficient understanding of disruptive changes 58%
Resource constraints 50%
Pressure from shareholders, short-term profitability 38%
Insufficient priority by line management 33%
Insufficient priority by top management 21%
Workforce strategy not aligned to innovation strategy 17%

71% believe future workforce planning is a leadership priority

Strategies



67% are confident strategies are suitable

Workforce Disruption

Industry Average

STABLE	61%	16%	HARD	HARDER
Employment outlook	Skills stability	Current share of female workforce	Ease of recruitment, current	Ease of recruitment, 2020

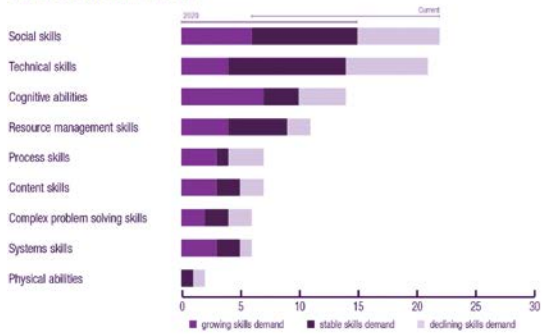
Main Job Families

Job families	Expected change, 2015–2020	Skills stability	Current share of female workforce	Ease of recruitment, current	Ease of recruitment, 2020
Manufacturing and Production	decline	66%	18%	neutral	harder
Assembly and Factory Workers	−1.43%				
Sheet and Structural Metal Workers					
Architecture and Engineering	growth	62%	13%	hard	harder
Electrotechnology Engineers	4.83%				
Industrial and Production Engineers					
Transportation and Logistics	growth	63%	13%	hard	harder
Supply Chain and Logistics Specialists	3.13%				
Transportation Attendants and Conductors					
Sales and Related	decline	4%	16%	hard	neutral
Sales and Marketing Professionals	−1.88%				
Sales Representatives, Wholesale and Technical					

Expected Impact on Job Quality

Skills Forecast

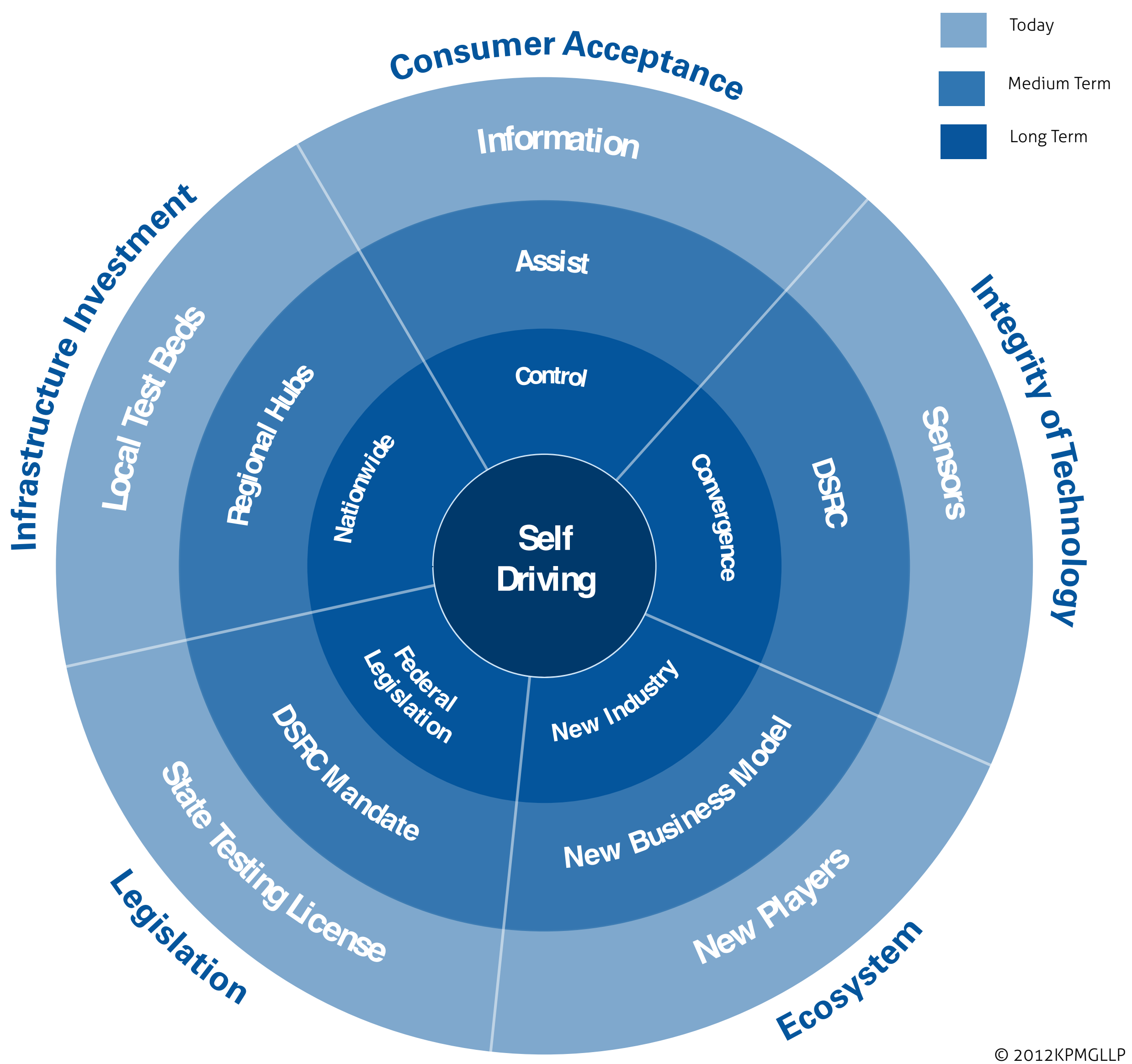
Skills Change, Overall Industry



SENSIBILITY TO CHANGE

TECHNOLOGY ADAPTATION & VULNERABILITY
Organizations introduce new technology to get the most efficient usage in the shortest time frame with the least expense. Marketing and incentives can be effective in capturing a portion of the targeted user base. People who adopt new technology when it first becomes available are known as the visionaries and early adopters. Visionaries adopt technology because they like to be first. They can see the potential benefits the technology brings and are willing to pay the price, in terms of risk, financial cost, time, and support to gain those benefits. Because change comes slowly, many hesitant users question the benefits of change and may need exposure to influential leaders and peers before they can see themselves as technology users. Learning itself is often stressful and many hesitant users have a very low tolerance for complexities in usage or the risk of failure.

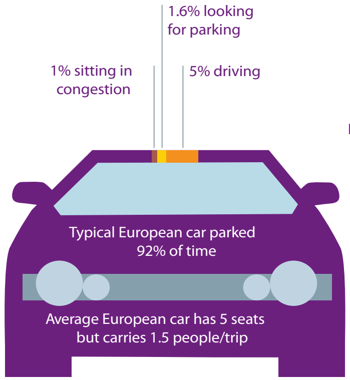
Many people would adopt new technologies if they could, but they need additional support to do so. The key to capturing this group as users is to analyze their needs and put in place support programs that enable them to adopt with a low risk of failure. Fear of technological vulnerability is also an important factor to consider, ie. the chance that a technological system may fail due to external impacts. In some cases groups have interests in maintaining practices that cause vulnerabilities, while in other cases groups have vested interests in maintaining vulnerabilities themselves. These latter cases are especially difficult to deal with since they challenge prevailing belief systems.



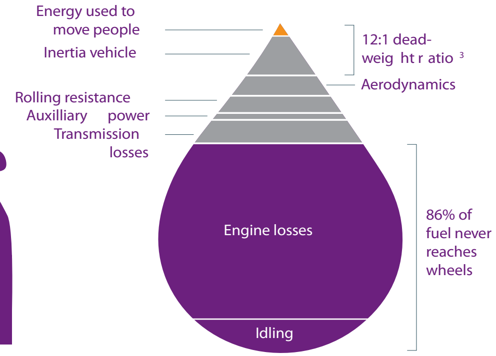
FUTURE OF PARKING

Currently, a car is parked 92 percent of the time in a garage, on a street or at a house. When the car is used, only 1.5 of its 5 seats are occupied. The deadweight ratio often reaches 12:1. Less than 20 percent of the total petroleum energy is translated into kinetic energy, and only 1/13 of that energy is used to transport people. As much as 50 percent of inner-city land is devoted to mobility (roads and parking spaces). But, even at rush hour, cars cover only 10 percent of the average European road.

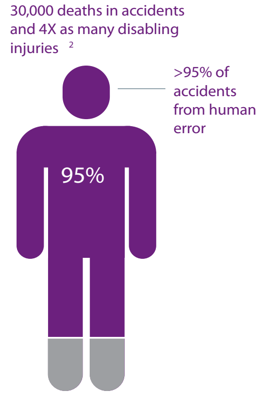
CAR UTILISATION [1]



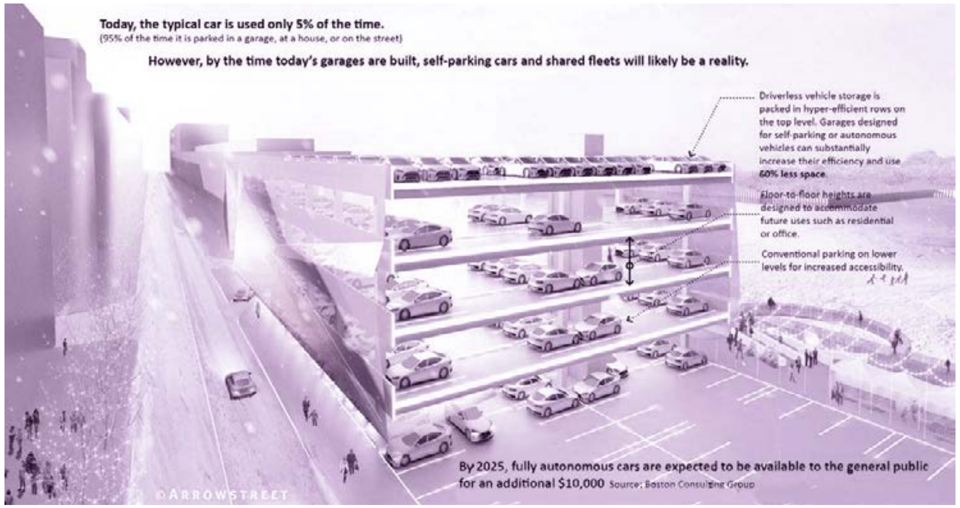
TANK-TO-WHEEL ENERGY FLOW - PETROL



DEATHS AND INJURIES/ YEAR ON ROAD

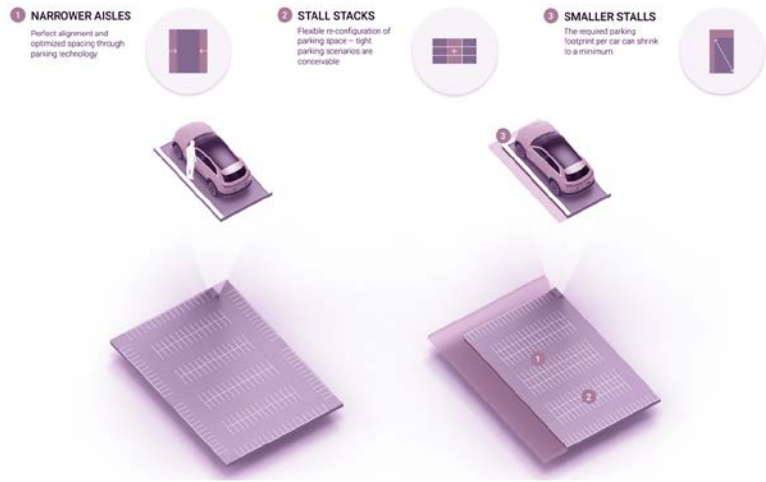


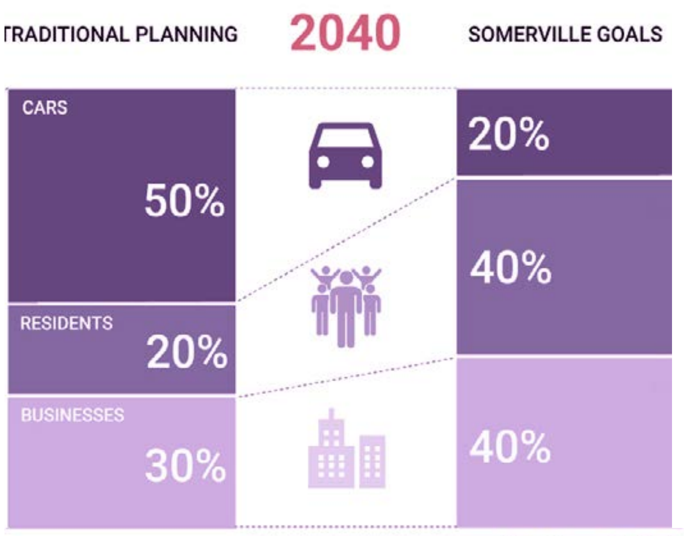
LAND UTILISATION: **5%** Road reaches peak throughput only 5% of time and only 10% covered with cars then **50%** 50% of most city land dedicated to streets and roads, parking, service stations, driveways, signals, and traffic signs

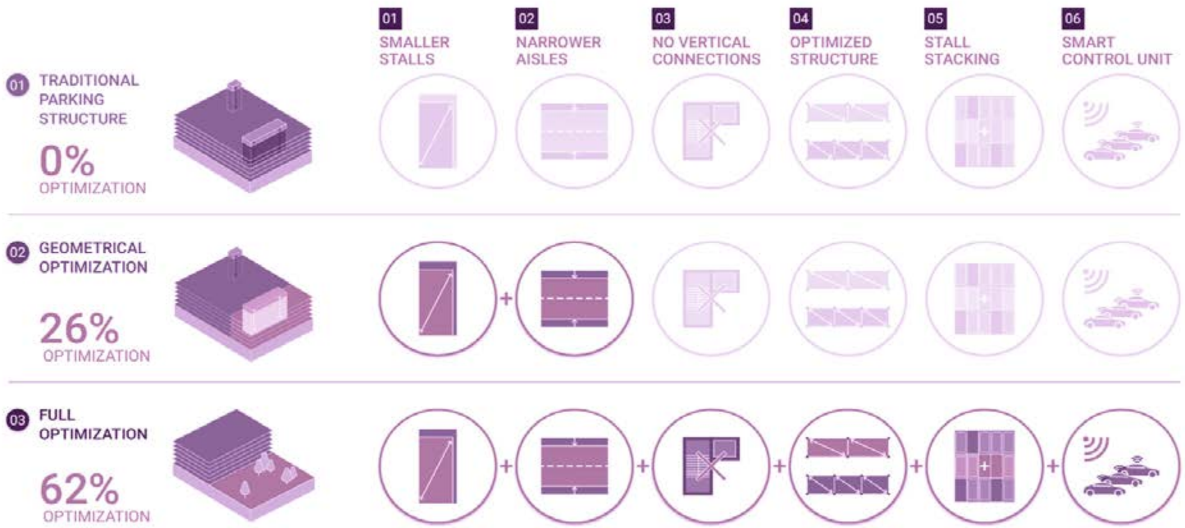


FUTURE PROOF PARKING GARAGES
Self-driving cars promise to improve the efficiency of parking garages over the next 20 years, relieving drivers of stress and freeing up building space for more productive uses. Different manufactures and designers are exploring how automated parking will downsize the amount of parking space.

According to Audi, if a parking garage is planned exclusively for self-parking cars, the space can be used more efficiently: Driving lanes are narrower, stairs and elevators are unnecessary, and vehicles can be parked in several rows, one behind the other.







INDIVIDUAL

SOCIETY

LIFE

ENERGY

HEALTH & HAPPINESS

"The truly smart City invites it's citizens to co-create new solutions, instead of treating them as consumers to sell new services to"

Gert-Joost Peek

TRANSPORT & HEALTH

PHYSICAL INACTIVITY
Physical inactivity is a leading risk factor for ill health in developed countries. Forms of transport that entail physical activity, such as cycling and walking, separately or in conjunction with public transport, offer significant positive health gains. Planning and decision-making, however, have often overlooked them.

In the EU, many trips are short and most of them are made by car. This contributes to over 30% of adults being insufficiently active during a typical week, and to a prevalence of obesity that increased by 10–40% between the late 1980s and the late 1990s.

IMPACT OF THE AIR POLLUTION TO THE HEALTH
Generally if you are young and in a good state of health, moderate air pollution levels are unlikely to have any serious short term effects.

Elevated levels and/or long term exposure to air pollution can lead to more serious symptoms and conditions affecting human health.

This mainly affects the respiratory and inflammatory systems, but can also lead to more serious conditions such as heart disease, and cancer. People with lung or heart conditions may be more susceptible to the effects of air pollution. Children face special risks because of amplified activity of their lungs.

Pollutant	Health effects at very high levels
Nitrogen Dioxide, Sulphur Dioxide, Ozone	These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases
Particles	Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases
Carbon Monoxide	This gas prevents the uptake of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease

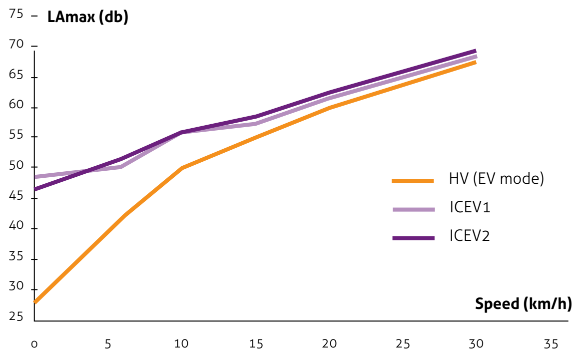
> The table shows the types of health effects experienced by the most common pollutants at elevated levels [46]

NOISE LEVELS

IMPACT TO LIVING BEINGS

Road traffic sound pollution is of particular interest in urban environments given the large exposed population and the long exposure times. Between 20% and 30% of the EU population are exposed to noise levels higher than 65 dBA during the daytime and 55 dBA during the night. For such noise levels, a number of studies have reported significant correlations with cardiovascular diseases, respiratory diseases, type 2 diabetes, and adverse birth outcomes.

Children chronically exposed to loud noise show difficulties in attention span, memory, problem-solving ability and the acquisition of reading skills. EVs have a significantly lower noise impact at low speeds as the figure shows.



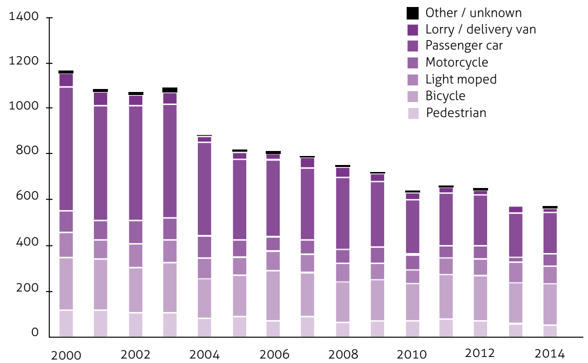
> Noise levels of conventional and electric vehicles [35]

ACCIDENT RATES AND MAIN CAUSES

ANNUAL ROAD FATALITIES IN THE NETHERLANDS

The number of fatalities among vehicle occupants has fallen significantly, and among pedestrians, a gradual decline in fatalities can also be observed. The decline is less obvious for other modes of transport. Fatalities among cyclists are no longer declining.

The causes for road fatalities are diverse. The main causes for accidents are inadequate surveillance which is responsible for about 20,3% of all accidents, whereas distraction accounts for roughly 15% and decision errors for 34,1%.



> Annual number of road fatalities of transport types [9]

Total Crashes per year in USA	5.5 milion
% human cause as primary factor	93%
Economic Costs of USA Crashes	300 bilion $
% of USA GDP	2%
Total Fatal & Inurious Crashes per Year in USA	2.22 milion
Fatal Crashes per Year in USA	32,367
% of fatal crashes involving alcohol	31%
% involving speeding	30%
% involving distracted driver	21%
% involving failure ti kep in proper lane	14%
% involving failure to yield right-of-way	11%
% involving wet road surface	11%
% involving erratic vehicle operation	9%
% involving inexperience or overcorrecting	8%
% involving drugs	7%
% involving ice, snow, debris, or other slippery surfaces	3.7%
% involving fatigue or sleeping driver	2.5%
% involving other prohibited driver errors (eg. improper following, driving on shoulder, wrong side of road, improper turn, improper passing, etc.)	21%

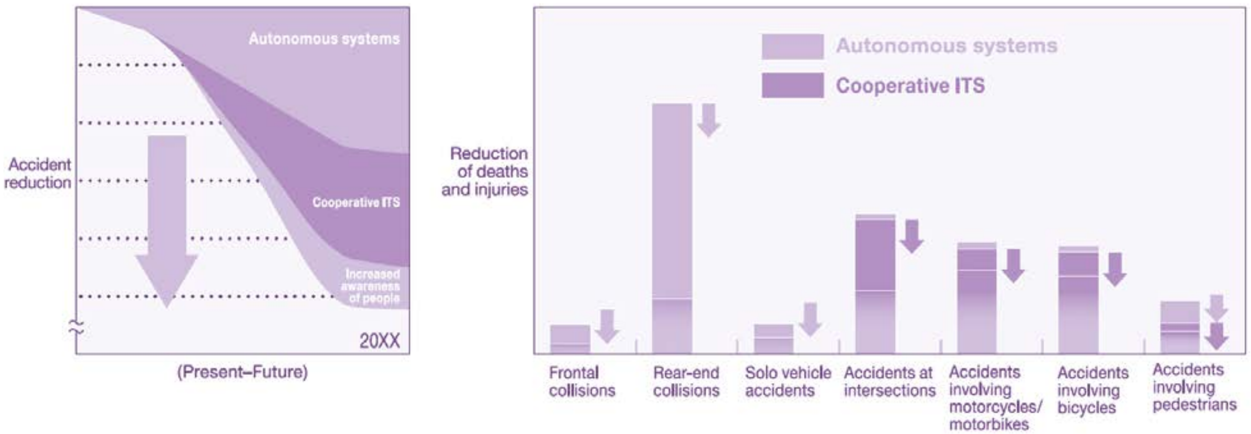
> Total cost of the car accidenst in the USA and an overview of human errors causing the incidents

SAFETY

Automated vehicles may have the potential to save lives. 32,675 fatalities were reported in the US in 2014. These are mainly (90%) due to human induced factors such as drunk driving, distraction, and failure to remain in one lane. These are assumed to be similar in the Netherlands. A vehicle which is able to diminish the possibility for human error has great potential to lower accidents significantly. This might lead to a total reduction of fatalities of about 95% to 99%. But to achieve this extraordinary reduction, total road coverage by autonomous vehicles is necessary. An AV adoption of 90% would lead theoretically to 21,700 saved lives in the US.

One downside may be that AVs are not yet able to drive in heavy rain or on snow. Left turns and reading hand signals are also still a problem. The main issue, nevertheless, is the direct interaction between conventional driven vehicles and AVs. Human drivers simply do not have the wherewithal to interact with such type of car. These issues need to be solved to achieve the positive goals set for automated driving. Cooperative ITS can partly overcome these obstacles through enhanced interconnection of traffic participants. The system is very promising with regards to accident reduction.

> Positive effect of autonomouse systems and cooperative ITS on traffic safety



ACCESSIBILITY

KEY FACTORS
Accessibility in the Netherlands varies in each area and location and is sometimes not sufficient to address the burden on the systems.

The key factors which influence accessibility are:

- areal dispersion,
- public transport connectivity,
- interrelation between different transport modes
- coordination policies to make traveling nicer, cheaper, more simple and quicker.

The amount of time spent plays a significant role. Some trips are canceled because connections demand too much time and effort. Not only does the accessibility of transport modes play a role but also the distance covered has a large influence. Comfort is of great importance but it is also subjective. A fit person in their thirties experiences comfort differently than somebody who is retired.

Conclusions

The goal of this chapter is to identify relevant data information and give a clear insight into the present status towards self-driving vehicles as a part of the infrastructure in the Netherlands.

ENERGY

Fuel choice is a key aspect of future automated transport solutions. Cars with electric propulsion have increased significantly in numbers over the last few years. Subsidies from the Dutch government are the main reason for this trend. It is questionable if this trend will continue as soon as the financial support stops.

Electric vehicles have a variety of advantages. The environmental impact is lower, but only if the energy demand is covered by renewable energy sources and not, as is currently the case, by conventional fossil-fuel sources. It is also important not to forget the life-cycle impact of batteries. Battery technology for AVs may solve electricity storage issues in combination with smart grids but in contrast, it is also responsible for a significant environmental impact at the production stage and in end-of-life treatment.

MATERIALS

Vehicle technology is, however only one aspect of the future of AVs. Successful implementation of self-driving vehicles demands an extensive network of information systems. Intelligent Transport Systems (ITS) offer information services to and from vehicles. The cooperative version goes one step further. It is capable of giving comprehensive data of the environment to every transport service included. Cooperative ITS can lower costs for transport drastically. Full implementation would result in positive benefits from 2022 on.

LIFE

Automated transport gives the opportunity to make more space available for nature, mainly at locations where individual owners replace a street-parked car for shared options or new affordable automated taxi-services. Street parking can also be replaced by automated valet parking, including the option of wireless charging.
This spatial benefit can lead to an improvement of eco-system services and biodiversity, but not necessarily so, depending what governments and residents prioritise in the scarce urban surface available.

CULTURE
The mobility as a service concept is another opportunity for the future. Car possession will be no more , so users purchase a trip and not a vehicle. The key therefore is a multi-modal concept, which represents a unification of all transport modes into a mutually system. Public forces and also the government must push for smarter cities and successful climate management. The City of Amsterdam is a frontrunner in this field with a variety of projects. Efforts are made in plenty of countries to enable complete coverage of charging infrastructure for AVs.

One of the biggest obstacles to full implementation of self-driving cars are the legislative preconditions. The driver has to be, at any time, fully in control of the vehicle. Exemptions of this rule can be made in the Nether-lands but only with an application at the RDW. To make automation a success, self-driving has to become the norm. Liability and privacy concerns are therefore the biggest barriers.

ECONOMY
In general, automation can lead to significant savings in all domains if a transport system with less vehicles in total numbers and higher efficiency can be achieved. Construction costs for streets will be lower due to less demand.

Congestion costs will be possibly reduced or disappear completely due to the fact that not-driving allows for other activities on board. Costs related to human and environmental health would be eliminated almost completely.

Costs for climate change mitigation would be lower due to a reduced impact if the right energy choices are made. Nevertheless, to get these positive effects initial investments must be made, which would be recouped by benefits relatively quickly. The positive effects might be reversed or weakened if automated driving leads to an increase in vehicle possession due to accessibility to individual transport for everyone (even people without a driver license).

HEALTH
Less air pollution caused by automated vehicles has the potential to significantly improve air quality in urban areas. The main reason for this is the transition to electrical propulsion as the technology of choice and the sourcing of electrical energy from renewables. (emissions would be otherwise shifted to different locations). The convenience of self driven vehicles has the potential to cause an increase in physical ailments like obesity due to low physical activity. To avoid such developments automated cars should not compete with other transport modes like cycling.

The most significant advantage of self-driving vehicles is the opportunity to lower fatality rates in traffic dramat-ically. Approximately 90% of all accidents are due to human error. Around 60%-70% percent fatalities occur in the urban areas. These would be diminished signifi-cantly by full implementation of automation potentially saving 400 lives in the Dutch cities.

HAPPINESS
What’s to say in general about autonomous driving as a factor of hapiness? The old lady visiting a friend in the hospital, avoiding a bus trip with interchanges, will surely be happy to get from A to B in an comfortable and affordable way.
The daily commuter will be happy to slide through the traffic jams without even paying attention and answer some last e-mails instead, to be free for the evening.
And for the fans of driving: it is not likely that it will be illegal as far as we can see.

SELF-DRIVING CITY

THE DREAM

"Old people began to cross the continent in their own cars. Young people found the driverless car admirable for petting. The blind for the first time were safe. Parents found they could more safely send their children to school in the new car than in the old cars with a chauffeur."

The Living Machine"
by David H. Keller, Wonder Stories, 1935

Today self-driving cars are on the verge of a major breakthrough. However, the first experiments started in the 1920's followed by promising trials in the 1950's. In late 1980's, the first self-sufficient and truly autonomous cars appeared as a result of university projects such as Navlab and ALV projects in 1984 (Carnegie Mellon University) and Eureka Prometheus Project in 1987 (Mercedes-Benz & Bundeswehr University of Munich).

In spectacular Futurama ride for General Motors at the 1939 World's Fair, American designer and futurist Norman Bel Geddes combined the electronic speed and collision control systems common to railroads with the highway system.

He imagined trench-like lanes that would keep cars apart in their own "tracks." The idea was to drive to the freeway normally, then engage the automatic systems and kick back until your exit. Related visions involved magnetic trails built into the road's surface, or physical slots or troughs, or train-like rails engaging hidden steel wheels on the inside of each tire.

Eighty years after the first ideas of autonomous cars and smart roads, the dream seems to have changed little. The goals remain the same: safety, comfort, equal access and efficient traffic flow to reduce congestion. What did change in the meantime is our global perspective of urban society.

The postwar dream of the garden city with dedicated functional zones has shown the downsides of social segregation, traffic congestion and environmental impact. Many cities are now in the process of densification, revitalization and gentrification. The mobility challenges that come along are huge: we have to intensify public transport, manage and clean private transport and (re)conquer space for pedestrians and cyclists. All in a battle for the scarce square meters with other needs than transport such as green, water and space to meet and rest. But the good news is that technology improves with even higher speed.

Self-driving vehicles are soon expected to outperform human drivers in all aspects of automobile maneuvering. Legislation is being renewed to make this all happen. Traffic lights, stations, streets and highways can all be connected to manage traffic efficiently and allow individuals to select the transport means most suitable for their need on a specific occasion: mobility as a service. With these new services, new players enter the mobility market such as Uber, BlaBlaCar, Snappcar and Greenwheels.

Could this trend precipitate the end of the city bus, collisions, congestion and parking shortages effectively eliminating all the negative effects that cars have had on urban structures since the sixties? The effect on urban society remains largely unknown.

THE NEED FOR A VISION

So, will we witness how self driving vehicles fulfill all our urban mobility needs naturally? There are many reasons why we can't afford such a passive role.

These are the most essential reasons:
» Support equitable transport
» Manage mobility growth
» Anticipate for change
» Deal with the ethics

EQUITABLE TRANSPORT

Self-driving taxi and bus services are likely to become an affordable choice that can replace other types of (semi)public transport. The introduction of these services as 'last mile' transport from train and metro hubs or as airport parking shuttle has until recently been limited to dedicated trajectories. Now that the big step of driving on public streets is ready to break through (Uber is testing), it is time for governments to reconsider their strategy for public transport. How can all people, being young or old, disabled or in good physical shape, have equal access to transport in these new services? How can public finances be used in an era where subsidies for unprofitable bus lines may no longer be needed?

"Self-driving cars are what we make them! We SHOULD NOT be passive bystanders in this shift. Policy will guide how these vehicles and systems develop. Policy can be shaped by engaged citizens."

NACTO

MANAGE MOBILITY GROWTH

If self-driving does meet all it's promises of affordable, accessible and safe transport for all, mobility growth will be an inevitable, natural result. History shows that the introduction of better transport means results in more transport. On the long term, in the perspective of a nearly entire fleet of connected vehicles, highway capacity can be used more efficiently. However in the complex urban street patterns with so many different vehicles, human interaction and an endless number of possible connections and destinations, efficiency is not a likely benefit. An increase of traffic congestion is. We will need to find new ways to manage mixed urban traffic, such as stimulating cycling, car and ride sharing of introducing systems of road pricing.

BIG Architects - 'driver-less' vision for Audi Future Initiative

"Currently, the assumption is that fewer vehicles will be on the road in dense city areas, but that traffic will increase in the intermediate areas. One possible development in the inner city is the creation of safety zones, accessible only to vehicles equipped with automatic accident prevention systems. This frees up space occupied by safety measures such as guardrails."

Dieter Zetsche, chairman of the board of Daimler AG

"Cities around the world have recently made enormous strides in integrating pedestrians, bicyclists, and automobiles, and improving safety, but if traffic efficiency becomes the primary motivation for adapting cities to driverless cars, we may see a return to the separation between automobiles and pedestrians that was popular in the middle of the 20th century."

NACTO

ANTICIPATE FOR CHANGE

Street surfaces, buildings and bridges are designed to last 25, 50 or even 100 years. With an expected break through of self-driving, connected and electric driving in the coming decades, each design choice on mobility should be related to future proof for these technologies. Where an average urban street is now divided in sidewalks, car, bus or bike lanes, and street parking, the future street is designed for interaction. Meeting people, hopping on and off self driving taxi shuttles, and exchanging packages will determine the designs together with other urgent needs like climate adaptation. If the new parking garage provides valet parking and wireless vehicle (dis)charging, who needs that old street parking that claims valuable public space?

The diagram represents the effects of the self-driving cars on different levels through time:

1. **Based on ELSIA categories:**

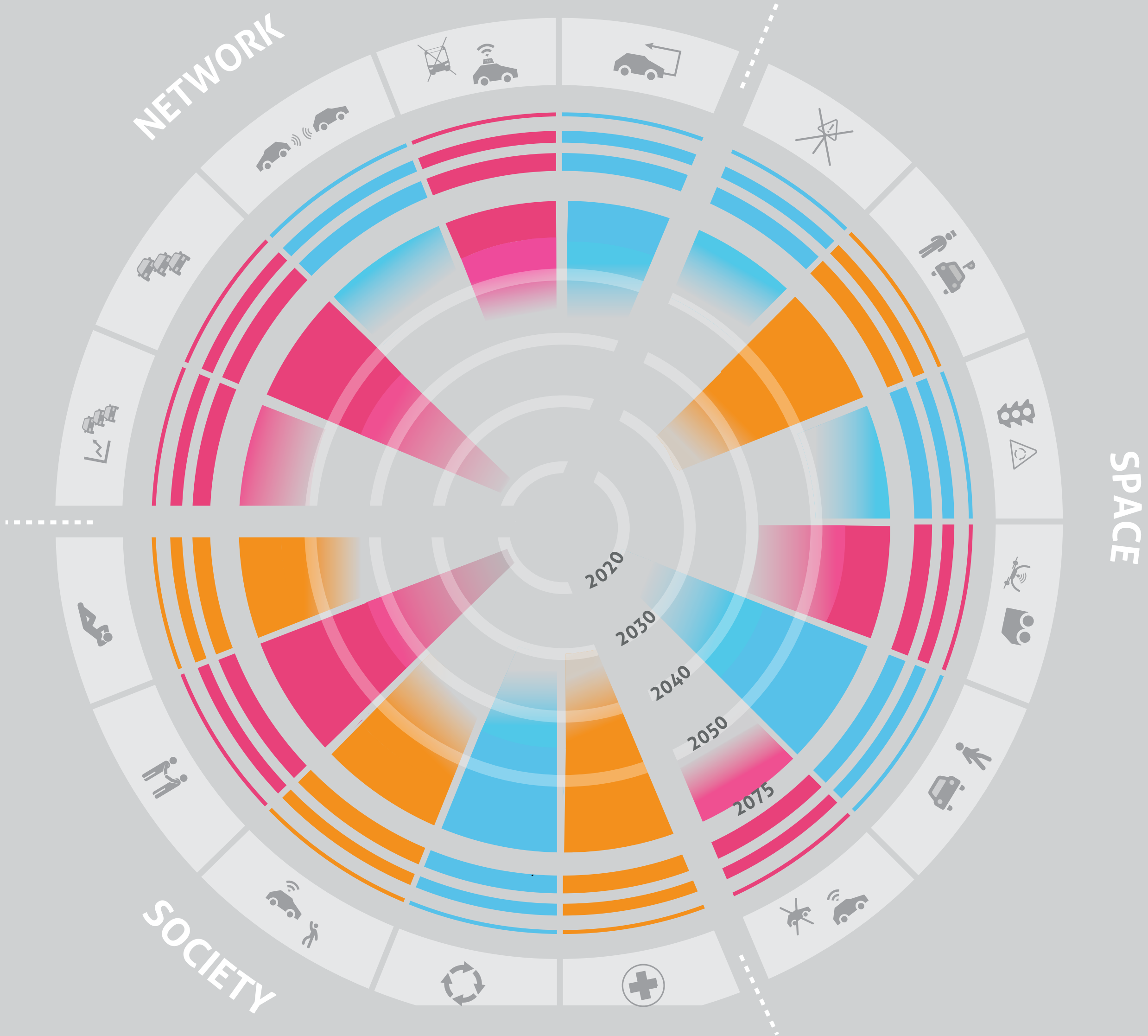
energy & material

economy & culture

health & happiness

2. **Time:** 2020 - 2075+

3. **Context:** network, space and society



NETWORK	exponential growth of road traffic
	road capacity between urban cores and highway under pressure
	highway capacity more effectively used (connected driving)
	(shared) taxi replaces non-profitable bus and tram lines
	valet parking causes extra local rides
SPACE	no traffic signs needed
	no front door street parking needed due to valet parking
	reconstruction of intersections and roundabouts
	exchange space for distribution
	passenger exchange space replaces parking space
	less parking needed due to carsharing
SOCIETY	less road casualties
	reduction of raw materials due to carsharing
	accessible and affordable transport for all
	local community building due to car and ride sharing
	time for other activities on board

Olli - shuttle system of General Motors

DEAL WITH THE ETHICS

Industrial leaders of the automotive industry such as Germany and Japan show remarkably low numbers on consumer faith in self driving cars. Letting go of the wheel is not only a matter of faith in safety, it is also a blind step of faith in internet. Concerns are strong about internet privacy, vehicle hacking, liability and decision making of the board computer when it comes to your safety versus somebody approaching you.

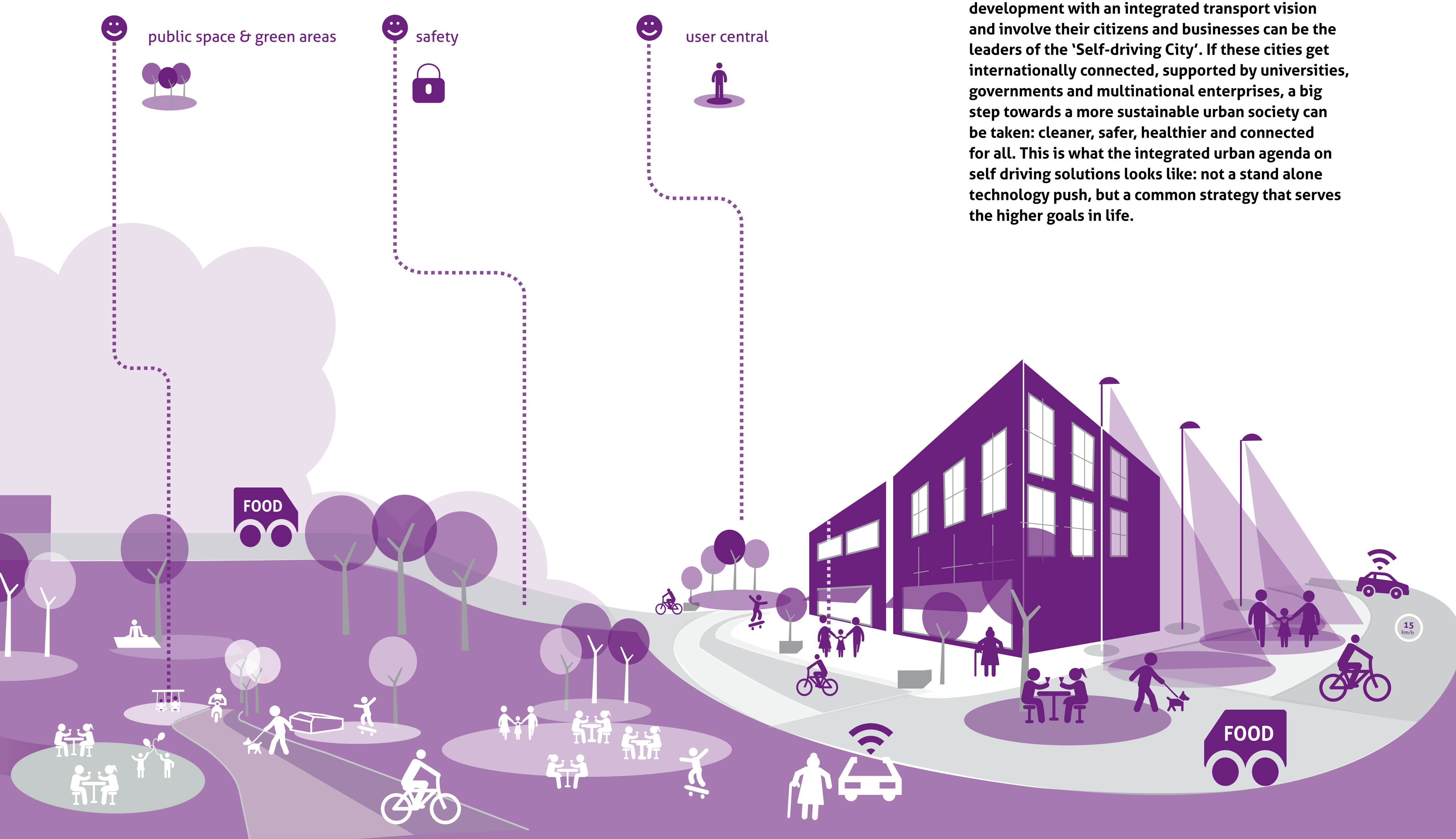
Global public and industrial leaders need to join forces to deal with the ethics of self-driving vehicles and provide transparent legal frameworks that allow individual users to have a choice to be in charge.

"New forms of transport have often been the product of technological progress. But they have also been the agents of rapid social change. Current forms of transport organize us in one of two ways: as private individuals behind our own wheels, or as users of public, mass transit systems. Each is a way of participating in the life of the city, and each has always had a certain ideology associated with it. But driver-less individual transport could, perhaps, transform these old battle lines. The prospect of combining individual autonomy with mass public transit might present a chance to realize a long-dream-of urban utopia: a kind of fully automated socialized system that gives us individual autonomy and freedom."

Sam Jacob,
architect & designer at Sam Jacob Studio

INTEGRATED URBAN AGENDA

Cities that have the ability to combine research & development with an integrated transport vision and involve their citizens and businesses can be the leaders of the 'Self-driving City'. If these cities get internationally connected, supported by universities, governments and multinational enterprises, a big step towards a more sustainable urban society can be taken: cleaner, safer, healthier and connected for all. This is what the integrated urban agenda on self driving solutions looks like: not a stand alone technology push, but a common strategy that serves the higher goals in life.



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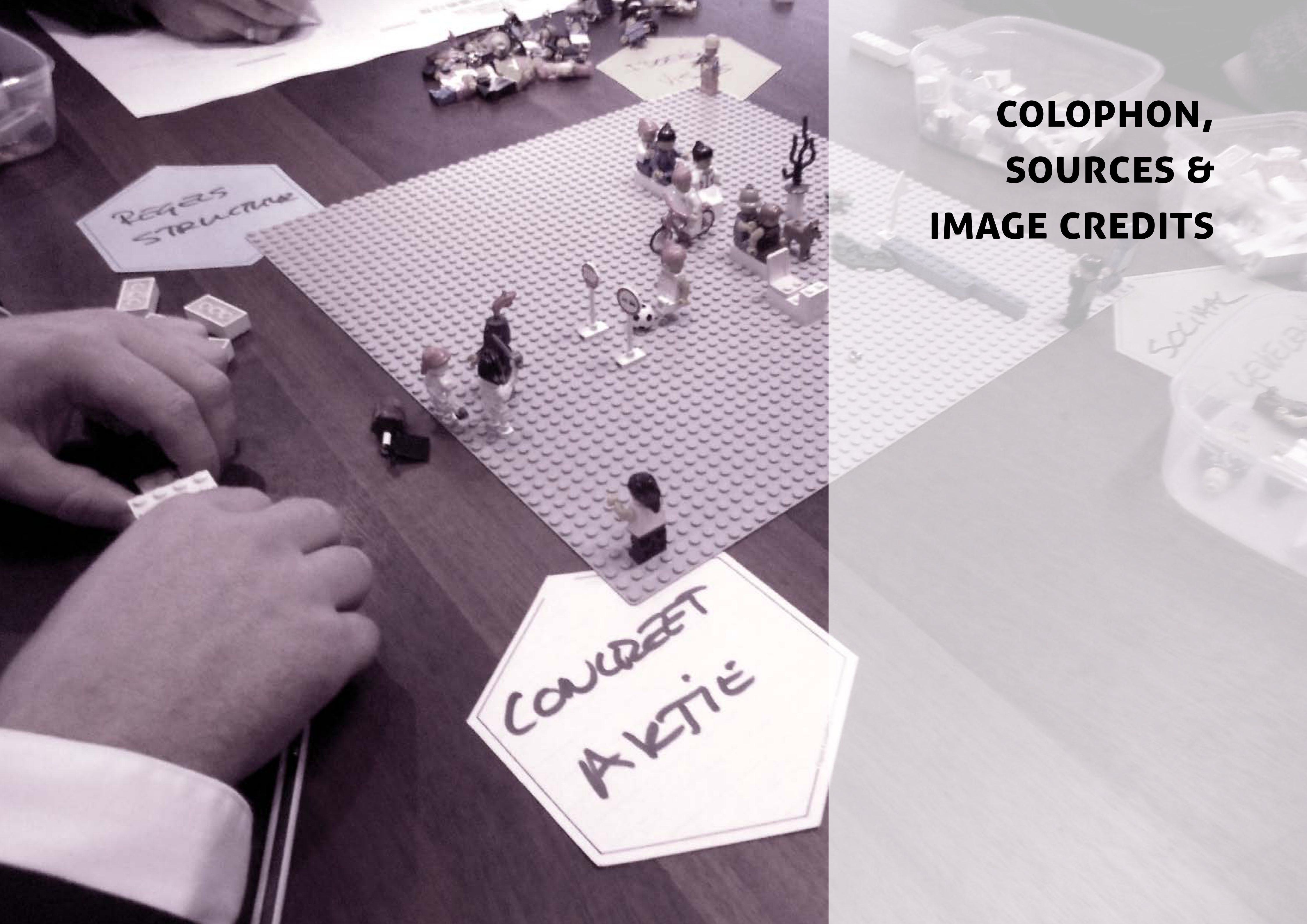

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EXECUTION

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Stadhuisplein 15, 3012 AR Rotterdam
+31 10 737 0215
www.except.nl

Except research team
Antonia Sore
Bart Stoffels
Ludovica Paterni
Chantal Klaver
Benjamin Pilzer
Monica Velasco
Casper Haanappel

Editing and design
Antonia Sore
Bart Stoffels
Ludovica Paterni

Quality control
Danny Edwards

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Reanne Boersma - TU Delft
Judith Boelhouwers - Gemeente Rotterdam
Dennis Potter - gemeente Capelle aan den IJssel
Celine Lonis - Schiphol Real Estate
Steven van der Kleij - Rotterdam The Hague Airport BV
Diede Labots - Gemeente Den Haag
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SOURCES

TREND ANALYSIS
Websites
- http://www.vtpi.org/future.pdf
- http://www.futuristspeaker.com/2012/01/driverless-cars-a-driving-force-coming-to-a-future-near-you/
- https://drive.google.com/drive/folders/0B7cfXDEf7IicNkI0dVJNY1ZHRGc
- https://drive.google.com/drive/folders/0B7cfXDEf7IicNkI0dVJNY1ZHRGc
- https://gigaom.com/2015/12/15/exploring-the-worlds-first-3d-printed-cars/
- http://traveltips.usatoday.com/effects-traffic-congestion-61043.html
- http://nexus.umn.edu/Papers/MountNext.pdf
- https://www.navigantresearch.com/research/smart-grid-10-trends-to-watch-in-2015-and-beyond
- http://www.vtpi.org/avip.pdf
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- https://hu.wikipedia.org/wiki/Wikip%C3%A9dia:Sharing_economy#/media/File:3022028-inline-3022028-slide-slide-16-1024.jpg
- http://www.unece.org/fileadmin/DAM/trans/doc/2014/wp1/ECE-TRANS-WP1-145e.pdf
- http://www.bridges-to-technology.com/page23.html

*** All websites were checked for validity at April 21, 2016.**
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PRECEDENT RESEARCH
Websites
- http://www.fosterandpartners.com/projects/masdar-development/
- http://audi-urban-future-initiative.com/en/blog/somerville-test-laboratory-future-urban-mobility
- http://www.cycling-embassy.dk/wp-content/uploads/2015/05/Copenhagens-Biycle-Account-2014.pdf
- http://www.kimnet.nl/publicatie/chauffeur-aan-het-stuur
- http://www.kimnet.nl/publicatie/mijn-auto-jouw-auto-onze-auto
- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401562/pathway-driverless-cars-summary.pdf
- https://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/self-driving-cars-next-revolution.pdf
- http://www.gelderland.nl/zelfrijdend-voertuig
- http://connectedcities.eu/showcases/parkshuttle.html
- http://www.nu.nl/gadgets/3989165/deels-zelfrijdende-vrachtwagens-bij-zwolle-openbare-weg.html
- http://easymile.com/featured_projects/gardens-by-the-bay/
- http://faculty.washington.edu/jbs/itrans/cvs1.htm

SOURCES

- http://faculty.washington.edu/jbs/itrans/itrans1.htm
- https://www.snappcar.nl/auto-verhuren?gclid=CjwKEAiA04S3BRCYteOr6b-roSUSJABE1-6BNWfGbtMVw1J3oEs79Uv_ZFZz_skjf3GZPC0Y9mo_YhoC5Lfw_wcB
- https://www.teslamotors.com/
- https://www.google.com/selfdrivingcar/
- http://www.anwb.nl/bestanden/content/assets/anwb/pdf/auto/nieuws-en-tips/rapport-inventarisatie-zelfrijdende-auto-def.pdf
- http://www.anwb.nl/bestanden/content/assets/anwb/pdf/auto/nieuws-en-tips/rapport-inventarisatie-zelfrijdende-auto-def.pdf
- http://www.extremetech.com/extreme/226395-toyota-turns-to-guardian-angel-self-driving-cars

*** All websites were checked for validity at April 21, 2016.**
Other sources: Except Integrated Sustainability

DATA COLLECTION
Other

1. Energieverbruik door verkeer en vervoer 1990-2014. Compendium voor de Leefomgeving. (2016).
2. Ecological footprint of Dutch consumption. Compendium voor de Leefomgeving. (2010). Ecological footprint of Dutch consumption
3. End of life vehicles (ELVs). Eurostat. (2016).
4. Basisdaten Bioenergie Deutschland. FNR. (2014).
5. Netherlands: Balances for 2013. IEA. (2016).
6. The Netherlands in 21 infographics. PBL. (2014).
7. Bereikbaarheid verbeeld. PBL. (2014).
8. AUTOMATED DRIVING LEVELS - SAE INTERNATIONAL STANDARD. SAE international. (2014).
9. SWOV Fact sheet Road fatalities in the Netherlands. SWOV. (2015).
10. SWOV Fact sheet Serious road injuries in the Netherlands. SWOV. (2015).

Reports & scientific articles

11. Improving freight efficiency within the "last mile": A Case study of Wellington's Central Business District. Allen, B. (2012).
12. The nature and value of ecosystem services: an overview highlighting hydrologic services. Brauman, K. A., Daily, G. C., Duarte, T. K., & Mooney, H. A. (2007).
13. Externe en infrastructuur-kosten van verkeer - Een overzicht voor Nederland in 2010. CE Delft. (2014).
14. Assessment framework for EV and PV synergies in emerging distribution systems. Chaouachi, A., Bompard, E., Fulli, G., Masera, M., De Gennaro, M., & Paffumi, E. (2016).
15. What it takes to achieve clean, cheap, safe mobility for everyone (part 1). Cobbenhagen, R., & Hoefsloot, L. (2015).
16. Daimler Sustainability Report 2014. Daimler AG. (2014).
17. Cooperative Intelligence of Vehicles for Intelligent Transportation Systems (ITS). Daniel, A., Paul, A., Ahmad, A., & Rho, S. (2015).
18. Preparing a nation for autonomous vehicles. Fagnant, D. J., & Kockelman, K. M. (2013).

SOURCES

19. Self-driving vehicles | Mobility, public transport and road safety. Government of the Netherlands. (2016).
20. Air quality in Europe - 2012 report. EEA (2012).
21. Air quality in Europe - 2015 report. EEA (2015).
22. C - ITS Platform. European Commission. (2016).
23. Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles. Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Stromman, A. H. (2013).
24. Experiments on autonomous and automated driving : an overview 2015. Hottentot, C., Meines, V., & Pinckaers, M. (2015).
25. A Comprehensive Review of "Mobility as a Service" Systems. Kamargianni, M., Li, W., & Matyas, M. (2016).
26. Methods for calculating the emissions of transport in the Netherlands. Klein, J., Hulskotte, J., van Duynhoven, N., & Hensema, A. (2014).
27. Climate Scenarios. KNMI. (2014).
28. Chauffeur aan het stuur. Kennisinstituut voor Mobiliteitsbeleid. (2015).
29. Mijn auto, jouw auto, onze auto. Kennisinstituut voor Mobiliteitsbeleid. (2015).
30. Electromobility in the Netherlands. Ministry of Economic Affairs. (2015).
31. Smart Grids and Electric Vehicles: Made for Each Other?. Morgan, T. (2012).
32. Comparative economic and environmental analysis of conventional, hybrid and electric vehicles - The case study of Greece. Nanaki, E. A., & Koroneos, C. J. (2013).
33. National Motor Vehicle Crash Causation Survey Report to Congress. NHTSA. (2008).
34. Rotterdam: Climate Change Adaptation Strategy. Van Peijpe, D., Boer, F., Hurtado, J., Jorritsma, J., Marin, E., Wissing, A., … Wirschell, N. (2013).
35. Road traffic noise effects on cardiovascular, respiratory, and metabolic health: An integrative model of biological mechanisms. Recio, A., Linares, C., Banegas, J. R., & Díaz, J. (2016).
36. Self-driving cars : the next revolution. Center for Automotive Research. Silberg, G., & Wallace, R. (2012).
37. Planetary boundaries: Guiding human development on a changing planet. Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., … Sorlin, S. (2015).
38. Ruimtegebruik en autogebruik in de stad - Ruimtelijke gevolgen van een parkeerbeleid. Tindemans, H. (2006).
39. The price of transport Overview of the social costs of transport. Vermeulen, J. P. L., Boon, B. H., Van Essen, H. P., Den Boer, L. C., Dings, J. M. W., Bruinsma, F. R., & Koetse, M. J. (2004).
40. Co-operative Driving on Highways. Visser, R. (2005).

Websites
41. amsterdamsmartcity.com/about-asc
42. amsterdamsmartcity.com/projects/theme/label/smart-mobility
43. cyberlaw.stanford.edu/wiki/index.php/Automated_Driving:_Legislative_and_Regulatory_Action
44. multicity-carsharing.de
45. hybridcars.com/top-6-plug-in-car-adopting-countries/
46. uk-air.defra.gov.uk/air-pollution/effects
47. techtimes.com/articles/67253/20150728/driverless-cars-safe.htm

SOURCES

48. nos.nl/artikel/590251-forse-toename-elektrische-auto-s.html
49. psa-peugeot-citroen.com/en/corporate-social-responsibility/sustainable-mobility/mobility-assistance
50. rdw.nl/sites/igk/Paginas/Praktijkervaring-opdoen-met-intelligente-transportsystemen-(ITS).aspx
51. rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers
52. stateoftheair.org/2013/assets/images/stick-figures-800.png
53. telematicswire.net/mobility-as-a-service-maas-launches-first-on-demand-mobility-service-in-finland
54. economist.com/news/international/21663218-sedentary-living-has-reached-epidemic-proportions-you-have-waked-me-too-soon
55. toyota-global.com/innovation/intelligent_transport_systems/infrastructure

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"Beyond the factor of a car that needs no human driver, the spatial implications for our cities are undeniable. The sooner architects can learn to work with and appreciate this technology, the better."

Rem Koolhaas