THE MOBILITY-LIVABILITY REVOLUTION

ENGAGING AUTOMATED VEHICLES TO IMPROVE AMSTERDAM'S CITY CENTER

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P1 Report

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STUDIO

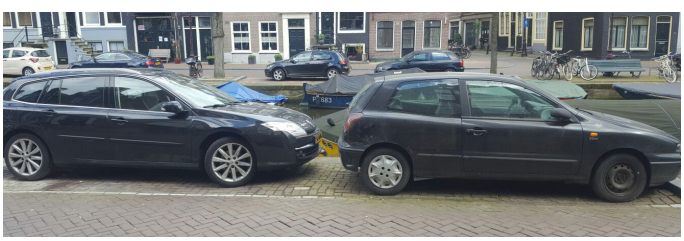
Design of Urban Fabrics

MOTIVATION

As a lifelong admirer of the city of Amsterdam I visit the city often.* I always enjoy walking through it and every now and then I sit along one of the canals and just observe the city happening. At a certain moment I realized that Amsterdam had existed before cars did and that parking along the canals had obviously been realized after that. This idea fascinated me and slowly I started to imagine what the city center would look like if cars would be banned from it. Of course I knew this wasn't realistic but still I couldn't help but dream. Years later I was having a discussion with a friend about automated vehicles and how they would impact society. After a while we figured out that if they were fully automated they would be able to park themselves anywhere and it was at this point that we realized that the point at which people wouldn't need a parking spot right next to their house might be closer than ever. Not long thereafter I realized this could mean that for Amsterdam, the canals could become free of parked cars and as a pedestrian I would then be able to actually see the canals when walking along them again. And so it began.

** Photo of the author at Dam Square (photo by grandma, 1992)*

** Dam Square in 1690, 1890, 1989, and 2016. (images by Jan van der Heijden, unknown, Ramón Durán, and igg)*



† The view on the canal and the influence of cars on it. (photo by author)

INTRODUCTION: THE CITY IN TRANSITION

Amsterdam has seen many mobility transitions since its establishment. As most cities, when people first settled, they exclusively walked through the city. For Amsterdam, soon an infrastructure for boats was added and through time, this has been succeeded by stage coaches, trams, bicycles and cars.* The city has always been in transition and the way people move around has had a major impact on the city and its residents. New ways of moving around bring new possibilities and endlessly optimistic humans always welcome these new ways of moving around, often thinking they will solve the problems caused by previous modalities. Sometimes they do. Fortunately, Amsterdam's streets are no longer covered by a thick layer of horse shit. But often, they bring with them a completely new range of problems. And so when a new modality gleams on the horizon, we are often eager to welcome it, because it will solve all of our problems. Now, we have found that while cars have brought us a range of new possibilities, they have come to dominate public space and our sensory observations of it.† The solution is at the horizon though, and it is the selfdriving car. Or is it?

PROBLEM FIELD

The city of Amsterdam has been growing and it keeps growing. In the period between 2008 and 2013 the city got 75.000 new residents, 50.000 new working people, and tourists stayed a whopping additional 4.200.000 hotel stays per year (Gemeente Amsterdam, 2015b). All these people move through the city using different modalities, yet the amount of public space stays approximately the same. According to simple initial measurements by the author, for a representative part of the inner city of Amsterdam, approximately 77% of public space that is not occupied by the canals is occupied by car infrastructure. Some of this infrastructure is also used by public transport but the share seems excessive nonetheless. The remaining 23% is recreational public space and infrastructure specifically for slow traffic.* This absence of ample space for slow traffic leads to uncomfortable and sometimes unsafe conditions. Bicyclists increasingly report they see disadvantages of using a bike; bicycle paths are getting more and more crowded and so are bicycle parking facilities (Gemeente Amsterdam, 2015a). On top of this, 7% of bicyclists have been involved in a traffic incident over the course of 6 months preceding the report, the amount of road deaths is stable at 15 a year and the amount of serious traffic injuries is rising (Gemeente Amsterdam, 2015a). Meanwhile, pedestrians often have to do with sidewalks no wider than half a meter that somehow double as bicycle parking nonetheless.† In short, the problem statement can be defined like this: **Amsterdam attracts many people. The amount of residents is increasing and the amount of visitors has also risen over the last years. This growth has many benefits for the people of Amsterdam and for entrepeneurs, but at the same time it puts pressure on accessibility, public space and livability.** All these aspects revolve around slow traffic. First, accessibility, slow traffic greatly improves this. According to Jeff Speck

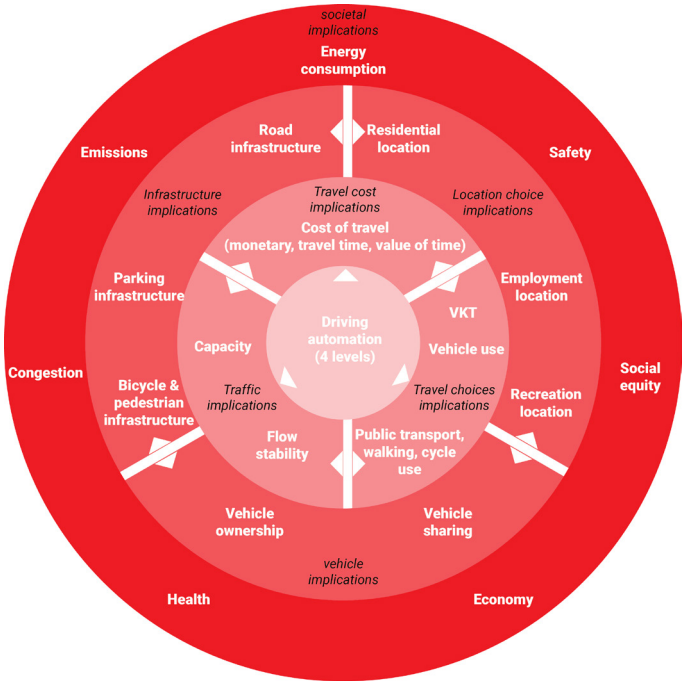
** From top to bottom: calculations of percentage of public space that is respectively occupied by recreational public space, slow traffic infrastructure and fast traffic infrastructure. (images by author)*

† Narrow sidewalk occupied by bicycles at the Geldersekade, Amsterdam (image by Google Streetview)

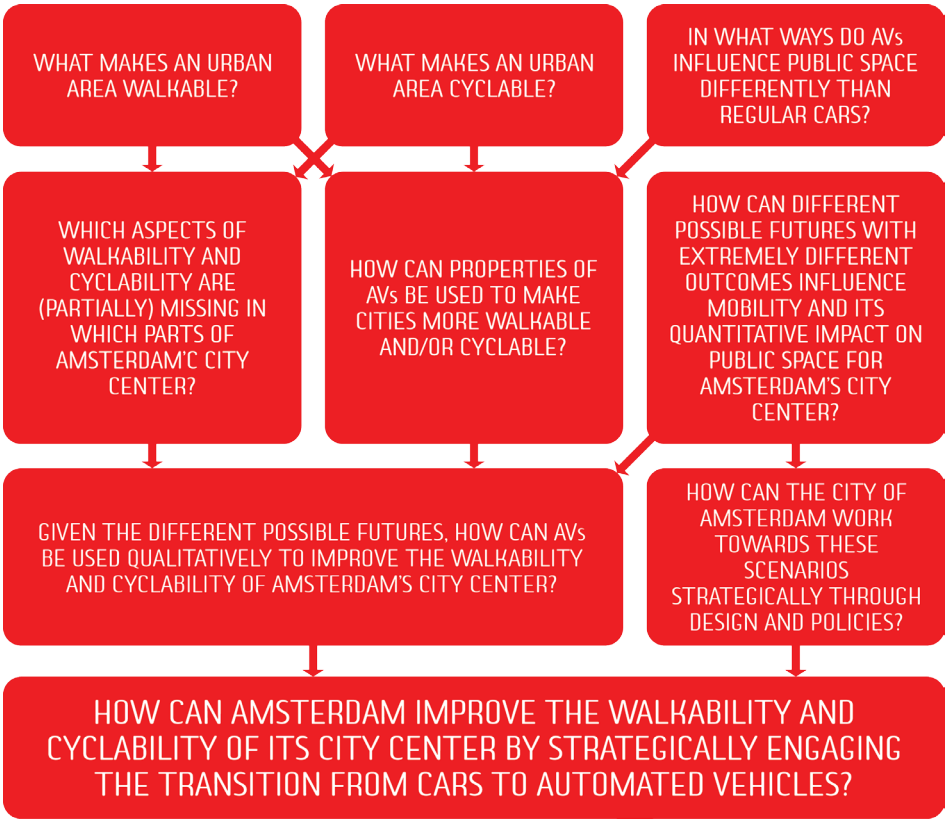
** In these famous photos, the difference is shown in space occupied by cars, bicycles, and pedestrians. (photos by Press-Office City of Münster)*

(2012), a typical bike lane handles five to ten times the traffic volume of a car lane twice its width. Pedestrians take up even less space and it doesn't take a genius to figure out that they as well accomodate a higher traffic volume than car lanes.* Second, public space, if we are talking about recreational public space here, the public space meant for interaction, then it can be argued that pedestrian networks are this type of public space. As Jane Jacobs put it: "Lowly, unpurposeful, and random as they may appear, sidewalk contacts are the small change from which a city's wealth of public life may grow" (1961, p. 72). If we're talking about the quantity of public space, slow traffic uses significantly less space. It was already noted that cars use approximately 77% of public space, this is only logical, considering the amount of space a car occupies. According to Speck (2012), the amount of space needed to park a single car can accomodate ten bicycles. Pedestrians take up even less space, they park their shoes indoors and occupy no public space in doing so. Third, livability, this is also greatly improved by favouring slow traffic over motorized traffic. Gehl (2011), notes that the automobile has caused cities to become duller and more monotonous and that it is an important driver of the trend transforming lively cities into lifeless cities. Speck (2012), notes that the pedestrian is "the canary in the coal mine of urban livability". Finally, as is pointed out in ARTGINEERING's report 'More Cycling - Better City' (2016), cities that are attractive to cyclists are also attractive to residents (and tourists and businesses for that matter). Summarizing, if the city wants to address its problems concerning accessibility, public space, and livability, it needs to improve its walkability and cyclability. Part of this task is to transform car lanes or car parking spots into slow traffic networks. This brings with it a new problem as most of Amsterdam's city center has just one lane for car traffic and there is already a shortage for parking. But there might be a solution: the automated vehicle (AV),

which is also known as the self-driving car. The AV has been under development for quite a while already and road-testing is happening more and more often (Anthony, 2014; "Convoy of self-driving trucks completes first European cross-border trip," 2016; Topham, 2016). This new technology brings with it a lot of new opportunities. It is predicted that early AVs with relatively low levels of automation will impact VKT, vehicle use, public transport use, bicycle use, flow stability, road capacity and cost of travel while later versions with high levels of automation up to full automation will also impact bicycle and pedestrian infrastructure, parking infrastructure, road infrastructure, location of residence, employment and recreation, vehicle sharing, vehicle ownership, safety, energy consumption, social equity, economy, health, congestion, and emissions (Milakis, Van Arem, & Van Wee, 2015).* Examples of new possibilities include centralized parking facilities, on-demand public transport, and on-demand shared vehicles. These, and other, possibilities might facilitate a transition from car infrastructure to slow traffic infrastructure. As such, the transition from cars to automated vehicles will be embraced as an opportunity to improve slow traffic in Amsterdam. **The goal of this graduation project is to develop a strategy for the municipality of Amsterdam on how the transition from cars to AVs can be engaged to improve accessibility, public space, and livability through the improvement of walkability and cyclability.**



** Ripple scheme of implications of automated vehicles, low levels of automation influence aspects in the inner ring while levels of automation from conditional automation (as defined by SAE, 2014) and up also influence the outer two ripples (image by author, based on Milakis, Van Arem, & Van Wee, 2015)*



** Flow chart showing the hierarchy of main research question and subquestions that need to be answered to find an answer to the main question. (image by author)*

RESEARCH QUESTIONS

The main research questions is **"How can Amsterdam improve its walkability and cyclability by strategically engaging the transition from cars to automated vehicles?"** To answer this question, sub questions were formulated.* Each subquestion will be discussed shortly and their relevance within the whole will be explained. The first three subquestions, 'what makes an urban area walkable?', 'what makes an urban area cyclable?', and 'in what ways do AVs influence public space differently than regular cars?' are very similar and so is their relevance. They need to be answered in order to establish a theoretical foundation. As such, the answers to these questions will form a large part of the theoretical framework. The question 'which aspects of walkability and cyclability are (partially) missing in which parts of Amsterdam's city center?' needs to be answered to find out which parts of the city center need to be redesigned and to establish what kind of redesign is necessary where. The fifth question, 'how can properties of AVs be used to make cities more walkable and/or cyclable?', needs to be answered to find out in which way AVs can contribute to a solution. Some ways might be apparant immediatly but by answering these question, hopefully, more possible applications will come to the surface which can be used when redesigning the city center. The question 'how can different possible futures with extremely different outcome influence mobility and its quantitative impact on public space for Amsterdam's city center?' needs to be answered because not much is known yet about what AVs will change and what mobility will be like when they are ubiquitous. Extreme possibilities need to be explored so that an anticipation strategy is ready even in extreme cases. The question 'given the different possible futures, how can AVs be used qualitatively to improve the walkability and cyclability of Amsterdam's city center?' will find an answer that shows how AVs can improve walkability and cyclability as much as possible in extreme possible futures. Combining this with the answer to the last question, 'how can the city of Amsterdam work towards these scenarios strategically through design and policies?' will create a basis from which the main question can be answered. Answers to all subquestions along with a design exercise answer the main research question.

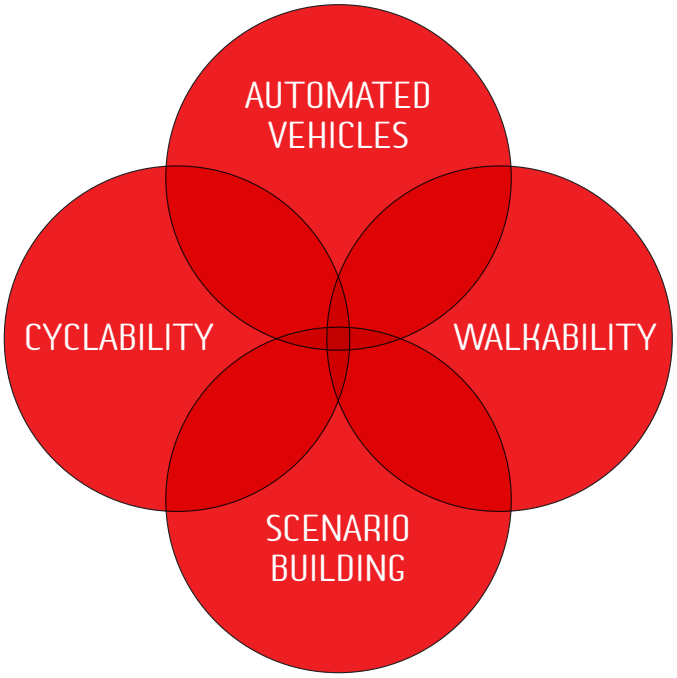
METHODOLOGY

Different methods are used to answer fundamentally different questions throughout the process. The entire methodology will be explained in seven steps:

STEP 1. [method: literature research]
Literature studies will be conducted on walkability, cyclability, automated vehicles, and scenarios. These studies together will form the theoretical framework.* The walkability and cyclability studies will spawn normative criteria that Amsterdam's city center needs to meet in order for it to be optimally walkable and cyclable. These criteria will be used later on. The study on automated vehicles will explore the properties specific to automated vehicles and the impact that these properties can have on public space, both spatially and otherwise. The scenario study will be used to create a scenario building methodology, which is necessary to conduct the next step.

STEP 2. [method: scenario building]
Because not much is known as of yet about the way automated vehicles will influence public space an explorative study will be conducted to find this out. Important questions to answer in this stage are: How much car traffic will there be? How many parked cars will there be? How much room will cars occupy? An answer to these questions will be sought by building 'external scenarios'. Different scenarios will each represent a different extreme –but plausible– future in which the answers to these questions vary greatly. The scenarios will be used as a foundation for design which will guide further research about the possibilities of automated vehicles.

STEP 3. [method: workshop]
Based on the literature studies that were conducted on automated vehicles, walkability, and cyclability, applications of automated



** The theoretical framework will mainly be constructed from theory from the fields of 'walkability', 'cyclability', 'automated vehicles', and 'scenario building'. (image by author)*

vehicles to improve walkability and cyclability will be sought. This will be done through a series of small workshops with peers to find as many possible applications as possible in a relatively short time. This study will be non-specific concerning place, it will generate generic solutions that could be applied on different locations.

STEP 4. [methods: spatial analysis, mapping]
Based on the literature studies on walkability and cyclability a spatial research will be conducted on Amsterdam's city center to find out which walkability and cyclability criteria are met, and to what extent, in each part of the city center. In other words, if one of the criteria is 'safety', a map will be made of the city center, indicating spatially whether or not it is safe to walk and/or bike there. These type of maps will be made for all normative criteria that were found for the city center.

STEP 5. [method: design]
Using the maps created in step four and the applications of automated vehicles from step three, designs will be made for all scenarios that were made during step two. The scenarios from step two sketch different possible futures quantitatively, meaning that quantitative outcomes are defined for each scenario. This step will qualitatively apply automated vehicles to research for all these futures how the walkability and cyclability can be optimized for Amsterdam's city center given the quantitative conditions each scenario contains. This will yield integrated scenarios that show how different external factors can be dealt with. The integrated scenarios will include maps of the city center showing which strategical interventions should be made where, and street-level designs for different typologies found in the city center to show what the strategical interventions will result in from a human perspective.

STEP 6. [method: workshop]
Through a series of small workshops, methods will be searched through which the municipality can guide development towards each scenario. For example, if one scenario presents a decreased use of cars because of international law prohibiting recreational car use driven by climate change, Amsterdam could guide development towards this scenario by implementing policies that ban unnecessary traffic from the city center. During this step, both spatial interventions and policies will be sought. These will be used during the next step.

STEP 7. [methods: design, scenario building]
Based on the results from step five and step six, a normative scenario will be constructed. To achieve this, the scenarios from step five will be judged with regard to the normative criteria set during step one. It is expected that each scenario will perform better than the others with respect to at least one criterium. Based on these performances, the best from each scenario will be combined into one normative scenario. This scenario will include a normative endstate and a strategy to work towards this state. To create this strategy, the results of step 6 will be used. The intended end products are a map of the city center suggesting where strategic interventions should be made, street-level redesigns of representative parts of the city center, a strategy set off against a timeline that suggests interventions and when they should be implemented, and vignettes for relevant actors, describing what their day will look like if the design would be reality.

SCIENTIFIC RELEVANCE

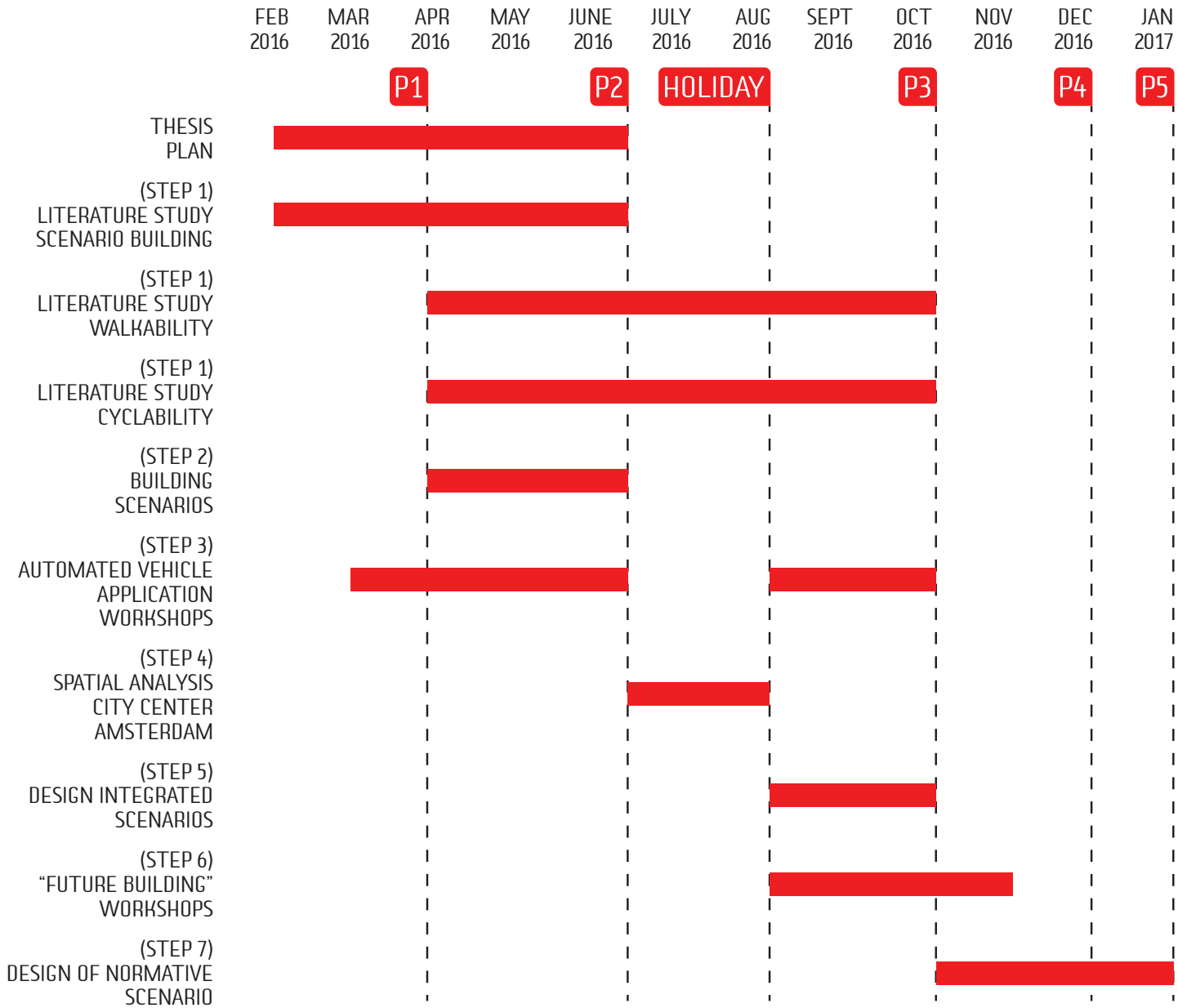
Large companies like Google, Apple, and Uber have been road-testing automated vehicles for several years already and gradually they are introducing the public to this new technology.* Even though research on AVs indicates that they will have a large impact on society and urban contexts (Milakis, Snelder, Van Arem, Van Wee, & Homem de Almeida Correia, 2015), as of yet, not much research has been conducted on what the spatial implications will be. Cities are facing the Collingridge dilemma concerning automated vehicles: they don't have enough information about the technology to predict its impacts but when the information will be available the technology will already be so embedded that it will be much harder and more expensive to control and use it (Collingridge, 1980). The scientific relevance of this project is to find out what the impacts of AVs on the urban context can be and how the transition towards AVs can be engaged for solving problems concerning accessibility, livability, and public space rather than letting it tear apart cities as has happened with the car.

SOCIAL RELEVANCE

Residents of cities around the world, among which Amsterdam, are increasingly facing the negative effects of urbanization and globalization. More and more people visit and move to the city. This has put pressure on accessibility, livability, and public space. Citizens are increasingly complaining about tourism and its effects on the city. Overcrowding has become the new reality and infrastructures are increasingly being outgrown by demand. The social relevance of this project lies in finding a way to make the city center retain its qualities that make it an attractive place for all its users.

** An automated vehicle, the Mercedes-Benz F 015, drove through Amsterdam and then displayed itself dramatically at Dam Square on March 13, 2016. (photo by Bart Maat)*

** Still from Mercedes-Benz' commercial 'Baby' showing a baby in (what is currently still known as) the driving seat, driving through a city with his dad asleep in the backseat. (source: https://www.youtube.com/watch?v=-PRiaUTaI9M)*



** The time-planning from the beginning of the project in february 2016, to the P5. (image by author)*

TIME PLANNING

The graduation has been planned in different steps, for each major step (steps two, five, and seven), a nine-week term has been allocated. The other, supporting, steps are often spanning different terms because their results are in part required before starting the next term but during the term they will be expanded.*

WALKABILITY & CYCLABILITY

This part of the theoretical framework has the goal of setting normative criteria for the city center of Amsterdam that would optimize walkability and cyclability. The basis for these criteria is adapted from Jeff Speck, who provides an excellent framework in his book Walkable City (2012). According to Speck, a city is walkable if it provides the means for walking to be useful, safe, comfortable, and interestering. He further states that all of these conditions are essential and none alone is sufficient. A further explanation on these four conditions will be given and then they will be elaborated upon by describing the criteria that need to be met in order for an urban area to be walkable and cyclable. The first quality an urban area needs is that it needs to facilitate useful walks. Simply put this means that most aspects of daily life should be present within a walking distance and that they should be organized in a way that walking serves them well. The second quality that an urban area needs in order for it to be walkable is that it needs to be safe. This is pretty straightforward but worth noting is that it is not just about actual safety of pedestrians but also, more interestingly, about perceived safety. The third quality an urban area needs is that it needs to be comfortable for walking, this is basically about getting the scale right. If an outdoor area is perceived as too grand, it usually fails to attract pedestrians (Speck, 2012), if on the other hand an area is too narrow, it leads to overcrowding, and subsequently extended travel times. The final quality Speck states an urban area needs is that it needs to be interesting. Simply put, it needs to provide a view on unique buildings, urban qualities, and human life. Interestingly, Speck (2012) notes that the same things that make a city walkable also make it cyclable. He further notes that if an urban area is useful, safe, and interesting for pedestrians, it also usually is for cyclists. This means that seperate normative criteria need to be set for cyclability only with regard to comfort.

NORMATIVE CRITERIA

These normative criteria are based on ten steps of walkability defined by Speck (2012), however, because the context is different*, the steps have been adapted into criteria to make the city center of Amsterdam optimally walkable and cyclable.

Usefulness

Criterion 1: Mix the uses
Add functions of daily life where necessary. If, for example, areas in the city center are not within walking distance of a supermarket, supermarkets should be added to serve these areas.

Criterion 2: Let Public Transport Work
Make sure a proper public transport network is in place for long distance travel and in case people feel like not walking back.

** Speck's work is written as a guideline mainly for North American practitioners.*

Safety

Criterion 3: Protect pedestrians and bicyclists
This can be done in different ways. Physical barriers between modalities can create safety but comsume a lot of space. Another, extremely interesting option, is Hans Monderman's shared space, which is the opposite. All modalities share the same infrastructure and safety results from the face that people tend to be more watchful in uncertain conditions. Shared space favours slow traffic and can fit many different modalities in a limited amount of space, as such might be an interesting solution for some parts of the city center.

Comfort

Criterion 4: Get the scale right
In the problem statement, it was made clear that the city center of Amsterdam is facing problems regarding overcrowding. As such, getting the scale right means adding capacity to existing infrastructures. In particular, bicycle infrastructure has reached its limit.

Interestingness

Criterion 5: Plant trees
Trees are a way to divide areas into subareas while in the process making the area more interesting. Furthermore, they have been shown to reduce stress (Ulrich, 1983; Ulrich et al., 1991) and to have many cognitive benefits (Berman, Jonides, & Kaplan, 2008).

Criterion 6: Stimulate visual enrichment
Pedestrians and bicyclists value having something to look at while they move. This can be unique buildings, other spatial urban qualities, or urban life. This means that the qualities that the city has should be visible from pedestrian and bicycle infrastructure. For example, parked cars along the canals form a problem because they block the view on the water, which is internationally recognized as one of Amsterdam's defining qualities.

Criterion 7: Connect attractors
Creating attractive and uninterrupted routes between the cities attractors will further stimulate walking, particularly among tourists, who form a large part of Amsterdam's walking crowd, but also among residents.

Some of these criteria, such as safety, are (relatively) subjective. Further literature research will be conducted to create a framework for objective judgement of these criteria.

AUTOMATED VEHICLES

This part of the theoretical framework will explore what possibilities automated vehicles hold for the future. Because the automated vehicles will be used in an explorative research, the possibilities will be based on the most technologically advanced model described by literature.

Before going into more detail on possibilities, a short introduction will be given on automated vehicles. First of, there are different levels of automation and a transition from regular cars to automated vehicles will likely be a gradual one (Litman, 2015). SAE International recognizes six levels of automation (SAE International, 2014). No automation, driver assistence, partial automation, conditional automation, high automation, and full automation.* In this project, the final level, full automation, will be considered as it holds the most possibilities. Another important division is between autonomous vehicles and connected vehicles (Bhat, 2014). The former functions autonomously and acts based on inputs observed by the vehicle itself, while the latter functions through inputs received from an external communications network.† Timmer and Kool (2014) state that autonomous and connected vehicle technology will have to complement one another if a reliable cost-effetive automated vehicle is to be developed. However, because both have very different outcomes, possibilities on both ends of the spectrum will be considered when implementing automated vehicles in the scenarios.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	N/A
1	Driver Assistance	the driving mode -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the driving mode -specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the driving mode -specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene	System	System	Human driver	Some driving modes
4	High Automation	the driving mode -specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver	System	System	System	All driving modes

** Levels of automation as defined by SAE International. (image by author, adapted from SAE International)*

AUTONOMOUS VEHICLE	CONNECTED VEHICLE
AI located within the vehicle.	AI wirelessly connected to an external communications network.
"Outward-facing" in that sensors blast outward from the vehicle to collect information without receiving data inward from other sources.	"Inward-facing" with the vehicle receiving external environment information through wireless connectivity, and operational commands from an external entity.
AI used to make autonomous decisions on what is best for the individual driver.	Used in cooperation with other pieces of information to make decisions on what is "best" from a system optimal standpoint.
AI not shared with other entities beyond the vehicle.	AI shared across multiple vehicles.
A more "capitalistic" set-up.	A more "socialistic" set-up.

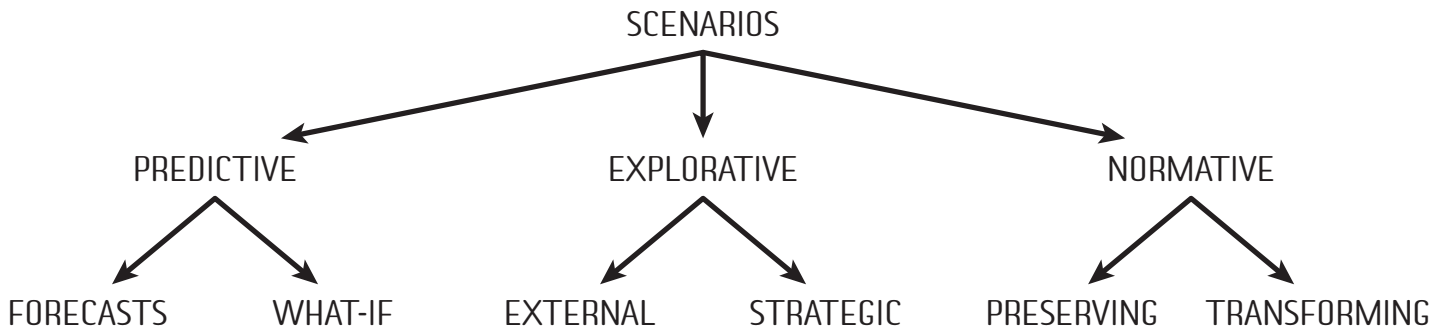
†Differences between autonomous and connected vehicles according to Bhat (2014). (image by author, based on Bhat, 2014)

Further research will provide a cohesive list of possible ways in which automated vehicles influence public space differently than regular cars. Milakis, Van Arem and Van Wee (2015) provide a comprehensive ripple scheme which features categories in which possible changes can occur as a result of automated vehicles (see page 6). The ripple scheme remains unspecific though and provides no more than mere categories. A more specific list of possible ways in which AVs influence public space differently than regular cars will be constructed over the rest of the period in which automated vehicles will be studied. The, as of yet unfinished, list looks as follows:

- Car use by children, elderly, and the disabled. Estimated to cause an increase of VKT of up to 40% (Brown, Gonder, & Repac, 2014).
- Car ownership decrease as a result of car sharing (Litman, 2015; Silberg et al., 2012).
- Car ownership increase as a result of dropping vehicle prices (Litman, 2014).
- Increased car occupancy rate as a result of car sharing (Brown et al., 2014).
- Increase of VKT as a result of fuel cost drop resulting from more efficient driving (Brown et al., 2014).
- Lower cost for freight traffic and taxis (Litman, 2014).
- Less “searching traffic” of cars looking for a parking spot (Brown et al., 2014).
- Larger vehicles to accomodate more comfortable travelling (Gucwa, 2014).
- More strictly enforced speed limits (Gucwa, 2014).
- Reduced infrastructure investments: narrower car lanes, no protecting measures, no signage, etc. (Silberg et al., 2012; Wagner, Baker, Goodin, & Maddox, 2014).
- Significant reduction of parking space in urban areas because automated vehicles drive themselves to peripheral parking spots (Anderson et al., 2014; Begg, 2014).
- Partial transformation of human-driven car infrastructure into slow traffic infrastructure because automated vehicles use space more efficiently (Begg, 2014; Silberg et al., 2012).
- Degrading walking and cycling conditions resulting from increased motorized traffic volumes (Begg, 2014; Litman, 2015).
- Reduced risk for pedestrians and cyclists because automated vehicles are not subject to human error within the vehicle (Litman, 2015).
- Different value of time because car rides can be spent more efficiently, resulting in less interaction between ‘motorists’ and the ‘outside world’ (Gucwa, 2014; Litman, 2015; Snelder, Van Arem, Hoogendoorn, & Van Nes, 2015).

SCENARIOS

According to Börjeson, Höjer, Dreborg, Ekvall, & Finnveden (2006), three scenario categories can be distinguished. These are predictive scenarios, explorative scenarios, and normative scenarios. Within each category, they distinguish two types. The first category, predictive scenarios, can be either forecasts or what-if scenarios. The second category, explorative scenarios includes external scenarios and strategic scenarios. The last category, normative scenarios, includes preserving and transforming scenarios. Each type of scenario has different uses and when using scenarios it is thus important to first establisch which type of scenario is most useful for intended purposes. For this graduation project, we need to understand what impact mobility can have on public space at a specific point in the future. To find this out, the most useful type of scenario is the external scenario. According to Börjeson et al. (2006), external scenarios are useful when one is trying to find an answer to a question in the form of 'what can happen to the development of external factors?'. This is what we're looking for, we want to know how external factors can influence the demands regarding mobility and how this influences public space. Having established what type of scenarios we will be building, we can now move on to creating a methodology for building the scenarios. This will, of course, be done based on scenario building theory.



** Scenario typology with three categories and six types. (image by author, based on Börjeson et al., 2006)*

SCENARIO BUILDING METHODOLOGY

Based on literature, a scenario building methodology has been established.† For each step of the methodology we will shortly describe what it is and what its relevance is for the process.

†Scenario building methodology (image by author)

The first step is to set the issue of concern (Chermack, 2007; Godet, 2000; Ratcliffe, 2002; Schwartz, 1991; Wright, Bradfield, & Cairns, 2013; Wright & Goodwin, 2009) and the timeframe (Schoemaker, 1995; Wright et al., 2013). In this step, it needs to be made explicit what the purpose of building the scenarios is and what the timeframe will be over which the scenarios are constructed. Failing to properly address the issue of concern can lead to failure of the entire exercise (Perrow, 1999). Explicitly mentioning the timeframe can help guiding the process. Longer timeframes relate to larger uncertainties and thus they result in more 'extreme' scenarios.

The second step of the scenario building process is to challenge the perception of scenario building participants, as Wright and Goodwin (2009) describe, people often have overly narrow or wrong perceptions of the issue of concern. Introducing a method to liberate the creativity of the human mind can (partially) overcome this, which makes the scenarios more diverse and thus more 'reliable' as the principal behind building scenarios is to explore an array of possible futures as broad as possible. Possible techniques to challenge perceptions are to introduce the theory behind espoused theories to make participants aware of their subjective perception (Chermack, 2007; Uotila, Melkas, & Harmaakorpi, 2005); the inclusion of 'remarkable people', or people who have a different expertise, who offer different views on the issue of concern (Chermack, 2007; Wright & Goodwin, 2009); the introduction of systems thinking throughout the process to stimulate participants to think more holistically (Chermack, Lynham, & Ruona, 2001; Mietzner & Reger, 2005); role-play, or making people act out roles of actors who would be involved in the scenarios to imagine how they would influence the issue of concern (Wright & Goodwin, 2009); the introduction of a pluralistic present, making participants individually create scenarios, reasoning from their own, subjective, image of the present (Vervoort, Bendor, Kelliher, Strik, & Helfgott, 2015); and drug-induced scenario building, hallucinogenic drugs can open up new pathways in the brain, liberating the creativity of participants (Salewski, 2012).

The third step is to identify the key driving forces influencing the issue of concern (Arcade, Godet, Meunier, & Roubelat, 1999; Chermack, 2007; Godet, 1987; Phelps, Chan, & Kapsalis, 2001; Ratcliffe, 2002; Schoemaker, 1995; Schwartz, 1991; Wright et al., 2013). Driving forces can be trends or events that would influence the issue of concern. According to Börjeson et al. (2006), this is an especially important step when constructing external scenarios because it is this step in which the external factors that influence the issue of concern are established. The driving forces together form the basis of the eventual scenarios. As can be seen below, it is possible to iterate back to this step after continuing to the next step when more driving forces are found.

The fourth step is to identify the key stakeholders (Chermack, 2007; Schoemaker, 1995). In this step, stakeholders are identified who have an influence on the issue of concern or the identified driving forces. When constructing external scenarios a broad range of stakeholders can be identified because both directly and indirectly involved stakeholders can be relevant when establishing the development of external factors.

The fifth step is to rank the driving forces (Chermack, 2007; Schwartz, 1991; Wright et al., 2013; Wright & Goodwin, 2009). This means they should be judged on both likelihood and impact (Schwartz, 1991). High impact, high probability driving forces should be present in all scenarios, low impact driving forces will only appear in scenarios if they fit in by chance, and high impact, low probability driving forces determine the basis of the scenarios.

The sixth step is to cluster the driving forces (Wright et al., 2013). Here, synergies or causal reletions are sought between driving forces to form clusters. Driving forces that are ranked as having a high degree of certainty will likely appear in more clusters while driving forces that are unlikely to happen will likely be limited to one or few clusters.

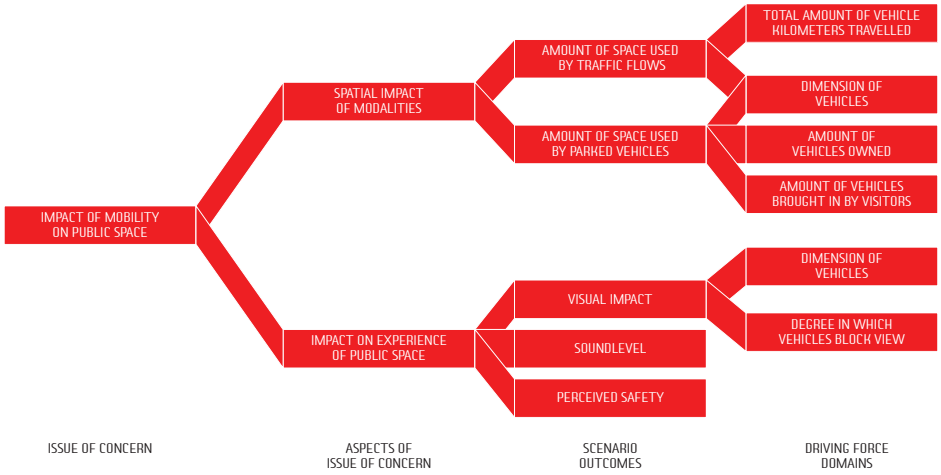
The seventh step is the initial construction of the scenarios (Arcade et al., 1999; Chermack, 2007; Wright et al., 2013; Wright & Goodwin, 2009). Here, the clusters are clustered together to form internally coherent scenarios.

The eighth step is to construct a narrative structure for the scenarios (Chermack, 2007; Ratcliffe, 2002). The scenarios are further elaborated and a narrative structure is created. Driving forces are added to complete causal chains if necessary.

The ninth step is to check the scenarios for plausibility (Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998), differentiation (Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998), consistency (Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006; Von Reibnitz, 1992; Wilson, 1998), decision-making utility (Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998), and novelty (Chermack et al., 2001; Heinecke & Schwager, 1995). Plausibility here means that it should be actually possible for the scenario to unfold as is described. Differentiation means that all scenarios should be different with respect to the issue of concern, is their outcome really different or are they just variations of each other? Consistency means that the combination of logics on which the scenarios are built should form a coherent whole. Decision-making utility means that the scenarios should be helpful in addressing the issue of concern. Novelty means that the scenarios should shed a new light on the issue of concern. The scenarios should show possible outcomes that are likely not to have been considered fully.

The tenth step is to flesh out scenarios that do not perform in all checks from step nine. After this step, there is again an option to iterate part of the process if necessary.

Finally, the scenarios can be used. They will now reflect possible futures which reveal information about the development of external factors with respect to the issue of concern.



** The issue of concern (left) dissected into sub-aspects. (image by author)*

STEP 1: SET THE ISSUE OF CONCERN AND THE TIMEFRAME

The issue of concern here is the impact that mobility will have on public space. The timeframe is between now and the point in time where automated vehicles will be ubiquitous. The impact of mobility on public space depends on a range of factors.* In the supporting image shown top left, the issue of concern itself can be seen on the left side and from there it is dissected into smaller aspects. The third column shows the desired outcomes of the scenarios. Scenarios should reflect information about the amount of space used by traffic flows, the amount of space used by parked vehicles, the visual impact of vehicles from public space, the soundlevel experienced in public space caused by vehicles, and the perceived safety of public space.

STEP 2: DECIDE PERCEPTION CHALLENGING METHODOLOGY

For this process, because of the limited amount of available time, two techniques were selected that can be used in a relatively short time. These are the use of remarkable people and systems thinking. The scenarios will be constructed by the author, who will employ a systems thinking approach and conversations and interviews will be conducted with 'outsiders' to create broader scenarios. This will be done in an informal way, both because this saves time and in order for the subjects not to hold back on 'weird' answers which are the kind of answers that can actually broaden the scenarios.

STEP 3: IDENTIFY KEY DRIVING FORCES

In this step the driving forces are identified. On the next page, a visual respresentation is shown of the driving forces. Changing mobility can be caused by changing demographics, changing reasons for travel, and modal shifts. These three categories then can have subcategories within which the driving forces are shown. These driving forces were established through many conversations, interviews, and brainstorm sessions with peers, experts, and friends.

STEP 4: IDENTIFY KEY STAKEHOLDERS

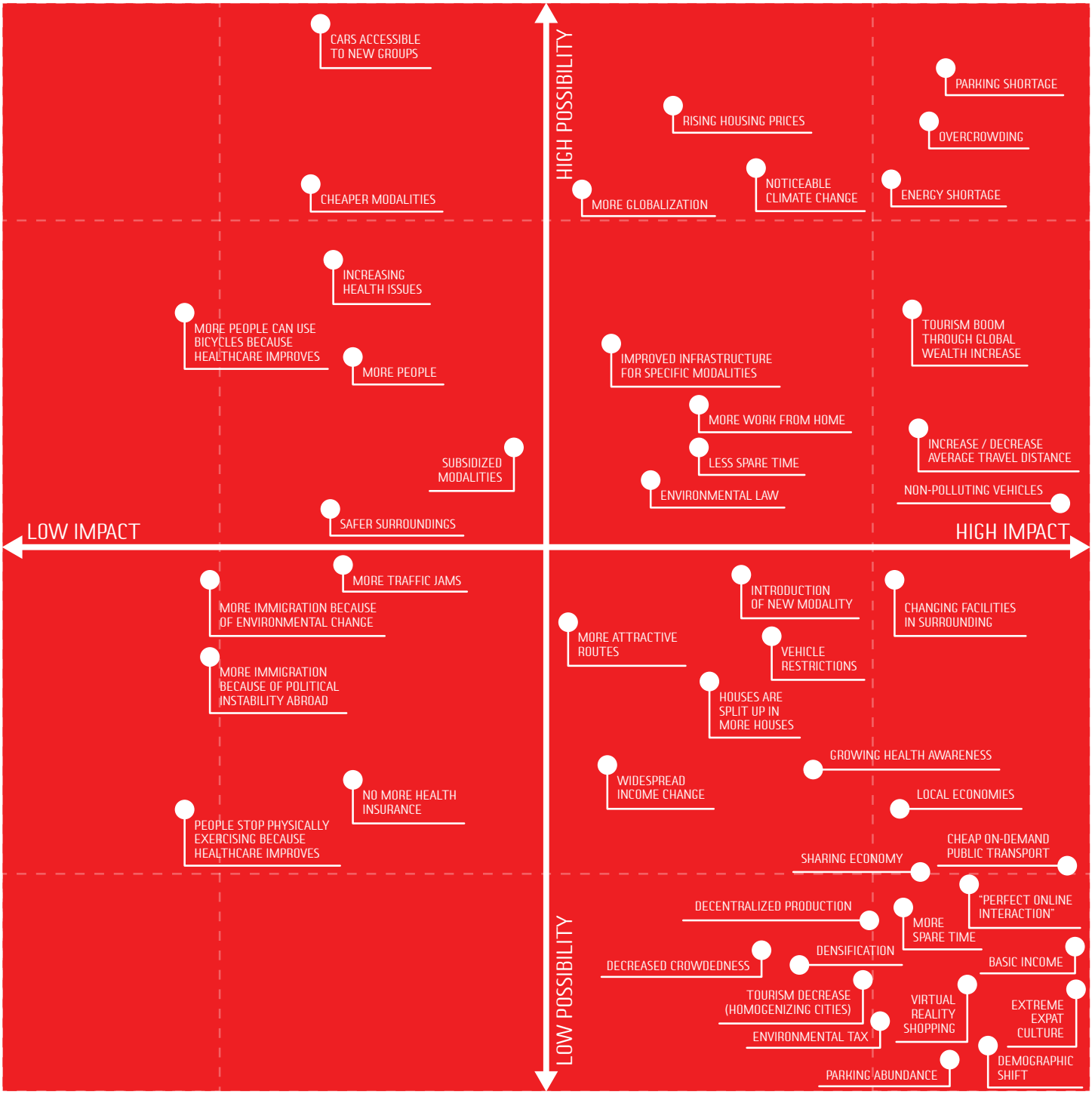
Key stakeholders that were identified are long-time residents, new residents, entrepeneurs, the public transport sector, highly educated, tourists, students, expats, travellers, elderly, young families, and the governmental institutions influencing mobility policy. These groups all influence mobility on different scales and as such their decisions and behaviour will impact the way mobility will influence public space in possible futures.

CHANGING MOBILITY	MODAL SHIFT	FINANCIAL REASONS	BASIC INCOME / SUBSIDIZED MODALITIES / ENERGY SHORTAGE / PRICE REDUCTION OF MODALITY / ENVIRONMENTAL TAX / SHARING ECONOMY / WIDESPREAD INCOME CHANGE
		CONVENIENCE, DISTANCE & TIME	VEHICLE RESTRICTIONS / TRAFFIC JAMS / PARKING SHORTAGE / PARKING ABUNDANCE / INCREASE AVERAGE TRAVEL DISTANCE / MORE LOCAL "DESTINATIONS" / IMPROVED INFRASTRUCTURE / NEW MODALITIES
		ENJOYMENT	MORE SPARE TIME / MORE "ATTRACTIONS" / SAFER SURROUNDINGS / DECREASED CROWDEDNESS
		PHYSICAL LIMITATIONS	TECHNOLOGICAL IMPROVEMENTS OF MODALITIES / IMPROVED HEALTH SECTOR
		ENVIRONMENTAL CONCERN	NON-POLLUTING VEHICLES / NOTICEABLE CLIMATE CHANGE / ENVIRONMENTAL LAW
		HEALTH	GROWING HEALTH AWARENESS / IMPROVING HEALTH SECTOR / INCREASING HEALTH ISSUES
	CHANGING REASONS FOR TRAVEL	MORE / LESS "GOING OUT"	INCOME CHANGE / CHANGING AMOUNT OF SPARE TIME / IMPROVED ONLINE INTERACTION / CHANGE IN FACILITIES
		MORE / LESS PHYSICAL EXERCISE	CHANGING HEALTH SECTOR / CHANGING HEALTH AWARENESS / CHANGING HEALTHCARE SYSTEM
		MORE / LESS SHOPPING	CHANGE IN ONLINE SHOPPING / DECENTRALIZED PRODUCTION / CHANGING CONSUMPTION PATTERNS
		MORE / LESS COMMUTING	BASIC INCOME / LOCAL ECONOMIES / GLOBALIZATION / LOSS OF JOBS / MORE JOBS / IMPROVED WORKING-FROM-HOME-FACILITIES
	CHANGING DEMOGRAPHICS	AGEING POPULATION	IMPROVING HEALTHCARE / BASIC INCOME / GROWING HEALTH AWARENESS
		MIGRATION / IMMIGRATION	GLOBALIZATION / CLIMATE CHANGE / POLITICAL INSTABILITY / TECHNOLOGICAL ADVANCEMENT
		MORE / LESS TOURISM	TECHNOLOGICAL ADVANCEMENT / GLOBALIZATION / CHANGING POLICY / HOMOGENIZATION OF CITIES / LOCAL LIFESTYLES
		APPEAL TO OTHER DEMOGRAPHIC GROUPS	OVERCROWDING / GLOBALIZATION / CHANGING HOUSING PRICES / CHANGING FACILITIES / CHANGING LIVING ENVIRONMENT / CHANGING SAFETY
		POPULATION GROWTH	DENSIFICATION / SMALLER HOUSING UNITS / FUNCTION CHANGE / CHANGING HOUSING PRICES

Identification of driving forces, left the issue of concern, right the drving forces that influence them specifically named. (image by author)

STEP 5: RANK KEY DRIVING FORCES

In this step key driving forces were ranked according to likelihood and impact.* Both rankings are based on average estimations of the author and participants. It must be noted that the gravity of the impact is specifically the gravity of the impact on the mobility and public space for the city center of Amsterdam. So, while the event in which people stop exercising physically because of improving healthcare might have a large impact on society as a whole, the impact on the mobility and public space of the city center of Amsterdam is relatively small. Possibilities are based on the assumption that automated vehicles are already ubiquitous, because this was defined when setting the timescale.



** Ranking of the driving forces according to possibility and likelihood. (image by author)*

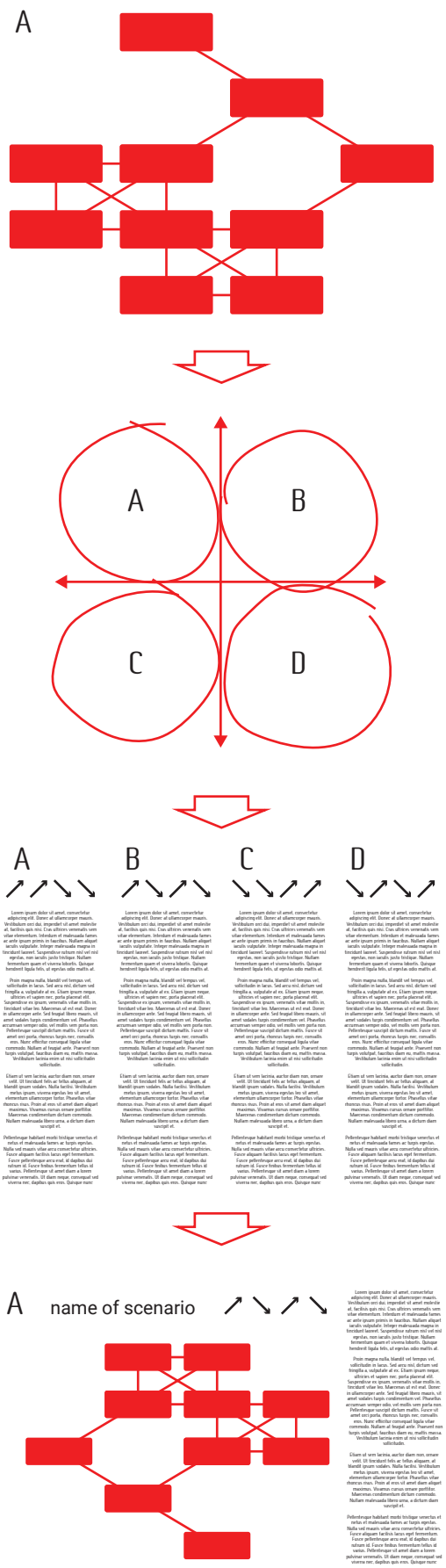
STEP 6: CLUSTER DRIVING FORCES

In this step, causal relations and synergies are sought between driving forces and clusters are made accordingly.* In the scheme, driving forces that are either causally related or between which a synergy exists are connected by lines.

** Clustering of the driving forces. (image by author)*

STEP 7 – 10: INITIAL CONSTRUCTION, NARRATIVE CREATION, CHECK, AND SELECTION

The last steps, step seven, eight, nine, and ten have been conducted through a heavily iterative process. Many iterations were made and after each iteration, the resulting 'scenarios' were reflected upon, often through conversations with peers. Scenarios is put between quotation marks here because many times the results would not actually be full scenarios but rather large clusters of driving forces or incomplete stories about the future. Even though the steps were followed during the scenario building exercise, describing each iteration in retrospect makes no sense and would obscure the important outcomes of the scenario building exercise. For this reason, instead of describing step seven, eight, nine, and ten seperately, a summary of the process will be shown in which simplified versions of the iterations and their limitations will shortly be described (also see image page 23).



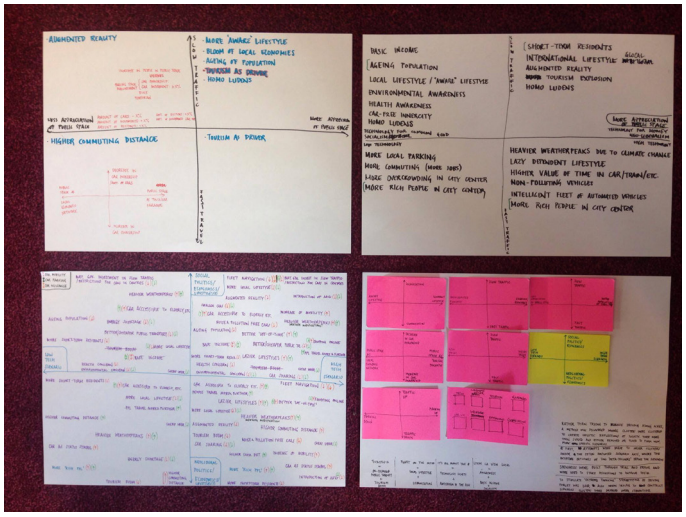
Different iterations that were gone through during steps seven to ten. (image by author)

The first iterations focused on simply clustering the clusters that were found in step six. This led to partial stories that were mainly missing consistency. The 'scenarios' were missing important driving forces that were needed to create a coherent story that is plausible to unfold based on just the combination of the driving forces that they were composed of. However, they did provide a range of possible starting points to expand from further.

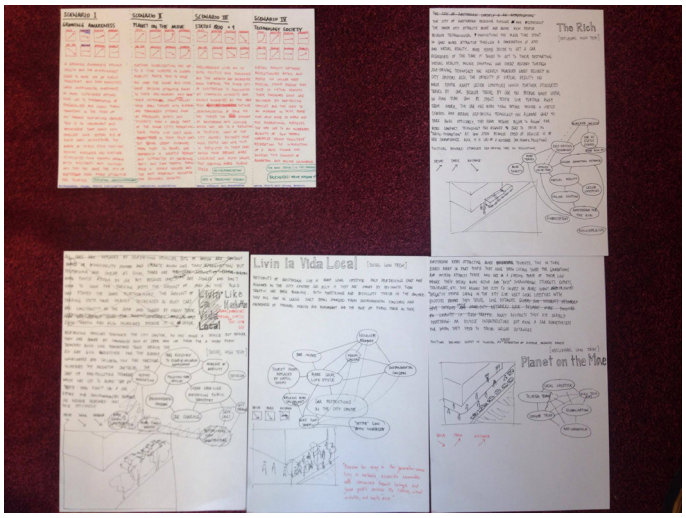
After a while, attempts were made to order the scenarios along a axes. This is a popular form of creating scenarios. In it, meta-drivers are chosen which function as an umbrella for other drivers. For example, economic growth could be such a meta-driver because when there is economic growth, it is likely that there is also more consumption, more jobs, more commuting, etc. When working with this method, two meta-drivers are positioned along axes and this leads to four scenarios where scenario B is the extremely positive outcome of both metadrivers, scenario C is the extremely negative outcome of both meta-drivers and scenarios A and D are the other two possible combinations. Worth noting here is that positive and negative do not necessarily reflect good or bad here. For example, an extremely positive traffic growth might be a bad thing depending on who judges it. While trying to create scenarios along axes, often a method was employed to think in stereotypes to stimulate the process of organization ("People who do this probably also do this and this"). Probably because of this, it was found that scenarios that were created according to this method were often overly simple, they did not reflect the holistic nature of the issue of concern. Meta-drivers that were tried were Local-Global; Awareness-Ignorance; Slow Traffic-Fast Traffic; Individual Economy-Sharing Economy; Public Space Appreciation-Public Space Depreciation; Car Ownership Increase-Car Ownership Decrease; Locally Focused Public Space-Tourism Focused Public Space; High Tech-Low Tech; Socialism-Neoliberalism; Traffic Increase-Traffic Decrease; and Parking Increase-Parking Decrease.

This method was succeeded by a method where all meta-drivers that were tried during the previous phase were combined in different ways and scenarios were then constructed around these combinations where possible. This was quickly found to be too complex and the issue of concern itself was often lost in the large amount of outcomes belonging to each scenario. However, it did embrace the holistic nature of the issue of concern.

Finally, a combination of the previous methods was employed. The clusters of driving forces were combined and through systems thinking attempts were made to create narrative structures around these clusters of clusters. Here, the clusterings found through the axes method were also helpful. The scenarios found through this last method were refined during a few final iterations. Some scenarios were combined into more holistic scenarios, some were fleshed out, and some were just elaborated further. It was after this point that it became apparant that the scenarios could still be organized along axes, namely axes containing a growth or decline of traffic on one axis and growth or decline of parked vehicles on the other axis. These are the most important outcomes of the four scenarios that were found with respect to the issue of concern but immediately placing these along axes would not have resulted in the same richness of the scenarios which will be supportive when designs will be made for each scenario later on. It is concluded that there is not one right or straightforward way of establishing the scenarios. Rather, it is a fuzzy process much resembling a design process in which the result will eventually become apparant after much trial and critical reflection.

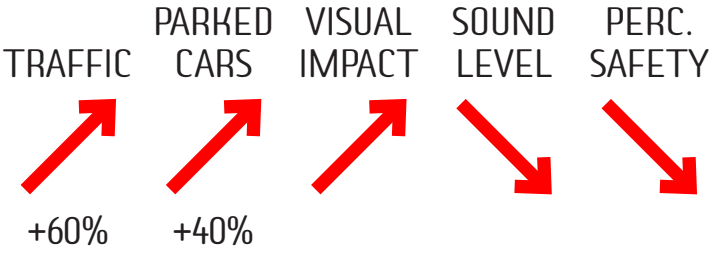


Examples of some iterations using the axes method handwritten. (photo by author)



Examples of some iterations using the meta-driver method and the combined method, handwritten. (photo by author)

SCENARIO 1
IT'S ALL ABOUT THE MONEY



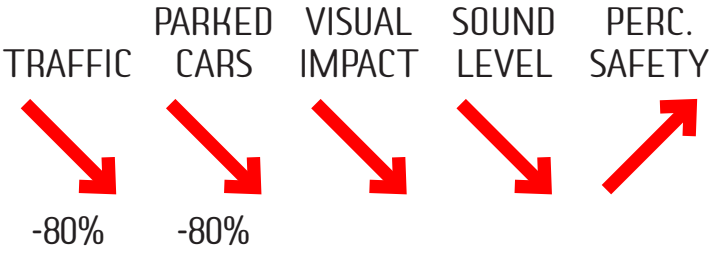
DEMOGRAPHIC SHIFT TOWARDS:
highly educated
entrepeneurs
tourists

POLITICAL CATALYSTS
laissez-faire politics

In this scenario, large technological innovations guide development largely in line with developments of the past decades. Especially virtual reality has a huge impact. People shop in virtual reality and have their purchases delivered. A select few make a lot of money and it is these people who live in the city center of Amsterdam. They have jobs all through the country and their own private office vehicles which have grown in size to accomodate office space and room for virtual reality hardware. Large commuting distances are seen as less of a problem because the time travelled can be spent well with virtual reality technology. People have adapted lazier lifestyles because of new technology which has further decreased slow traffic.

In this scenario Amsterdam keeps attracting more and more tourists. This leads to overcrowding and related nuisance. This sparks a demographic shift where the city center gets occupied mainly by demographic groups who settle in the city center temporarily for a specific phase of their life (students, expats, travellers, etc.). These groups live relatively local lifestyles with some exceptions where they travel large distances to visit family or to travel the world. Most of these people mainly move with bicycles, public transport or on foot. The amount of cars thus greatly decreases. At the same time, local economies flourish, both in the creative sector and in the service sector. The city center keeps its mixed use character and even improves on it. The density increases as more houses are split up to answer to the high housing demand at 'reasonable' prices.

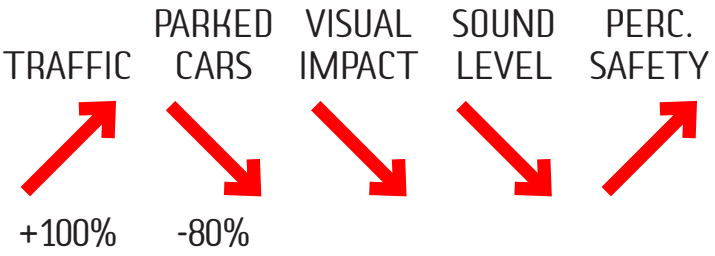
SCENARIO 2
PLANET ON THE MOVE



DEMOGRAPHIC SHIFT TOWARDS:
students
expats
travellers
tourists

POLITICAL CATALYSTS
slow traffic stimulation
tourism stimulation
attractive living environment

SCENARIO 3
TOURISTOPIA



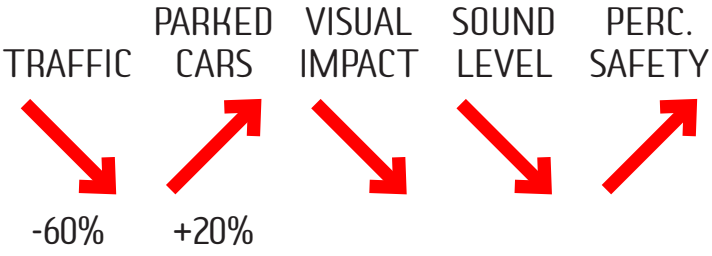
DEMOGRAPHIC SHIFT TOWARDS:
entrepeneurs
tourists
long-time residents
young families

POLITICAL CATALYSTS
stimulation of tourism
public transport investment

In this scenario global tourism booms and historical city centers are an important destination. Technological progress has sparked the use of uber-like public transport that shows up on demand and drives towards a destination of choice for a price similar to towards bus fare. Privately owned vehicles are largely replaced by this public transport. Because this automated public transport is so accessible, more people are using it than ever before and at any given moment, more vehicles are on the road than ever before. However, because these vehicles don't park, more space has become available in the city center. Also, because children can now use the cars and cars have become very safe and clean, the city center has become a popular place to live for young families.

In this scenario, climate change instigates international restrictions on mobility. As a result, slow traffic becomes more popular and local economies thrive. People still own cars but they are restricted to limited use and so they mainly catch dust along the road. Tourism also sharply decreases as a result of international mobility restrictions and the monotony of nutella-shops is replaced by a more mixed-use network tailoring the needs of locals. The political movement that has sprung from the climate change has marked the beginning of a new socialism and this has led to a basic income for everyone. This basic income has further induced a need for slow traffic and recreational public space where people can meet each other.

SCENARIO 4
LIVIN LA VIDA LOCAL



DEMOGRAPHIC SHIFT TOWARDS:
long-time residents
entrepeneurs

POLITICAL CATALYSTS
car restrictions
slow traffic stimulation
tourism reduction policies

*† ‡
Manum iam. Ibus hum te, omantes, spiemurs facta pro nos, quit.
Esce ilium, iurnirmihi, P. Cate, noverop ublicipse in nostillaris, su ia vit L. Upiosta nticena, nostistereo, ur. cuscero eluderdist vestam sestratuam id con Etritu que inemusul vius, ne mandam intium prae aperis, nit; nons lostie is cupios aude te o ius ina, ut viviu que tam, Catum nonc ora

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SCENARIOS
definitions, typologies, and methodologies

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Abstract - Design is, by definition, a discipline concerned with the future. Scenarios can help one understand uncertainties about the future and subsequently anticipate possible future events. Since the inception of scenarios the term has gone through many transformations both in literature and practice, notably within the discipline of Urbanism. This has led to confusion surrounding scenarios and their possible applications. As a result, they are rarely used anymore by Urbanism students and when they are they are often used incorrectly. In this paper comprehensive definition of the term scenario is abstracted from literature and is found to be the current state of affairs, a possible future state, and a chain of events linking present with this possible future. Furthermore, the typological categorization proposed by Börjeson, Höjer, Dreborg, Ekvall and Finnveden, distinguishing forecasts, what-if scenarios, external scenarios, strategic scenarios, preserving scenarios, and transforming scenarios, is found to be comprehensive. Lastly, scenario building methodologies from the literature are combined into a detailed step-by-step methodology that can be used by urban designers.

1. INTRODUCTION

Design is, by definition, a discipline concerned with the future. Products of design are produced in the future, be it a close or a very distant one. As such, it can be argued that designers in part shape the future. Recently, scholars have increasingly made attempts to emphasize the function of design for the future (2013; Hales, 2013; Margolin, 2007) and it is also often argued that materialising the future produces the experience of the present (Berger, 1967; Brassett & O'Reilly, 2015; Godet, 2000). Designing for longer time horizons naturally leads to higher degrees of uncertainty and as uncertainty increases it becomes more logical to methodologically address the uncertainties. Urban design, by nature, tends to deal with long time horizons and so it seems logical to study the future as an urban designer. An important tool for future studies is the scenario. Scenarios, rather than trying to predict the future, deal with possible futures (Burt, Wright, Bradfield, Cairns, & Van der Heijden, 2006; Chermack, Lynham, & Ruona, 2001; Mietzner & Reger, 2005). Furthermore, they are distinguished from other futures techniques by systems thinking and taking into account multiple futures rather than one future (Mietzner & Reger, 2005). Wilkinson states that scenario planning can help understand uncertainties about the future. This, he argues, helps scenarists recognize disrupting events early on and allows them to rehearse appropriate response to those scenarios so that they are prepared when the disruptive events covered by the scenarios unfold (L. Wilkinson, 1995). This is what Schwartz calls a future memory, it is the advantage that is created by having considered a disruptive event when it occurs even though it has not actually occured before (Schwartz, 1991). This is the core of scenario building but since their inception, scenarios have gone through many transformations in many different directions and as a result the

term is now used in many different ways. This has led to much fuzziness surrounding the term (Mietzner & Reger, 2005). Scenario theory has come to use many different definitions of the word and even more methodological approaches to working with scenarios. The same has happened to scenario building within urban design. As a result, there is a lot of uncertainty within the discipline about what scenarios are and how they can be used. This is reflected by the way scenarios are discussed within the branch of Urbanism at the TU Delft. Tutors and professors use the term in different ways, causing confusion in students and subsequently discouraging the use of scenarios. This paper try to clear up this confusion by reviewing important landmark publications on scenarios and more recent publications that expand on the most well known methodologies. In chapter two, an overview of different definitions of the term scenario will be given. In chapter three, a typological overview will be given that shows different types of scenarios and what their applications are. Finally, chapter four will bring together scenario building methodologies from literature and will combine them into a clear, step-by-step methodology for building scenarios.

2. SCENARIO DEFINITIONS

When it comes to scenarios, scholars seem to consent over one aspect, they need to address a plausible future state, that is, the described future state should be internally consistent. However, there seems to be disagreement over whether that future state should be predictive, explorative or normative. The next section will further discuss this difference as it relates to different scenario typologies. Another thing scholars disagree over is the scope of what exactly a scenario encompasses. Some scholars define a scenario as a specific future state (image 1, S3), for example, Michael Porter (1985) defines scenarios as "an internally consistent view of what the future might turn out to be – not a forecast, but one possible future outcome". Other scholars add to this the chain of events leading up to this future state from the current state of affairs (image 1, S2 & S3) (Godet, 2000; Godet & Roubelat, 1996). Another group of scholars also include the current state of affairs in the definition, thereby emphasizing the importance of research of trends that might set in motion a specific chain events leading up to a scenario (image 1, S1, S2 & S3) (Burt et al., 2006; Wright & Goodwin, 2009). By adding current trends to a scenario, these scholars define a scenario as an account of past, current state of affairs, a propagation of the past into the future and a future state. Wright and Goodwin describe this as "an explanation based on causal logic of how a particular scenario unfolds from the past to the present to the future" (Wright & Goodwin, 2009).

3. SCENARIO TYPOLOGIES

As was already mentioned in the previous section, scholars disagree on whether a scenario is predictive, explorative, normative or can be more of these. Börjeson, Höjer, Dreborg, Ekvall and Finnveden (2006) distinguish these three types of scenarios as the main categories of scenario typologies. They further distinguish some sub-typologies within these main typologies (image 2).

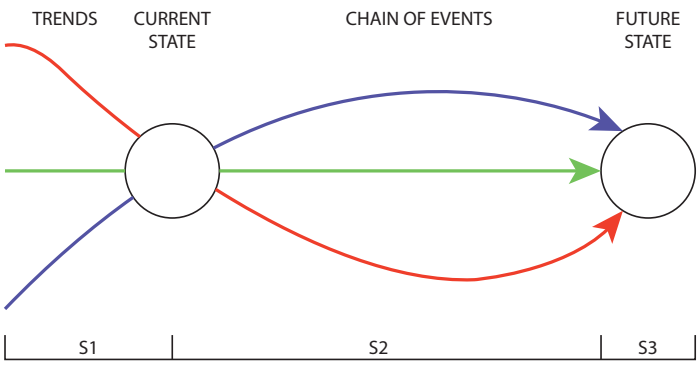

image 1. scheme of different parts of definitions for the term scenario. (image by author)

3.1 Predictive scenarios

The first category of predictive scenarios is based on the question “What will happen?”. It would be rejected as being scenarios at all based on early developers of scenarios and contradicts most literature of scenarios which specifically mentions that scenario building is about possible futures rather than probable futures. This is recognized by Börjeson et al. (2006), who emphasize that the category was added because it is often used in this way by practitioners. Because this paper aims to compare literature to urban design practice, the category was left in as well. Interesting to note here is that predictive scenarios have self-fulfilling characteristics. If an increase in car traffic is predicted, more roads will be built, which in turn might lead to more car traffic showing up through the “build it and they will come”-principe.

3.1.1 Forecasts

The first type of prediction that Börjeson et al. (2006) distinguish is the forecast. Forecasts respond to the question “What will happen, on the condition that the most likely developments unfold?”. Forecasts aim to find the most likely future. As such, they are often based on models which quantify likelihood of certain events.

3.1.2 What-if

The second type of prediction that Börjeson et al. (2006) distinguish is the What-if scenario. It responds to the question “What will happen, on the condition of some specified events?”. What-if scenarios aim to find out what is likely to happen, given that a certain event will take place. They are useful for creating an appropriate response to an event that is (likely) going to take place.

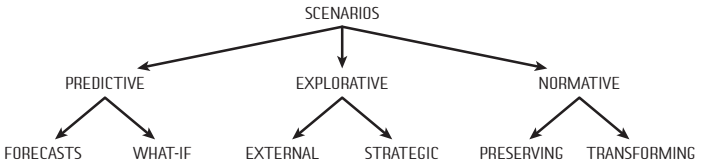

image 2. scenario typologies as defined by Börjeson et al. (2006) (image by author, based on Börjeson et al.(2006))

3.2 Explorative scenarios

The second category, explorative scenarios is the most prominent one and it is also the one most closely related to how scenarios were initially intended. It is based on the question “What can happen?”. Many authors have stated the importance of scenario building for opening up new ways of thinking and thus challenging existing views of what the future can be like, thereby helping to better anticipate what the future will actually be like to improve decision making (Chermack et al., 2001; Daum, 2001; Fahey & Randall, 1998; Kok, Van Vliet, Bärlund, Dubel, & Sendzimir, 2011; Neilson & Wagner, 2000; Schoemaker, 1995; Slaughter, 2000; Van der Heijden, 1996; Vervoort, Bendor, Kelliher, Strik, & Helfgott, 2015; A. Wilkinson & Eidinow, 2008; Wright & Goodwin, 2009). Chermack and Lynham (2002) state that for explorative scenarios, desirable outcomes of scenario building are changed thinking, improved decision making, improved human learning and imagination, plausible stories about the future and improved performance. Many authors state that for explorative scenarios, an important property is that they are able to communicate the complexities of possible futures to make sure that the relevant aspects of the scenario will actually be used (Neilson & Wagner, 2000; Ratcliffe, 2002).

3.2.1 External scenarios

Börjeson et al. (2006) distinguish external scenarios as a type of explorative scenario. External scenarios are based on the question “What can happen to the development of

external factors?". They aim at creating a strategy that is robust across a wide range of possible future developments (Börjeson et al., 2006). Van der Heijden (1996) defines external scenarios as mental models of the external world through which ranges of possible future developments are projected.

3.2.2 Strategic scenarios

Another type of explorative scenario that Börjeson et al. (2006) distinguish is the strategic scenario. It responds to the question "What can happen if we act in a certain way?" Strategic scenarios aim aim to describe a wide range of possible consequences of certain strategic decisions or interventions.

3.3 Normative scenarios

The third category, normative scenarios, responds to the question "How can a specific target be reached?". Among this category falls the planning of utopic images of the future. For normative scenarios, the study has explicitly normative starting points, and the focus of interest is on certain future objectives and how they can be realised (Börjeson et al., 2006). For normative scenarios, the scenario itself might become a tool for achieving one or more of the objectives. Scenarios have the ability to compose coherent, systematic, comprehensive, and plausible stories from a complex array of elements (Dreborg, 1996; Mietzner & Reger, 2005; Ratcliffe, 2000). This means that they can communicate aspects that were found about the future that would otherwise be very hard or even impossible to communicate with other involved actors (Neilson & Wagner, 2000; Ratcliffe, 2000). This makes normative scenarios a very powerful tool for convincing. Or, to paraphrase Vervoort et al. (2015): the imagining of future worlds can empower people in the face of the unknown to envision and pursue better worlds. Godet (2000) states that action is meaningless without a goal, strenghtening the use of normative scenarios, and quotes Seneca as saying "there is no favourable wind for the man who knows not where he is going." Like predictive scenarios, normative scenarios can have a self-fulfilling effect (Wright & Goodwin, 2009).

3.3.1 Preserving scenarios

Börjeson et al. (2006) describe preserving scenarios as a type of normative scenario. Preserving scenarios respond to the question "How can the target be reached, by adjustments to the current situation?". According to Börjeson et al. (2006) preserving scenarios are appropriate when the target can be reached within the prevailing structure of the system.

3.3.2 Transforming scenarios

Another type of normative scenarios that Börjeson et al. (2006) recognise is the transforming scenario. Transforming scenarios respond to the question "How can the target be reached, when the prevailing structure blocks necessary changes?" In contrast to preserving scenarios, transforming scenarios are appropriate when a structurally different system is required to achieve the target. A typical method associated with transforming scenarios is backcasting, this leads to a number of target-fulfilling images, which present a solution to the target. These are presented alongside a strategy of what could be done in order to achieve the target (Börjeson et al., 2006).

3.4 Combining scenarios

Of course, it is possible to use more than one scenario typology. Börjeson et al. (2006) state that having different typologies can be useful

because different typologies have different objectives. Godet (2000), for example describes a project which uses exploratory scenarios for identifying possible futures and normative scenarios to define a strategy to deal with these possible futures.

4. SCENARIO BUILDING METHODOLOGY

As Chermack, Lynham and Ruona (2001) state, there are many methods for the process of scenario building. Yet, it is hard to find a detailed step-by-step methodology. In this section, an attempt will be made to bring together methodologies described in scenario theory into one detailed scenario building methodology that can be used by urban designers. An overall structure that can be recognised in most methodologies consists of six phases. These are, chronologically ordered: setting the scope, challenging perceptions of scenarists, generation, integration, reflection, and application. Some methodologies described in the literature encompass all of these phases, others only a few. Most theories state sub-steps for the phases that they include in their methodology. In this section, all phases will be discussed in subsections which will explain which steps the phases consists of according to scholars.

4.1 Setting the scope

Setting the issue(s) of concern
mentioned by: Chermack, 2007; Godet, 2000; Ratcliffe, 2002; Schwartz, 1991; Wright, Bradfield, & Cairns, 2013; Wright & Goodwin, 2009
This is the first and most important step. It is about deciding which decisions need to be made or what the purpose of building the scenarios is. Perrow (1999) has stated that a lack of articulation about the issue(s) of concern has resulted in failure of the process.

Setting the time frame
mentioned by: Schoemaker, 1995; Wright et al., 2013
This step is, quite straightforward, about deciding a time-frame to the scenario analysis. This step can be useful for some scenario exercise but might not always be relevant. This explains why it isn't explicitly mentioned more often.

Examine past rate of change
mentioned by: Schoemaker, 1995
This step is only mentioned by Schoemaker and curiously comes before the identification of elements that drive change. So it presupposes that the rate of change can be determined just by looking at the historical development of the focal issue itself. As such, this step is also not always useful.

Estimate future rate of change
mentioned by: Schoemaker, 1995
This step, again, is only mentioned by Schoemaker. As it also comes before the identification of elements that drive change of the focal issue it can be concluded that Schoemaker is talking about a gross estimation based on extrapolation of the past rate of change and/or intuition. Like the last step, it might not be relevant for every scenario building exercise.

4.2 Challenging perceptions of scenarists

This phase is about introducing techniques that can liberate the creativity of the human mind, or can set participants free of mental maps that shape their perception. Wright and Goodwin (2009) describe several pitfalls of the scenario method which relate to narrow perception of participating scenarists. These are inappropriate framing of the focal issue, in particular by experts, and cognitive and motivational bias. Wright and Goodwin suggest that these pitfalls might be overcome

by introducing techniques that challenge participants' perceptions. Different theorists suggest different techniques and while some of these could be combined, it would be non-sensical to include all methods in one process. Therefore, the steps here are not really steps but more alternative methods that can be used to challenge the perceptions of participating scenarists.

Introduce espouses theory
mentioned by: Chermack, 2007; Uotila, Melkas, & Harmaakorpi, 2005
Here, a suggestion is made to explain to participating scenarists the difference between espouses theories, how people think they act, and how they actually act. By making explicit this difference, it becomes easier for participants to distinguish between these two and through this it is theorised that they will be more aware of their epistemological view on the focal issue which makes it easier to look at the issue from different perspectives.

Inclusion of 'remarkable people'
mentioned by: Chermack, 2007; Wright & Goodwin, 2009
Here, people who are experts on subjects seemingly unrelated or only loosely related to the focal issue are included in the process. Because these people tend to have a different point of view their inclusion can shed a new light on the focal issue and its development in the future.

Introduce systems thinking
mentioned by: Chermack et al., 2001; Mietzner & Reger, 2005
Systems thinking can create a more holistic view on possible futures. Mietzner and Reger (2005) even define it as a distinguishing quality of scenario building as a futures technique. By making explicit however, the concept of systems thinking, it is theorised that participating scenarists do a better job at thinking holistically and thus overcoming the limitations of their personal view on the focal issue.

Role-play
mentioned by: Wright & Goodwin, 2009
According to Wright and Goodwin (2009) a technique to overcome the limiting effect of one's personal point of view is role-play. They suggest that participants can imagine different stakeholders and go through the scenario building process through their point of view. They justify the legitimacy of this method through the work of Maslow (1943), stating that it is possible to reason from the perspective of other people because they rationalise from the same basic needs. According to Wright and Goodwin (2009), if the way people operate is based on the same basic human motivations, then the conditions for reasoning from other people's perspective through analogy are favourable.

Introduce pluralistic present
mentioned by: Vervoort et al., 2015
According to Vervoort et al. (2015), a method to achieve a wide range of scenarios is through the introduction of a pluralistic present, they quote Ramírez and Selin (2014) as saying: "settling into too much plausibility reduces interest into a lowest common denominator made up of commonly held assumptions, baseline expectations, 'the usual suspect' categories, and simplistic preconceptions and extrapolations". According to Vervoort et al. (2015), each participant should formulate their own, subjective, present state and start building scenarios from that view of the present. They argue that this will yield more diverse scenarios.

Drug-induced scenario building
mentioned by: Salewski, 2012
According to Salewski (2012), drug-induced illusions can shed a new light on possible

futures. As such, use of (hallucinogenic) drugs can be used to open up participants' mental models and lead to novel views of the future. Because many drugs are restricted by law however, there are ethical limitations attached to this method.

4.3 Generation

This phase is concerned with generating information about the focal issue that is necessary for further development of the scenarios. Techniques for generating knowledge are for example workshops, surveys, brainstorm sessions, interviews and panels.

Gather information
mentioned by: Chermack, 2007; Ratcliffe, 2002
This step is about quickly gathering some basic information concerning the focal issue.

Identify key stakeholders
mentioned by: Chermack, 2007; Schoemaker, 1995
This step is about identifying which stakeholders are concerned with the focal issue and what their view on the issue likely is.

Identify driving forces
mentioned by: Arcade, Godet, Meunier, & Roubelat, 1999; Chermack, 2007; Godet, 1987; Phelps, Chan, & Kapsalis, 2001; Ratcliffe, 2002; Schoemaker, 1995; Schwartz, 1991; Wright et al., 2013
In this step relevant variables are listed and forces driving the development of the focal issue(s) are established. This is one of the most important and extensive steps in the process in which the base is formed on which the scenarios eventually will be based.

In-depth historical research
mentioned by: Bradfield, Derbyshire, & Wright, 2016
This step is only mentioned by Bradfield et al. (2016), they argue that in-depth historical analysis about the focal issue can strenghten the process. They also note, however, that this step significantly extends the duration of the scenario building process. As such, this step is only useful for very specific scenario building processes in which extrapolations of historical trends could significantly improve the process.

Rank key forces
mentioned by: Chermack, 2007; Schwartz, 1991; Wright et al., 2013; Wright & Goodwin, 2009
In this step, the driving forces that were astablished during the previous step(s) are ranked according to degree of importance and degree of uncertainty (Schwartz, 1991).

4.4 Integration

Clusting driving forces
mentioned by: Wright et al., 2013
In this step causally related driving forces that were found during the generation phase are clustered. Forces with a high degree of certainty can be clustered in more than one cluster while low uncertainty forces are clustered less often.

Define cluster outcomes
mentioned by: Wright et al., 2013
For each cluster, two extreme but plausible outcomes are defined.

Initial scenario construction
mentioned by: Arcade et al., 1999; Chermack, 2007; Phelps et al., 2001; Ratcliffe, 2002; Schoemaker, 1995; Schwartz, 1991; Wright et al., 2013
Clusters are combined to form internally coherent scenarios which describe a possible chain of future developments.

Elaboration of deeper scenario structure
mentioned by: Chermack, 2007; Ratcliffe, 2002
The initial scenarios are further elaborated through a description of the underlying driving forces and systems. A narrative is created so that the scenario communicates as a coherent story.

Scenario augmentation
mentioned by: Schoemaker, 1995; Wright et al., 2013; Wright & Goodwin, 2009
The scenario can be augmented to include highly unlikely events that have no cause and can as such not be causally predicted. This step is only useful in specific cases and does not always have to be included.

4.5 Reflection

Check plausibility
mentioned by: Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998
The scenarios should be checked for plausibility. Is it actually possible that the scenario will happen?

Check differentiation
mentioned by: Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998
Are all scenarios fundamentally different or are some just variations of each other? All scenarios should be fundamentally different and more extreme in at least one aspect than the other scenarios.

Check consistency
mentioned by: Börjeson et al., 2006; Von Reibnitz, 1992; Wilson, 1998
The scenarios should be checked for consistency. The combination of logics on which the scenarios are built should form a coherent whole.

Check decision-making utility
mentioned by: Chermack et al., 2001; Heinecke & Schwager, 1995; Wilson, 1998
Each scenario should be useful. Do all the scenarios help in answering the issue(s) of concern?

Check novelty
mentioned by: Chermack et al., 2001; Heinecke & Schwager, 1995
All scenarios should shed a new light on the issue(s) of concern. Do they change current thinking about the focal issue(s)?

Fleshing out
mentioned by: Schwartz, 1991
All scenarios that do not answer to the previous steps in the reflection phase should be fleshed out. After this step, if not enough scenarios remain, the process can be iterated from the generation phase.

4.6 Application

Determine scenarios to be used
mentioned by: Schoemaker, 1995
Once enough scenarios are built, a decision can be made as to which scenarios will be used. Often this will be all scenarios that are left at this point but it might be that too many valid scenarios still remain, in that case, a decision has to be made on which scenarios will and which won't be used.

Examine implications of scenarios
mentioned by: Chermack, 2007; Schwartz, 1991; Vervoort et al., 2015; Wright & Goodwin, 2009
During this step, the implications of the scenarios on the focal issue(s) are examined. This is a lenghty and important step, which for some explorative scenarios is what the entire exercise is about.

Select leading indicators that will signify events
mentioned by: Chermack, 2007; Ratcliffe, 2002; Schwartz, 1991

If the scenarios were built with the intention of responding to specific future events, this step is mandatory. Participants decide which events signify that the future is heading towards one scenario rather than the others so that action can be taken at that point.

Determine strategy
mentioned by: Phelps et al., 2001; Van der Heijden, 1996
In this final step, a strategy is determined which responds to the events that belong to each scenario. For many scenario building exercises this is the ultimate goal of the entire exercise.

4.7 Alternative methodology

While most scholars describe methods which have a similar structure, as is shown above, there are some exceptions. Wright and Goodwin (2009) suggest a methodology where one moves backwards from objectives rather than forward through causal logic. They argue that especially the combination of both traditional scenario building and backwards scenario building can have a positive effect on the likelihood and the desirability of the eventual outcome. A method they suggest is first imagining desired or feared future states and then trying to imagine how they could have happened, given that they already have.

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