Bachelor Thesis Erasmus School of Economics

Making Parking Flex Again

The Road to City Happiness Starts at the Transition Hub

K. van Lieshout

Student number: 371007

Supervisor: Dr. P. van der Zwan

Abstract

In this thesis research a sophisticated business idea for improving the current mobility issues such as congestion, CO_2 emission and particulates is elaborated. This innovative, paradigm shifting and highly automated Transition Hub along with its complementary mobility services can provide the solution for this societal problem of inefficiency. The main focus is placed on the externalities of the Transition Hub. The results show that the Transition Hub has the potential to solve many issues regarding mobility and environment in cities like Rotterdam. If located efficiently, the Transition Hub can reduce inter-city traffic by offering both flexible parking spaces and additional services such as the Wheelie and OlegO. Emission of CO2 and particulates are reduced when using the Transition Hub.

This thesis also shows that the Transition Hub will transform the inflexibility of real estate by using its modular design. Offices, living quarters, shops or storage facilities are options to build in a Transition Hub next to the Flex Parking area. By concentrating commercial activities near the Transition Hub it is expected that congestion in neighbourhoods is reduced and efficiency of commercial activities is increased.

Table of Content

1. Introduction

Nowadays, the parking situation in most metropolitan cities is becoming a source of frustration for daily travellers by car. Especially during rush hours, one can experience a substantial part of the whole trip searching for a parking space in congested urban areas. One study claims that over half the cars driving downtown in cities with serious parking problems are cruising to find a parking space, thus resulting in unfavourable congestion (Arnott & Rowse, 2009). Despite the fact that such large and agglomerated cities have put certain effort in improving the efficiency of parking in their most traffic-crowded areas, new technological advances are yet to be placed (Van der Knaap & Van Wee, 2004). Evenmore, experts predict a stable increase in the population of densely populated urban cities (Centraal Bureau voor de Statistiek, 2013), which can be directly linked to the demand for transport and therefore the amount of cars.

These different problematic factors regarding the parking situation have led to the current study on increased efficiency of parkings.
This study tackles both the complication of inefficiency and inflexibility of current parkings simultaneously by offering a comprehensive and integrated plan. We build this research on the business ideas and product concepts of Van der Wijngaart's Engineering Services[1]. Van der Wijngaart's Engineering Services recognises the waste and pollution problem and aims to prevent these with innovation and change. The concepts of Van der Wijngaart's Engineering Services are based on a circular approach to product life cycles and the company uses creative processes to connect different industries. Van der Wijngaart's Engineering Services currently offers modular products in the farming industry and is lead by Mr. Aad van der Wijngaart.

The present thesis looks from a holistic angle at the mobility needs of the city of Rotterdam and introduces these business ideas and product concepts of Van der Wijngaart's Engineering Services. Van der Wijngaart's Engineering Services has designed a concept of Flex Parking, which we rephrase in a more sophisticated way to "Transition Hub", to solve Rotterdam's congestion and particulates problems and to create a new paradigm of mobility. This study aims to legitimate the use of the Transition Hub in the infrastructure of a city on an economic basis.

[1] For more information on Van der Wijngaart's Engineering Services, see: http://www.wijngaart.nl/

But is this new business idea truly the right way to solve this issue?
The overall central question in this study, consisting of three separate but complementary theses, is: *"How will Transition Hubs function in Rotterdam?"*
Although all three theses are researched and formulated separately, they do consist of a general part, which was jointly made. This common part consists merely of the introduction and the theoretic framework partially, specifically the pages 2 to 15.

The subcentral questions, indicating a clear distinction between the theses, to this central question are:

- *"Is the Transition Hub economically feasible for implementation in Rotterdam?"*
- *"What is the best entry strategy for the Transition Hub in Rotterdam?"*
- *"What other functions can be performed by the Transition Hub in Rotterdam?"*

In the present thesis, the emphasis will be placed upon the *externalities* of the Transition Hub, the mobility components which are interconnected to this and the possibility to exploit other functions at the Transition Hub. Therefore, the central question in this study is:

"What other functions can be performed by the Transition Hub in Rotterdam?"

This Transition Hub will, besides parking, provide two different types of electronic means of dependent individual transportation, the OlegO and the Wheelie. This study legitimates the use of the Wheelie and the OlegO. These two means of transportation can increase efficiency for the traveler by reducing the time traveled between the Transition Hub and the final destination. In this way the total travelling time of an individual or group of individuals is shortened; a mobility advantage.

In this study, the main focus is placed upon the parking situation in the city of Rotterdam. Rotterdam, being commonly known as the 2nd largest city of the Netherlands, is very popular for its important core commercial activities, infrastructure, society and especially for its port. Whilst Rotterdam currently counts more than 25 'big' parkings (Rotterdam.nl, 2015), the congestion is seen as a serious problem, which could only get worse. Citizens of the neighborhood around

Winkelcentrum Keizerswaard experience increased problems with parking and are becoming furious at the municipality for not solving these issues after repeatedly discussing the issue (Roubos, 2013).

What is even more problematic is the fact that the existing parking is not considered flexible when it comes to the efficiency of the traveler. Most journeys require the use of multiple means of transportation and therefore a flexible connection between these. Parking nowadays usually consists of a less comfortable walk of at least 10 minute from the parking to the destination.
The existence of efficiently-operating parkings causes less congestion and undoubtedly stimulates the clustered areas important for business environment, thus positively influencing the regional economic growth (Arnott, 2005).Two main reasons contribute to this disturbing issue, being unavailable properties and technological inefficiency. Every square metre in the downtown of Rotterdam is essential for the companies located nearby, leading to minimal optimally located parkings. Also, the current existing parkings are claimed to take up more space than they should. A clear distinction at this point should be made between individuals with a long-term parking contract and just the simple 'shopper', who has no parking spot assigned to him in advance. Because of such diversity in businesses in the downtown of Rotterdam, it is quite difficult to predict what proportion of the total users of parkings are shoppers.

Besides the restricted mobility businesses and people face, another problem is embedded in the logistical system of a city. Goods and services are not optimally allocated in every neighbourhood for businesses and people. Goods and services are usually provided in fixed locations in the city from where business and logistical operations are conducted. Goods and services are transported from that point to the residents, such as the delivery of packages or letters. This causes additional unwanted traffic in urban areas of commercial freight and services (Crainic et al, 2004).

Another problem regarding the logistical system of a city is that people have to commute from home to their work destination, while in most cases the work place will not or cannot provide parking for their employees, forcing employees to travel longer and use more means of transportation than the optimal number of means needed. Research has shown that if an employer provides parking for their employees, 63 percent commute by car to their work. Only 16 percent commutes by car if the employer does not provide parking, which forces commuters to use public

transport instead of individual transport (Jansson, 2010)

In addition to the scarcity of parking spaces, the parkings are located in the centre of the city. As for Rotterdam, most of the parkings concentrate in the centre of the city. Residents, commuters and tourists travel to these parkings, thus congesting the centre of the city. Besides congestion in the inner city, the highway around Rotterdam is one of the most congested infrastructures in Europe. According to INRIX Traffic Scorecard Rotterdam is the sixth worst congested city of Europe in 2011 (INRIX, 2012). Also the exits of the A15 near Rotterdam are considered to have the highest congestion costs in the Netherlands (TNO, 2008). Though the crisis and the stagnating economic growth has decreased the congestion in Rotterdam (INRIX, 2012), it is expected that congestion will rise again, since there is an expected rise in economic growth in 2015 (Centraal Bureau voor de Statistiek, 2015).

Rotterdam has relatively and absolutely the highest concentration of particulates in the air due to traffic and industrial and port activities. Rotterdam has tried to tackle this environmental problem, since particulates are the second most harmful factor for the lifespan of the average resident of Rotterdam (Burdorf, 2009). In 2008 several researchers published findings that particulates are even deadlier than previously thought, emphasizing the need of reducing particulates and particulate standards in the city (Ballester et al., 2008). The maximum allowed concentration, set by the European Union, of 25 milligram per cubic metre is often surpassed in the daily measurements of particulates in Rotterdam (Landelijk Meetnet Luchtkwaliteit, 2015).

To fight these particulates, the Transition Hub will also purposely function as a central hub for electric cars and other fully or semi-electric vehicles, which are being used more and more often (Adriaanse, 2013). The municipality of Rotterdam supports the use of electric vehicles by providing charging points on streets and offering a subsidy for an own charging point on privately-owned properties (Nederland Elektrisch, 2015). Also other subsidies are offered to incentify the use of 'cleaner' vehicles, resulting in improved environmental conditions through less CO2 emission and less noise. So whilst the Transition Hub appears attractive for the standard daily traveller, it also contributes to society's push for more sustainability for the long term (Forbes, 2010).

The main findings of the thesis are that the Transition Hub could serve as a revolutionary new way

of parking, traveling and consuming. By using its modular design, easy accessible services such as the Wheelie and OlegO and its more efficient design than conventional parking garages we will show that the Transition Hub will be an addition to the city of Rotterdam.

After the introduction about the central problem in this thesis study, a theoretic framework follows. In this section, the main theories and concepts are discussed. Subsequently, the sources of the relevant data collection are discussed in the data and methodology section, along with the used calculation and assessment methods. In the following part, the results from the analyses are presented. In the final conclusion and recommendations part, the central question in this study is answered.

2. Theoretic framework

The theoretic framework covers several concepts as well as economic theories. The concepts are taken from literature and adjusted in such a way that they fit within this specific study.

2.1. Concepts

2.1.1. Mobility

Mobility is the concept of moving from one point in space to another point in space at a certain cost of moving. Costs of moving are time, energy, money or something else such as comfort. In this research the focus lies on maximizing mobility in relation to time and money since these two are easily linked to the economic domain. Mobility of an individual is optimal when the individual can travel from point A to point B and minimizes the time costs.

For the sake of clarity, we define four different dimensions of mobility; these are the dimensions that are present in every day of our lives but that are not distinguished by their character. There are two categories and two levels to mobility. The two levels are: individual mobility i.e. travelling on one's own and mass mobility i.e. travelling in a group. The two categories are: independent mobility i.e. without a vehicle and dependent mobility i.e. with a vehicle or another instrument. An individual can choose to travel on an individual level or on a mass level and by independent means or dependent means.

2.1.1.1. Mobility market structure

From an economic perspective, on the mobility market it may take people longer to reach their destination because of regulation, market imperfections or market failure. In practice, this means it could take people longer to reach their destination because of for example traffic lights, walking from train to metro or a traffic jam.

The points of delay can be categorized according to their nature. There are congestion points and transition points. A congestion point occurs within one means of mobility, a transition point occurs between means of mobility. Both congestion points and transition points can be expected or unexpected. Besides, both congestion points and transition points cause costs.

There are therefore expected congestion points causing expected congestion costs (e.g. traffic lights), unexpected congestion points causing unexpected congestion costs (e.g. traffic jams or detours), expected transition points causing expected transition costs (e.g. transfer time) and

unexpected transition points causing unexpected transition costs (e.g. delay of train connection).

The market is assumed to be perfect besides the points of delay mentioned before. This means that there are no other costs of moving in this market besides those. There are no costs other than time related to the points of delay; costs such as rescheduling an appointment or missing a business deal are assumed not to incur. A perfect market also means for example that everyone drives at the same average speed and that every car uses the same average liters gasoline per kilometre.

2.1.1.2. Travelling

Travelling by independent means is always necessary to reach a destination. However, the dependent individual dimension has an advantage in providing flexibility: the possibility to reach the destination in close proximity. The advantage of using dependent mass resources is the availability and shorter traveling time between two locations. These locations are however set. In practice there can be a lot of transition time changing from dependent mass resource to another dimension or dependent mass resource.

If a person wants to travel from A to B, that person has a decision to make regarding the mobility dimensions. This person can choose to travel independently individually, e.g. walking, but this action is not happening in the economic domain. For this research, this basic situation is taken as reference point. But people travel by more means than independent individual means.

An individual could use an individual means of transportation to reach his destination in close proximity, but it is likely that there are expected and unexpected congestion costs. Another option is to use public transport, which causes shorter traveling time between stations, but this option has transition costs and the possibility of high unexpected transition costs. The third option is combining both individual and mass transport.

An individual is usually confronted by fixed and variable traveling time when traveling. Since the market is perfect, it is assumed that an individual has no significant influence over the fixed traveling time. The variable traveling time is the expected congestion time and expected transition time incurred when traveling between point A and point B.

2.1.1.3. Coping with market conditions

It is of public interest that unexpected congestion costs and unexpected transition costs are minimized. Minimizing these costs might be in the interest of private parties too but this is mostly

not the case. This leads to moral hazard problems and inferior lock-in in innovation. Solutions to these situations can be found in integral approaches. These can be enforced by governments or offered by companies if the market situation gives room for innovation.

Transition time is minimized when there is no time between the use of one mean of transportation and the other mean of transportation in order to reach the destination. For example, a transition between a train and a bus is minimized when both stations are at the same location and both the train and the bus arrive at the same time. An individual tries to minimize his or her traveling time costs by reducing his or her transition time cost.

The inherent problem of the conventional means of transportation is that all means are limited in their flexibility in the city centre. In the city centre cars, motorcycles and bicycles need to be parked in designated areas, which are almost never directly connected with the destination or the transition location. Therefore, those designated areas pose an extra transition for the individual and causes the total traveling time cost to increase. For public transport a similar, but a more static problem arises. Most bus, metro, tram or train stations are located at the centre of their neighbourhood, but are not directly accessible for every individual, implying inefficient transition time.

The trade-off between time and money counts too when moving to the city centre which is reflected in the willingness to pay for mobility, in metre per second, given a certain location. This is the demand side of the mobility market.

The supply side of the mobility market is diverse in its approach to serving the market: parkings, car manufacturers, public transport etc. serve the market in their own way. This study looks at an integral way of serving the mobility market.

In order to serve the mobility market, the best parts of independent and mass transport have to be taken and have to be reconsidered in an integral way.

2.1.2. Elements of the Transition Hub

The Transition Hub is an innovative, automated parking, providing coherent and complementary travelling services to pursue one's journey. This section describes the key elements that make the

comprehensive Transition Hub a well-thought solution for the current mobility market.

2.1.2.1. Flex Parking

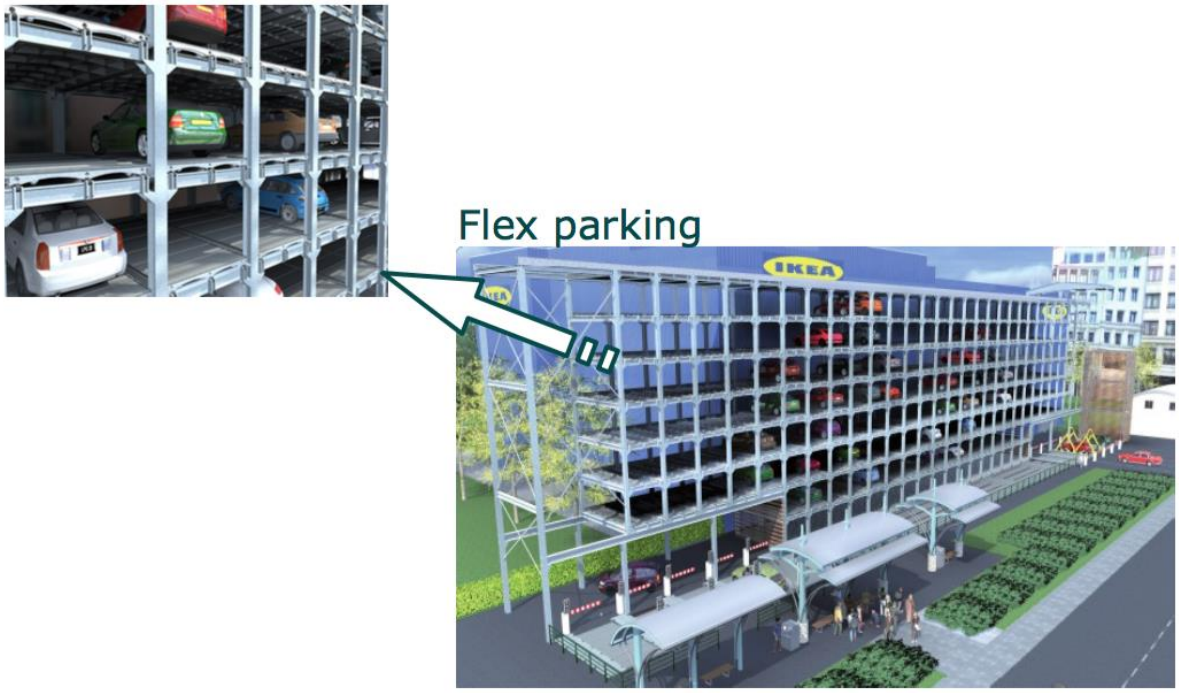

Figure 1: Flex Parking

Flex Parking can be explained as a sharply innovated version of existing parkings and can be viewed as beneficial for both the individual traveler as for the city as a whole. This idea basically requires less total size for the same amount of parking spaces, decreases total parking time and improves flexibility; these benefits will be briefly explained as follows.

Firstly, Flex Parking is able to provide at least the same amount of parking spaces of conventional parkings, by using significant less total space as a whole. This is possible because of the technologically advanced method of parking, which the Flex Parking adopts. Instead of the regular way of parking a car in a parking with multiple stories, the Flex Parking allows an automated, robotic crane to place the car in an empty parking space. This crane is highly technologically advanced and is comparable to the automated cranes used in the operations of the Haven of Rotterdam. Learning and adopting the way such advanced cranes are used and implementing this in

a totally different industry, can be very beneficial and can deliver a direct boost to efficiency. The main idea behind adopting this technology is to save the individual a great deal of (valuable) time when travelling from point of departure to point of destination. One can simply drive up to this Flex Parking, place its car on the right spot and immediately pursue their journey. After the car is placed, the automated crane is supposed to finish the job of parking the car in a quick, safe method. This crane is designed and pre-programmed to purposely execute this order in an efficient way.

Also, making use of such an automated crane minimizes the probability of human errors/casualties. In the conventional way of parking, an individual uses its own driving skills, built through experience, to properly park a car in the for the car designated parking space. Also, it is safe to assume that not every car driver consists of the same level of skillfulness and focus. Because human behaviour is subject to human errors and other factors, the chances that an individual experiences a problem when parking is higher.

Another huge benefit of the Flex Parking is that it requires a considerable smaller total area for the same amount of parking spaces. In conventional parkings, an individual needs to be able to make turns, drive up to parking space, drive up to the different stories and be able to perform manoeuvres when necessary. A normal car requires at least a width of 6 meters to be able to make normal turns, which are usually necessary to make when parking the car. By making use of the Flex Parking and its services, all this 'wasted' space is removed and every single parking space is optimally utilized.

The Transition Hub combines all dimensions of mobility shaping an integrated mobility market. With regards to the competitors, taxi, train, bus, tram, metro, private car usage, carpooling, parkings, private bicycle usage, bicycle renting it is important to note that the Transition Hub aims to combine all of these in this integrated mobility market. The Transition Hub is a unique as well as a superior service when looking at all these competitors separately. As mentioned earlier, the market is shattered with high costs in time or money when going from one part of the supply chain to another.

2.1.2.2. Wheelie

Figure 2: The Wheelie

The Wheelie is a compact, light-weight (<10 kg), electric vehicle suited for one person to cover distances not greater than 10 kilometres per day. Its speed is maxed at 25 kilometres per hour and will be the equivalent of the scooter with a blue number plate in the Netherlands, which speeds is also capped at 25 kilometres per hour. It is designed to have a length of 0.8 meters, a width of 0.3 meters and a height of 1.2 meters in its normal situation. It is also designed for flexibility and manoeuvrability so that one can carry the Wheelie on either the back or by pulling it at the front. This mean of transportation can prove to be incredibly handy when moving from point to point within the inner-city, so called intra-city movements. This enables the traveler to quickly switch from a mean of transportation to a dependent individual mean. The Wheelie should be allowed in both traffic and public transport as it will increase the efficiency and reduce transition time cost for travelers. It will also be possible for both consumers and businesses to customize their Wheelie's, as seen in figure 2, by adding logos or texts. Consumers may desire to personalize their wheelies, while businesses could benefit from brand exposure. As soon as the number of travellers making use of this new and flexible mean of transportation increases, others will undoubtedly be positively influenced and probably follow this hype. Possibly, the Wheelie can also be used for fun-riding.

2.1.2.3. OlegO

Figure 3: The OlegO

The OlegO is a modular, small, one-manned, electric vehicle which can be used for a variety of activities. It has a range of approximately 25 kilometres and can reach speeds up to 45 kilometres per hour. Though unsuitable for highways, the OlegO is a mobile and fast vehicle to transport one in a city and thus improves overall city mobility. It is especially transport from a centre to the edge of the city that is suitable for the OlegO; so called inter-city movements. The OlegO is a motorised quadricycle, which are allowed by law on bicycle lanes and do not require a driver's licence. Just as in the case of the Wheelie, It will also be possible to customize the appearance of the OlegO for businesses and customers for branding or personal purposes. Also, it is plausible that individuals will make use of the OlegO to do daily grocery shopping. By introducing this smaller and more flexible vehicle, the current stream of traffic can be spread.

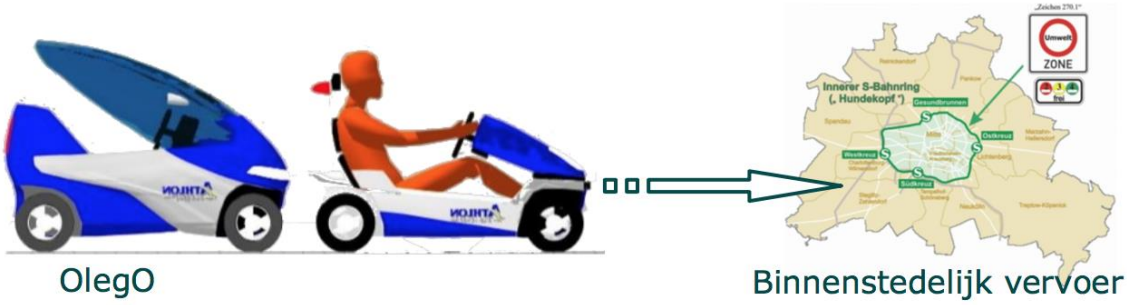

Figure 4: Mobility of the OlegO

2.1.3. The function of the Transition Hub

The Transition Hub allows travelers to quickly switch between means of transportation. As said above, a parking is almost never directly connected to the destination of the traveler, thus by

parking, a traveler has to travel an additional distance from the parking to the destination. The Transition Hub minimizes the time needed to travel this additional distance by providing the Wheelie and the OlegO. This makes traveling via a car a flexible way of transportation. By lowering the barriers to travel without a car in a city, the Transition Hub provides a platform where environmental and congestion friendly vehicles are used in the city. Both health and pleasure of life will increase due to less environmentally hazardous fumes and less congestion.

2.1.3.1. Modular usage of the Transition Hub

Figure 5: Flexible real estate

The Transition Hub is designed in a way that allows private or public parties to locate their operations in or next to the Transition Hub. The modular design enables parties to quickly build and insert an office, storage, logistical, living or other commercially used space (hence mentioned as a module) into the modular structure of the Transition Hub. The main advantage of the modules is the flexibility of properties. The module is easy to add and remove to and from the Transition Hub. The Transition Hub is therefore multifunctional and can be repurposed in a small amount of time to something entirely else. When there is a dire need of living quarters for students, the municipality or the university can add several living quarters in or next to the Transition Hub. If the need for extra living quarters for students is lower the next year, the modules can be easily removed to be replaced by either additional parking spaces or other modules. This multifunctionality will revolutionize the

way cities think about the use of properties and land. Locating parking, goods and services in exactly the same places increases efficiency, reduces congestion and unnecessary emissions and adds value to the Transition Hub.

2.1.3.2. Environmental benefits of Transition Hub

The Transition Hub enables travelers with electric and semi-electric vehicles to charge their vehicle whilst parked in the Flex Parking. The ground level of the Flex Parking is reserved for the charging electric and semi-electric vehicles, since charging requires the driver to insert the charging socket manually. With electric mobility is meant all vehicles for which an electric motor is the primary source of propulsion (Mckinsey, 2014). The Transition Hub could provide parking for electric and semi-electric vehicles for up to 20 percent of the total parking spaces, considering the growing trend of car-users. It has been shown that by increasing the supply of electric charging stations, the demand for electric cars increases profoundly (Sierzchula et al, 2015). The Transition Hub will function as the new centre for such environmentally neutral vehicles and will contribute to the stimulus that the Dutch government wishes to achieve. The Transition Hub gives the opportunity to solve the environmental challenges Rotterdam is facing regarding carbon dioxide and particulates.

Since it is possible to combine modules with parking, the amount of traffic in the city centre is restrained to the Transition Hub, which frees other, densely populated parts of the city of its congestion issues. Therefore the amount of emissions and sound generated by car traffic can be reduced to improve overall living quality. Because governments increasingly aim to keep their major cities cleaner and more peaceful, the costs this brings for society is growing. Realizing a reduction of these, which is the one of the objectives of the Transition Hub, would imply accomplishing various direct and indirect environmental benefits.

3. Data and Methodology

3.1. Social Economic Analysis

The social economic analysis takes a broader, overall perspective on the costs and benefits of the project on both private and social parties. In this analysis the main focus will be placed upon the external costs and benefits of exploiting this project, thus taking into account the externalities on society. The key challenge in predicting such effects through estimation and their magnitudes lies in correctly quantifying them, thus requiring a careful approach to prevent over- and underestimation. In this analysis, the main external problems will be emphasized. In order to study this a varied selection of literature is examined carefully. Firstly, traffic problems in cities are summed. After that societal benefits of the Transition Hub are discussed. Following the benefits of the Transition Hub economic, technological, environmental and societal trends are discussed. Finally, this study will show that the Transition Hub will take these trends into account.

This study states the problems of cities and tries to give a solution for these problems via the use of the Transition Hub. To estimate the societal benefits achieved through congestion reduction in the inner-city, an economic approach will be used. Making use of existing city mobility data and municipalities' objectives, a quantitative approach is used to predict concrete beneficial results of the Transition Hub.

Firstly, it is important to identify to what extent the current stream of cars cause congestion in the inner-city. The next step is to make a realistic assumption what proportion of car-travellers will choose the newly developed, alternative method of the Transition Hub.

More difficult to quantify, because of a more subjective nature, is the unpleasance for individuals caused by traffic congestion. For some travellers, every single minute wasted in a traffic jam is worth a considerable amount of money. For other, more patient travellers, the congestion costs per minute are lower. This study uses scores given by residents of Rotterdam about the state of traffic in the city. This study argues that on basis of these scores a few problems could be solved by using the Transition Hub.

Several trends are researched via literature regarding traffic and mobility in the city. These trends

are divided in three subcategories:

-Economic trends

-Technological trends

-Environmental trends

-Societal trends

These trends are then divided into several trends per subcategory. The trends are chosen on basis of the capabilities of the Transition Hub, since it would be unnecessary to contemplate on irrelevant trends which do not have a link with the Transition Hub.

The trends are examined on basis of scientific literature. After that the role of the Transition Hub in fulfilling these trends or solving particular problems regarding trends is discussed.

Though it is hard to quantify trends and the capabilities of the Transition Hub, this study does quantify the reduction in emission of carbon dioxide and particulates and of the damage of noise pollution if the Transition Hub is used. All the data regarding carbon dioxide is derived from the report from 2007 of emissions of CO2 (RotterdamClimateInitiative, 2007) and data regarding traffic from a report about congestion(de Vries, 2013). The data regarding particulates is derived from the Institute for Public Health and Environment of the Netherlands and Directive 2008/50/EC by the European Parliament and Council of May 21, 2008, on ambient air quality and cleaner air for Europe. Comparing both the current situation and the capabilities of the Transition Hub will translate in a reduction of emissions when the Transition Hub is used.

For noise pollution both literature and databases are viewed. For economic damage of noise pollution this study uses the research of Martin et al. (2006), which states how much economic damage is to expected in a city like Rotterdam. Finally, this study argues that the Transition Hub is an ideal opportunity to reduce both emissions and noise pollution.

Every subcategory gives in the end a reason why the city should invest in one or several Transition Hubs.

4. Results

4.1. Societal traffic problems

The single most important source of societal misfortune for cities such as Rotterdam is congestion, caused by traffic (Cohen, 2006). Despite the fact that the Netherlands is leading in organizing its highly advanced infrastructure at both the intercity and the intracity levels (NationEncyclopedia, 2015), certain problems caused by daily traffic cannot and should not be neglected. The current mobility situation causes various problems, which are unfortunate for society as a whole but especially for citizens of nearby areas in the inner-city.

As mentioned before, one of the main mobility problems is congestion in traffic, simply caused by too much cars in a too dense populated area (inner-city). Because commercial activities are centralized in the inner-city, as a result of the phenomenon called agglomeration, too many people have to be in the same business-related area, usually at the same time. These rush hours contribute significantly to the congestion problem and indicate the existence of bottlenecks in the cities' infrastructure. Not only is this unfavourable for individual car travellers who get stuck in traffic, and to their annoyance lose a considerable amount of time, but businesses and companies can also consider this as a problematic matter. Businesses based in the inner-city might possibly see their sales decrease as a result of employees or products arriving late, miss other kinds of important commercial opportunities and in the worst case even consider moving their offices. These outcomes might sound harsh or unlikely at first, but it is important to bear the negative effects of congestion in mind.

The second main societal mobility problem is the pollution caused by CO2 emission and high particulates concentration. These two problem factors will be extensively explained in the upcoming chapters, where the functionality of the Transition Hub once again can play a vital role in tackling these problems.

The last main societal mobility problem is noise pollution, which requires special emphasis, because excessive noise leads to a substantial amount of health problems for citizens of the surrounding areas. Again, we will explain in the next chapter how the Transition Hub could help solve the noise pollutions problems.

4.2. Societal Benefits

The Transition Hub can provide a solution to most of the previously mentioned mobility problems of nowadays society. Implementing this project, which has the main idea of improving efficiency on multiple dimensions in metropolitan areas, can prove to be extremely beneficial to society. Some of these societal benefits can be observed immediately and directly, whilst some benefits will increase in a more indirect way when taking into account the various trends.

A direct societal benefit can be identified as a benefit which is advantageous to both the individual traveller as to the society. By making effective use of the Transition Hub, mostly located at the outskirts of the inner-city, a substantial amount of travellers will experience savings in time and money. Many travellers will, as far as may be assumed, choose to bypass the busy downtown, park their car in the Flex Parking and continue their journey by making use of the complementary services of Wheelie & OlegO provided by the Transition Hub. This would presumably lead to a reduction in traffic in the busy inner-city, causing less congestion, CO2 emission and noise pollution.

4.3. Congestion Reduction

One study claims that over half the cars driving downtown in cities with serious parking problems are cruising to find a parking space, thus resulting in unfavourable congestion (Arnott & Rowse, 2009). Solving the problem of parking could thus reduce the amount of cars driving downtown in cities up to 50%. What is also shocking is the fact that of all traffic jams in the Netherlands the ones in Rotterdam are responsible for the highest damages in economic terms (TNO, 2008). Goods cannot be delivered on time and there are large and unnecessary fuel losses. These unexpected costs can affect the entire supply chain in an unfortunate way. TNO (2008) claims that an estimated amount of 60 million euros is lost, as a result of traffic jams in this area.
The Transition Hub could be a way to divert some of the traffic coming into the city. If the proposed locations of the Transition Hub were to be approved, there will be 7 different parking locations for travelers. With an average number of 500 parking spaces per established Transition Hub the maximum number of cars which can be diverted for the whole day is 3,500 cars, although more cars can be stored in total. Assuming that the occupation rate is around 70%, it can be argued that more than 2,500 cars can be diverted from the city centre for the whole day.

When looking at the impacts of mobility on the quality of life, a study in Canada suggests an increase in mobility leads to an increase the subjective quality of life. A survey done in 2014 about the opinions of residents of Rotterdam on the current mobility situation shows a remarkable finding. As shown in figure 3 the scores given on the flow of car traffic in the city show that residents are unsatisfied. Even more, the scores given on parking in the inner-city are considerably low.

How do you think about...	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Flow of traffic in the inner-city	5,5	5,4	5,5	5,6	5,3	5,4	5,5	5,5	5,7	5,7	5,9	5,9
Parking of the car in the inner-city	4,8	4,8	4,9	4,9	4,9	5,0	5,2	4,9	5,2	5,2	5,3	5,4

Figure 6: Scores from 1 to 10 of residents of Rotterdam about traffic in the city
Source: Gemeente Rotterdam, 2014, p. 51

The subjective scores of the residents of Rotterdam show that there has to be improvement on both issues, especially since all other subjects scored better than these two issues. The Transition Hub will offer plenty of opportunity to park cars. With its easy access and its complementary services like the Wheelie and OlegO, the Transition Hub could become a solution for the parking issues currently present in the city. With more people able to park the flow of traffic will increase, since research has shown that almost half of the traffic in the inner-city is due to people looking for a parking space.
Thus we can assume, for the specific case of the city of Rotterdam, that the use of the Transition Hub can reduce congestion and improve life satisfaction.

4.4. Trends and the role of the Transition Hub

A trend is a general development of a particular subject. There are different kind of trends; this research distinguishes economic trends, technological trends, environmental trends and societal trends. Trends are important because they can reduce uncertainty about the future.

4.4.1. Economic trends

This type of trend relates to macroeconomic developments such as inflation level, the market structure like the rise of infant industries and micro-economic developments such as the size of businesses or company needs.

4.4.1.1. E-commerce

The market for online shopping has grown exponentially the last few years (CBS, 2011). Companies like Amazon.com hire postal services to deliver packages all over the world. This increase in package delivery, which needs a greater volume of space than simple letters, causes urban areas to be flooded with delivery vans. This is unnecessary when the Transition Hub is used as a central pickup point for a neighbourhood. Much like a KIALA pickup point, often located at a local store, or a pickup point at a supermarket for packages, the Transition Hub could serve as such a pickup point. Not only that, due to its modular design it could serve as a distribution point as well, where larger quantities of letters and packages are arranged and distributed in the neighbourhood. Besides packages it is possible to place a distribution facility for supermarkets. Since e-commerce is also getting more popular for the daily groceries, the Transition Hub could serve as a multifunctional service hub, where a resident can park, use a Wheelie or OlegO, buy groceries, receive packages, go to work or live.

4.4.2. Technological trends

This type of trend relates to research fields, technological possibilities, acceptance of technology and the price regime of a technology.

4.4.2.1. Flexibility, Sharing and connectivity

The world is more connected than ever before. And with that connectivity come new possibilities to distribute the wealth and opportunities between people. One of the main upcoming trends is the trend of sharing your property with other people (Hamari et al., 2015). Applications like Toogethr, an app for carpooling, and Peerby, an app for sharing things with your neighbours, allow people to share their property with other people. Also applications like Airbnb and Uber enables people to rent out easily their property to other people. Instead of consuming products from large companies, people can now share and use property. Property therefore becomes much more flexible than in the previous century. The future is that you do not have to own a product to use it.

So how does this trend fit in the idea of a Transition Hub? As previously said, the Transition Hub has a modular structure. The structure either facilitates parking spaces or other modules, like offices. The modules are easy to remove and can be replaced by other modules when needed. The Transition Hub makes land property and real estate flexible. Nowadays there is a considerable problem regarding empty office space in Rotterdam (Vastgoedmarkt, 2013). Instead of leaving it

unoccupied, with the chance of being occupied by squatters, cities have tried to transform some office buildings to residential buildings. Though there are possibilities to repurpose real estates, it remains an inefficient way to use property. The Transition Hub and its modular design are the new frontier for property. If nowadays a city would have such a structure with office spaces, then the city could easily repurpose those office spaces to whatever is needed. Even more, the city could remove the offices entirely and not place anything back if there is no demand for other modules. Sharing and flexibility would not only be possible for consumers, but also for entrepreneurs, residents and the government.

4.4.2.2. Internet of Things

Internet of Things is the connectivity via internet between physical objects. The Personal Computer was one of the first physical objects that was connected to other Personal Computers. Recently the mobile phones were connected via Internet, causing an increase in innovations of applications and services. Internet of Things is based on the trend that many physical objects are or will be in the near future connected to each other, to consumers and producers (Weber & Weber, 2010). A very recent example of such objects is the integration of networks and computers in the energy infrastructure in homes. The so called 'Smart metre' enables people to operate several services, such as heating or lighting, via the Internet. The energy supplier can retrieve information from the metre for services and billing. The future is also promising. Self-driving cars, robotics and more integration of computers and physical objects are near. The Transition Hub could exploit this trend by using an easy service system for parking. A traveler parks his car at the Transition Hub and registers his car's licence plate at the platform. The car can be retrieved via an app or through the phone automatically if the owner of the car approaches the Transition Hub. This will make parking easy and flexible instead of waiting in line for a ticket counter to buy a parking ticket.

4.4.2.3. Electric Vehicles

Although Europe as a whole is entering the initial adoption phase of electric mobility, sales have foregone the margin of 1% in some countries. Especially countries such as the Netherlands and Norway have seen high uptake rates. As shown in figure 7, the Netherlands is the European runner-up with more than 4% of new car sales falling into the Electric Vehicle (EV) category in 2013 (McKinzey, 2014).

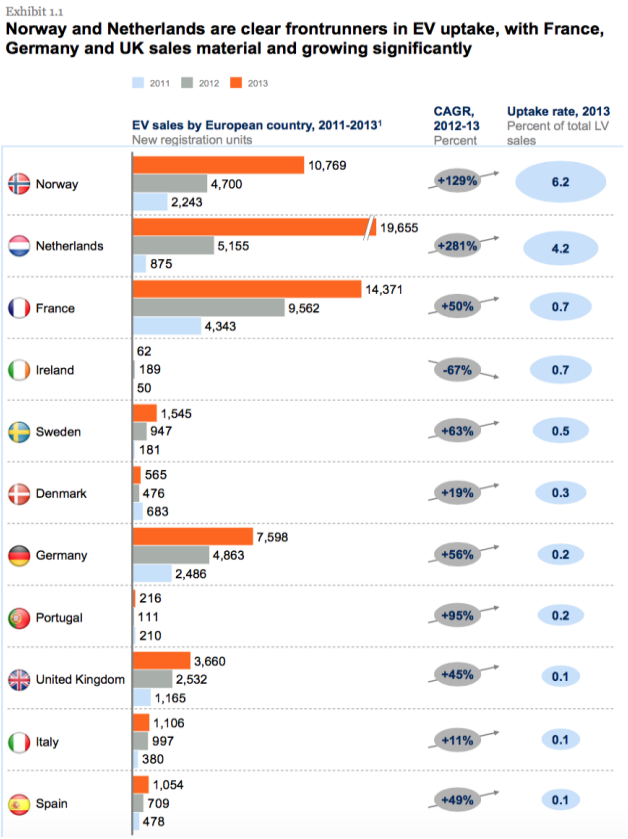

Figure 7: Sales of electric vehicles

Source: McKinzey, 2014, p.10

Three key motives for adoption of the electric mobility emerge. Firstly, carbon footprint reduction is very much desired by EU governments and some even are even willing to pay a premium for it. Secondly, considerable driving and usage benefits exist for EV users. One of these include preferential parking permits in dense urban areas (e.g. city of Amsterdam). Another benefit can be to allow EV users to drive in bus and taxi lanes and thereby save time during rush hours. The last motive is the possible cost saving one can get by choosing for an EV. Without subsidies, EVs are significantly more expensive than normal cars. But in some specific cases, as a result of government subsidies, EV models can be cheaper than their counterparts. Considering all three motives and the top position the Netherlands has on the EV sales ranking, the Transition Hub anticipates on the course of events by building a large space with electric vehicle charging points as well as the use of the Wheelie and OlegO.

4.4.3. Environmental trends

This type of trend relates to developments in CO2 levels, particulates levels and other environmentally damaging developments.

4.4.3.1. Carbon Dioxide Concentration

The municipality of Rotterdam has the objective of reducing 50% of its CO2 emission in 2015 relative to the emission level in 1990.

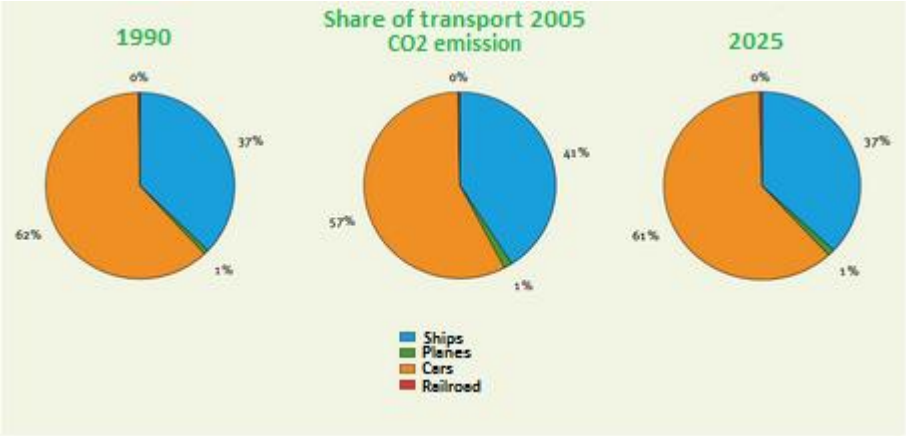

Figure 8: Proportion of emission cars

Source: RotterdamClimateInitiative, 2007, p.28

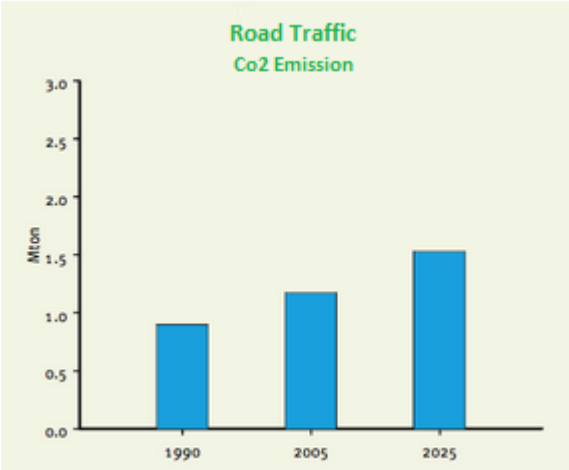

Figure 9: Total emissions of CO2 for cars

Source: RotterdamClimateInitiative, 2007, p.28

A large portion of the gas emitted by vehicles is emitted by cars as can be seen in figure 8 and 9. The total CO2 emission in 2005, when looking solely at the car traffic in Rotterdam of individuals, is 759,121 ton/year. Looking at the existing categories, we can assume that only the travellers of the inner-city will cause a reduction in CO2 emission and the travellers on the highways will remain the same. When distinguishing the latter category from the total, the total CO2 emission of travellers in the inner-city amounts is 419,971 ton/year. By examining an existing report on the motives of daily travellers, we can observe that 22 % of the inner-city car travellers merely travel daily from home to work and vice versa. 7 % of the total travellers indicate that they travel in the inner-city for business-related matters. These two groups summed up form 29 % of the daily individual car travellers in Rotterdam, thus accountable for around 30 % of the CO2 emission. This is equivalent

to a CO2 emission of (30 % of 419,971 ton/year) 125,991 ton/year. The two mentioned categories are relevant for our economic approach, because these groups are most likely to use the beneficial functionalities of the Transition Hub. The other categories are of less importance as they are presumably not the most relevant factors explaining CO2 emission.

The Transition Hub will function as a gateway for traffic to and from the city. Nowadays the only option for travelers is to park right next to their destination, if possible, or as close by as needed. This results in unfavourable emissions in the inner city. The Transition Hub offers, due to its flexibility and the availability of the Wheelie and OlegO, an option for travelers to park their car somewhat further from their destination, while decreasing traveling time and increasing flexibility for the driver.

Based on the percentages, the concrete assumption can be made that the Transition Hub will persuade at least 50 % of the daily car travellers of the inner city of the two categories to use the Transition Hub. As a result, we can assume that the 125,991 ton CO2 emission annually will be cut in half to an approximate amount of 63,000 ton/year.

In addition to this finding, in figure 10 is shown what the emission is divided into four speed categories. It shows that slow inner city traffic and fast traffic on the highway contribute equally to the pollution, thus emphasizing the need of cleaning the inner city by reducing incoming traffic from the highways.

			E-factor	Emission
Road Traffic		mln vkm	g/vkm	ton/jaar
	< 55 km/h	1.217	267	325.013
	55-75 km/h	405	167	67.710
	>75 km/h	163	167	27.247
	Highway	1.757	193	339.150
Total				759.121

Figure 10: Emission of CO2 divided into four speed categories.
Source: RotterdamClimateInitiative, 2007, p.47

4.4.3.2. Particulates Concentration

Particulates are microscopic particles which have a diametre smaller than 10 micrometre. Though particulates are also formed in nature, almost 70% of the particulates are emitted by man made machines in the Netherlands (RIVM, 2013). Especially cars contribute to the high concentration of

particulates in urban areas. Particulates are a great hazard for the health of citizens. According to a report from the government in 2013, particulates concentrations with a size between 2.5 and 10 micrometres in Rotterdam vary, on average, between 22 and 27 µg/m3 (RIVM, 2013), which is considerably lower than the European norm of 40 µg/m3 (Directive 2008/50/EC). However, the number of days on which it is allowed to exceed this limit is only 7 days. Rotterdam surpasses this number on average, which means that people are exposed to unnatural high concentrations of particulates too long. Smaller particulates concentration, called super particulates, vary on average between 13 and 17 µg/m3 compared to the 25 µg/m3 European norm (RIVM, 2013). The Netherlands has promised to reduce 15% of the particulates at the end of 2020 (Directive 2008/50/EC).

As said above, by using the Transition Hub it is possible to reduce the number of cars driving into the city and therefore decreasing particulate concentrations in the inner city, thus increasing life health and length. If we assume that the city of Rotterdam has the same goal as the Dutch government of reducing the particulates with 15% at the end of 2020, over 22% of traffic in the inner city of Rotterdam should be reduced, assuming that all car traffic emits around the same amount of particulates in every part of the city. This should be possible when using the Transition Hub, because there will be enough capacity, as mentioned above, to park a substantial amount of cars.

4.4.3.3. Noise pollution and damage

The damage done by noise pollution is often underestimated. A new study has shown that over 4% of the population is affected by noise pollution. An estimated amount of 640,000 adults encounter sleep and health problems and 290,000 adults experience severe sleep disorders from the noise of traffic in the Netherlands. This is accountable for 0,3% of the total acute heart attacks happening in the Netherlands annually (Van Kempen & Houthuijs, 2008). Researchers suggest that the cost of traffic noise pollution is around 1% of GDP (Martin et al., 2006). It can safely be assumed that the cost in Rotterdam is at least as high and probably will be higher than 1% of its GDP, due to the fact that Rotterdam is one of the largest cities in the Netherlands. The GDP of Rotterdam in 2010 was approximately 40,750 euro's per capita, which is derived from the database of the OECD. With a total of 1,496,629 inhabitants, the total GDP of Rotterdam in 2010 was around 60.9 billion euros. 1% of that GDP is the noise pollution cost. Approximately 600 million euros per year are associated with noise pollution cost in Rotterdam. The introduction of a Transition Hub would not wholly solve this problem, but it could help with partly reducing noise pollution by reducing the traffic in the inner city.

4.4.4. Societal trends

This type of trend relates to the need development of households, the public opinion, societies structure and demographic developments.

4.4.4.1. City marketing

City marketing is the phenomenon where marketing and branding strategies are applied to fit the cities' needs and requirements. According to a study of Balencourt & Zafra the state of the city's economy and number of tourist influences people's perception of a city (Balencourt & Zafra, 2012). Rotterdam is known to be an innovative hub for real estate, since a part of Rotterdam was leveled during a bombing in World War 2. Since then new skyscrapers erected into the sky, transforming the old destroyed city in a modern city. Recently two new additions to the city got the attention of tourists worldwide: the Markthal and the revised Central Station. These two buildings were innovative in design and functionality, providing a different view on traveling with the train and shopping. Partly thanks to these new innovative buildings Rotterdam was announced to be the best European city to live in 2015 by the British think tank Academy of Urbanism.

In this context the Transition hub will be a new innovative concept which Rotterdam could be the first city to adapt this idea. It offers more efficient parking while it does not need as much space as conventional parking garages. It offers possibilities to provide flexibility for residents, travelers and real estate.

4.4.4.2. Demographic factors

Experts predict a stable increase in the population of densely populated urban cities (Centraal Bureau voor de Statistiek, 2013), which can be directly linked to the demand for transport and therefore the amount of cars. It will inevitably lead to a more crowded city which negatively affects the residents and tourists in the city. Parking space will be scarcer and, while land space to build on already is low in Rotterdam, additional parking spaces must be build. Instead of using inefficient conventional parking garages, the Flex Parking offers more parking spaces with more convenience while using less space than conventional garages. It will also support the goal of reducing the number of cars driving into the city.

5. Conclusion

This study started off with the situation description of metropolitan cities; parking is a growing source of frustration for daily travellers by car, especially during rush hours. Congestion is an enormous problem that will likely increase in the future due to demographic trends and insufficient societal and infrastructural adaptation. Congestion could be solved for a great deal by improving currently existing parkings in terms of efficiency and by building new, innovative and thus better parkings.

This study is embedded within the latest trends using business idea and products of Van der Wijngaart's Engineering Services, which are applicable to the city of Rotterdam. The research revolved around the question:

What other functions can be performed by the Transition Hub in Rotterdam?

This study has dealt with the potential of the Transition Hub. It also dealt with the environmental aspects of mobility and the trends for the coming 20 years.

The challenges cities face in the coming decades are clear. The increase in emissions of CO2 and particulates and the congested inner city will not solve itself. Noise pollution and a lower quality of life could be the result of these issues. Not only does a city face environmental and societal problems, but also logistic problems. How will we distribute goods and services within a city? And how does a city deal with the inflexibility of real estate?
The innovative design and concept of Van der Wijngaart's Engineering Services will tackle these problems. The Transition Hub will introduce an entirely new way to solve the upcoming challenges by providing a flexible, time efficient way of parking. Not only that, it will provide additional means of transportation, the Wheelie and OlegO. These two services increase flexibility and mobility of a traveler drastically. Combining these three services will result in a reduction of emissions of both CO2 and particulates as well as congestion. The inner-city will be more inhabitable and both residents and tourist will enjoy the benefits a cleaner and quieter city has to offer.
The Transition Hub also solves logistical problems related to the distribution of goods and services within the city and real estate problems such as the inflexibility of the construction market. This

inflexibility of the construction market is solved because the modular design allows the Transition Hub to be multifunctional and to be adjusted fairly quickly and cheap at key logistical locations. Dependent on the type of demand the Transition Hub's modular design will allow for an easy and flexible way of using real estate. If demand is lower for some reason, the modular design allows for quick adjustments to satisfy other needs.

Finally, the Transition Hub can serve as a central pickup point for goods and services. Instead of package delivery or other house related services, which burdens the inner-city infrastructure with unnecessary activity, residents and businesses can both shop and receive packages at your local Transition Hub. Even more, instead of using the car for these activities, the cleaner Wheelie and OlegO can also be used for these activities.

This allows for many innovations and trends to jump on board and exploit the Transition Hub. In that sense the Transition Hub does not only mark the transition of one vehicle to another but also marks the transition of the old logistical model to a new paradigm.

6. Bibliography

Adriaanse, M. (2013, december 24). Elektrische auto's in trek. Retrieved from Elektrischeauto.nl: http://elektrischeauto.com/elektrische_auto_verkoop_2013/ (Accessed on 15 May 2015)

Arnott, R. (2005). Spatial Competition between Parking Garages and Downtown Parking Policy. Boston: Boston College.

Arnott, R., & Rowse, J. (2009). Downtown parking in auto city. Regional Science and Urban Economics Vol. 39, 1-14.

Balencourt, A., & Zafra, A. C. (2012). City Marketing: How to promote a city? University of Umea.

Ballester, F., Medina, S., Boldo, E., Goodman, P., Neuberger, M., Iniguez, C., & Künzli, N. (2008). Reducing ambient levels of fine particulates could substantially improve health: a mortality impact assessment for 26 European cities. Journal of Epidemial Community Health, Vol. 62, 98-105.

Burdorf, L. (2009). Ongezondste stad. Monitor Erasmus MC, no. 5, 15-18.

Centraal Bureau voor de Statistiek. (2011, March 30). Online winkelen steeds populairder. Retrieved from CBS: http://www.cbs.nl/nl-NL/menu/themas/vrije-tijd-cultuur/publicaties/artikelen/archief/2011/2011-3335-wm.htm (Accessed on 15 May 2015)

Centraal Bureau voor de Statistiek. (2013, January 4). Bevolking vier grote steden groeit tot 2040 met 333 duizend inwoners. Retrieved from Centraal Bureau voor de Statistiek: http://www.cbs.nl/nl-NL/menu/themas/bevolking/publicaties/bevolkingstrends/archief/2012/2013-bevolkingstrends-groei-grote-steden-art.htm?RefererType=RSSItem (Accessed on 15 May 2015)

Centraal Bureau voor de Statistiek. (2015, June 24). Economie groeit met 0,6 procent in eerste kwartaal 2015. Retrieved from CBS: http://www.cbs.nl/nl-NL/menu/themas/dossiers/conjunctuur/publicaties/conjunctuurbericht/inhoud/kwartaal/economie-groeit-met-06-procent-in-eerste-kwartaal-2015.htm (Accessed on 15 June 2015)

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in Society vol. 28, 63-80.

Crainic, T. G., Ricciardi, N., & Storchi, G. (2004). Advanced freight transportation systems for congested urban areas. Transportation Research part C: Emerging Technologies Vol. 12, 119-137.

de Vries, C. (2013). Verplaatsingen in Rotterdam, Stadsregio en Nederland, 2004-2011. Rotterdam: Centrum voor Onderzoek en Statistiek.

European Parliament and Council. (2008, May 21). Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe . Retrieved from Eur-lex Europa: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0050&from=en (Accessed on 7 July 2015)

Forbes. (2010, December 15). Consumers Overwhelmingly Want CSR. Retrieved from Forbes: http://www.forbes.com/sites/csr/2010/12/15/new-study-consumers-demand-companies-implement-csr-programs/ (Accessed on 16 May 2015)

Hamari, J., Sjöklint, M., & Ukkonen, A. (2015). The Sharing Economy: Why People Participate in Collaborative Consumption. Journal of the Association for Information Science and Technology, 1-10.

INRIX. (2012). Files dalen wereldwijd: INRIX Traffic Scorecard geeft een onthullende blik op de worstelende economieën in Europa. Amsterdam: INRIX.

Jansson, J. O. (2010). Road pricing and parking policy. Research in Transportation Economics Vol. 29, 346-353.

Knaap, R. v., & Wee, B. v. (2004). Hoe te komen tot een transitie naar duurzame mobiliteit: een verkenning van theorieën. Zeist: Colloquium Vervoersplanologisch Speurwerk.

Landelijk Meetnet Luchtkwaliteit. (2015). Actuele luchtkwaliteit fijnstof. Retrieved from Landelijk Meetnet Luchtkwaliteit Rijksinstituut voor Volksgezondheid en Milieu: http://www.lml.rivm.nl/index.php (Accessed on 29 May 2015)

Martin, M., Tarrero, A., González, J., & Machimbarrena, M. (2006). Exposure–effect relationships between road traffic noise annoyance and noise cost valuations in Valladolid, Spain. Applied acoustics Vol. 67, 945-958.

McKinsey & Company. (2014). Evolution. Electric Vehicles in Europe: gearing up for a new phase? Amsterdam: Amsterdam Roundtable Foundation.

NationEncyclopedia. (2015). The Netherlands - Infrastructure, power, and communications. Retrieved from NationsEncyclopedia: http://www.nationsencyclopedia.com/economies/Europe/The-Netherlands-INFRASTRUCTURE-POWER-AND-COMMUNICATIONS.html (Accessed on 9 July 2015)

Nederland Elektrisch. (2015). Subsidies. Retrieved from Nederlandelektrisch.nl: http://www.nederlandelektrisch.nl/thema/bedrijf/regelingen-subsidies/ (Accessed on 29 May 2015)

Rijksinstituut voor Volksgezondheid en Milieu. (2013). Dossier Fijn stof. The Hague: RIVM.

Rotterdam.nl. (2015). overzicht openbare parkeergarages. Retrieved from Rotterdam.nl: http://www.rotterdam.nl/overzichtopenbareparkeergarages (Accessed on 30 May 2015)

RotterdamClimateInitiative. (2007). Nulmeting uitstoot CO2 Rotterdam. Rotterdam: DCMR Milieudienst Rijnmond

Roubos, L. (2013, March 7). Steeds meer parkeerproblemen rond Keizerswaard. Retrieved from Rijnmond: http://www.rijnmond.nl/nieuws/07-03-2013/steeds-meer-parkeerproblemen-rond-keizerswaard (Accessed on 15 May 2015)

Sierzchula, W., Bakker, S., Maat, K., & van Wee, B. (2015). Worden door financiële prikkels meer elektrische auto's verkocht? Tijdschrift Vervoerswetenschap Vol. 51, 110-131.

TNO. (2008). De kosten van de kwetsbaarheid van het wegennet in de Randstad in 2008 en 2030. Delft: TNO.

TNO. (2013). Filegolven Rotterdam. Rotterdam: TNO.
van Kempen, E., & Houthuijs, D. (2009). Omvang van de effecten op gezondheid en welbevinden in de Nederlandse bevolking door geluid van weg- en railverkeer. The Hague: RIVM.

Vastgoedmarkt. (2013, September 12). Kantorenleegstand Nederland hoogste van Europa. Retrieved from Vastgoedmarkt: http://www.vastgoedmarkt.nl/nieuws/2013/09/12/Kantorenleegstand-Nederland-hoogste-van-Europa http://www.vastgoedmarkt.nl/nieuws/2013/09/12/Kantorenleegstand-Nederland-hoogste-van-Europa (Accessed on 8 July 2015)

Weber, R. H., & Weber, R. (2010). Internet of Things. New York: Springer.

