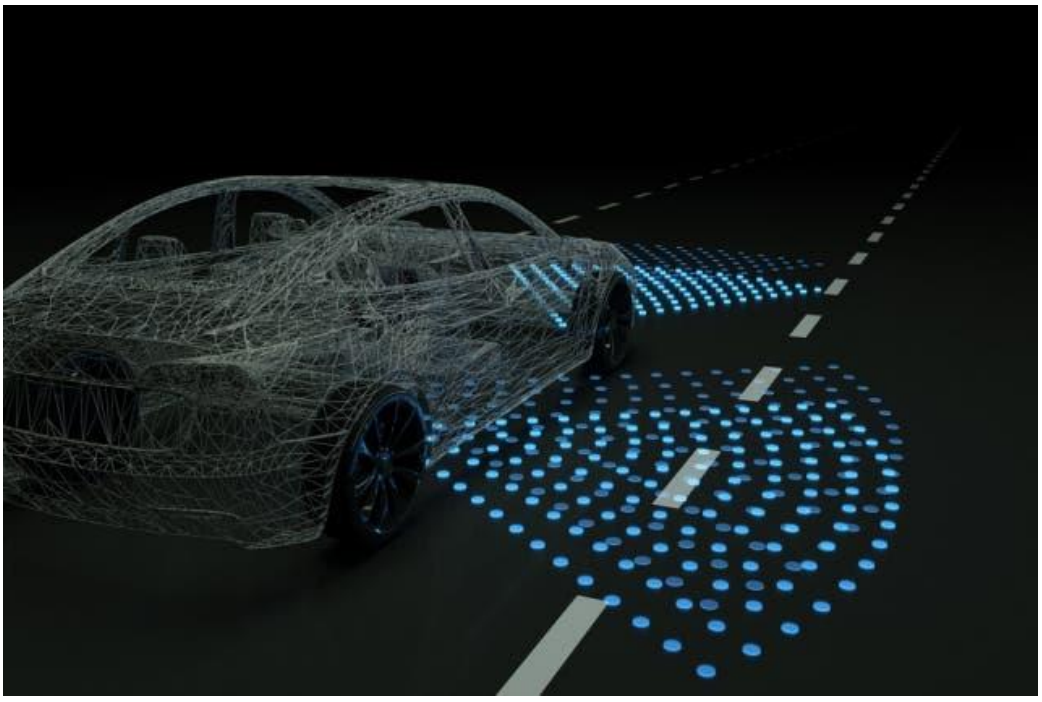
AUTOMATED VEHICLES AND LAND – USES

The case study of Amsterdam city



university of groningen

MSc student: Theodosios Velalis (s4148223)
Supervisor(s): dr. E. (Emma) Puerari

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Environmental and Infrastructure Planning program
Faculty of Spatial Sciences

Abstract:

The implementation of Autonomous Vehicles (AVs) as part of the mobility and transportation system in urban areas is one of the most prominent sectors for innovation. However, many components of the implementation have yet to be thoroughly investigated. Aspects concerning the implementation of AVs in the urban mobility system have started to be surveyed via project in various countries of the European Union. The current research study aims to explore "the challenges and consequences of implementation of AVs to the land-uses of Amsterdam city." To frame the implementation of AVs in the mobility system, the use of transition theory is applied. Moreover, the conceptual model combines specific aspects of the tension variables with the categorization of land-uses included in the research study. Additionally, the use of systematic literature review is encompassed to provide with the necessary data, since many aspects of implementation have not been fully explored. Via the literature review variables that affect land-uses investigated and based on these variables, a Scenario Building process is utilized. Following the results from the Scenario Building process, the Multi-Criteria Analysis (MCA) is used to determine the relationship between the variables explored in the systematic literature review and how they affect the land-uses. The case study of Amsterdam city area is employed to assist in the visualization and conceptualization process. Expected results of the research, even though the lack of field data for the implementation, are the strongest in the causal relationship between Density/Sprawl and the rest variables through the MCA process.

Keywords

Sustainable mobility and transportation, Transition theory, Automated Vehicles, Smart City, Land-use

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Introduction

The introduction of Autonomous Vehicles (AVs) has started to have a considerable impact on the mobility system around the globe. Currently, the AVs are implemented mainly as innovative projects, to define the consequences, modifications and societal problems, that such an implementation may create. Projects such as the "Zelfrijdend busje Olli" in Amsterdam city, Driverless Shuttle Trial in Newcastle NSW (Australia) and L3Pilot in 10 European countries have shown the complexity of an implementation. Also, lots of new issues arising in the face on an AVs implementation, that have yet to be explored. Hence, this research is needed to explore a part of the urban consequences of AVs implementation in the urban environment. The research question that is the main focus of the current research study can be described as "the challenges and consequences of implementation of AVs to the land-uses of Amsterdam city." Also, the exploration of the tension variables between the AVs and land-uses is explored. Furthermore, these tension variables are considered as the central axis that connects the implementation scenarios with the theoretical framework. The criteria or components that are discovered through the systematic literature review are used to create possible scenarios. After the completion of the scenario narrative, the application of Multi-criteria analysis (MCA) is conducted to assess and evaluate those scenarios.

This research study is structured by five parts that will ultimately serve as the chapters. The first part will serve as an introduction, that will present and elaborate in the theoretical framework of the study. In the first chapter, the theory that the analysis is based, is included. The distinction between the terms of transition and transformation is described, and an elaboration on transition theory is made. Additionally, the tension variables are presented and explored to depict the link between the theory and the conceptual model. Also, the definition and taxonomy of AVs is included to describe the link between the transition theory and AVs' implementation. The second chapter is devoted to the elaboration and synthesis of the conceptual model of the research. Moreover, this chapter describes the methodological process that is included in the current research study. The third chapter includes the process of the systematic literature review and the results that derive from this process. It should be mentioned that the research question for the current study had to be redefined due to the nature of the topic and available data. Hence, in the process of this literature review, the main research question was modified from "the challenges of implementation of AVs in the public transportation", to the current research question, "the challenges and consequences of implementation of AVs to the land-uses of Amsterdam city." However, this modification could pose a possible obstacle for the progress of the literature study since the definition of the research question is vital to the results generated. Moreover, the Scenario Building process is included in this chapter, that is the focal point between the literature review and the MCA that is employed for the selected case study. After the completion of Scenario narration, the MCA process is presented along with the evaluation of each scenario. During the MCA process, a stakeholder analysis is made to ensure the correct conceptualisation of the context of the case study. After the stakeholder analysis, the criteria of the MCA process are presented, and the MCA matrix is formed. The use of GIS software was deemed necessary for the depiction and visualisation of the current state of the case study area, and the variable visual representation. Next, the fourth chapter of the current research study includes the results of the analysis framework. Also, a summary of the overall process of study is encompassed and the drawing conclusions for the optimal scenario. Lastly, guidelines derived from the concluding remarks are presented in this final chapter of the current research study; Thus, concluding the process of the current thesis.

1 Theoretical Framework

Transition is referring to the state where significant changes are taking hold and alter the current state of the regime. Due to this characteristic, transitions are considered to be complicated and long – term processes that are the result of pressure from multiple actors (Geels W. F., The multi-level perspective on sustainability transitions: Responses to seven criticisms, 2011).

The transition theory derives from the realisation of societal complexity and the introduction of "wicked" problems. The dominant characteristic of these problems is that they are unstructured/undefined and that derive from many aspects and levels of society (Rittel & Webber, 1973). One of the approaches for analysis of these persistent, "wicked", problems are complex systems theory (Loorbach D., 2010). The realisation of society as a complex system gave the fertile ground for ideas such as innovations, non-linear approaches and uncertainties that are crucial elements of societal change and revealed dynamics, patterns and mechanisms that are frontrunners for the societal systems (De Haan, 2006 in Loorbach D., 2010). Transition theory has two different perspectives that dominate the current literature: Complexity perspective and Policy perspective. The first is focused on the complex adaptive systems, and on the other hand, the Policy perspective is more focused on policy changes. So, transition theory can be descriptive, prescriptive and normative, which means that it can analyse changes and transitions in socio-technical "environments", it can develop governance strategies and policies. Also, the goals for transition theory are clear and well defined, which makes transition theory a normative theory. The theory of complex adaptive systems is the base for the complexity perspective of the transition theory. That being said, according to Loorbach (2010), transitions derive when the dominant structures of the socio-technical "environment" become unstable due to pressure from exogenous or endogenous "forces". The transition theory tries to analyse the complex interactions of various "agents" (individuals, organisation, networks, regimes) and the progression from a stable regime state to another non-linear trough changes (Loorbach, 2010).

According to transition theory, the socio-technical regime is highly dependent on the "socio-technical landscape". According to Rip and Kemp, the term of the socio-technical regime is believed to be the broader context that influences the niche – innovations as well as the regime dynamics (Rip and Kemp, 1998). In this level, the material and technical settings are including along with demographical trends, the political ideologies and philosophical concepts, the macro-economic designs and the values that correlate to the existing social standards. The landscape-level fluctuates as a result of various factors, such as climate change, that slowly alter throughout time.

One other level of the transition theory is the various niche – innovations. By niche – innovations, this study is referring to the definition mention by Frank W. Geels, that niche innovations are "protected spaces" (Geels W. F., 2011). In these so-called, spaces, innovations are brought to attention because of the demand of various users that have special needs that the current regime cannot meet and that through innovative concepts those need can be met. These niche – innovations play a very crucial role in transition theory, because they propose and lead the way to new pathways that the current regime cannot trespass and provide the system with the choice of change. These innovations are being promoted and developed by actors that work in small networks and often are peripheral or recluses to the regime that is currently dominant.

Following the above concept of transition theory, it is required here to distinguish the difference between the terms of "transition" and "transformation". In various cases, use the terms of "transition" and "transformation" are almost interchangeable. However, even though the two terms share a metaphorical expression of ambition to change and alter the environment or the social-technical structure by utilising solutions, the two terms have fundamental differences. The two terms have a slight distinction on how to

describe, interpret and support radical non-linear alteration (Hölscher, Wittmayer, & Loorbach, 2018). The comparing application of the term "Transition" and "Transformation" in the system focus dimension is that the first focuses on the complex adaptive systems and the second in the large-scale processes of change in combination with social-ecological interactions. However, even if the two terms share the same dynamic and processes, the 'Transition" term develops around the way non-linear changes occurs, whereas the "transformation" focuses of the patterns of changes emerge and their consequences. Also, "transition' focuses on interventions that support sustainability transition, and "transformation responds to the effects of changes concerning individual motives and values to support the transformation. Also, "transition" refers to the process of a non-linear shift from one dynamic equilibrium to another. Also, the terminology of sustainability transition concerns the large-scale societal changes that are introduced as essential for solving "grand societal challenges" (Loorbach, Frantzeskaki, & Avelino, Sustainability Transitions Research: Transforming Science and Practice for Societal Change, 2017).In this research, the term "transition" is going to be used. There are two models to describe a transition: Multi-Level Perspective (MLP) and Multi-Phase Perspective (MPP). Also, the Policy perception is more focused in the prescriptive side of transition theory and includes the transition management concept.

1.1 Multi-level Perspective

The multi-level perspective is a framework that is used for unravelling the complex interactions between the agents of a socio-technical system, that may occur in many facets and levels (Geels W. F., 2010). According to the multi-level perspective, there are three analytical levels: Niches, Socio-technical regimes and Socio-technical landscapes. These levels, who were introduced in the above paragraphs, are vital for the conceptual framework for the current research study. This essentiality of these levels is based on the multi-level perspective that every complex adaptive system can be described using these levels of reference. These levels are the configurations that increase the stability of the socio-technical systems (Geels W. F., 2010). The patterns that exist in a socio-technical system and define the interactions between the agent of the socio-technical system are called "Socio-technical trajectories".

Niches - innovations: Are novelties that are primarily unstable and radical that emerge from the micro-level. They are considered to be low-performance socio-technical configurations that are carried and developed in small dedicated networks of agents, may often originate outside of the socio-technical system (Geels & Schot, 2007).

Socio-technical regimes: The notion of socio-technical regime includes the broader community and their activities. This inclusion means that everything is regarded as a normality, in scope that the socio-technical system is included. The socio-technical regime can lead to lock-ins, path dependency and cognitive routines that stabilise the existing trajectories (Geels & Schot, 2007).

Socio-technical landscape: It is the exogenous environment that exists outside of the direct influence of the other two levels and their agents. The socio-technical landscape consists of the macro level, and its changes are far slower than at the rest of the levels. (Geels & Schot, 2007)

The paper from Geels W. Frank (2002) present an elaborate research in the concepts mentioned above of niches, regimes and landscape.

As it is apparent, the MLP is a framework that is more incline to the scale and relation between the socio-technical levels of the system and has little influence from the agency in the whole socio-technical system. The latter is one of the main criticising points and structures the main arguments of the opposing analytical frameworks. As it is stated in from Geels & Schot (2007), in contrast to the breadth of the socio-technical regime concept, the regime transformation is mainly depicted as a monolithic and inflexible

process that derives from rational thinking and choice and as such it is overlooking disparities in perspective.

One central concept that should be mention at this state is how regime transition is happening and what are the drivers that enable these transitions. According to Smith et al. (2005), the regime transition is dominated by two transformation processes: shifting selection pressures on the regime and the coordination of resources (Smith, Stirling, & Berkhout, 2005). In this concept, the transformation term is used as an interchangeable term for transition. By the term "selection pressures", it consists of the pressures that being applied by the socio-technical landscape and its changes, and by the pressures that the niche-innovation level can apply to the socio-technical regime. The fore mention transformation processes are visualised as two dimensions that form four types of transitions. These types of transformation have the following categorisation:

"Endogenous renewal": this type of transformation happens when the internal agency of the regime, using the internal resources, response to the identified pressure by making rational choices and calculated endeavours (Smith, Stirling, & Berkhout, 2005).

"Reorientation of trajectories": an external or internal shock in the dominating regime has, as a result, a response of the regime's agency using the internal resources. This response leads to a type of transition that is identified as "reorientation of trajectories" (Smith, Stirling, & Berkhout, 2005).

"Emergent transformation": as a result of uncoordinated pressures that originate from the niche-innovation level, that is outside of the dominant regime, leads to this type of transition (Smith, Stirling, & Berkhout, 2005).

"Purposive transitions": these types of transitions are a result of a coordinated and rational choice that occur from outside the dominant regime. These types of transitions are deliberated and intent to meet the needs of different societal expectations or interests (Smith, Stirling, & Berkhout, 2005).

As it is apparent, this type of conceptualisation of typology of transition is more incline to the governance aspect of transition theory. Even though the use of this typology of pathways is crucial to understand and explain how transitions happen, it is vital to realise that variable that creates tension and may result to transitions are often intertwine and can work parallel. Hence, most pathways can be explained not at the time of their unfolded but at a later time and with great caution. This characteristic makes this categorisation more prone to the transition management perspective, that is excluded from the context of the current study as it is normative, thus on another conceptual frame that this study. Geels and Schot (2007) criticise this typology as, according to their perspective, every transition becomes coordinated and planned in process, after the alignment of visions. Following the above categorisation of transition pathways, the plausible transition from conventional vehicles to AVs can be described by the fourth category of the transition pathway.

The transition for conventional road transportation system to an automated one, share lots of similarities with the fourth category of transition pathways, namely "purposive transitions" (Smith, Stirling, & Berkhout, 2005). As it is apparent in the context of the current study, the transition from conventional automobiles to AVs is supported by supra-national organisations such as the European Union (European Commission DG Internal Market, Industry, 2017), and international corporations such as Tesla Inc. (Tesla Inc., 2020). Hence, the transition pathway, described in the above categorisation, that is aligned with the current progress of the AVs implementation transition is the purposive transition category.

1.2 Multi-Phase Perspective

The use of multiple-stage/phases to describe the transition of a socio-technical system is not a new concept. The multi-phase perspective adds the dimension of time to the transition analysis by dividing the transition concept to multiple phases that can then be analysed and elaborated on individually. Even though the Rostow (1960) and Boulding (1970) had used multiple phases to define transitions, this study is more concentrated on the multi-phase perspective as it is presented in Grin et al. (2010) where the 4 phases are used to describe a transition in socio-technical systems (Grin, Rotmans, & Schot, 2010). These four phases are as follows:

1. **The pre-development phase:** In this phase, the equilibrium of the socio-technical system is dynamically changing, but the results are not yet to be seen as the changes are majorly taking place in the background.
2. **The take-off phase:** This is the phase where the threshold of the background changes is achieved, and the process of transition is starting to become visible.
3. **The acceleration phase:** This phase is the stage were the structural changes, of the socio-technical system, are becoming visible.
4. **The stabilisation phase:** Where a new equilibrium state is achieved, and even though it is dynamic, the socio-technical system is considered to be at "inertia". (Grin, Rotmans, & Schot, 2010)

Otherwise called the S-curve, from their figurative representation of an S that starts with the pre-development phase and ends with stabilisation phase. This representation depicts the change of equilibrium state and stabilisation to a new state of equilibrium (Van der Brugge, Rotmans, & Loorbach, 2005).

The multi-phase perceptive can be used in parallel to the multi-level perspective to define and analyse a transition in a socio-technical system. Also, it should be mentioned that the five-stage model that Rostow (1960) used to describe the economic development through the concept of transition theory, is more focuses and applicable in the developed countries of the globe and is more fixed in the growth that the development in the broader context. The visual representation of the transition phases of the MPP is the so-called "S" shape curve that represents the ideal transition process. In this ideal transition, the societal system can achieve a higher level of organisation and complexity by adjusting to the external and internal changes (Grin, Rotmans, & Schot, 2010).

The obstacles for the ideal transition to happen is, among others, the path-dependency and lock-in situations that every societal regime is establishing. Path-dependency happens because the investment of agents of the dominant regime have made to keep the regime as stable as possible. This situation has as a result that, the previous choice that the societal system has made exclude some opportunities. According to Grin et al. (2010) for the system to break free from this path-dependency and inertia, some external force must be applied. This external force could be from the societal landscape or the niche-innovation level. This situation varies and is discussed in-depth on the following subchapters.

Moreover, due to path -dependency and pressure applied by the dominant regime in the societal system, there is the possibility that the system's innovations become blocked and never accomplice to gain enough momentum so as the transition process to proceed. This lack of momentum means that the system can be led to a reverse transition process, and the system will eventually die (Grin, Rotmans, & Schot, 2010). These alternative versions of the "S" shape curve depict the possibilities of the "Lock-in", if the acceleration state is not prosperous, the "Backlash", if the new equilibrium is not achieved, or the "System Breakdown" state that the state of the system is dissolved (Grin, Rotmans, & Schot, 2010).

1.3 Link – AVs & Transition Theory Link – AVs & Transition Theory

Mobility is one of the main pillars, upon which, the current societal system is founded. The issue of transporting persons or goods from a point A to point B with the most efficiency in time and resources is and has always been a complex matter. The reason behind this complexity is because the mobility issue is ever-changing in definition and nature. This characteristic of mobility is due to the technological innovations that have been introduced now and then in the socio-technical regime making the transportation issue more efficient but more complicated. The means of transport, policies and laws that regulate the transportation system as well as the various stakeholder parties that have an interest in the field of transport are adding complexity to the already complex system of transportation, as the time progresses.

Transition theory derives from complexity theory and tries to conceptualise the transitions that occur in complex adaptive socio-technical systems. On this notion, one of the significant technological/product/system innovations in the transportation systems around the globe, namely the Automated Vehicles (AVs), will challenge the landscape of the transport system to change drastically. When becoming true/concrete, the implementation of AVs will create a transition in the transportation system that will affect not only this system, but the entire socio-technical system of our society, as shown in the papers of Papa & Ferreira (2018) and Ferreras (2013).

The impact of AVs' implementation in the transport system is indicated to be great, but the academics and researchers cannot predict the whole depth of change and the outcome that will have as a result (Papa & Ferreira, 2018). Be that as it may, the majority of literature documents agrees that some critical decisions have to be taken to steer such transition (or in other words transport systems change) to a desirable outcome.

Two main changes, distinguishable by nature, have been identified. First, those that can be easily predicted since they are in direct influence of the adoption of AVs in daily life. Second, those that are not so easily deductible because they are influenced by employing the implementation of the AVs in the transport system. Some of the impacts that the AVs are bound to have in our socio-technical system can be divided into the following categories (Thomopoulos & Givoni, 2015; Papa & Ferreira, 2018; Gavanas, 2019):

- Transportation
- Land-use
- Other infrastructures and technologies
- Planning
- Governance

These categories include aspects of the transportation system that will be affected by the possibility of implementation of AVs innovations. The following paragraphs try to elaborate on the categories as mentioned above and present with some foreseen changes that may occur through the implementation process.

First, the changes in the transportation category that derive from the implementation of AVs are relevant to safety and mobility. Statistic studies have shown that a significant part of road incidents occur due to the viability factors in human perception and reaction (Ferreras, 2013). This characteristic means that with the implementation of AVs in the transportation system, a large percentage of the incidents that are happening in the road transportation system could be avoided. Also, disutility and travelling time, considered as expenses, can reconsider as advantages through the implementation. This advantage can help the public transportation system to an extent even further without the limitation that human drivers impose.

Secondly, Land-uses are bound to be affected by the implementation of AVs. Due to the history and characteristics of the land-uses, the implications of the implementations can be very different. In the current study, the focus is concentrated into European cities, such as the case study of Amsterdam city. European cities have high density in comparison to the American ones; this characteristic influences the public transportation system, as well as the land, uses that exist inside the cities (Gavanas, 2019). Because of the history of the human society, most cities have centres that have been organised and created long before the existence of automobiles, which means that the roads and Land-use of the historical centres of most cities are not suitable environments for private automobile's usage.

Thirdly, with the implementation of AVs in the transportation system, a large number of infrastructures and technologies will have to adapt and be replaced. For the AVs to have optimum efficiency some infrastructure, such as roads, sensors, receivers and another crucial part that will need to be constructed or replaced for the implementation of AVs. Also, these alterations will affect the way that planning will be produced. This change in the planning process means that regulation and policies, as well as urban design and planning, will be change accordingly. Zoning and Land-use permits may be affected as the implementation of AVs will have an impact on the cost of travel time and the safety.

Last but not least, governance and regulation are going to change for the socio-technical regime to respond to this transition effectively. One of the main changes that the implementation of AVs, either on the public or on the private transportation, will surely achieve will be the impact that transportation and commune will have in our daily life. Although these are some of the categories that the implementation of the AVs will affect, either direct or indirect, some other alterations are not so straightforwardly predicted and will require much investigation to discover them. Because of this, the current study will include only the above mention categories of factors.

The above paragraphs present some central categories that are bound to be affected by the implementation of AVs in the public transportation system. The planning category, and the possible challenges, will be the central point of focus in the current study. This "restriction" does not mean that the ramifications, by the AVs implementation in the public transportation, to the other categories will be excluded. However, the current study will restrict itself to the extent of interactions between the planning category and the other ones.

One of the main crucial concepts for the planning and realisation of the transport system is the concept of accessibility. As a critical resource for the accessibility concept, this study will refer to it by the work of Geurs and Van Wee (2004). Accessibility is defined as "the extent to which land-use and transport systems enables individuals to reach activities using a (combination of) transport mode(s)" (Geurs and Van Wee as mentioned in Papa & Ferreira, 2018). The components of accessibility concept are: land-use, transport, temporal and individual.

As mentioned above, implementation of AVs either in the private ownership market or in the public transportation, will have consequences in the land-uses of a city. These consequences mean that the accessibility and restriction of the land-uses may change accordingly. Individuals may gain or lose accessibility due to changes in the land-use restrictions that may not always be a result of regulations but only as a product of other factors such as travel time.

The notion of transport as it is conceptualised in the accessibility concept derives from the features of the transportation system and the utility indicators for an individual to use this transportation system to reach the destination (Papa & Ferreira, 2018). This notion is directly linked to the temporal concept that derives from the "time gap" that is available to an individual to use, participate or take advantage of the transport system for the continuation of his/her activities. Inclusion of accessibility as a factor in the

transportation planning reveals that some of the features that categories the transportation system as a "complex adaptive system".

1.4 Automobility as a Concept

The concept of automobility has a duality in its perception. According to Urry (2004), the term "automobility" includes two concepts. The concept of the car-driver as a hybrid of specific human activities, that derived from motion and transportation, and the concept of automaton or automatic, that includes the objects or machines that can have a capacity for movement. In other words, the concept of "auto" mobility includes the notion of autonomous humans that in combination with machines can autonomously move along the designated areas that are purposefully constructed for this kind of activities (Urry, 2004).

Based on this perception, "automobility" can be perceived as a non-linear, self-organising system that is ever-expanding in the global perspective. The self-organising characteristics of the automobility system can be identified, as, after the invention of the current petroleum car, the whole complex of mobility has started to grow without limit. The automobility system includes the infrastructures, peripheral activities and many novel objects, technologies and signs that contribute in order for the system to regulate. The automobility concept created a path-dependency phenomenon to the social structure of society, creating thus the necessary conditions for its self-expansion.

"Automobility" is a conception that uses the "freedom of the road" as a source for its validation. It is not strange that the past century was named "century of car" as its expansion has exceeded many limits over the past years (Urry, 2004). This feeling of freedom changed the urban and regional planning rapidly, making the car as a dominant means of transport and the pillar that upon it is based on the daily routine of many human activities. The innovation of car has altered the way that the city was planned, zoning the districts and separate social and economic deeds that were integrated for thousands of years. By doing so, the complexity of the planning process has increased expediential and thus creating a complex and self-organising system.

Nevertheless, the automobility concept could not exist without the innovation of the automobile. The concept of the automobile gave the human society the flexibility of transportation, and at the same time, through its many alterations and modifications, it made every human being a potential driver. Based on that notion, the petroleum vehicles shortened the time of transportation. They created the need for infrastructure that will connect every possible destination as it is apparent for all the innovations that the human society has created, the strife to exceeded the limitations is ever-present making "fertile ground" for new inventions and novelties.

1.4.1 Definition and taxonomy of Automated Vehicles (AVs)

Moreover, since computer engineering and wireless connection has become a commodity in our time, the new technology automobiles have created a future scenario that was considered to be impossible in the past. Automated Vehicles that will be able to function without the intervention of the driver are a possibility soon. However, there is a considerable variation of vehicles that include the Advanced Driving Assistance System (ADAS).

According to the taxonomy of the SAE International organisation includes six categories of vehicles that Automated Driving Systems (SAE International, 2014):

Level 0 – No Automation: This category of vehicles includes the vehicles that the human intervention is at its highest. The human driver performs the driving operation, but there is an assistance from the electronic parts of the vehicle.

Level 1 – Driver Assistance: In this category, the driver's task is assisted by a driving assistance system in either steering or accelerating/decelerating according to the data that it perceives from the external environment. The driver performs all other functions and activities.

Level 2 – Partial Automation: The driving assistance system has full control of the steering and acceleration/deceleration functions, while the human driver has the supervisor of the driving environment and fallback performance of the dynamic driving task.

Level 3 – Conditional Automation: The control of the steering, as well as the control of the acceleration/deceleration process, is entirely operated by the driving assistance system. The monitoring of the external environment is also in the duties of the assistance system, leaving only the fallback of performance of the dynamic driving task in the intervention of the human driver.

Level 4 – High Automation: The control of the environment, as well as the execution of the steering, acceleration/deceleration and fallback performance processes, are in the control of the driving assistance system, leaving only a few driving modes of the system's capacity in the control of the human driver.

Level 5 – Full Automation: all aspects of the dynamic driving task are performed by the driving assistance system in every environment and fallback situation. Every driving mode of the system's capacity is automated, and the intervention of the human driver is not required to perform the dynamic driving task.

It should be noted that the levels 0 to 2 are considered to be in the supra-category of "Vehicles that the human driver observes the driving environment", whereas the rest levels are in the supra-category of that the ADS is supervising the driving environment. In the context of this study the investigation for the implementation and the consequences of it in the urban palling transportation environment, refers to the vehicles that belong to the second category, the levels 3 to level 5 Automated Vehicles.

1.4.2 Government intervention

According to the argumentations of Cohen and Cavoli (2019), the scenario of the introduction of level 4 and 5 AVs in the social context of the liberal and market-driven developed countries will have a negative effect without the intervention of government. This assumption is based on level 4, and level 5 AVs introduced to the market as other automobiles in the past. The consequence of such an introduction is established on a "Laissez-faire" scenario. Their scenario is grounded upon two main arguments.

First, the transport ownership and use models of the present will continue in this future development. This assumption is based on the empirical results of the level 1 driving assistance automated systems that have already become part of the current mainstream production. Also, the conventional cars will slowly be replaced by the AVs on account that the production and use of the conventional cars will become obsolete. Second, that even of the shared AVs become mainstream, which is possible, the ownership of these shared AVs will be on the hands of profit-driven private companies that will be allowed to compete for the market share without restrictions from the government.

Based on this type of scenario, the paper draws some conclusions that are in alignment with the argumentation line provided in the current study. On the aspect of traffic congestion, the private ownership of AVs will give the possibility for a large amount of the current population to participate in the surface transportation system, a fact that will deteriorate the state of the current traffic environment. Another crucial argument in the results of this specific paper is that the implementation of AVs in regards to the accessibility feature of the passenger transportation. This argument involves the gap between the poor and rich in regards to the accessibility will be eventually widened by the introduction of the AVs to the private market ownership. (Cohen & Cavoli, 2019).

Also, another focal point in the prediction pattern of the AVs' implementation can be found in the exploration of possibilities that such an implementation may have in the land-uses of urban planning processes (Litman, 2020). The use of AVs can alter the urban development policies; thus, the Land-use regulations, by two possible outcomes. The favourable scenario is that through the use of AVs, the transport policies will achieve to promote the quality of life and urban areas can become more attractive for residency (Papa & Ferreira, 2018). Most of the affected land-uses will be associated with parking space and density/sprawl. However, the adverse scenario is that the focus of the urban land development will be fixed to accommodate the use of AVs, hence detriment the other social groups (Litman, 2020).

As it is apparent, the focus point of the current research study, is the land-uses in relation with the implementation of the AVs. The literature that has been located for the completion of the current analysis framework is presented in chapter 4, were an elaboration of the systematic literature review process is depicted. Following this argumentation, the main research proposal of the current topic can be more crucial in the way of implementation of AVs shortly. By implementing the AVs in the transportation system, the government will provide the majority of the citizens with opportunities and attributes that will be otherwise impossible for the broad majority to have access to these services.

Besides, the majority of the road accidents are due to inattentions and human errors, that are the result of speeding, alcohol and fatigue (European Commission DG Internal Market, Industry, Entrepreneurship and SMEs, 2017). The AVs could create a safer public transportation system that will simultaneously decrease the cost of public transportation and give the authorities the possibility of creating a more reliable and elaborate network of transportation.

Concluding this briefly theoretical overview of the transition theory and its analytical concept, at this point, it is crucial to mention that the transition theory is a relatively "new" concept based on the notion of perceiving the societal systems as complex and adaptive systems. However, the background literature for transition theory and its conceptual parts is rather broad and evolving rapidly. Transition theorists have investigated transitions that have either developed on their own due to exogenous needs of societal system or have been dictated by entrepreneurs and strategies like energy transition in the Netherlands, which because of the recent climate change impacts have become a much-heated debate.

To link the transition theory with the research topic of the current study, it is found crucial to present a brief background review in the concept of the Automated Vehicles (AVs) and its scientific history that relates to the topic of unique and urban planning. This review will help the reader understand the link between the automobility concept, the transition theory and complex adaptive systems.

2 Conceptual Framework

2.1 Variables of the current relationship between AVs and Transportation regime

As mentioned in the above chapter, the alteration that will occur after the implementation of the AVs are numerous. On this account, there is a tension between the current dominant transportation regime, that is driver centred, and the AVs' niches. This tension derives from the factors that prevent or delay the introduction of the AVs in the current transportation system. These factors will be elaborated on this subchapter to conceptualise a clear depiction of the current situation. These constraining factors can be divided into four categories that interact with the planning process, each on a different aspect, and should be taken into consideration in the planning process. These constraining factors serve as a filter for the focus of the current study that is, the consequences of AVs' implementation in public transportation in the planning process.

The factors, as mentioned earlier, can be divided roughly into four categories:

- Economy
- Infrastructure
- Social factors
- Governance/Policy

The next paragraphs attempts to elaborate on these four categories, further with the use of examples. Also, an account of the constraining factor for every category will be presented for better understanding and conceptualisation.

The first category of factors is the economic category. The economic factors that are included in the economy category, and delay or prevent the implementation of the AVs that derive from the niche-innovation space to the dominant transportation regime, are firstly the investment capital. More specifically, the investment capital engulfs the wealth that is invested in the conservative means of transport, either in the public system or in the private-owned means of transport. The public transportation system has invested in the continuation of the current path of transportation means; however, alterations have been made because of the pressure of the authorities for more sustainable transportation. However, the occasional replacement of the internal combustion vehicles that operate in fossil fuels is not a promising gap for the implementation of AVs on a dominant role in the public transportation system.

Moreover, in the economic factors that create a tension between niche-innovation and dominant regime, the price of innovations is included. To elaborate in this, one should consider that the price of a fully automated vehicle, as it is now the case in the economic market, is relatively higher than that of a conservative vehicle. Although the technological improvements in the field of AVs are more than promising and this promise will eventually lead to a lower price for the AVs in the future, the current prices implement a large number of AVs for public transportation an obstacle that needs to be considered. Nevertheless, as it is always the case with innovations, the cost for construction and distribution as well as the other fixed rates will be diminished in the process of transition in making it a part of the dominant regime.

The second category that is in direct influence of that of the economy is the infrastructure factors. This category of factors that delay the implementation of AVs or create tension between the dominant regime and the niche space includes the current investment capital that is in the form of infrastructures. These investments, like road and other infrastructure that accompany them, can be seen as an obstacle for the implementation of the AVs in the transportation regime. As it is stated in the previous subchapter, the centres of most European cities are often "equipped" with roads that are too narrow and so old that may not have the necessary standards for a significant alteration in the public transportation system. Additionally,

other replacements in infrastructure may be needed for the implementation of AVs to be realised. These alterations include sensors, receivers and other technologies that will ensure the connection of the AVs to the Intelligent Transportation System (ITS) Center.

The third category of factors that create tension between the niche-innovation and the current transportation regime is the Social factors. This category includes factors such as distrust for the AVs to handle situations that may occur during stressful situations. The ethical discussion about the automation of vehicles has shown that the social consciousness of the public may not be ready for the whole extend of the consequences that this transition will deliver. There are many doubts and fear about the AVs and their "predetermined" choices that they will make in a stressful situation. These "predetermined" choices mean that, in a situation that will require for the AVs to choose between protecting their passengers or other individuals, there are little to no good choices and their consequences are the source of mistrust and fear among the public and academic circles respectively. Mistrust is placed because when a driver has to make a choice, his morals and ethics are tested and, if ann incident occur, the resolution of the situation comes from the judicial process. Nevertheless, in account to the AVs making such a choice, the manufacturer must input the choice, predetermined, and may result in severe social consequences (Bonnefon, Shariff, & Rahwan, 2016). Additionally, the implementation of AVs may result to an alteration in the road behaviour of many users and could potentially to have cases of exclusion of individuals as an outcome of their implementation (Thomopoulos & Givoni, 2015).

The final category of constraining factors is the category of Governance/Policy. The existing governance and policy is fixated in the use of standard vehicles, and a path-dependency has been created constraining the niche-innovation of AVs to become dominant. Policies and strategies will have to alter and transform for the AVs to become that dominant means of transport steadily. This need of alteration means that stakeholders (such as sale enterprises, manufacturers, distributors) that are currently dealing with standard vehicles and major market parties, like fossil fuel companies, will have to reach a consensus with the public authorities and create a safe space, that is currently lacking, for the AVs to be accepted to the commercial industry.

Moreover, a potential implementation of AVs will have significant planning uncertainties and will change the spatial design of the cities. Land-use regulation, as well as infrastructure permits, may have to be altered to accommodate the implementation of AVs in the public transportation system. For the use of AVs to be efficient and effective, the constant connection of AVs with the central ITS system can result in implications in the planning and organisation of public transportation conceptualisation and operation. Also, design implications will occur. The road infrastructures, as well as the whole city design, will have to adapt for the AVs to be adequately implemented in the urban grid.

To conclude, these tension variable shows the constraining factors that exist between the socio-technical regime and the niche-innovation implementation. However, after describing these tension variables, the implementation of AVs is consider quantifiable to explore the consequences of such an implementation to land-uses of Amsterdam city.

2.2 Conceptual model

The conceptual model is part of the framework of this research has as a goal to present, visualise and link the various variables of the current study. The variables of this study are the same as the fundamental concepts of the leading research question that is the focal point of the argumentation line. The fundamental concepts of the current study have all the characteristics demanded to consider variables for the conceptual model of this framework.

In other words, the fundamental concepts of the leading research question will serve as the variables that will be linked to the conceptual model. The nature of the link between the variables and the conceptual model has to be that of causality. The properties of the causal relationship between the variables and the conceptual model are of strength and direction.

The direction of the relationship between the dependent and the independent variable can be either positive or negative. This division means that in a positive direct relationship between the variables, the increase of the independent variable will cause an increase in the dependent variable. In a negative direction relationship, an increase in the independent variable will cause a decrease in the dependent variable of the conceptual model.

The strength properties of the causal relationship between dependent and independent variables can take four forms. These four forms are: no effect, weak effect, moderate effect and long-lasting effect. The weak effect describes that a significant alteration in the independent variable will cause a small change in the dependent variable. Furthermore, a moderate effect means that a change in the independent variable will cause an alteration of similar measure to the dependent variable. On the other hand, a strong effect means that a small alteration of the independent variable will cause a significant change in the dependent variable of the conceptual model.

The fundamental concept of the current research that originate in the main research question is:

- Transition theory
- Automated Vehicles (AVs)
- Spatial and physical planning
- Public transportation planning
- Future state of the urban planning/design as well as the institutional design

The independent variables that are a part of this study's conceptual model are transition theory, Automated Vehicles (AVs) and the spatial and physical planning of the case study, and in extent every case that shares similar characteristics as that of the case study of the current research topic. The dependent variables of the current study are the public transportation planning as well as the future state of the urban planning/ design that will have a direct impact on the institutional design of the case study.

The conceptual model of the current study, along with the causal relationships of the independent and dependent variables, is represented in the following figure.

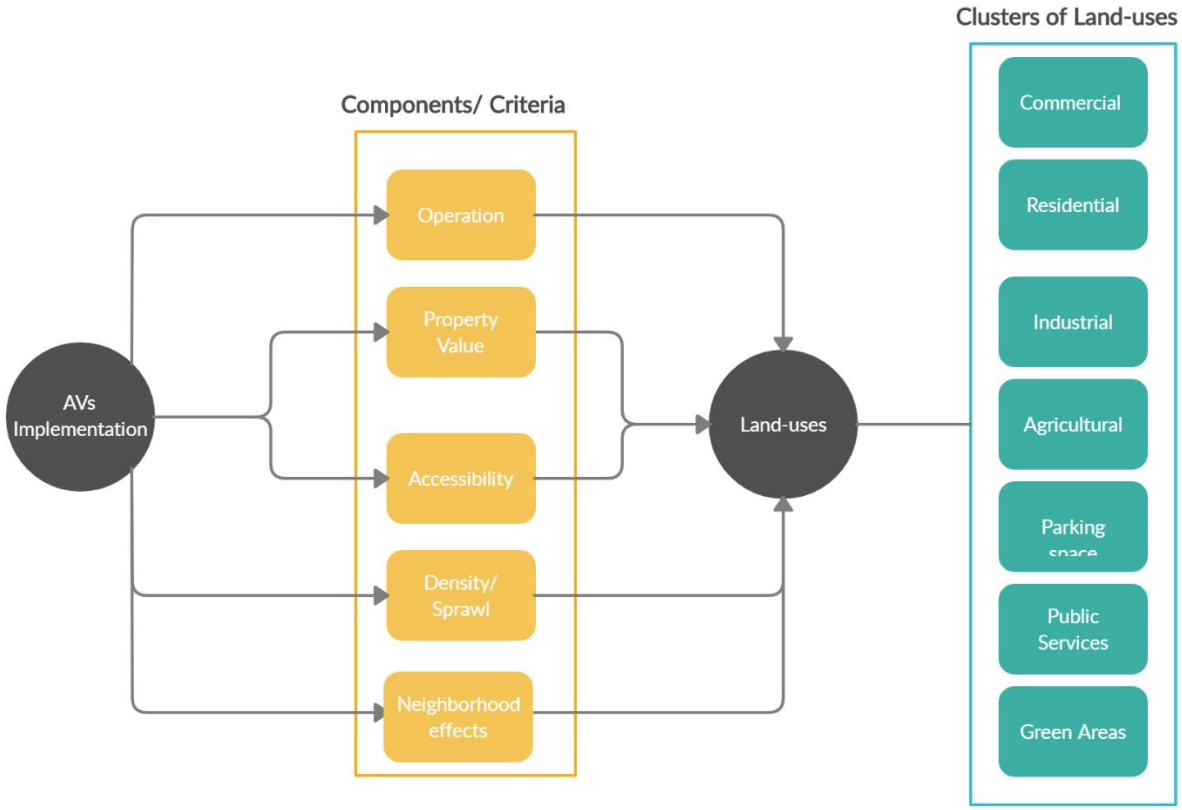


Figure 1: Conceptual Model

3 Methodology

The methodological process that the current research will adopt can be roughly divided into three main steps. First, a systematic literature review was conducted to define and explore the literature and epistemological background of the impact that a plausible implementation of AVs will have in the current land-uses. Secondly, a Scenario Building process based on the variables that were the result of the systematic literature review. Thirdly, a Multi-criteria analysis was conducted with the use of inputs from the systematic literature review's results. Because of the nature of the topic, the challenges and implications of AVs' implementation in land-uses, the actual data are scarce. The literature review that was conducted showed that since the implementation is yet to be realised, no quantitive data are available. However, Scenario Building and other decision-making processes is used to visualise the impact of the implementation on the land-uses. Also, GIS software was used, as the third step of the methodological process, to provide with a visual representation of the challenges that the AVs' implementation will create to the land-uses. The criteria explored to provide the base for the creation of scenarios, that were evaluated through the MCA process.

Also, the component result from the systematic literature review derives from the tension variables that were explored in the conceptual framework of the current study. As was mentioned above, the tension variables create an obstacle to the transition path; however, these tension variables generate crucial components for the complex adaptive system of mobility in the urban environment. For this reason, the process of systematic literature review was selected to find and investigate these components that constitute a significant part of the AVs implementation transition. Additionally, the components explored in the systematic literature review are used as input for the Scenario Building process, thus creating a scenario based on each component. This process shows the direct link that these components have with the implementation, and the variables that create tension in the transition. Tension variables create obstacles as an intended factor, since they can be considered as "gears" or "resources" that have to be redirected to a specific path (transition pathway). The element that creates tension is the inertia that these variables have to be shifted to a new direction. Nevertheless, they generate vital components for every plausible future investment or scenario. Hence by utilising the systematic literature review process, the components that derive from the tension variables can be found and defined to be able to create a holistic point of view of the implementation. This view is depicted in the concluding remarks of the current study.

3.1.1 Systematic Literature review

A systematic review is a process of desk study to collect, define and evaluate the conclusion and data provided by the series of studies in a specific topic. With the use of Systematic literature reviews, the researcher explores and investigate the collective knowledge that has been acquired over the years, upon a specific topic. Also, Systematic review is a method that helps the researchers solidify and specify their knowledge in the topic and focus on the information and evidence for highly complex situations and "wicked" problem solutions (Petticrew & Roberts, 2006). The appeal of systematic literature review concentrates on the characteristic that many research publications and studies, often contradict with each other, thus creating a maze of data, information and opinions that conflict one another. However, to have a systematic literature review that is comprehensible, the use of inclusion criteria is necessary. Also, the problem is not limited to consistency but the amount of information that may result in overload. The systematic review is usually carried out in seven stages (Petticrew & Roberts, 2006).

The first step in doing a systematic review is to define the research question and the boundaries within which the review will take place. The primary research question for the current study is "*the challenges and consequences of implementation of AVs to the land-uses of Amsterdam city*". The sub-questions derive from this primary question is as follows:

- What are the variables that dominate the relationship between the implementation of AVs and land-uses?
- Which type of land-use is more affected by the implementation?
- What conclusions can be drawn by the existing literature for the implementation of the AVs?
- What were analytical tools used to visualise and describe the impact of this implementation to the land-uses?

The second step is to define the criteria as mentioned earlier for the inclusion of the located studies. The definition of the criteria will be more explored and explained in the next chapter. The third step is to carry out a literature search to locate the studies that will be appraised in the systematic review process. In the methodological framework of the current study, the use of terminology, such as **"Automated vehicles"**, **"self-driving vehicles"**, "**autonomous vehicles"**, **"driverless cars"**, **"connected and autonomous vehicles"** was included for the location of relevant studies for the systematic literature review. As it is described in the next chapter, these keywords were used interchangeably for the location of a more considerable amount of studies. Also, the included literature will have to explore the relationship between the AVs innovation and the spatial planning process. The fourth step is to present the result of the location process and evaluate them according to the criteria of the review. The fifth step includes the appraisal of the literature documentation that was located. The next step includes the synthesis action and assession of heterogeneity in the located studies. Last, seventh, step of the systematic literature review is the presentation of the results and conclusion of the completion of the process.

The elaboration of the process and results will be presented in the next chapter and will serve as an input for the Multi-criteria analysis. The results of the systematic literature review will be used as a baseline for the definition of criteria in the Multi-criteria analysis. Also, the weighting process for the criteria will be constructed upon these results.

3.1.2 MCA

Multi-criteria analysis is an analytical process that allows the conductor of the research to define, evaluate and choose between the "best" possible choices, with the use of various criteria. The MCA process is used to determine the options and "navigate" through the complex decision-making procedures. Eight steps can describe the usual MCA process. However, to begin the MCA process, the main question and sub-questions of the study should be first be defined. The definition of the main question was made in the above subchapter, as the "challenges and consequences of implementation of AVs to the land-uses of Amsterdam city", can serve as the base point for the first step of the MCA process. The following paragraph depicts the steps of the MCA process, as explained in the manual for the communities and local governments by the UK government (Department for Communities and Local Government, 2009).

The first of the MCA process is the definition of context that the MCA will be conducted together with the key players and decision-makers. Firstly, the aim of MCA is included, hence the importance of the central question of research. After that, the second step is to define the options – possibilities that are evaluated in the MCA process. This step is intertwined with the third step of the analysis, to define the criteria, values, consequences and objectives of the analysis. The fourth step describes and assesses the value associated with the consequences of each option. The next two steps of the MCA process includes the assignment of weights in the criteria mentioned above and combining the weight and scores of each option, thus derive in the scoring matrix for the available options. The seventh step is to examine the scoring matrix and evaluate-decide on the "best" possible option. The last step of the MCA process is the conduction of a sensitivity analysis to adjust and calibrate the weight assignment for the available options, thus conduct the steps from six to eight if it is deemed necessary.

The process of MCA conducted for the current study, and the results are presented in the following chapter. On the following paragraphs, the triangulation for location of data is elaborated, and the case study is presented. Also, the criteria by which the case study was selected are included in the designated subchapter.

3.1.3 Triangulation

For a research study to be firmly grounded and have an impact on the analytical topic, it should include a type of triangulation to understand, corroborate and analyse the necessary data for the extraction of concluding remarks. Triangulation is the process of verifying and validating various information from as many sources as possible to have a better understanding of the parameters and variables that constitute the system. According to Denzin (1978), triangulation can be divided into four basic categories: i) Data triangulation, ii) Investigator triangulation, iii) Theory triangulation, and iv) Methodological triangulation. Additionally, the first category, data triangulation, can include three subcategories of analysis: time, space and person analysis (Denzin, 1978). Firstly, data triangulation consists of using different data sources to constitute and verify the necessary data for a research study. As it is apparent from the subcategories of analysis, methods of differentiated the "data" triangulation is on account of time, space or the social organisations of persons. The second category of triangulation, "investigator" triangulation refers to the method of using a group of "observers" to research and investigate the object of analysis (Denzin, 1978). Likewise, "theory" triangulation refers to the process of using multiple perspectives to analyse the observing entity. The last category of triangulation is the "methodological" triangulation. This category of triangulation is divided into two categories: within-method and between-method triangulation. The first, within-method triangulation, entails the process of using multiple strategies of one method to examine the collected information keeping the same scale of unit. The second, between-methods triangulation, utilise a combination of different method, and units to examine the object of observation. For the literature review that is part of the current study, the use of "data" triangulation is developed. Also, as part of the method for collecting information, via interviews, the use of "investigator" triangulation is utilised to ensure neutrality and validity of data. The validity and neutrality of the data is ensured with the inclusion of various actors of the socio-technical system. Through this method, the existence of any bias or other limits in opinions, can be avoided, thus ensuring the cogency of the concluding remarks.

3.1.4 Case study

The spatial and social characteristics of this research, extrude the use of case study method. The selective process by which this case study for this implementation was made, Is presented in the following subchapter. Since, by applying the use of a case study, the chain of argumentation can be more concrete and verified. Also, the data collected through a case study can be observed and maintained more clearly. This research includes a case study procedure to establish the data collection progression. According to Yin (2009), three overriding principles significant can be used for any data collection effort.

- **The use of multiple sources:** The purpose of numerous resources as a method is referred to as triangulation. The use of a case study is favourable to the concept of triangulation, as it allows the researcher to contact and draw information from various sources in an efficient way.

- **The idea of a case study database:** A digital database, containing the data that will be used for the conclusion drawing and for the proposals, that will include the raw data, the results of different analyses and the literature that has been used for this research.

- **Maintain a chain of evidence:** This notion results a model structure of the evidence and thus readers can have a clear perspective of the data and the process of analysis that will lead to the conclusions of this research. For this reason, this research aspires to have a transparent research design, creating a case

study protocol, describing the procedures that were followed in the data collection process, using proper referencing and transparently using data to answers the research question.

The choice of case study for this research study was based on the following criteria. Firstly, the case under study had to be prominent for an innovation such as the AVs' implementation. This concept means that areas with a small amount of residence and density were excluded from the selection process. Also, one other criterion for the selection was the "willingness" of the local authorities for the implementation of the understudy innovation. Furthermore, the selection of the case study had to be made in consideration with the availability in time and number of the necessary data. For the reasons as mentioned above, the city of Amsterdam was selected as the case study. Amsterdam city is one of the major metropolitan areas of the Netherlands and has a wide range of influence. Also, the city of Amsterdam has made a declaration on self-driving and connected vehicles as part of the EU policy on AVs.

Moreover, because of the density of residence in Amsterdam city, an implementation of AVs will have a significant impact on the daily life of its residents. Lastly, an implementation of such an innovation is more likely to be in major metropolitan areas, where it will be most effective. Also, the political and economic consequences of such an implementation will be more apparent in a metropolitan area. Thus, the interviews, included in the process under study, were focused on the AVs' implementation in Amsterdam city.

4 Data

This chapter includes the systematic literature review and the MCA process that constitutes the analytical framework of the current research study. As is was mentioned in the previous chapter, the analytical framework contains a systematic literature review, that is made in seven steps, and an MCA process that ins concluded after the completion of eight steps. The results of the systematic literature review are used as an input for the MCA process. These results serve as a base for the completion of the weighting process, which is the fifth step of MCA. This input of the systematic literature review, serve as the eight per cent of the weight for the weighting process of MCA, with the rest percentage appointed in the research's opinion. The following subchapter depicts the systematic literature review process that was conducted in the analytical framework of the current research study.

4.1 Systematic Literature review

4.1.1 Definition of research question

As it is mentioned in the previous chapter, the first step of the systematic review process is to define the research question as clear and transparent as possible (Petticrew & Roberts, 2006). As it is elaborated in the next paragraphs, the phrasing and the keywords of the research study play a vital role in the process of the systematic literature review (Petticrew & Roberts, 2006). The three steps taken for the current research question to be form clearly, were firstly the necessary amount of knowledge on the topic for the conductor. This step means that an early investigation of the components of the implementation had to be conducted. Through this early investigation, possible knowledge gaps were explored, thus creating the conditions for the second step. The second step was concentrated on the use of the results. Due to the innovative nature of the research topic, the results at this stage of implementation were informative and directive. This realisation came with the notion that any future planning process that will include the concept of the AVs will surely need to consider the implications of the implementation in the urban environment, and as an extent in the land-use regulations. This realisation constitutes the third step of the definition process for the main research question. The next process for framing the central question as clear and transparent as possible was dividing it into several sub-questions regarding five aspects of it. These five aspects are: population (that is in the interest of research), intervention (the subject of research question), comparison (the comparison of different options), outcomes and context (Petticrew & Roberts, 2006). In the concept of the current research question, the population aspect refers to the general public that benefits or has a potential to be benefitted by the implementation of AVs. Also, the aspect of intervention refers to the implementation of AVs in the mobility and transport system of urban areas. On account of comparison, the current systematic literature review is focused on the comparison between the current and future state of the urban areas. The last two aspects of the research question are shared, also in the following MCA process. The outcomes are evaluated based on possible future scenarios, as the implementation has not yet been achieved. The context of the research question remains the same as was introduced in chapter 2 and 3 of the current study. Lastly, it should be mentioned that, in the knowledge of the author, there is no equivalent study that researches the current topic, with the same analytical framework or the same theoretical framework. These characteristics make this study an innovative one, thus validates the loss of quantitative data considering the implementation of AVs related to land-uses. However, the use of systematic literature review outputs served as input of the following MCA process. The next subchapter depicts the process of determination of the type of studies that were concluded in this systematic literature review.

4.1.2 Determination of the inclusion criteria

To decide and determine the type of studies that will be included in the current literature review, a hierarchical scheme will have to be implemented beforehand. This "hierarchy of evidence", it is called,

helps to determine the validity and legitimacy in the research of the literature document and classify them after their location. This hierarchy determined the internal validity of the evidence provided by the located studies (Petticrew & Roberts, 2006). The hierarchy used in the current literature review is similar to the one found in the guide provided by Petticrew and Roberts (2006). However, another method used to determine the type of evidence derived from the located studies, is via typologies. This typology includes Qualitative research studies, Surveys Case-control studies, Cohort studies and other systematic reviews (Petticrew & Roberts, 2006). In the current literature review, a mix of the two methods was used to determine the type of studies that were included. The types of research studies that were included for the systematic literature review were: Qualitative research studies, Surveys, case-studies, Books, Reports and Scientific articles. Also, the criteria by which the located studies were included in the current literature review are as follows.

One of the criteria for inclusion of located studies was the terminology of AVs to be depicted in the context of referring study. This inclusion relates to the topic of the studies that were located. Due to the nature of the topic, the studies that include Scenario Building processes in their analytical framework were prioritised. This concept was included because, Scenario Building processes can describe and determine causal relationships that may affect the decision-making process; thus highlight the relationships that may create future situations that are concealed in the current time. As it is apparent that no implementation of AVs has been achieved, in large scale, yet the analytical tool of Scenario Building process is vital to the exploration and research of the current study.

Also, the second criterion for the inclusion of the located literature studies was the presence of the relationship between the AVs' implementation and land-uses. This criterion was proven vital for the inclusion of the located studies, since more of the existing literature on AVs is either technical or focused on policy measures. This characteristic made the continuation of the process somewhat complicated, because a number of the located studies were not qualified on this criterion. Thus, as it is shown in the next subchapter, the majority of the located literature for the AVs' implementation was partially qualified on the above mentioned two criteria.

Moreover, the inclusion of reports and research plans that refers to projects that have concluded and are vital, yet scarce in literature review. During the completion of the current literature review conduct was made with the Bureau Marineterrein Amsterdam that is currently conducting an experimental project of AV implementation. However, it should be mentioned that this project serves a different purpose than the focus point of the current research study, having different methods of analysis and criteria for the conceptualisation and realisation of the project. Nevertheless, conduct was made to ensure the possibility of inclusion for their preliminary research in the current research study. Also, the inclusion of reports for the technical and operational feature of the AVs was made, since these features can affect the land-uses indirectly. However, the result of these reports concluded that technical and operational feature of AVs are not area-based, with the improvement of the technology, hence have little effect in some of the land-uses as showed in the MCA process. The next subchapter elaborates more on the method of locating the literature documentation and clarifies the process of the search of the literature.

4.1.3 Literature Search

The systematic literature search process is not an effortless nor hasty. The use of various mean for retrieving literature have to be employed to ensure the relevance and effectiveness of the search process (Petticrew & Roberts, 2006). The use of web search engines, as well as library search, was deemed necessary to ensure that the relevant and fundamental literature documents were located. As was mentioned in chapter 3, the use of specific keywords was applied to ensure the relevance of the located documentation. However, the inclusion of found literature was considered the analyses and the inclusion of consequences

of land-uses concerning AVs. Also, it should be mentioned that due to the COVID-19 pandemic, the literature search was limited in online literature retrieval.

Nevertheless, a sufficient amount of literature documentation was located and processed to ensure the overall appraisal of the systematic literature review. An overall amount of 46 literature documentation were located, from which the nine were qualified for the inclusion criteria. These criteria were partially qualified by the 37 of the total 46. The criterion that excluded most of the located literature documentation was the inclusion of land-use consequences. However, these 37 literature documents were used to substitute possible gaps in the author's knowledge and create the overall framework of the current research study. The method of locating the amount as mentioned above, of studies for the literature review was complemented with the "snowballing" search method, meaning to use the retrieved studies to identify others in the same scientific field and topic. Also, it should be mentioned that no other literature review was located that qualified the criteria for the inclusion for the current literature review.

Moreover, policy documentation from supra-national organisations as well as corporations were included, thus ensuring that overall validation of the located evidences was apparent. Thus, the use of "sensitivity" and "specificity" was used to guarantee the precision of the current literature review. "Sensitivity" refers to the number of studies that retrieved during the literature search process, whereas "specificity" refers to the number of studies that are relevant to the topic of the research, from the total amount of studies conducted (Petticrew & Roberts, 2006). However, it is difficult to determine the precise sensitivity and specificity of the literature review research, as it is challenging to know the exact numbers of studies that were conducted for the specific topic. Also, there is a trade-off between the two ratios, "sensitivity" and "specificity", as a large proportion of the one may exclude the large proportion of the other (Petticrew & Roberts, 2006).

For this reason, the current literature review deemed necessary to focus more on the "specificity" of the included studies, to create a more validated review and present the readers with a better overview of the research topic. However, as stated in the previously, some studies and reports were included as to complete any existing knowledge gap in technical, operational and economic factors that may indirectly affect land-uses.

Also, as was mentioned in the previous chapter, during the process of literature search, the use of keywords in various online search engines was deemed necessary. These keywords were **"automated vehicles", "self-driving vehicles", "autonomous vehicles", "driverless cars", "connected and autonomous vehicles".** However, the use of these specific terms was regarded as crucial, for document focused on the topic of AVs the use of those terms is interchangeable. Nevertheless, the majority of the scientific documents refer to this type of automobiles by the terminology of "automated vehicles" or "autonomous vehicles". In contrast, the policy and strategy documentation, as well as the commercial articles, use the term of "self-driving vehicles." Nonetheless, in the literature search process included in the current study, the use of every keyword mentioned above was utilised, to ensure the detection of every important literature document available. The results of the systematic literature review search are extensively elaborated on the next subchapter.

4.1.4 Results of the literature review

The results from the literature review are comprehensive yet devious. From 46 literature documents that were located in the current literature review, 37 were partially qualified to be included since their topic was relevant to the implementation of AVs, but lack of depicting the relationship between the implementation and Land-uses. However, the relation between the AVs' implementation and Land-uses are elaborated on the rest of the located documents, nine in number. From this number of included studies,

four clusters can be presented throughout the relationship between the AVs' implementation and the Land-uses that they contain in their context. These four categories are firstly the studies that focus on the sprawl as a result of the implementation of AVs to land-uses. These studies emphasise that the essence of the land-use impact is concentrated in the increasing urban sprawl phenomenon that will be produced by the implementation (Hawkins & Habib, 2019; Cohen & Cavoli, 2019). The argumentation of increasing sprawl, due to implementation of AVs', is based on the choice of residents to move from the city centre or employment areas. Avs will be able to navigate and operate themselves without the intervention of the human passengers; commuters will be able to conduct other processes. Thus the travelling time will not be considered as an expense, and residents can travel greater distances daily for employment. This characteristic is estimated to add in the augmentation of sprawl in urban areas (Hawkins & Habib, 2019; Cohen & Cavoli, 2019). The second cluster of studies emphasise the connection between the implementation of AVs' and the parking areas in the urban grid (Heinrichs, 2016; Thomopoulos & Givoni, 2015; van Arem et al., 2016). The argumentation that is the centre of these three studies is that parking spaces will be affected by the implementation of the AVs, since there would be no need for the destination and the parking area to be close to each other. Since the AVs will be able to operate without their drivers, parking areas can be in the distance from the designated drivers; thus parking spaces can be relocated outside of the city centre or even the city. This relocation will create an opportunity for reuse of the available space for other uses, more productive.

Especially in the cities and city centres that vacant space is valuable (van Arem et al., 2016). However, the authors of these three studies are refrain from making any further suggestion on the impact of AVs' in the rest type of land-uses. The third type of cluster studies is emphasising the impact on the quality of life (Litman, 2020; Papa & Ferreira, 2018). By creating scenarios, these studies emphasise on the optimistic and pessimistic outcomes that an implementation of AVs has as a result. The authors of these studies aim to present the advantages and disadvantages of an implementation of AVs. The optimistic scenario derives from the concept that the urban areas will become more attractive to citizens, and the governmental policies regulate and promote the use of AVs in a way that is beneficial for all the residents of the city. On the contrast, the pessimistic scenario evolves the concept that the urban environment is reshaped to accommodate the use of AVs, but to the prejudice of other social groups. As it is apparent, the use of scenario is crucial in the exploration of a topic like the implementation of AVs, due to the lack of quantitive data (Litman, 2020; Papa & Ferreira, 2018). The last cluster of studies included in the current literature review focuses on the overall impact of implementation, but do not qualify to be on the categories as mentioned above (Gavanas, 2019; Kang, 2019). In these two studies, various suggestion about the relationship between AVs and land-uses, and conclude that opportunities that derive from this implementation are many. Nevertheless, throughout all of the nine studies, the conclusion is limited to the suggestion that the lack of physical (quantitive) data deter the researchers to draw reliable conclusions.

To conclude the presentation of the results of the current literature review, the following conclusion can be drawn. As it is apparent from the studies as mentioned earlier, the criterion of land value is ever-present in a potential implementation of AVs. A swiftness of residents to relocate to the outer areas of an urban environment, will inevitably affect the price of land in the city centre as well as the new residential areas. Also, density and sprawl are directly affected by the relocation of the resident and constitute the second criterion. Besides, density and sprawl are directly linked to the concept of accessibility that can be perceived as the third criterion.

Moreover, another criterion that can be used and is mentioned in the above-included studies of the literature review is the concept of neighbourhood effect. These four criteria, combined with a fifth that is repeatedly present in the literature review, on the partially qualified studies, are used as drivers to create

scenarios for the following MCA. The fifth criterion is the operational factors of the AVs implementation, such as 5G base installations and 5G macros. The following subchapter elaborates on the narration of the scenarios created as an input for the MCA process.

4.2 Scenario Building

As is mentioned above, the conclusion of the literature review has produced five "criteria" (components) upon which the scenarios for the MCA process will be built. Each scenario will derive from the exploration of a single criterion as a driver and will not explore the relationship between the existing criteria, which means that in every scenario narration the exploration of a specific criterion is made. In contrast, the other criteria are considered to be stable. The Scenario Building process is vital to the current research study since the topic of research concern a new future equilibrium. The Scenario Building process is not a tool for prediction, but a management tool that is used to improve the quality of decision making (Wilson, 2000). By creating a story of plausible cause and effect links that links the current decision making with the future condition, Scenario Building depicts that weight of the decisions that are made as well as the possible path-dependency (Bengston et al., 2012). Through the Scenario Building process, the readers can understand the challenging factors that are the focal point of the current thesis. To create a scenario process, fist the identification of "drivers" for the scenarios is crucial (Meinert, 2014).

4.2.1 Operational Factors

The exploration of a scenario-building process based on the operational factors of AVs' implementation is deemed unnecessary for the following two reasons. Firstly, the operation of AVs does not affect nearby land-uses, since the installation for the operation are not significant in size, thus do not affect the urban environment. This characteristic means that the 5G macros, that are the base stations of the connection of the AVs with every necessary instrument do not affect the land-uses. The second reason for not exploring an "operational factor" scenario, is that the impact of the operational factors the cultural fear that it may affect a particular type of land-uses (hospitals, schools and other social type land-uses), if the radiation standards are not followed. This reason means that for those that fear that such installations may affect certain social groups, the issue is more in the cultural domain than in urban planning.

4.2.2 Land prices (Scenario 1)

This driver for the creation of a scenario derives from the conducted systematic literature review. Land values can be described as the value of both the land and of any improvement made to it. In the narration of this scenario, because of the implementation of AVs, the city residents are willing to travel longer distances. This choice means that residents will relocate themselves further from their place of employment, most likely to the suburban areas of the city for the luxury of a better environment. By doing so, the city centres will lose lots of residential areas that can either reused differently, or remain vacant. However, this will ultimately have an impact on the land prices for the residential areas near the city centre by decreasing the land value. Also, the suburban areas will increase in demand, for the land-use of resident; thus increasing the land value for the outer city areas. This increase in demand is sure to create conditions of the extension of the city borders, hence the possibility of an ever-expanding city. This ever-expanding city may burden the environment further as well as economic and infrastructure sources of the administrative authorities.

4.2.3 Density / Sprawl (Scenario 2)

The implementation of AVs in the current mobility transportation system is considered to alter the notion that travelling time is an expense. This characteristic can affect the urban build environment and create conditions for sprawling effect in the inner and outer city areas. The willingness of the commuters to travel greater distances on daily bases can result in city sprawling and may ultimately put a strain in the resources of the administrative authorities (economy, infrastructure). In this scenario, the similar

characteristic with the "land prices" scenario is that the possibility of an ever-expanding city is dominant. However, because changes in the urban built environment are usually taking hold, slower than the changes in technology or social structure, there is a chance of creating further density in the suburban areas in the outer city. This further density will force the borders of the city to a further extension, thus creating the ever-expanding problem. Also, the quality of life could be affected due to the new urban environment.

4.2.4 Accessibility (Scenario 3)

Accessibility as a driver can be described as the level of accessibility that individuals have to significant routes and nodes (Kang, 2019). The level of distance measures it to adjacent freeway interchange and distance to adjacent major arterial. The role of accessibility to create a scenario is that by the implementation of the AVs', the design and properties of the urban road infrastructure may be altered. Due to the ability of AVs to operate without the intervention of human inside, the space between two travelling AVs can ideally be reduced. This characteristic can mean that the size and design of the road infrastructure can be modified. Also, since the AVs' are always connected with everything and can predict the traffic flow in the next intersection, the size and features of road intersections may be altered. This alteration can create a plausible obstacle to the other users of the road as well as the pedestrians. However, these obstacles can be predicted and bypassed by the administrative authorities through strategic planning.

4.2.5 Neighbourhood effect (Scenario 4)

The neighbourhood effect can be perceived as the effect that the land-uses can have in the central area of a neighbourhood, which derives for Christallers' "central place" theory. Via the implementation of AVs the border and distances of these "Christaller" patterns can be expanded, thus creating difficulties in the rest of the social groups of the urban environment. Since AVs can travel greater distances, consumers may choose to travel to more prominent commercial centres, instead of the local ones, thus having a direct impact on the economic nature of the neighbourhood. This choice may prove detrimental for local enterprises that will ultimately be abandoned, thus significantly alter the urban environment. Also, this possibility can create problems for the other users of the road network and social groups. Moreover, these new patterns in the urban grid can extent the sources of the administrative authorities by creating the need for extended urban road network.

The scenario, as mentioned above, narrations are used as an input for the MCA process. Through this process, the optimum scenario and various consequences of the implementation of AVs in the land-uses of Amsterdam city are explored. The next chapter presents the MCA process and the evaluation process that is included in the location of the optimum scenario. After that, the conclusions can be drawn, based on the results of the MCA process.

4.3 Multi-Criteria Analysis

The use of MCA as a process for define, critique and evaluate the options in a decision-making procedure is not a new approach. MCA is a process that assists in the evaluation of various option and decision for solving various "wicked problems", that originate form complex adaptive systems (Rittel & Webber, 1973). As it is apparent from the whole analytical process in the current study, the implementation of AVs in the transportation system of Amsterdam city can be defined as a "wicked" problem. Even though, in a manner of technicality every analysis that utilises criteria for evaluation of a decision can be described as "Multi-criteria" analysis, it should be mentioned that the formal type of MCA utilises a weighting system to define better and decide upon the best possible decision. This reason is the primary condition for choosing to include the use of MCA in the analytical framework of the current research study. The utilisation of weight in MCA, create an ideal evaluation process for decision-making upon the selection of the best scenario available for the solution of the implementation problem. The first step of an MCA process in the

definition of the context that the MCA is conducted. A stakeholder analysis was made, to define the MCA context, understand and explore a potential implementation in Amsterdam city.

4.3.1 Stakeholder analysis

Stakeholder analysis derives from the stakeholder theory. The stakeholder analysis is part of the procedure of stakeholder management. The critical topic of stakeholder management theory is the definition of the "people/actors that are affected, directly or indirectly, by a policy or a project". This definition of stakeholders is one of many, with one of the earliest given by R. Edward Freeman (1984) who stated that a stakeholder is *"an individual or a group who can affect or is affected by the achievement of the organisation's objectives'. (1984:46) "* (Bryson, WHAT TO DO WHEN STAKEHOLDERS MATTER: Stakeholder Identification and Analysis Techniques, 2004). However, it should be mentioned that the definition of stakeholders have undergone various alteration from the moment of creation until today.

Nevertheless, for all the changes that the definition has undertaken, the crucial point is that there is no denial that stakeholders are vital for the process of planning and realisation of a project. The process of including the stakeholders in the procedure of planning and constructing a project has direct relation with the "self-determination" right. The vital role that every stakeholder play in the process of a project, makes their satisfaction, even minimal, one of the essential point for the successful realisation of a project (Bryson, WHAT TO DO WHEN STAKEHOLDERS MATTER: Stakeholder Identification and Analysis Techniques, 2004). However, for the administration to keep the stakeholders satisfied and include, an identification is first needed. Thus, stakeholder identification is crucial for the overall progress of a stakeholder analysis. Michell et al. (1997), in their work, propose a way to identify the classes of various stakeholders. This categorisation derives from the stakeholders' capacity to possess one or more of the following attributes: i) Power to influence the outcome of the project, ii) the legitimacy to participate in the processes of the project, and iii) the urgency of the claim that the stakeholder (Mitchell et al., 1997). On this account, because of the capacity of stakeholders to possess one or more of those three attributes, a total of eight stakeholder categories can be established.

The Dormant Stakeholders: this category of stakeholders are the ones that have as an attribute, the power that can impose in the project, but lack the other two attributes.

The Discretionary Stakeholders: This type of stakeholders possess the attribute to legitimacy, but lacks the power or the urgency to influence the activities of the project.

The Demanding Stakeholders: Those are stakeholders that have urgency as an attribute, but no other attribute on account of the project.

The Dominant Stakeholders: Stakeholders that have power to influence the outcome of the project and the legitimacy to participate in the deliberation processes belong to this category.

The Dangerous Stakeholders: This type of stakeholders are characterised by power and urgency but lack the attribute of legitimacy. Thus this type of stakeholders can coerce and try to influence the activities of the project.

The Dependent Stakeholders: Stakeholders that have both urgency and legitimacy but lack the power to influence the outcome and the activities of the project, belong to this category.

The Definitive Stakeholders: This category of stakeholders include all those that have the above three attributes in their possession. This characteristic means that potentially every stakeholder can be included in this category by acquiring the missing attributes.

The Nonstakeholders: In this category, all those that cannot be considered as stakeholders are included. This characteristic means that if an individual or group loses the attribute that have, they are included in this category.

It should be considered that stakeholders are a vital part of every policy and project due to the increase system's network interconnectivity (Bryson, WHAT TO DO WHEN STAKEHOLDERS MATTER: Stakeholder Identification and Analysis Techniques, 2004). Thus the purpose of stakeholder analysis is to depict a more precise picture of the "system" and the interactions that the actors. This characteristic of the stakeholder analysis is aligned with the notion of complexity theory that describes the world in subsystems that are complex and adaptable.

In the current study, the use of a fundamental stakeholder analysis was deemed as necessary to investigate the influence and power for the possibility of implementation of AVs in Amsterdam city. The fundamental stakeholder analysis includes three steps in its pure version. These steps are: i) identify as precisely as possible the stakeholders of a project, ii) identify the criteria with which the various stakeholders assess the project, and iii) evaluate the performance of the project in according to the stakeholders' criteria (Bryson, 1988). In the case study of the current research, by following the above mention steps, the identification of the stakeholders' was made by the author. This identification process was made via researching and brainstorming on the case of Amsterdam city implementation of AVs. For the overview of the results of this research and the identification of stakeholders, the following table was included. Also, a categorisation in the legal state of the stakeholders' was made that will contribute to the second step.

Public	**Private**	**Non-profit**
European Commission – Mobility and Transport	Automotive Manufacturers	Bureau Marineterrein Amsterdam
Cabinet and Parliament	Automotive sellers and distributors	AMS Institute
Ministry of Economic Affairs	GVB – Door en door Amsterdam	
Ministry of Infrastructure and Water Management	Automobility local market	
Amsterdam Transport Authority	Residents	
Municipality of Amsterdam		

Table 1: Stakeholder identification for the implementation of AVs on Amsterdam city

According to the "STRATEGIC PLANNING FOR PUBLIC AND NON-PROFIT ORGANISATIONS: A Guide to Strengthening and Sustaining Organisational Achievement" by Bryson John M. (1988) that depicts the three steps of the fundamental stakeholder analysis, the second step is the identification of the evaluation criteria of stakeholders. Also, the identification of the evaluation criteria of the stakeholders was made by the author of the current study. The methods by which the specification of this evaluation criteria can be obtained are two. Firstly, by the use of literature research and study from the group or individuals that conduct the stakeholder analysis. This method is vital as there are cases of stakeholders that will conceal their agenda and criteria for various reasons. Secondly, the use of surveys, group discussions and interviews can be used to acquire the evaluation criteria. This method can be useful as the first method can have incomplete or false results (Bryson, 1988). In the current research, the use of the first method was deemed essential, and combined with the second for maximisation of the necessary results. Thus, the use of the interview to obtain the criteria for evaluation of the implementation of AVs in Amsterdam city was crucial. However, it should be mentioned that the identification of evaluation criteria process was majorly based on the literature review and the brainstorming procedure, as was mentioned in the first method. The results from the second step, specification of the evaluation criteria of stakeholders'

for the project, are shown in the following table. Also, in the following table, the categorisation of stakeholders, following their power and influence over the project is included. The evaluation criteria were divided into the categories of "requirements" and "concerns" for every stakeholder. This distinction was made to help with the depiction of the criteria and the method by which were obtained.

Stakeholder	Requires	Concerns	Interest	Power
Public				
European Commission – Mobility and Transport	• Conflict resolution (Member states)	• Balance between the member states (development)	High	High
Cabinet and Parliament	• Economic development and welfare	• Welfare of the residents	Low	High
Ministry of Economic Affairs	• Economic development	• Balance between economy and development	Low	High
Ministry of Infrastructure and Water Management	• Effective maintenance and construction development	• Finding new resources for infrastructure projects	High	High
Amsterdam Transport Authority	• Better regulation in transportation	• Decrease in transportation disturbances	High	Low
Municipality of Amsterdam	• Less traffic conjunction	• A better balance between costs	High	High
Private				
Automotive Manufacturers	• Increase in demand	• Maximisation of profits	High	Low
Automotive sellers and distributors	• Increase in demand	• Maximisation of profits	High	Low
GVB – Door en door Amsterdam	• Continuation of contract of collaboration	• Maximisation of profits	High	Low
Automobility local market	• Increase in demand	• Maximisation of profits	Low	Low
Residents	• Effective mobility and transportation	• Better transport expense ration	Low	Low
Non-profit				
Bureau Marineterrein Amsterdam	• Active research	• Innovation in transportation	High	Low

	topics and fields			
AMS Institute	• Active research topics and fields	• Innovation in transportation	High	Low

Table 2: Stakeholder Matrix combined with power – interest categorisation.

In align with the above table, the stakeholders were categorised into four groups based on their level of interest and power. This categorisation is made to create the following scheme of power versus interest gid. This type of grid separates the stakeholders per their level of interest and power as it helps the creators of the stakeholder analysis to understand and define the relationship between the stakeholders (Bryson, WHAT TO DO WHEN STAKEHOLDERS MATTER: Stakeholder Identification and Analysis Techniques, 2004). This matrix will assist on the third step of the fundamental stakeholder analysis, that is to investigate the level of satisfaction that the stakeholders gain from the project. By defining the groups, the creator of analysis is informed on how to handle the four groups of stakeholders. As mentioned in Bryson (2004), the group of stakeholders that have a high level of interest and power are called "players". This category of stakeholders should be carefully managed as they have the most prominent role in the project activities. The group that has a high level of power but are content with a low level of interest about the project are named "context settlers". The "context settlers" should be kept satisfied as these stakeholders are the ones that usually include national and supranational organisations. However, the low-interest level of "context settlers" means that the project managers should not depend on these type of stakeholders to have an active role in the project activities. Next, the stakeholders that have a high level of interest but a low level of power to influence the activities of the project are called "subjects". This category of stakeholders should be kept informed during the activities of the project; nevertheless, their capacity to influence the outcome of the planning and realisation activities of the project is limited. Lastly, the stakeholder group that has a low level on both power and interest in the planning and realisation of the project is entitled "crowd". This type of stakeholders should be monitored in their relationship with the planning and realisation activities of the project. The result of the categorisation of the stakeholders into four categories is depicted in figure 4. The interviews conducted for the current study were selected based on which category the stakeholders belonged and their relationship with the project activities. Also, the willingness of interviewees, and the time, constrain for finalisation of the study played a significant role in the stakeholder analysis.

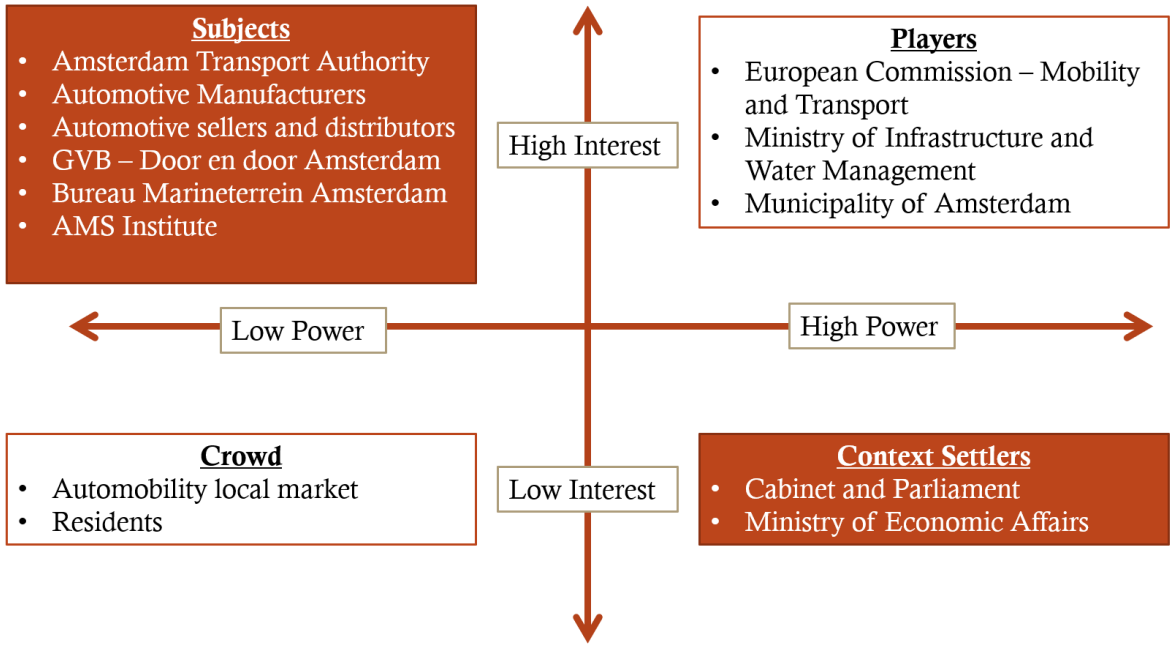


Figure 2: Stakeholder categorization of Interest and Power

To understand and employ the MCA process correctly, the stakeholders identification process was made. After the identification process is complete, the objectives and criteria of the MCA process can be detected, thus proceed to the options identification step. The objectives of the current MCA process are first to identify the effect of the criteria, as mentioned earlier in the case study of Amsterdam city. Secondly, through the MCA process, the sensitivity and functional relationship between the land-uses and the criteria are explored. This relationship can facilitate the concluding remarks of the current study and create the base for further exploration and study. Having defined the objectives of MCA, the criteria have also to be defined to proceed with the process. The criteria are defined in the third step of the process, and a more elaborate presentation of objectives based on the research questions.

The next step after the identification of context and key players, is the identification of the available options that are required to continue with the MCA procedure.

4.3.2 Available options identification

The available options for the MCA derive from the narrative of scenarios that were building in the previous subchapter. These scenarios were based on the components that originated from the systematic literature study, that was included in the analytical framework of the current research study. These components are, first, the land prices that may be affected by the possible implementation of AVs, either in the public or private sector. Secondly, the phenomenon of density/sprawl that emerge in urban areas under certain circumstances. Next, the concept of accessibility is used to narrate the third of the fourth scenarios created in the analytical framework of the current research study. Lastly, the concept of neighbourhood effect is utilised to explore the narration of the last scenario that is under research for the analytical framework of the current research. These four scenarios are utilised to explore the consequences of AVs' implementation on land-uses in the case study of Amsterdam city and will be evaluated with the use of the MCA process. A "sensitivity" matrix has been made to evaluate the effect that these four components have on the land-uses of the case study. This matrix derives from the systematic literature review. Also, the

broader knowledge of the author was combined with the overall conceptualisation of the "sensitivity" matrix.

Land-use / Variable	Commercial	Residential	Industrial	Agricultural	Parking space/vacant	Public Services	Green Areas
Operation	-	-	-	-	-	+	+
Property Value	+	+	-/+	-	+	-	-
Accessibility	+	+	+	-/+	-/+	-	-
Neighbourhood effect	+	-/+	-	-	-	+/-	+

Table 3: "Sensitivity" Matrix (Components- Land-uses)

The above matrix indicated the effectiveness of the components concerning the land-use clusters that were created for the analytical framework of the current literature review. The "+" sign indicates the Land-uses that are affected by the indicated components. The "-" sign indicates the Land-uses that remain unaffected by the indicated variable. As it is apparent in the above table, the operation variable is affecting the public services and green areas categories. This effect is considered since the operation of AVs relies upon 5G "macro" base station installation that have radiowaves, which may cause public protest if the installations are near schools, hospitals and places that vulnerable social groups exist, in general. However, concerning the rest of the land-use clusters, that are included in the current research, the operational variable has little to no effect, as it does not take considerable land space or modify the urban environment in any other way. The property value or land price, as it is included in the Scenario Building process, has a considerable effect in the commercial, residential and parking space, whereas its effect in the industrial land-use category varies. The commercial, residential and parking space categories are in close relation to the land prices, and any fluctuation of it can cause significant difference. Also, the land price, as a variable, can cause significant alterations in parts of the industrial Land-use category, but most of the components of this category remain unaffected by the variable. This abnormality is based on various factors, such as the size of the industrial use and its financial independence, creating a complex configuration that should be explored individually for further substantial evidence. However, land price has little to no effect on the rest of the land-use categories, due to the nature of these categories. The third variable that affects the majority of the land-use categories in the table is the accessibility. The accessibility variable affects the commercial, residential and industrial categories, as these are the categories that depend highly in the road infrastructure existence, either for distribution of goods or for commuting. Also, the categories of agriculture and parking spaces are not so highly dependent on the accessibility variable, as in the first case, agricultural Land-use does not depend in the same extent as commercial or residential land-use, and for the second case, the full automation mode of the new vehicles will uncouple the need for high accessibility. On the contrast, the categories of public services and green areas have little dependency on accessibility to the road infrastructure network. The last variable that is included in the "sensitivity" matrix is the variable of neighbourhood effect. This variable is highly effected to the category of green areas and the land-uses of residential use and public services, even though they are highly depended at the current state, will be less dependent based on the level of autonomy from the AVs. This concept means that the distance between the residential or public service areas and the other Land-uses can be increased without significant alterations in the daily life of the urban residents.

On the contrary, agricultural land-uses, like glass houses that exist in suburban or outer urban areas, do not depend on neighbourhood effect and are unaffected by any alterations of it. The same argumentation applies to industrial and parking spaces land-use categories. However, the neighbourhood effect variable is highly influential in the commercial land-uses, since this kind of use relies much upon the proximity and distance factor for its profitability and operation. It is thus concluding the elaboration upon the "sensitivity" matrix. However, for better understanding of the matrix, an elaboration upon the components of land-use clusters should be made.

4.3.3 Land-use Clusters

As it is apparent in the table, the categorisation of the land-uses for the Amsterdam city area has been divided into seven clusters. These clusters are divide based on a shared characteristic or similarity in nature of the components of each category.

The first category of land-use clusters is the commercial land-use. This category includes every land-use, regardless of the financial wealth and influence, that is considered as part of the commercial service use. This characteristic means that land-uses like little commercial services, market places and large corporations that specialise in commercial services are all included in the commercial category. This type of inclusion was made for two main reasons: firstly, the categorisation of land-uses should be up to a number that would be easy to handle and present, and secondly, because the use of AVs has no significant variety on account of the size of the commercial service.

The second category of land-use is the residential land-use cluster. In this category, every residential use is included, either permanent residency or temporary residency, such as hotels and other residential services. As it is apparent in the literature review that is included in the analytical framework of the current, residential land-uses are highly dependable on the road infrastructure, in the urban environment, and this type of land-use is the most significant component of the urban landscape of a city.

The third land-use category is the industrial. This type of category includes every industrial service that can be found in an urban environment. Also, in this category, heavy industrial land-use, as well as light industrial land-use are included, due to two main reasons. These two main reasons are similar to the first category's reasons for broader inclusion. The first reason is that the number of land-use categories have to be limited to a manageable number of categories. The second reason is that the effectiveness of the AVs in the variety of industrial land-uses are similar, hence is considered to be reasonable to compose a larger group of the industrial services to explore the effects of AVs' implementation.

The next category in the land-use division is the agricultural category. This category includes every use that can be characterised as "agricultural" and can be found in the urban or suburban (peripheral) environment. This category includes greenhouses, cattle breeding areas and allotments that are exploited for agricultural uses are in the majority unaffected by the implementation of AVs.

Furthermore, the next category of land-uses in the taxonomy of the current research study is the parking space/ vacant category. This category includes every parking space that is meant for passenger vehicle use and can be affected by the implementation of AVs. Parking areas of Amsterdam city can be dispersed and integrated into the road infrastructure system. These spaces are highly dependable of an AVs' implementation and are easily affected by any alteration in the transportation system. However, with the implementation of AVs, a large number of parking spaces can be relocated to more distant areas, thus affecting the overall urban landscape.

The public services category of land-use include every non-profitable or private service use that exist in the urban environment. This category includes a variety of buildings like municipality services, hospital,

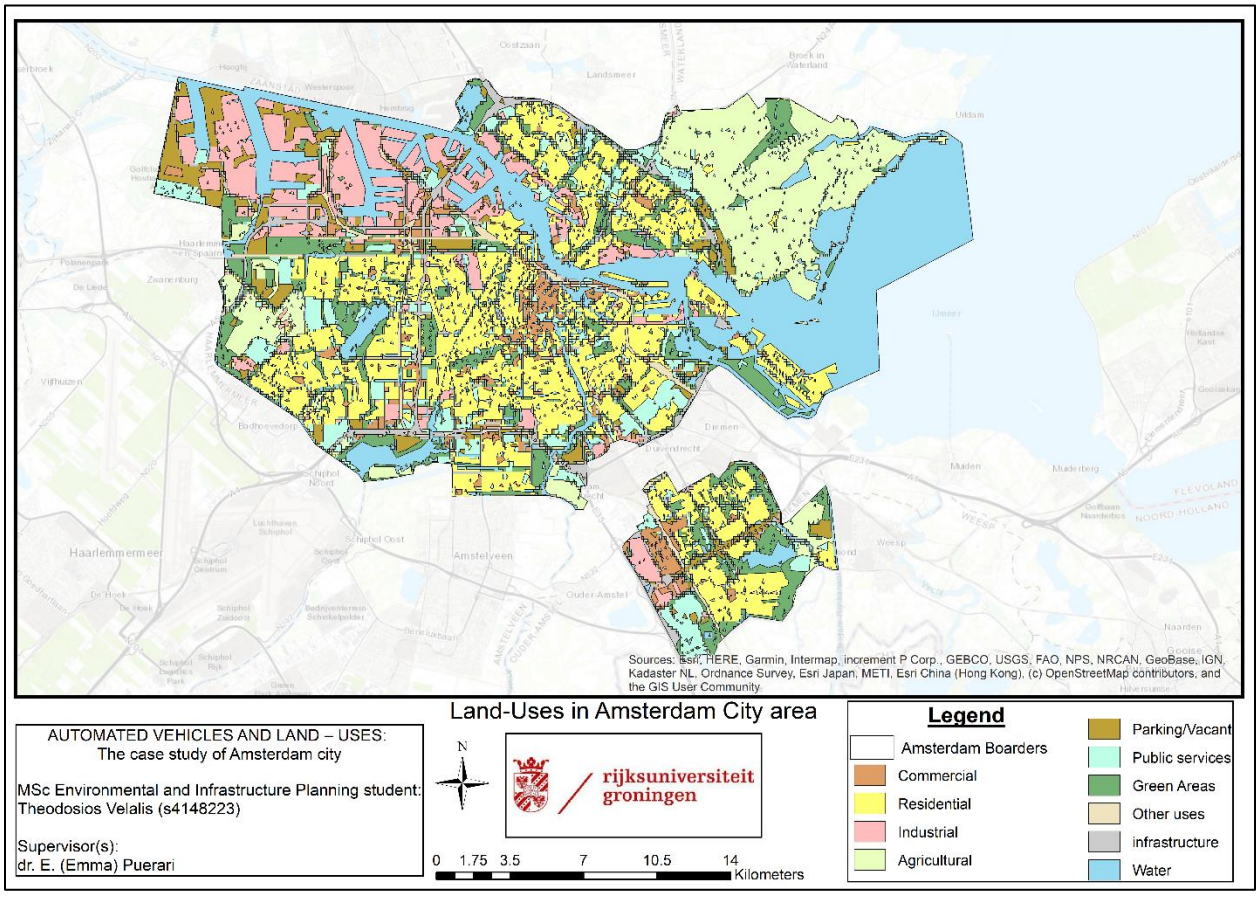
schools and universities, as well as police departments and community centres. The reason for including these land-uses in a single category is due to similarities in the implementation impact.

The last cluster of land-use is the category of the green area. This land-use category includes every green area that is inside the municipality borders of the Amsterdam city, which is the focus area for this research case study. Every green area that is used for recreational purpose, as well as every other green-related land-use, is included in this last category.

On the next subchapter, the GIS-based maps are presented to depict the current situation and the effects of the included scenarios in the Amsterdam city case. After the GIS maps for the four scenarios, the MCA matrix with the criteria and score is included. Through these, concluding remarks for the current research study are drawn.

4.3.4 GIS-based maps

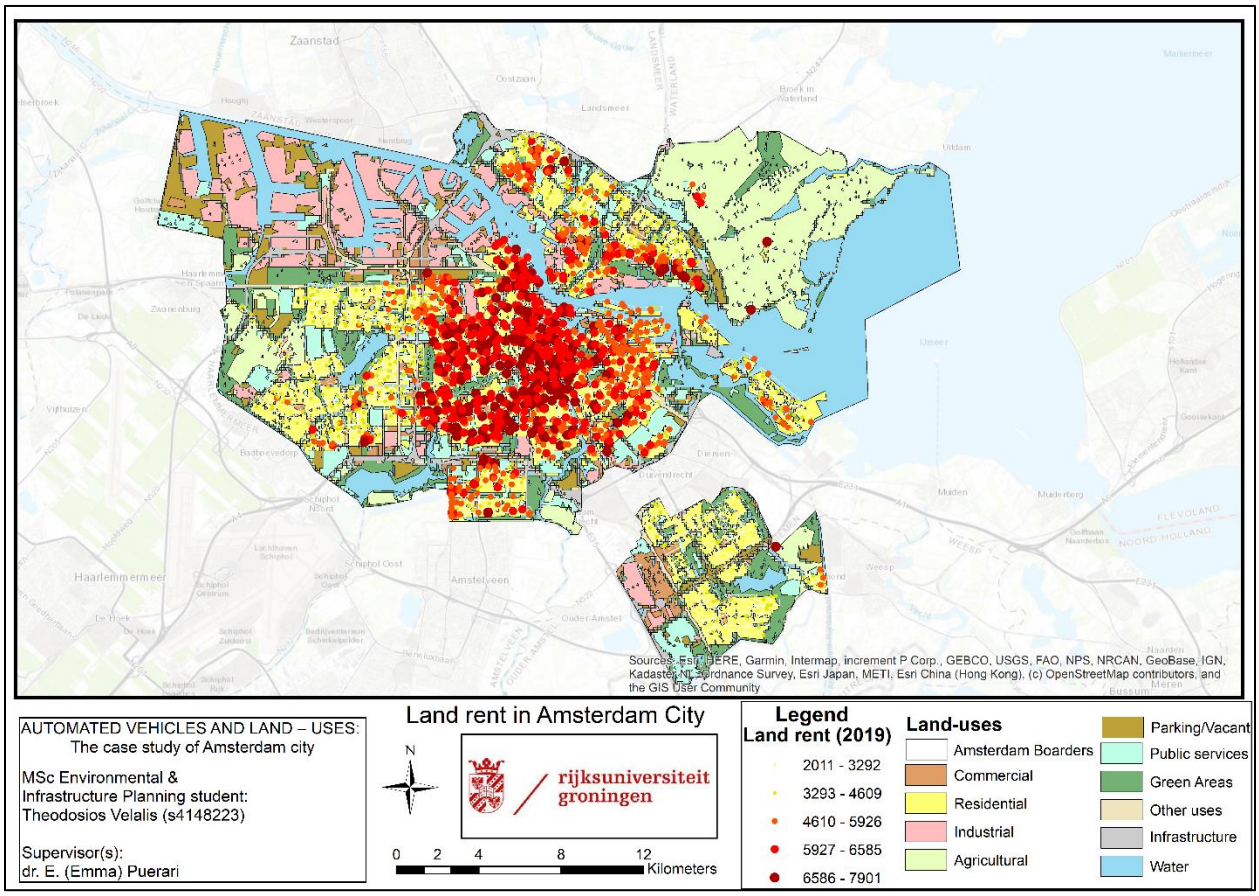
The following maps depict the current situation (2017) of land-uses, as is provided by the municipality of Amsterdam city. The spatial data that were used for the creation of the GIS maps were from the years of 2017, 2018 and 2019. These data showed the most recent development of land-uses in the Amsterdam area and were used as the initial input to create a depiction of the situation before the implementation, divided by the drivers of the Scenario Building process.



Map 1: Land-use in Amsterdam city (2017) based on the current research categorisation

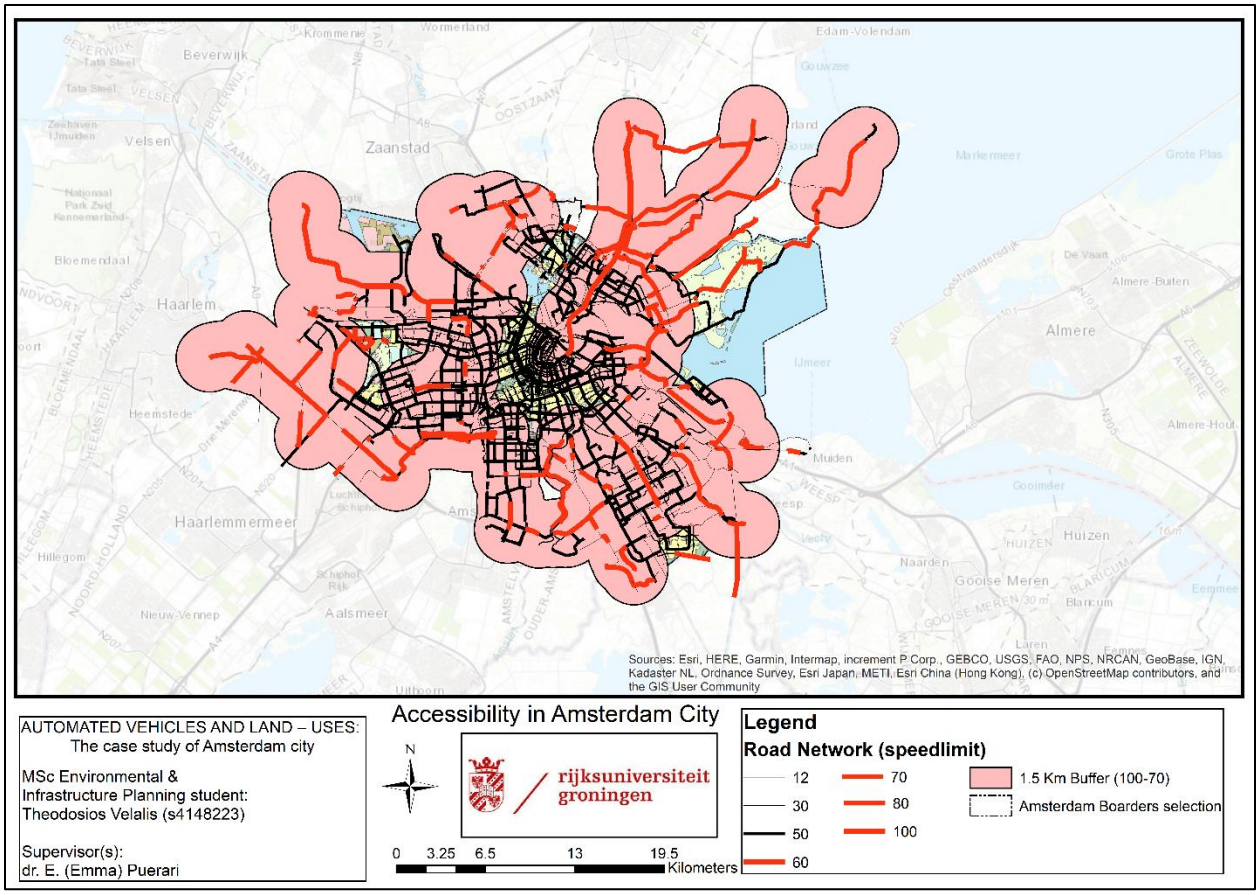
Map 1 presents the land-uses of Amsterdam city, with data of the year 2017, and the categorisation of the various land-uses was made based on the seven categories presented in the previous subchapter. Also

land-uses, not included in the categorisation mentioned above, and the infrastructures and water bodies, are presented in the map. Te purposed of this map is to present the most updated situation of the land-uses in Amsterdam city, thus helping in the conceptualisation of the consequences and scenarios included in the current research.



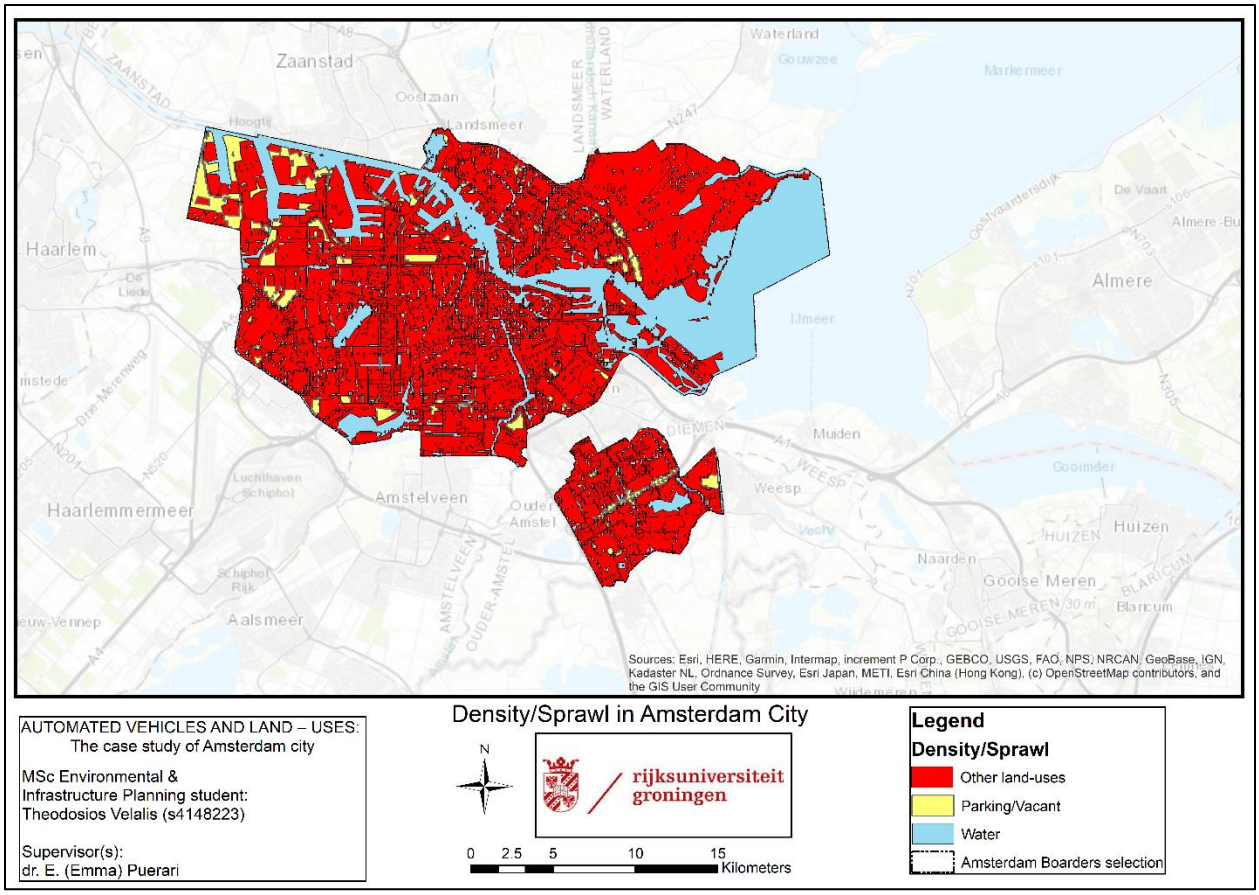
Map 2: Land rent in Amsterdam city (2019)

The above map depicts the land rent for the Amsterdam area and shows the taxonomy and increasing of the land rent (value) as the distance to the city centre decreases. As it is shown in the map, the land rent is divided into five categories, starting with 2011-3292 and ending with 6586 – 7901. The higher rent cluster that is included in the map is found in near the city centre of Amsterdam city. Through this depiction, a deduction about the land value in Amsterdam city can be made, hence as every European city, the land value in the city centre is higher than in the suburbs. This phenomenon, however, may change through the AVs' implementation. Although this is highly plausible, there is no way to predict this alteration, and thus its depiction is not possible. Nevertheless, through the Scenario Building process, the consequences of this alteration can be explored, even if its depiction is intricate.



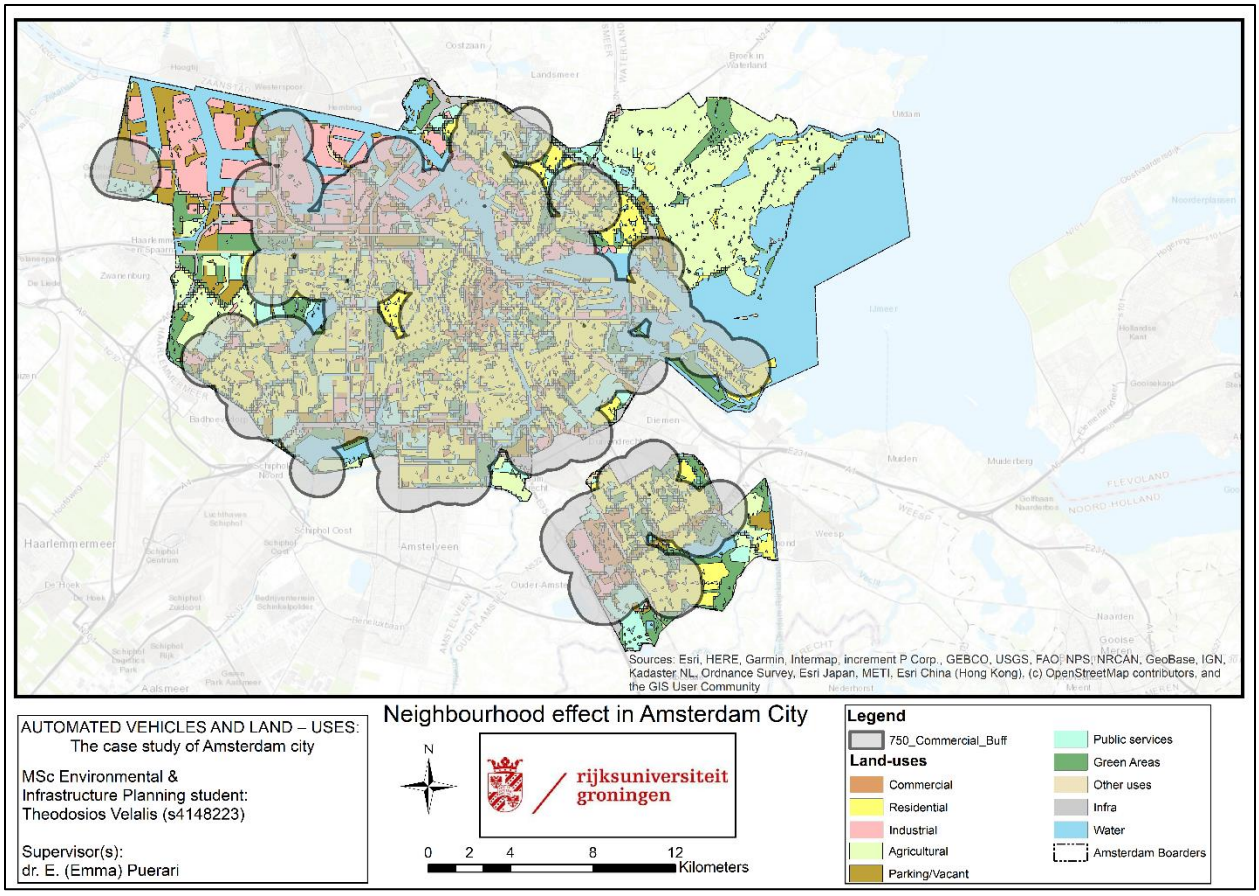
Map 3: Accessibility range of Amsterdam road network (1.5 Km)

The next map presents the accessibility concept of the current state of the road infrastructure of the Amsterdam city area. The accessibility is prescribed as the extent to which the land-use and transportation system allows individuals to reach certain destinations or conduct specific activities (Papa & Ferreira, 2018). In the framework of the current study, accessibility is depicted as the distance of 1.5 kilometres from significant arterials and highways, namely the roads that have a speed limit from 70 to 100 Km/hour. In the framework of the current study, the distance of 1.5 kilometres was deemed as the maximum limit for accessibility. This number is based on the opinion of the author and from deliberations with other researchers. As it is apparent in the map, some areas of the urban grid of Amsterdam city can be considered as having poor accessibility, since there are not included in the 1.5 kilometres radius from the significant arterial network of the road infrastructure.



Map 4: Urban Density in the Amsterdam area

The fourth map depicts the concept of density/sprawl, which is one of the five components that were used in the current study, derived from the systematic literature review. To present the density of the Amsterdam city area, the categorisation of land-uses had to be remade. This new categorisation resulted in two main categories, the category of vacant areas or areas that are used for parking space, and all other land-uses that are present inside the municipality of Amsterdam boarders. The inclusion of parking space in the first category was made, since parking areas can be removed or relocated without significant effort or significant consequences for the urban environment. By creating this map, the reader can have a holistic understanding of the current state of Amsterdam city, concerning the density and sprawl concepts. As it is shown, the vacant or parking areas in Amsterdam city are relatively low in number as opposed to the rest of the land-uses.



Map 5: Neighbourhood effect between commercial and residential land-use

On the last map, the neighbourhood effect between the commercial land-use and residential is depicted. Also, since this relationship between the commercial and residential uses is the main driver for the fourth scenario narration, this relation is presented in the above map. The distance that was selected as a radius for the neighbourhood effect of the commercial use is the 750 meters. The selection of the radius was made based on the same criteria as the accessibility radius. As it is shown in the map, some residential areas in the north, and the centre of Amsterdam city, can be considered outside of the neighbourhood effect of commercial land-uses. Also, the same phenomenon can be found in the southern suburban areas of Amsterdam city.

The maps mentioned above depict the current state of the Amsterdam city land-use grid and the four components that were used in the analytical framework of the current research. Following these maps, the MCA matrix is included, thus finalise the analytical framework of the current research study for the consequences of the potential implementation of AVs in land-uses in Amsterdam city.

4.3.5 The MCA Matrix

The central part of the MCA process is the concentration of the criteria and the evaluation components of the Scenario Building results to a central matrix. This type of matrix is included in the current research and depicts the main evaluation component of the four scenarios, and also explore the effect that the components as mentioned earlier have in each scenario separately. These components were drivers for the narration of four scenarios; however, they are also criteria for the evaluation of these scenarios in the MCA process. Having completed the systematic literature review, conducted interviews and research the

consequences of AVs' implementation, the following table can be created. This table consisted of the qualitative data gathered throughout the research of the current study and focused on summarising the remarks. These remarks are used to continue the process of MCA and thus drawn upon concluding remarks.

Scenarios / Criteria	**Scenario 1 Land price**	**Scenario 2 Density/Sprawl**	**Scenario 3 Accessibility**	**Scenario 4 Neighbourhood effect**
Operational	The functional part of the infrastructure does not directly affect the values of the land. Reduces operating costs and avoid traffic congestion.	Depending on the Density/Sprawl effect, the infrastructure will need to be lengthened (cost) and urban fabric increased.	Connectivity (IoT) in areas outside the urban grid can present obstacles to the operation of AVs.	Cases of fear and discrimination concerning antennas and specific Land-uses.
Property Value	Possible relocation of residents from the city centre to the suburbs. Reduction of the value of land in the city centre	Land costs in suburban areas will increase (Decentralization). Future balancing of downtown and suburban land prices.	In newly joined areas, accessibility is better, and this may affect land values.	Clusters will be created, resulting in the increase of land values from time to time.
Accessibility	Possibility of improving the accessibility of the inhabitants, as they will move to the suburban area, while in the centre due to the old city the accessibility is difficult. Reduction of travel time/costs due to on-time operation.	Sprawl/Accessibility sizes are inversely proportional, so as sprawl grows, accessibility decreases.	Accessibility to newly joined areas is better than the city centre. Also, the new roads will be designed differently.	Accessibility to newly joined areas is better than the city centre.
Neighbourhood effect	Increase the unit of central places for Land-uses as it is easier to access.	The Sprawl/Neighborhood effect sizes are inversely proportional, so as sprawl grows the neighbourhood decreases.	Increase of the Land-use unit since accessibility is increased.	Increase of the Land-use unit since accessibility is increased.

Table 4: Qualitative MCA matrix

However, the use of this type of matrix is limited and does not qualify the focal point of the MCA process. To use the data included in the above table, the use of a method to quantify the qualitative data that are included. Using the Likert scale, the qualitative information that have been collected are processed to quantify them. The Likert scale is a procedure for measuring attitudinal, qualitative data and quantified them (Boone & Boone, 2012). The Linkert scale is often divided into five types of answers regarding a question to gather data for the research. These types of answers are "No relationship, Little relationship, Neutral, Strong relationship and High relationship". These types of answers are quantified by modifying into numeral scores of "0.2, 0.4, 0.6, 0.8 and 1.0", respectively. These scores show the relation between the components and the consequences that they have in the Land-uses of the Scenario Building results.

The data that the qualitative MCA matrix depicts are the combined result of three sources of information. The first source of data for the completion of the MCA process, to deliver the scores of scenarios, is the systematic literature review. Through the systematic literature review, the existence of

relationships between the components and the consequences of Land-uses, in an AVS implementation scenario, are explored. Also, another source of information was the interviews that were conducted in the framework of the current research study. The interview was taken from representatives of the municipality of Amsterdam and the project of "Zelfrijdend busje Olli" in marineterrein in Amsterdam city. This project involves the implementation of an autonomous van that will be used in the vicinity of marineterrein area for public transportation. The interviews were conducted to explore the real-time data that could be provided by the implementation. Additionally, the general knowledge and deduction of the author was used to link the consequences of components to the scenarios. The formula for the quantification of the qualitative data gathered from the sources as mentioned above, is 75 per cent of the score, appointed to the systematic literature review data, 15 per cent provided by the information gathered by the interviews and the last 10 per cent is based on the author's knowledge and deduction.

Based on the configuration mentioned above, the earlier table of qualitative data can be formed as follows.

Scenarios / Criteria	**Scenario 1 Land price**	**Scenario 2 Density/Sprawl**	**Scenario 3 Accessibility**	**Scenario 4 Neighbourhood effect**
Operational	Neutral	Neutral	Neutral	Little relationship
Property Value	High relationship	Strong relationship	Neutral	Strong relationship
Accessibility	Little relationship	Strong relationship	Strong relationship	Neutral
Neighbourhood effect	Little relationship	Strong relationship	Little relationship	Little relationship

Table 5: Linkert qualitative data of MCA

The above table can be interpretative, and the qualified data can be quantified by the formula that was mentioned in the earlier paragraph. Hence, the MCA matrix is reformed and the appointed scores, along with weights, are depicted in the new table.

Scenarios / Criteria	**Weights**	**Scenario 1 Land price**	**Scenario 2 Density/Sprawl**	**Scenario 3 Accessibility**	**Scenario 4 Neighbourhood effect**
Operational	0.5	0.6	0.6	0.6	0.4
Property Value	2.0	1.0	0.8	0.6	0.8
Accessibility	1.5	0.4	0.8	0.8	0.6
Neighbourhood effect	1.0	0.4	0.8	0.4	0.4
Sum		3.3	3.9	3.1	2.2

Table 6: Final MCA matrix with quantitive data

The above table shows the scenario of Density/Sprawl has the most substantial relationship with the components/ criteria related to the implementation of AVs in Amsterdam city area. This characteristic is based on the total score of the scenarios, as it is showed in the quantitive data table. The scenario with the maximum score, indicates the more robust relationship with the components. In the following chapter, the concluding remarks of the current study are presented as well as suggestions for further exploration.

5 Concluding remarks

In alignment with the theoretical framework of the current research study, the concluding remarks that can be derived are as follows. Regarding the MLP levels for the case studied in the current document, they can be found from the stakeholder analysis, which is part of the MCA process. The sociotechnical landscape can be defined as the supranational organisations, like the European Commission – Mobility and Transport, that aims to endorse and promote the use of AVs in the urban and rural regions of its state members. Also, the niche-innovation level includes the Automotive Manufacturers, like Tesla and Local Motors, that spearhead the field of innovation in mobility for the implementation of AVs. Lastly, in the description of the implementation of AVs in Amsterdam city, the identification of the socio-technical regime comprises the administration organisations, such as the Cabinet and Parliament, the Ministry of Infrastructure and Water Management and the Municipality of Amsterdam. This definition of the levels described in the MLP of Transition theory reveals the complexity of the implementation and the multiple agents (stakeholders) that comprise the various levels and interact with each other. Through the use of MLP and stakeholder analysis, the complex landscape of AVs implementation can become apparent as well as the complexity in the interactions of the various agents (stakeholders).

As it was stated in the theoretical framework, the type of transition applied to the implementation of AVs is "purposive" transition. The reason that this type of transition is descriptive to the current state of implementation related to AVs is that "purposive" transition is defined as a result of a coordinated and rational choice that occur from outside the dominant regime (Smith, Stirling, & Berkhout, 2005). As it is apparent from the stakeholder literature, the implementation of AVs in the EU state members is coordinated and endorsed by the European Commission for Mobility and Transport. This characteristic makes the current transition for the implementation to align with the definition of the "Purposive" transition. Also, non-other definition of the three transition pathways includes the coordinated choice outside the dominant regime's frame. However, even defining the type of transition, there is an alternative descriptive perspective that should be explored to define the implementation transition holistically. This narrative perspective is the MPP conception of transition.

According to the MPP, the phase that describes the current situation of the AVs implementation in the urban environment in the case study area, and in extent in the whole country is the "Pre-development" phase. As was explored in the systematic literature review, the equilibrium of the current mobility regime has yet to show any significant alterations. This characteristic means that the transition has not yet reached a point where the results are actively effecting the equilibrium, but they occur in the background of the sociotechnical system. Nevertheless, the equilibrium is dynamically changing, as many resources and policies are focusing more and more on the innovation of AVs and its implementation. It is vivid throughout the systematic literature review documents that the technological resources are achieving multiple breakthroughs in recent years. These achievements are a result of the interactions between the various stakeholders in the niche-innovation level. Also, the pressure from the landscape level intensifies this swift in resources, as more rapid, sustainable transportation is deemed necessary by the supranational organisations. Also, the pressure that the ever-expanding need for parking spaces inside the urban environment applies to the regime level is evident to the effort applied to generate alternative means of transport. Based on these arguments, the phase of the implementation of AVs is the "Pre-development" phase and has yet to generate alterations in the current equilibrium of the mobility system.

Furthermore, the systematic literature review has revealed five components of the AVs' implementation that can be traced back to the tension variables explored in the conceptual framework of the current research study. The component of "operational factors" is directly linked to the infrastructure variable that as new instalments are required to maintain and operated the AVs in the urban environment.

Also, this specific component is affected by social factors that create tension in the progress of transition, as was explained in subchapter 4.2.1 of the current study. Moreover, Land prices, that is explored as a component/criterion for the analysis framework derives from the economy category of the conceptual framework. Also, the economic category variable includes the Neighbourhood effect component that affects the implementation of the AVs in Amsterdam city area. As it was mentioned in the 4.2.5 subchapter, commercial land-use is profoundly affected by the Neighbourhood effect, and as commercial use is also affected by the Economy variable, creates a direct link between the Economy variable and the Neighbourhood effect as a component for the implementation. The Neighbourhood effect is also affected by the Governance/Policy category. The reason for this is that policies affect urban plans in matters of zoning and land-use permissions. Another component related to the Governance/Policy variable is the Density/Sprawl component explored in the systematic literature review. For similar reasons to the Neighbourhood effect, density/Sprawl is highly dependable on urban master plans and land-use permissions, making it relatable to urban planning policies. Lastly, Accesibyity as a component to the AVs' implementation is related to infrastructure as was shown in the 4.2.4 subchapter that elaborates on the third scenario of the current research study.

Based on the above remarks, as well as the MCA process, conclusions can be drawn regarding the scenario that was selected as the most prominent one. The result of the MCA process was that the second scenario has the strongest relation to the component of the AVs's implementation. This characteristic means that the Density/Sprawl scenario is highly related to the tension variables that were categorised in the conceptual framework of the current study. Regarding this argument, the scenario is dependable to the Governance/Policy variable as density and sprawling are often considered in the visualisation and conceptualisation of masterplans. However, as it was stated in the 4.2.3 subchapter, the need for new urban space will put pressure on the planning process. Also, the land value of the suburban areas may increase as a result of the sprawling phenomenon; thus tension of economic affiliation is created, related to the Economy variable category explored in the conceptual framework. In addition, an extension of the road network may be required as a secondary effect of the sprawling phenomenon, which will create tension related to Infrastructure and Governance/Policy variable categories. These characteristics may hinder or prevent the scenario from realisation as part of the implementation of AVs.

Nevertheless, the Density/Sprawl scenario has drivers that also relate to the tension variables, putting pressure in the current dominant regime. One of these drivers is that a sprawling effect may create abatement in the land rent of the city centre, thus equalising the rent value between the suburban areas and areas close to the city centre for a prolonged period in the Amsterdam city area. Also, in the narration of the second scenario, "empty pocket" spaces can be created, thus more possibilities of recreational uses can occur in the urban environment. These recreational "pocket" spaces are considered vital, even as an aftereffect, for most European cities that have dense urban grid, as Amsterdam city has. Lastly, in the Density/Sprawl scenario, as well as the rest scenarios of implementation, the relocation of parking spaces in greater distances from the residential or commercial/ business areas plays as a significant part; hence improving the quality of the urban environment. However, in the duration of the current research, many data gaps were found considering the effect of new mobility system innovations, like the AVs, that have yet to be put to the test. These data gaps may be either due to lack of evidence regarding innovative technological systems or due to lack of focus in this direction by the administrative organisations responsible for implementing such plans. However, it should be apparent that the investigations and research upon plausible implementation may need these data to proceed. It is, therefore, crucial to examine these data gaps and mend them, before creating decision-making procedures, to have a clear view of the possible future situations. For these reasons, further research studies may require to assist in filling the data and knowledge gaps.

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7 Appendix

7.1 Interview with Mr Gerben Mienis - Representative of Bureau Marineterrein Amsterdam.

- 0.07: Thesis introduction
- 1.02: First of all, I would like to ask you in which part you are right now?
  - It's a collaboration of different parties, Government and also a public organisation the government, city of Amsterdam and the transport organisation, which used to be a public organisation ten-twenty years before, its a commercial party. Actually, it is a collaboration of different parties and we as the marine terrain of Amsterdam, we are between public and commercial party, moreover, our goal is to develop an old defence area which was in the city which need to became a city area.
- 2.24: This area is only for residence? What Land-uses are there?
  - Its difference over the years, we started six years ago, at 2014-2015, and our commission is to develop the area on a temporary base. So we are not going to the drawing table in order to have a residential area, working there, leisure there and sports. But it is more like a development of experimenting and doing, so all the building that would empty or handled over from the defence to us. We looked for tendency and parties and could be fulfilled, and could be meaningful for the development of the area. So, at this points we are writing a document which mainly focus on residential, learning, so that means it will introduce in school and learning institutions and working so this three are very dominantly for the document. But within these three themes, we are looking for "how do you develop an area like this?" and how does the city look in ten years. Even if the dwellers, maybe there are more and with different needs.
- 4.57: How the future situation is going to be with the implementation of the bus project?
  - We would like to see and to learn by this project, for example, if we don't allow vehicles like cars on the terrein. It is possible especially if you can enter the area with the car, then you need to come up with the alternative way, because people need to move. So, this is actually the starting point, we have a goal: zero cars in the area, in the Marineterrein. We started the search, with many tests or pilot and together with the city council and the Province, so local government, regional government and some transport parties, we subscribe for this challenge, which was a pilot done by Local Motors, an American company and they built this vehicle, because they want to deploy the "Olli" in Europe. Moreover, a couple of cities subscribe for this challenge and we won, so at the end of November and December, we will have two vehicles travel around in terrein. It sharted as an investigation. So what is needed to have these automated vehicles on site.
- 7.41: Is there any studies or research about the consequences for this implementation?
  - We did not study, we know other pilots of course for automated vehicles for secure area, one lane for this vehicle and it is no mixed traffic. So as far as we know this is the first time in Holland it is going to drive around in a public space, not a private space. There is a mixed area, of pedestrians and bicycles and a small amount of cars and other vehicles.
    - So, it would be two forms of transport system, conventional vehicles on the road and "Olli" is going to operate beside them.
  - Not at all, all are going to be in the same area in a public space. And the marineterrein area is private, but it is still submitted in order to reach the goal of zero cars, and the implementation of this kind of vehicles.

- 12.16: On the context of your project, was there any bias against the use of an automated vehicles, did you come up with any obstacle like the people just be awkward opposed or against the thought of having a driverless vehicles going around, did you expect something like this?
    - We are going to monitor and a lot of intervening so "Olli" is going to drive for three months, and we have different types of interviews of planning, maybe there will some hesitation, but until now we did not any signs of people being afraid. We do communicate on website and newsletter in which communicated that we are going to drive around with this automated vehicle. But to this point, there is no sign of people against the thought.
- 13.32: Did you have any technical problems or infrastructure modification of infrastructure?
    - Not really, just a little bit, very practical, in the corners that needed to be adjusted so the turn that it makes, but it a very small vehicle. It can carry nine people. It is a driverless vehicle, but there is a "host". So legally speaking he is the driver. So, in infrastructure, we have to adjust only two corners and we are going to drive, it is going to be additional voyage for the public transport, so we connect the bus line and the tram on the other side. There is the bus stop on the one side of the Marineterrein and on the other there is the tram stop. It is 1.02 km distance, and the "Ollie" is going to drive from 9 pm till depending on the battery. It is an electric vehicle and we have two of these vehicles, so the vehicle can drive for about 2 hours on battery. So it can have 2 batteries to drive 4 hours in the morning and then maybe 2 or 1 hour in the afternoon. Maybe we are going to experiment with the route, and if are some incidents, people jump in front of it without warning then we might do some linning or striping on the surface of the road to see if that helps.
- 17.22: Are there any difficulties with the financial life of the project?
    - The American company is going to pay quite a bit,
    - Which mean they are funding?
    - Yes, they are funding. We made a research before about the costs and the city of Amsterdam has a budget of innovation, the GVB, the transport company has a small budget for new business. And of course they are interested, also the Province has already budget which can apply, so it not difficult we have 5 stakeholders to funded, and 3 universities for the budget of research. Overall, it was not that difficult to get the funding together.
- 20.09: Are there any reports for the project?
    - We have a research plan in Duch, but I need to check in order to share it. So I will have to ask and then sent it your way.
- End of Interview

7.2 Interview with Johan Olsthoorn - Representative of Municipality of Amsterdam

- 2.25: thesis introduction
- 3.00: Relation between AV and Land-uses and if so what is your thoughts on it:
    - I would like to add that I am not the only one responsible for the research there are also other contractors, e.g. AMS, we do this together with them. Concerning the question, well… for now this is a pilot on a Marine terrain so we actually at the city are not sure yet if AV are a good solution in our problems. And this is actually a way to find this out. So now…
    - To explore every option, every possibility…
    - Ja, ja… So we want to… one of the aims is to learn if this actually effective method in… ja, where do we see the most benefit of AV in the first and last mile solution of transit and so with this pilot we are actually trying to test if this works for us, if it is safe, if it efficient, if people find it comfortable to use it and if actually working with [noise] (the first and last ?) mile adds something to it.

- 5.00: Do you think there is any bias against the AVs, from what your preliminary studies have shown, or your experience? I know for certain a similar project was made here in Greece, there was some bias against AVs, senior citizen didn't trust the whole concept, they were afraid of it. I do not know what was the situation In AM.
    - Ahmmm… Ja, we actually do not know yet. Because we are still preparing the project, we do not have any research results yet. So it is part of the research to see if it has an effect on the attitude of the public towards this type of transport
    - Ok
    - And so I think, that the picture will be diverse. So there will be people more open to something new, and other people that think it's unusual.
- 6.44: I would like to ask you is, I know that, from my interview with mr Gerben Mienis, he told me that the project is going to start the last quarter of 2020 and it is postpone due to the whole corona crisis, and I saw on internet on the site that it was supposed to start on 1st quarter of 2020 but it was postponed, do you think that a successful implementation, a successful project of "Olli" is going to help Amsterdam do a big step and implement such project on the whole municipality area? What is the attitude towards the project?
    - Hmhm, yes so there is actually two aim with, two goals we are achieving with the pilot project ee? One is to increase the insight of effectivity of AVs as a means first and last mile transportation, public transit. And the other is to learn of the implementation of such a service for in a case we want to upscale this and role it out in other parts we can do more effectively
    - So to see first hand what are the challenges of such an implementation
    - Uhmmm… so what I wanted to say is that there are 2 aims, so the outcome of the pilot can be still a success when it saws that AVs are not such an efficient means, then still we learned something and in case it is an effective means, ja, then we might consider to do this in other parts but we do not have a plan beyond this pilot yet. I must admit, because a big part will be … if it is really effective, profitable, it seems that now although it is an AV it still there will be a steward needed to vigilize it until the start of these vehicles will start to really drive autonomous without a steward, it does not look so probable that it is a promising business case, for this type…
    - Not if the technology makes leaps to more autonomous vehicles sort to speak
    - Jaja there is well one thing is the technological leap, the other is of course the acceptance of the public and also the law, the jurisdictional law, the RDW. the Dutch road authority that need to approve it that this type of vehicle is allowed to operate in the road with ought a steward, and I do not think that we are that far yet now.
- 11.30: You mentioned something about the economic outcome of the project, do you have any indications over? Did you explore something over the economic framework of the project, did you explore something about the economic effects?
    - We are planning to interview people and ask if they are willing to pay for such a service and what amount, and we also thought to make an experiment with actually have equal pay with the OV-chipkaart but I think this is not so easy to realize. But this is what I think we can do for now with respect to economic profitability.
- 12.44: Do you as an expert have any thoughts about the effect that this project may have in area like Marineterrein like in the Land-uses or in the daily life of people working or living there. Do you have any suggestions or thoughts or anything?
    - Well, so you mean if there will be an interaction between this new service and Land-use.
    - Yes
    - People actually, maybe start to employ economic activities or something else.

- Yes, so from the literature I have research it suggests that if the AVs is done by private implementation lots of the Land-uses will be effected, mostly the parking spaces can be relocated to the outer ring of the city but this is always a suggestion that is fruitful for exploration but there is no concrete, solid evidence about it, so are you align with this way of thought or do you think that this is a utopia scenario?
    - Well yeah, I think that in this case, which is a bus, shuttle bus, that works as public transport and I think it is an addition which will increase the quality and the reach of public transport network which might be of influence of most choice for peoples, ee? And for instance, I see that this is the most probable that it would make this as a circus… for… would be in areas that in a less complicated environment than Amsterdam is on places that are… on for instance industrial area, or port, where there is less traffic, where there will be easier for the shuttle to navigate and where there is more probable they are allowed to drive with ought a steward. And will be the cost-efficient addition to in areas that have right now too little passengers for regular bus services.
- 16.52: So the main objective of this project is to see if it can be used as supplement to the existing public transportation in Amsterdam. So not to dominate it just to supplement it.
    - Maybe this will be additional in places there is now, not cost efficient to have actually regular bus service
    - In suburban areas where there is little demand?
    - Yeah, yeah, for instance one place we are thinking it will be Riekerpolder have you hear of it, do you know where is it?
    - I have heard, I am not entirely sure where is it.
    - Yeah, so that is an area SW of Amsterdam. And there are several offices there I think IBM is there and Prize watchhouse Hoopers and Quatradius, they have big offices and this offices are still far away from the metro stop and I think this companies are now organizing something themselves there is a shuttle bus during the rush hours or something, there such as
    - So to link between the metro station and the corporation offices
    - Yeah, yeah exactly and what you say about this Land-use change…, there will be less demand for parking spaces … and I think… if we go to private car ownership that will be… private cars will be autonomous to such a level that actually park themselves somewhere else or … or that people, can actually… yeah… don't have to drive themselves anymore for instance to work or can work inside the car and then they can get much more Land-use effect. But I think this is a little bit of different type of AVs maybe or… some levels further down.
    - Yeah higher level of automacy
- 19.52: Last question for you, I think I am good thank you, is there any chance if I can get my hands on the research plan of the marine terrain?
    - Yeah sure, I can send you that
    - Thank you very much I really appreciate that. Uhmmmm just to be sure I have all the information I need. Because I don't have the data necessary, but I need to propose some exploration, some indicators for some others.
- 20.44: I think I am ok right now I have all the needs that I need. Thank you.
    - OK, so next week we have a meeting, start eindkoms, so the first meeting with the road authority which it takes official, start kind of the project. So the road authority is coming to asses our plan on this pilot. Based on the information they delivered and we discussed there and to eventually decide if they are going to give us the permit to carry out this pilot here. This permit that it allows us to set the shuttle in the street. That will be next week and this research plan is part of that and there might be alterations to it due to the discussion there. We already

discussed that we actually should …. That we actually will add some research question about artificial intelligence. Because our shuttle, the shuttle we are going to have, that "Olli" have from the locomotives the are really excited about it because it has already a lot of artificial intelligence in it and they will learn stuff. Which (the pilot program) is interesting to them because they have to test the vehicle and they get a license for a vehicle that later on it will alter itself and then you know it will not be the same vehicle anymore as it actually was.

- 23.04: So the whole SIC? Relation of data that it will receive it will alter the technology it operates
  - Yeah
- 23.26: Oh last minute question, do you think that your representing of municipality, of your role, what I could gather can lack representative of the mobility department for the municipality, I am correct or do I got that wrong?
  - Uhmmm, I am an executive, I work there …
- 23.55: I would like to ask you if the municipality is more keen of a project of private of public automated vehicles. So if this project is successful but the results are not what we are expecting is there any chance that the municipality will be more favor to private implementation or the municipality is going to push towards an implementation of public AVs?
  - Hmmm, By private implementation you mean it will not be the city providing this services, that there will be other parties that will provide semi public or public transport services…?
- 25.03: When I say private implementation I was think, like, when that technology will be up for it. So that the cities will have private ownership of automated vehicles. Is the municipality going to allow that or it is going to push for a more public AV plan?
  - We don't have that yet, we do not know that yet, we are open for it. It is not really clear what the effects are going to be of AV. There might be benefits, for our goals. Our goals in movability and clean air, habitability and accessibility for different kind of people if this new mode… for this type of AV the private ones would add something to it will be for the benefits for these goals. We will be open for it. I think, that is what the city (is interested in)…. But for now we do not have
  - enough data yeah, thank you very much, I have everything now…..
- End of Interview