Self-driven MRDH
Automation as an opportunity to rethink the relation between mobility and territory
in the Rotterdam – The Hague Metropolitan Region

P2 report
Vincent Babeş
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Summary

Project description

Mobility revolutions in the past have not limited their effects solely on transport, but unravelled new lifestyles and new patterns of using the territory. This project intends to contribute to knowledge on the spatial impacts of a potential large scale adoption of automated vehicle (AV) technology in the Rotterdam – The Hague Metropolitan Region (MRDH) through extreme scenario construction. The scenarios are based on two parameters, the evolution of territorial density and the evolution of modal separation of traffic flows.

Problem statement

AV technology has the potential to extensively change mobility, and through this, the use of the city and territory. However, current research on AV is focused on their technical and legal aspects, while the possible spatial effects are not studied. The urbanism profession must understand the opportunities and risks entailed and take an active role in the interdisciplinary discussion on the development of this novel technology. The MRDH, because of its traffic congestion and pollution issues, its general interest in adopting AV technology, but also due to its polycentric and heterogeneous spatial structure, is an optimal testing ground for the proposed hypotheses.

Research question

How can we achieve liveability in the MRDH through urban planning and design tools in different spatial scenarios of AV technology adoption?

Contents

The central research method is scenario construction, based on radical hypotheses on the evolution of territorial density – high-concentration / low-density – and modal separation of traffic flows – total separation / total merging – after a potential large scale adoption of AV in the MRDH. The method is supported by a theoretical framework – scenario construction theory, research on automated vehicles and seminal case studies on mobility and the urban environment – and the analytical framework – mapping of current data and modelling of possible future situations focused on the research questions. The four scenarios are developed according to the same methodology. Two territorial transects are selected to analyse how the spaces occupied by mobility and the liveability indicators are influenced by land use and mobility changes as a consequence of AV adoption. Design and planning themes are developed through zoom-in studies in recurrent or exceptional spatial situations. These include: the shopping street, the boulevard, the flyover / underpass, the motorway as urban edge, different types of residential streets, the rural road, the urbanised port and the campus / business park. The scenarios are evaluated based on quantitative and qualitative criteria, such as efficiency and variety of the mobility system, quality of the public space, accessibility to housing, services, jobs and green areas etc. Finally, the feasibility of achieving liveability through urban design with AV implementation is reflected on and recommendations are made for further directions of research and development of AV technology.

Problem statement

Urbanism as a profession was born out of the necessity during the 19th century to accommodate cities to novel technologies of mobility and to improve living conditions of inhabitants in rapidly industrialising areas (Benevolo). The adoption of the automobile led to major changes in infrastructure, and emboldened and inspired members of the Modernist movement to re-think the city and imagine utopian urban models, which inspired the development of cities for the rest of the 20th century. The effects are universally known: spatial barriers, pollution, congestion. While these models received a strong and mostly well fundamented critique, the urbanism profession was gradually side-lined and replaced by others such as traffic engineers in the area of infrastructure planning. In many cases, the city was being remodelled for the technology. What if technology could be modelled around the city, with urbanists bringing an integrated approach that embodies environmental, social and economic sustainability? A unique opportunity in this direction is the possible future adoption of autonomous - or automated - vehicle (AV) technology (figure 1)

While the context of smart mobility contains a number of innovative concepts such as car-sharing, integrated digital platforms, on-demand mobility, mobility as a service, or electric bicycles, the AV is projected to have a major impact on the physical urban space, and is estimated to become widely adopted in between 5 to 10 years from 2015 (Gartner, van Arem et al). The potentials of AV would be in the fields of lower emissions, road safety, better territorial and social coverage of mobility, and integration with other modes.

Why is this important in the Netherlands and in the Rotterdam-The Hague Metropolitan Region (MRDH)? While the country is one of the most advanced in terms of environmental-friendly mobility such as cycling and public transport, still 73% of distances travelled by people nationally are by car (figure 2, CBS). This causes severe congestion (figure 4), especially in the MRDH (figure 3), and leads to major emissions of NOx, PM10 and CO2 (figure 5, CBS) which are damaging to the environment and public health.

The Netherlands are also particularly interested as a country in leading the innovation in the field of AV, and are promoting legislation change to enable AV across the European Union. There are also a number of pilot
projects, such as by Rotterdam public transport company RTM, truck platooning exercises on motorways, a fully implemented driverless unloading truck system in the Port of Rotterdam, and a driverless bus line called WePods between Wageningen and Ede.

The societal relevance of research in the field of AV and its effects on the city are thus to avoid foreseeable negative effects, and to aid an environmentally, socially and economically sustainable introduction of the technology, but also to ensure that safety and efficiency measures are balanced and integrated with the quality public space. The scientific relevance is first the insight on an unexplored territory: how would AV affect the urban environment. The research can also build guidelines and principles of design for use to their parties such as designers and municipalities, learn from historical failures of similar technological disruptions.

Mobility revolutions in the past have not limited their effects solely on transport, but unravelled new lifestyles and new patterns of using the territory. Autonomous vehicle technology has the potential to extensively change mobility, and through this, the use of the city and territory. The urbanism profession must understand the opportunities and risks entailed and take an active role in the interdisciplinary discussion on the development of this novel technology.
Above: Article about congestion on Dutch motorway, from www.dutchnews.nl


Right below: Extra travel time in the evening rush hour, idem.

Passenger distance travelled by modal split in the Netherlands, idem.

Journeys under 5km travelled by modal split in the Netherlands, idem.

NOx emissions by transport mode in 2013 in the Netherlands, idem.

PM10 emissions by transport mode in 2013 in the Netherlands, idem.

CO2 emissions by transport mode in 2013 in the Netherlands, idem.

Area occupied by road infrastructure types in the Netherlands, idem.
Aims

The aims of the project are:

To contribute to knowledge on the potential spatial impact of autonomous vehicles on the urban fabric and the territory in the Netherlands and in the MRDH;

To develop and test design and planning principles which can lead to an environmentally and socially sustainable adoption of autonomous vehicles.

These aims are embedded in the EMU key issue of “Mobility and network cities”, and in the TU Delft Urbanism department research themes of “Design of the urban fabric”, “Metropolitan spatial structures” and “Smart cities and metabolism”. They are also within the “3A” agenda of the Faculty of Architecture and Urbanism at TU Delft, in the “automation” field.

Research questions

The research questions deriving from these aims are categorised into one main research question, expressed spatially, and a number of secondary questions, expressed in comparable values (built density, soil coverage, network length, distance to services etc.) which support them. The main research question is:

How can we achieve liveability in the MRDH through urban planning and design tools in different spatial scenarios of AV technology adoption?

Secondary research questions:

What urban design and planning approaches could lead to an economically, socially and environmentally sustainable adoption of AV technology in different evolution scenarios of territorial density and modal separation of traffic flows?

How would autonomous vehicles affect accessibility to jobs, services and leisure in the MRDH?

How would autonomous vehicles influence air pollution in the MRDH?

How will the street section adapt to the use of autonomous vehicles?

What will be the land use pattern of the MRDH after the eventual adoption of autonomous vehicles?

Where would the logistic spaces for autonomous vehicles be located and what spaces in the city could be freed up?

Which mobility infrastructures will necessitate up- or downgrades?
Automated vehicles literature review

The theoretical framework will be built with studies on the automated vehicles and their application in the Netherlands. Especially the study of AV’s ripple effects is essential to understand the possibilities enabled by the technology. The studied effects include: on road capacity, mobility habits, and transport infrastructure; change in the value of personal travel time; ownership and sharing; location choices and land use; air pollution; road safety; social equity; economy; public health. The studies include a scenario research on AV in the Netherlands for 2030 and 2050 and include four possible outcomes:

1. AV in standby – rapid technological development, reluctant government: large scale implementation after 2030; lack of action results in traffic problems.
2. AV in bloom – rapid technological development, pro-active government: large scale implementation by 2025; demand management and regulations needed to curb growth; most probable scenario;
3. AV in demand – slow technological development, pro-active government: large scale adoption after 2040; demand management and regulations needed to curb growth; second most probable scenario;
4. AV in doubt – slow technological development, reluctant government; small scale adoption after 2045; available only as a premium service; most improbable scenario (Milakis, van Arem et al).

Automated vehicles literature review

Above: automated vehicle as imagined in the 1950s, from American Power Company.

Scenario matrix about development of automated vehicles in the Netherlands.

Potential value shifts.

Overview of projects in the field of automated and cooperative systems
In the Netherlands there is a small amount of research on possible outcomes of AV implementation. They are focused on the role of the urban motorway ringroad, but also look at how the automated vehicle can play a role in energy production at the neighbourhood level. Different street sections are also studied and intermodal transfer hubs from mass transit to slow city centre mobility.

This page: urban motorway re-imagined, strategy to move motorway underground, neighbourhood energy models using the road (Fransje Hooimeijer) and intermodal hubs between fast and slow mobility (UN studio). From Boomen, van den, T. de Boer, H & Hinterleitner, J (eds, 2017). Highway x City: The Future of the Urban Ringroad, BNA Onderzoek, Amsterdam.

Right: urban motorway section research, research of shared and separated traffic streets with AV idem.
Literature conclusions and the projects’ own classification

The effects of AV on the city and territory can be classified as first-order - street section, intersection functioning, parking, new infrastructures and new uses for obsolete infrastructures; second-order - land use and mobility choices; third-order: societal, economic and environmental impacts (Milakis et al 2017).
**Scenario construction method**

The methodology of the project will be in a research by design approach in the understanding of the EAAE. Within this approach, the main method is scenario construction in the understanding of scenario as a base for discussion, in which the alternative to the present reality is imagined on the basis of radical spatial expressions (Vettoretto).

Scenario construction is also a “tradition” of Dutch urban planning, where envisioning the future was an always essential mean of organizing the territory (Salewski). Scenarios are based on hypotheses, often radical, and consequent narratives of the future. The balance of rationality and imagination, of the quantifiable and the speculative is a core quality of the method. Scenarios can also be used as analytical devices in order to test developments, and depend strongly ‘on the research question, the employed models, the data used, and the transparency of the process’. (Salewski)

In this particular case, the scenarios would be based on the main research questions, delivering a total of four possible scenarios of effects of AV technology in the MRDH: high-concentration territory with dissolved separation between traffic modes; high-concentration territory with total modal separation of traffic; low-density territory with dissolved separation of traffic modes; and a low-density territory with total modal separation of traffic.

The scenarios will be analysed and compared using a set of evaluation criteria, developed from the secondary research questions. The criteria will be the scientific basis for the research method, and will be as much as possible expressed in a quantifiable way.

The scenarios would be developed in the form of territorial sections inspired from the theoretical framework case studies of historical visionary and realised projects.
Which are the liveability criterias most suitable to compare the scenarios? The Dutch national liveability index (leefbaarometer 2.0) uses indicators grouped in five categories: housing, physical environment, proximity to services, population, safety. Machiel van Dorst makes a categorisation from an urban planner’s point of view: health and security; material prosperity, inequality and happiness; social relationships; control; contact with the natural environment.

The project’s own set of criteria (see below) were chosen according to the feasibility to quantify or judge them based on the existing data and timeframe of the project, as well as according to the relevance to the study of automated vehicle technology.

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### Territorial analysis

Summary:

1. Mobility and urban development: quick history; polder urbanization, railways, motorways in relation to urban growth.
2. Scenario “zero”: existing projects and development trends (population, jobs etc.).
3. Multi-criteria analysis of the region.
4. Design elements: roads, no-car, parking, petrol stations, e-charge points, accessibility by car, accessibility only (or predominantly) by car.
5. Analysis methodology: why the section and transects.
7. Mobility landscapes typology: mapping (physical, accessibility, space syntax), photography of each mode and transfer point.

In terms of spatial analysis, the MRDH is a polycentric metropolitan region which includes 23 municipalities, the Port of Rotterdam, a “mainport” of the Netherlands, and multiple knowledge centres. It is a daily system, in which people live, work, travel and can spend their leisure time.

The analysis will focus on answering the secondary research questions, for example:

- Pollution, energy efficiency > length of average daily commute (ArcGIS);
- Environmental sustainability > built land coverage, asphalt coverage, permeability (ArcGIS);
- Quality of life > distance to services, open green (ArcGIS);
- Economic sustainability > access to jobs (ArcGIS), global integration (Space syntax);
- Quality of public space > street section design research, local integration (space syntax), pedestrian simulations (Space syntax, other methods).

The main methods employed will be:

- Morphological analysis;
- Space syntax;
- GIS mapping of transport and accessibility;
- Official data, infographics interpretation;
- Interviews with specialists (transport, AV);
- Interviews with locals.
Historical maps and interpretation of urbanization and infrastructure in 1821 (canal), 1932 (railways) and in 2016 (motorways). From www.topotijdreis.nl

Scenario zero. Proposed infrastructure projects

RandstadRail extension to Binckhorst/Scheveningen
source: mrdh.nl

4 line railway corridor Den Haag-Rotterdam
source: mrdh.nl, ns.nl

Driverless shuttles in Binckhorst, Rijswijk, TU Delft,
Rotterdam Airport, Schiedam, Rivium
mrdh.nl

New motorway connections Blankenburg tunnel, A16
Rotterdam North
source: rijkswaterstaat.nl

New Rotterdam bridges
source: mrdh.nl
Space syntax axial integration map with radius R=3

Soot emissions from road traffic, 2014. From www.leefomgeving.nl

NO₂ concentration in the air, 2014. From www.leefomgeving.nl

PM10 concentrations, 2014. From www.leefomgeving.nl

Corine Land Cover 2012

Number of cars per neighbourhood (buurt), 2014.

Number of public transport stops per neighbourhood (buurt), 2014.

Population per neighbourhood (buurt), 2014.

Number of jobs per neighbourhood (buurt), 2014.

Number of housing units per neighbourhood (buurt), 2014.

General life quality per neighbourhood (buurt), 2014. www.leefbaarometer.nl
Spaces of the car “on the move”
Main road network (dark red)
Local streets (light red)
Spaces of the car “stationing”

Large parkings (dark red)
On-street parking (light red)
Spaces of "no car"

Pedestrian areas (ocre)
Cycling infrastructure (yellow)
The section as a method of research and design

Below, from top-left to bottom-right:
Eugénio de Santos, street section, 1758. idem.
Eugène Henard, Rue Future, 1911. idem.

Peter Cook / Archigram, Plug-in City, 1964.
Sustenance components section. idem.
Road infrastructure typology

Google Earth imagery
Scenarios and case studies

Scenario 1. Clockwork City
Characteristics:
• densification only in existing urban cores
• territory connecting dense no-car urban blocks
• AV clearly separated from other modes
• highly efficient public multimodal transport

Design problems to tackle:
• overcome spatial segregation between urban blocks
• design and locate the multimodal hubs
• accommodate growth in intensive densification
• ensure access to green and water in the cities

References:
• Ville Radieuse, 1930, Le Corbusier

Hong Kong organic separation of flows between 1960 and today. From www.citieswithoutground.com


Scenario 2. Free Movement in a Patchwork Territory
Characteristics:
• densification only in existing urban cores
• territory of clearly determined fabric types
• AV and all modes mixed everywhere, with few exceptions
• variety of public and private multimodal transport

Design problems to tackle:
• accommodate growth in intensive densification
• ensure access to green and water in the cities
• extents and quality of shared traffic spaces
• re-evaluate existing dedicated infrastructures

References:
• Cities for People, 2010, Jahn Gehl


Milan, cca 1905. From commons.wikimedia.com

Living street, Ghent. From www.leefstraat.be
Scenario 3. Efficient Garden Region
Characteristics:
• growth mainly outside existing urban cores
• mixed territory of rural areas and light urbanity
• AV clearly separated from other modes
• highly efficient fast and slow regional transport networks

Design problems to tackle:
• coexistence and synergy of fast and slow networks
• promote active mobility and multimodality
• overcome spatial segregation created by AV roads
• maintain continuity and proportion of green areas in the region

References:
• Broadacre City, 1932, Frank Lloyd Wright
• Planning with water and traffic networks, 2015, Sybrand Tjallingii

Cycling highways. From www.archdaily.com and www.fosterandpartners.com

Regional model and activities model of the two networks strategy
Scenario 4. Open Space Territory
Characteristics:
• growth mainly outside existing urban cores
• low-density territory with spontaneous centralities
• AV and all modes mixed everywhere, with few exceptions
• isotropic accessibility with all transport means, low multimodality

Design problems to tackle:
• extents and quality of shared traffic spaces
• promote active mobility and multimodality
• re-evaluate existing dedicated infrastructures
• maintain continuity and proportion of green areas in the region

References:
• No-stop City, 1969, Andrea Branzi
References

Boomen, van den, T, de Boer, H & Hinterleitner, J (eds, 2017). Highway x City: The Future of the Urban Ringroad, BNA Onderzoek, Amsterdam


Hooimeijer, F (2017). In View of the Buffer Zone, in Boomen, van den, T, de Boer, H & Hinterleitner, J (eds) Highway x City: The Future of the Urban Ringroad, BNA Onderzoek, Amsterdam


Vettoretto, L (2003). Scenarios: an introduction, some case studies and some research prospects, Universita Iuav di Venezia