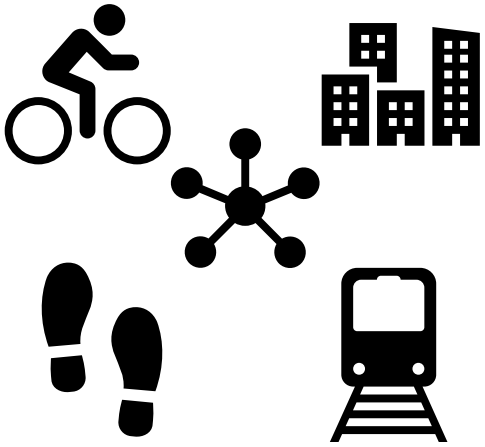
Master Thesis Spatial Planning

Transport Oriented Development in Mid-sized Cities

- A Multiple Case study in Den Bosch, Nijmegen & Zaanstad -



Master Thesis Spatial Planning (Spec. Urban & Regional Mobility)

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By Niels de Koning

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Abstract

The aim of this thesis is to explore whether TOD can make a meaningful difference in replacing traditional urban sprawl with sustainable urban densification in mid-sized cities. In doing so, a case study was developed in which 3 transformations in medium-sized cities were assessed using 6 pillars of transport oriented development.

This research started by developing a literature review to explain the concept of TOD. It also examined various theories for sustainable urban growth. Next, desk research was used to analyze the status of growth policy on a national scale with regard to mid-sized cities. Lastly, a case study was developed, involving 3 transformations in mid-sized cities: Den Bosch, Zaanstad and Nijmegen were explored using a TOD framework.

The results of this thesis indicate that TOD can be of serious value for growth policies in mid-sized cities. In each case it can be concluded that pillars of TOD have been realized in actual transformations, which can provide serious support for the inner-city growth task. Although there is no benchmark to assess whether certain pillars are sufficiently recognizable within the analyzed cases, even with a qualitative observation it can be determined that certain influences of transformations have effect on the way TOD manifests itself within the case.

With the development of this thesis, a generalizable model has not yet been developed. For further research it would therefore be of value if it could be determined whether the pillars of TOD also apply with other mid-sized cities. Also, for this thesis, much data was generated from visions and plans. Follow-up research could focus on whether the developments have had the desired effect on a modal shift.

Key words: Transport, Land use, TOD, Urban Growth, Mid-sized cities

Table of Contents

1. Introduction

1.1 Framework

The world is urbanizing. To manage this drift to the city, urban planners and policy makers are looking for different ways to keep the inner cities accessible and to satisfy the large group of urban dwellers in their facility and transportation needs. The effective use of mass transit systems and walkable cities seems to be the focus of urban development (Varma, 2017). Over time, the automobile has taken an important place in urban society, allowing people to increase their average distance from place to place. This made the urban environment less compact. The greater distances made possible to travel also had a negative impact on public transportation and walkability of the city. As a countermove to the automobile society, new urbanism emerged around the 1980's as a vision for urban development inspired as principles for town planning and mixed urban compact places (Varma, 2017).

Transport oriented development is a design concept that fits with the principles of new urbanism (Varma, 2017). It is used to control and direct negative patterns of urban growth. This is achieved by focusing as much as possible on public transport as the central form of transport in the city, to be combined with the possibility of reaching facilities in the city within a walking and cycling distance (Thomas et. al., 2018). The goal of TOD is to create a livable and accessible city for its residents. Where at the same time all kinds of different activities can be found within a small radius of 5 to 10 minutes walking (Salat, 2017). By engaging in urban development in a TOD manner, there are several benefits to be achieved. First, land and real estate values can rise at the best connected locations. Further, people living in a TOD location can save money and time as jobs become more accessible. Transportation costs as well as bridging time between living and working will decrease. Thirdly, increased use of public transport means will affect local CO2 emissions which previously were strongly influenced by the use of private cars (Salat, 2017).

Integrating transportation with land use provides a way of planning that is primarily focused on public and active transportation within a knotted transportation network. This multimodal transportation approach to urban development should thus ensure a reduction in private automobile use within, at least, the node. Reducing car trips and thereby increasing accessibility and livability of the city can be achieved by developing from a multimodal philosophy, together with a proper use of space (Vale, 2015).

The balance between the supply of transportation and land use is captured within the node-place model (Bertolini, 1999). This model can be used as a methodological framework to qualify a certain TOD. Using the model, the integration of land use and transportation can be identified. It can also identify the extent to which a particular location is in imbalance with regard to transportation options to and from the station (node), and the facilities found around the station (place).

The trend of strong urbanization is also occurring in the Netherlands. To keep the cities accessible, mobility policy must also adapt to this. Besides the increased trend to also make transport as sustainable as possible and the sharing economy is also becoming more normal, Prorail and municipalities are consciously working on the "Station of the future" (Prorail, 2019). Station development within the philosophy of TOD fits within the trend that is visible when it comes to dense urban development (Van Dinther, 2020). To realize the station of the future, the concept of multimodality is often mentioned. But how does this development of hubs relate to the development of the city and the use of this location itself? There is also a lot of talk in the literature about TOD around large metropolitan regions. But also in relatively smaller cities, a development influenced by TOD is being pursued (Thomas et. al., 2018). Can these smaller cities benefit as much from a renewed approach to urban development as larger station areas within and outside the Netherlands? To gain new insights on these questions, this research will focus on results, obstacles and opportunities for realizing mid-size station development based on a TOD approach.

1.2 Research Problem Statement

It is well established that land use and transportation planning must harmonize with each other to provide a good alternative to automobile transportation in cities. However, the planning of transport systems is in practice mainly determined by applying the same planning direction as previous developments, instead of thinking about transport developments in an integrated way, together with land use development. Also, looking at the TOD concept, many studies concentrate mainly on large metropolitan cities, where a good public transport network is already in operation. The focus is also on large urban densities, which means that in these types of cities the focus is often on increasing the urban density, without looking at the geographical context where a planner is located (Nigro, Bertolini & Moccia, 2019).

Nevertheless, the future of the Dutch transportation network also seems to be moving into certain facets of TOD planning, with the concept also seeming to gain a foothold in relatively smaller cities like those that pass by in the studies (MBK, 2020; Prorail, 2019). Despite the many scientific knowledge and practical examples, implementing TOD in the Netherlands appears to be quite complex (Tan, 2013). For example, there are many different actors involved in the development, it is a time-consuming task, and the positive story behind the TOD also includes certain barriers that must be overcome for proper spatial implementation (Tan, 2013). The complexity of these barriers will be further investigated through this research, as some of these barriers are also very context dependent. The first step is to explore the extent to which land use and transport developments are interwoven in medium-sized cities and the extent to which characteristics of TOD are reflected in planned urban developments.

1.3 Research aim and Questions

This research will explore whether TOD can make a meaningful difference in replacing traditional urban sprawl with sustainable urban densification. For this purpose, the extent of presence of different pillars of TOD that emerge from the literature will be examined and assessed. These pillars will be used to determine whether there are differences between cities and on what these differences are based. The aim is to discover whether TOD plays a significant part in urban densification strategies in medium-sized cities. In order to do so, cases are examined that differ from each other in some aspects. For example, a case that is already developed is analyzed, and a case that is not located around a large station is examined. The final aim arises, whether an advice on integrated land use and transport development can be offered to major urban development projects in mid-sized cities.

The main question that will be used during this research is:

"What does Transport Oriented Development of Railway station- areas add to growth policies for mid-size cities?" This research attempts to discover whether pillars of TOD can be observed in planned or realized transformations in medium-sized cities and if these pillars can have an impact on sustainable urban growth in mid-sized cities. Is it just going along with a metropolitan hype, or can TOD really keep Dutch medium-sized cities accessible and livable? To answer the main question, the main question will be approached by a number of sub-questions. Based on these sub-questions, an attempt will be made to provide the best possible explanation of the research problem.

1. *What is TOD?*

This sub-question will look at what the concept of Transport oriented development entails. Based on different theoretical concepts, the concept of TOD will be explained. For example: What are the advantages of urban development implemented with core values of TOD and what are the disadvantages? Also, what is the reason for the contemporary implementation of TOD and to what extent does the concept contribute to a possible solution for this cause?

2. What is urban growth & how is urban growth being managed?

This sub-question will explore how in theory and in practical is dealt with urban growth. As will be seen in the previous sub-questions, Transport Oriented Development is mainly driven by the realization of smart and sustainable urban growth. This chapter will also focus on different types of urbanization strategies and the assessment framework per strategy. For a more practical approach at the national level, growth plans and national agendas are being studied. For a more local, and case-specific analysis of urban growth, provincial and municipal agendas will be examined related to urban growth. Here, various facets of urban growth will be examined. Urban growth affects a city's demographics, political shifts, but also strongly influences the spatial appearance of the city. In this thesis these impacts will be framed up to housing, economic shifts and changes based on mobility and infrastructure. Also, there may be differences at different scales. For example, growth plans may possibly differ at the meso and micro levels. Also, agendas may differ between large cities and medium-sized cities.

3. How do the 6d pillars of TOD manifest in mid-sized urban transformations?

Regarding this sub-question, the assessment framework of transport oriented development, focusing on the units of analysis in the case study, will be explored in more detail. TOD is operationalized through six pillars. The effect of the transformation on these pillars provides insight into the value of TOD for medium-sized cities and in what way medium-sized cities can differ or correspond.

1.4 Scientific Relevance

The concept of TOD is mainly used in the literature as a designation for metropolitan urban development. This stems from the fact that sometimes urban expansion to the outside is simply not possible and cities are forced to fill in the city from the inside. This is called infill. Smaller urban agglomerations, where there is more peripheral space, seem better able to expand outwards due to the amount of residual space. However, it is still unclear whether development in the smaller city can provide the same benefits as in metropolitan areas. The more literature that is revealed about the concept, the more it can be an addition for further studies. This research will aim to provide scientific insights into TOD related to smaller cities, rather than the major metropolitan areas. In addition, this research may be used as a starting point for further research.

1.5 Societal relevance

By answering the research questions, this study attempts to make certain recommendations to policy makers concerning the position of the station area within the urban growth policy. As Tan (2013) points out, the implementation of TOD can be very difficult. The recommendations that result from this study could be the basis for the concerns around which plans should develop and how land use and transport decisions should be made. This also allows case-specific conclusions to be drawn. Also, based on this research, it can be determined to what extent national development policy in the coming years relates to municipal developments in mid-size cities. By analyzing development strategies on different scales, national and local, it can be determined to what extent a mid-size city differs or corresponds with its policy in relation to the national recommendations.

2. Theory Overview and Concepts

2.1 Introduction

To address TOD's concept, it is relevant to develop a deeper understanding about the role and position of hubs in the transportation system, since TOD's focus is on land use development around the train station area. Mobility Hubs are high-quality physical locations that combine a diverse range of sustainable and active modes of transport with pleasant accommodation options (Natuur & Milieu, 2020). These places are interesting locations for spatial planners because it is where large groups of people move past or on and where people meet each other. In other words, a hub has two main functions. On the one hand, it serves the goal of transporting people (further), which creates an attracting role for travelers. On the other hand, a hub has a nurturing effect by the presence of retail, leisure, business, and living around and within walking distance from the hub (Bertolini, 1999).

Based on how these two features relate to each other, four ideal situations can be distinguished, which are discussed in 2.4. When these 2 features are out of balance, developments can be realized to bring the hub back into balance. How these developments on one end have an effect on the other end can be found in 2.2, the Land use Transport Feedback Cycle. Once the interplay of the transport and land use dichotomy are clarified, Chapter 2.4 looks at the policy implications of how aspects of Transport Oriented Development should be incorporated into the planning process. This chapter is also the first introduction to the Pillars of TOD, which will be further elaborated in the operationalization chapter. In 2.5 a theoretical understanding of urban growth and its relationship to mobility will be established.

2.2 Land use Transport Feedback Cycle

The first section will focus on the underlying relationship between transportation and land use. Transport Oriented Development is the product that results from the identified relationship between land use and transport. This theoretical concept section will further explore this relationship and form a theoretical background for answering the first sub-question.

It is widely recognized that the use of land is strongly related to the way in which transportation patterns occur. The spatial segregation of human activities causes personal and goods transportation to make such activities possible. Therefore, the degree to which these activities and businesses are segregated from each other and the extent of the demand for these spatial activities influence the mobility behavior of actors such as households and firms (Chorus & Bertolini, 2011).

That the relationship exists is clear, however it is more difficult to determine the extent to which the provision of transportation, and for example, the presence of infrastructure can influence the use of the land. To uncover this relationship, one can draw on the land use transport feedback cycle (Wegener & Fürst, 2004). In this model it is shown that land use patterns partially determine the location of human activities such as living, working, shopping, education and leisure. This works as follows*:* The recognition that trip and location decisions are co-determined and therefore planning land use and transportation plans will need to be cooperative, has led to the land-use transport feedback cycle. This model is based on 4 different types of relationships. They are:

- The distribution of land uses: such as *residential industrial and commercial* over the urban area, determine what kind of activities will take place on a spatial scale, such as: *living, working, shopping, education or recreation* (Wegener & Fürst, 2004).
- The distribution of human activities in space requires spatial interaction or trips in the transportation system to overcome the distance between the locations of activities. (Wegener & Fürst, 2004).
- The distribution of infrastructure in the transportation system creates opportunities for spatial interaction which can be measured as accessibility. (Wegener & Fürst, 2004).

- Distribution and degree of accessibility then influence the decisions of how the land should be used, resulting in changes in the land-use system (Wegener & Fürst, 2004).

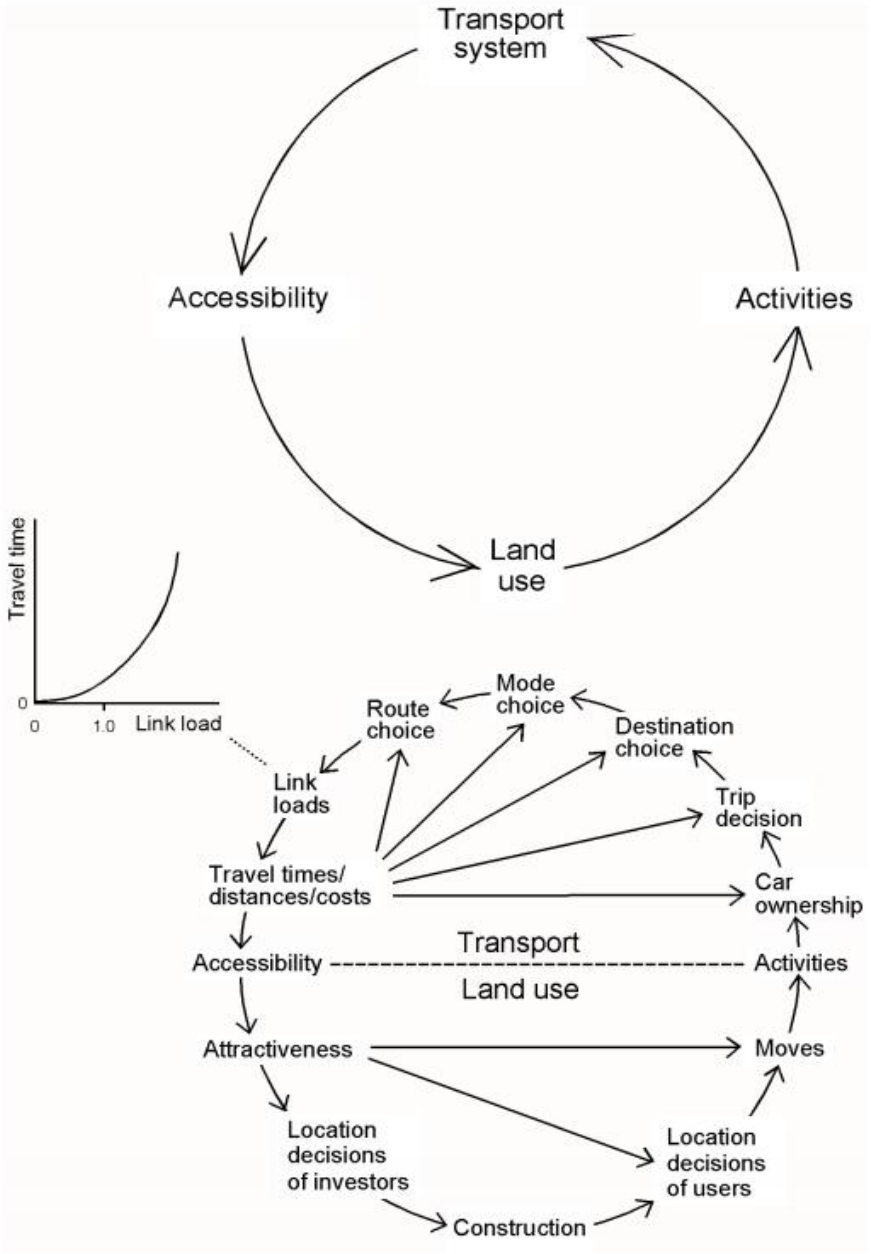

Figure 1. The Land Use Transport Feedback Cycle (Wegener & Fürst, 2004)

The main elements for indicating the interaction between land use and transport are shown in the following tables. It is structured by showing different impacts resulting from (policy) developments in various relevant areas of land use on transit and vice versa. Some of the essential factors that are addressed in the table include urban density, employment density, neighborhood design, location, city size, accessibility, travel cost and time.

Direction	Factor	Impact on	Expected Impacts
Land use on Transport	Residential density	Trip length	Higher Density will not directly lead to shorter trips. A mixture of workplaces and residences could.
		Frequency	Little impact expected, if trips are shorter, more trips may be made
		Mode choice,	Minimum residential densities are prerequisite for efficient Publ. Trans. More walking and cycling only if trips are shorter.
	Employment density	Trip Length	Concentration of workplaces in few employment centers tends to increase trips lengths. A balance of workplaces leads in average to shorter trips
		Frequency	Little impact
		Mode choice	Concentration of workplaces could lead to more usage of Public transport if support efficiently
	Neighborhood design	Trip length	Attractive public spaces and a variety of shops and service can induce more local trips
		Frequency	If trips are shorter, more trips may be made
		Mode Choice	Street layout, pedestrian spaces and cycling lanes could lead to more cycling and walking
	Location	Trip length	More peripheral locations tend to have longer trips
		Trip frequency	No impacts
		Mode choice	Locations close to Publ. Trans. Should have more Publ. Trans. Trips
	City Size	Trip length	Trip length = negative correlated with city size
		Frequency	No impact
		Mode Choice	Larger cities can support more efficient public transport systems more trips with public transport.

Table 1. Theoretically Expected Impacts of Land Use on Transport (Wegener & Fürst, 2004)

Direction	Factor	Impact on	Expected Impacts
Transport on Land use	Accessibility	Residential location	Better accessibility to activities will be more attractive for residential development, higher land prices and developed faster.
		Industrial Location	Better accessibility to motorways and railway- freight terminals will be more attractive for industrial development and be developed faster.
		Office Location	Better accessibility to airports, high speed railways and motorways will be more attractive for office development, higher land prices and more development.
		Retail Location	Better accessibility to customers and competing retail firms will be more attractive, higher land prices, more retail development.
Transport on Transport	Accessibility	Trip length	Good accessibility produces longer trips
		Trip Frequency	Good accessibility produces more trips
		Mode Choice	Good accessibility by car produces more rar trips, Good accessibility by Public transport produces more PT trips.
	Travel Cost	Trip Length	Inverse relationship between Travel Cost and Trip Length
		Trip Frequency	Inverse relationship between Travel Cost and Trip Freq.
		Mode Choice	Inverse relationship between Travel Cost and Mode Choice
	Travel Time	Trip Length	Inverse relationship between Travel Time and Trip Length
		Trip Frequency	Inverse relationship between Travel Time and Trip Freq.
		Mode Choice	Inverse relationship between Travel Time and Mode Choice

Table 2. Theoretically Expected Impacts of Transport on Land Use and Transport on Transport (Wegener & Fürst, 2004)

2.3 Node Place Model

In this section, the Node place model is explored in more detail. As we have seen, transit and land use are coherently interrelated. An investment in transit stimulates a development of land use. Hubs are places where a lot of transport flows by and meet and where also a great variety of functions can be found. They are interesting locations for businesses, stores, and living because of the proximity of all kinds of facilities. The Node Place model (Bertolini, 1999) assigns values to these hubs and attempts to represent whether a particular hub is in balance or whether node values are greater than place values. Charting this balance is important because it accurately reflects which part of the model is missing certain values and thus it can discover the extent to which investments need to be made to make the best use of the hub. Station areas are (or may become) important 'nodes' in both transport and non-transport networks (Peek, Bertolini, & de Jonge, 2006). Based on this theoretical concept, sub-question 3, concerning the importance of the station for the city, is theoretically supported.

Modern society, in which telecommunications and modern forms of transportation have developed, has initiated a trend in which urban development is less connected to physical proximity to places. As a result, many social and economic activities have fled the many inconveniences caused by high density building and have settled in new urban regions. Although, for other types of activities an opposite trend is evident. As more routine economic functions such as manufacturing and administration spatially decentralize, high quality services and financial services that require face to face contact, increasingly tend to concentrate in the urban centers (Bertolini, 1999). This also applies to cultural activities, media and entertainment. The dynamics of transportation nodes are a result of this spatial decentralization and concentration. The growing flow of people traveling along nodes is the result of the triangular relationship of working in one place, living in another place, and leisure in a third place. As a result of this dynamic, these transportation hubs are pretty much the only place where all these people from different sectors can still physically meet and interact. This means that social and economic activities that are built on physical proximity can flourish enormously around these nodes as a result of this potential. The condition of this development is that the transport hub should not be separated from its urban surroundings (Bertolini, 1999).

The basic assumption underlying Bertolini's (1999) node place model is, and it is fully in line with the assumption of the transport The Land Use Transport Feedback Cycle (Wegener, 2004), improving transport provision in a station location (or its node value) will, because of improved accessibility, create conditions favorable to the further intensification and diversification of activities there (Peek, 2006). In its turn, intensification and diversification of activities in a station location (or increase in its place-value) will, because of growth in the demand for connections, create conditions favorable to the further development of infrastructure there. The assumption in the

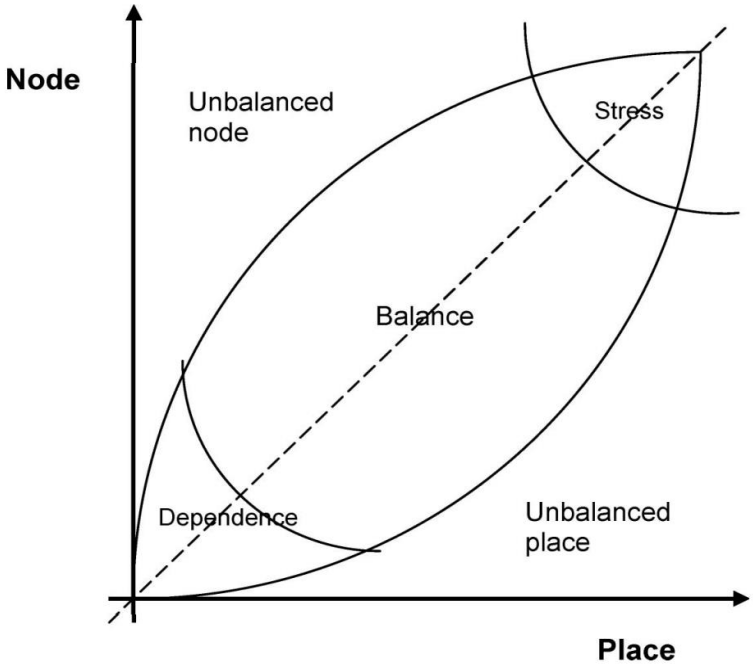

Figure 2. Node Place Model with five Ideal Situations Mentioned (Bertolini, 1999)

model is that, in the absence of interfering factors, all nodes will eventually position themselves around the diagonal equilibrium line.
Within the model, 5 ideal situations can be identified:

- Along the centerline are the nodes that are in "balance". Here, node and place value are equal and thus in balance.
- At the top of the midline are areas "under stress". Here the intensity and diversity of the node and place values are maximum. This means that the potential of land use developments is maximum, a strong node, and that this potential is also realized, which means it contains a strong place value. The same can be said about the potential for transportation development. Although, in these types of locations under stress, where large concentrations of flows and activities occur, conflict between multiple land claims easily arise, because of the scarce available land. This can cause further development of the transit potential to become problematic. A lot of central stations fall into these types of categories.
- At the bottom of the line are dependent locations. The struggle for space is minimal here, but the demand for transportation services from residents, working people and other users of transportation from this area, are both so low that the supply can be kept in place only by intervention of external factors, like local subsidies. Among these types of locations are small town stations for example.

In addition to balanced nodes, albeit under stress or dependence, unbalanced nodes also exist. Of these, 2 types occur.

- Unbalanced nodes: where the supply of transportation is relatively better developed than the urban activities located around the station. Think of newly opened stations at an urban fringe.
- On the other side are unbalanced places. Where the reverse is visible. Here the supply of urban activities is high, but the development of transportation in this area is low. Here, one can think of an old, hard to access, historic downtown for example.

These last 2 scenarios are interesting because they can make a shift within the model, by interventions on node or place value, to move towards a balanced system (Bertolini, 1999*)*.

For operationalizing the model, the 2 components will be approached separately. On the one hand, the criteria for the *place value*, which are typified in terms of activities and facilities around the selected location. On the other hand, the criteria for the *node value*. The degree to which these criteria are typified depends on the number of transfer opportunities and presence of different transport services. For addressing these criteria, van Bendegem, Bos & van der Heijden (2005) will serve as a reference.

Place Value. Depends on:

- Capacity of the place value: The total amount of square meters of activities and facilities.
- Complementarity: indicates the extent to which there is a function mix, specialization and blending of functions. The degree of function mix and specialization determines the functional position of the hub in relation to other hubs.
- Quality: Depends on the image and visibility of a location. Further, the quality of the urban structure and the amount of green vegetation. Also, the extent of social safety is important. For example: enough street lighting and camera surveillance (Bendegem et. al., 2005)

Node Value. Depends on:

- Availability of different modes of transport: Automobile, Public transport and Bicycle
- Chain mobility: The transfer possibilities between different kinds of modalities which increases the accessibility of a location. Improving chain mobility depends on the frequency and speed of modality connections.

- Travel-, transfer-, and waiting time between the transfer. But also the availability of all kinds of infrastructural facilities. Thinking of parking spots, cycling lanes etc. (Bendegem et. al., 2005).

2.4 Transport Oriented Development

This section discusses what the TOD concept entails, how it should best be implemented, and at what aspects a TOD development can be identified. It forms the theoretical background of the first sub-question, which elaborates on the TOD concept, and from previous studies discovered advantages and disadvantages of this concept.

Transport Oriented Development (TOD) can be described as node development, or simply, spatial development around a station to increase accessibility and thus the quality, social structure and economic value of urban regions. This requires strengthening the link between spatial developments and mobility development to improve economic and urban efficiency (Rutten, Schrijnen, & Gerretsen, 2010). Thomas et. al. (2018) state that TOD strategies are usually based on the idea that there will be social and economic benefits of implementation such as reduction of CO2 emissions, prevention of urban sprawl and higher property prices. Also, Papa & Bertolini (2015) state that under favorable conditions, TOD is seen as a concept that can help to shape polycentric cities and regions, boosting the use of public transportation, increasing the amount of walking and biking within a region, while at all times taking into account not hindering economic growth and not wasting the attractivity of a place.

Integrating land use and transportation is one of the most important strategic innovations for developing and generating a sustainable urban future (Suzuki, Cervero, & Luchi, 2013). The upsurge of urban projects around hubs stem from 4 factors (Peek et. al., 2006).

1. Concerns about urban sprawl and car-dependent patterns in cities can be recognized. A sustainable solution is to concentrate developments around nodes. This is seen as a good way forward towards a public transport and non-motorized urbanization pattern. Besides being a sustainability necessity it also has an impact on reducing the pressure on current traffic.
2. A second factor influencing hub development comes from the possibility of adding new transportation innovations to the hub. Think of high-speed lines, but also the possibility of building Tram tracks. This allows certain manufacturing-oriented activities to be further centered in peripheral zones and other activities to move more to the hub.
3. A third factor is to improve a city's competitiveness for living, working and consuming. Stations areas show up as excellent places for attracting large scale urban projects.
4. Market privatization and market orientation of transport providers is seen as a fourth factor for station development. As these transport companies increase accessibility, they are aware of the fact that it increases demand for facilities. This results in an increase in facility suppliers that consists of transportation-company related businesses. This trend is especially recognizable in Asia but is already slowly being noticed in western Europe and the USA.

Effective integration requires a convincing forward-looking vision of the future city, a well-designed institutional framework, and sustainable financial models. A well-integrated urban system of land use and transit provides an urban environment in which the demand for transportation in the form of motorized private transport is reduced and the focus is as much as possible on public transport as the central form of transport in the city, to be combined with the possibility of reaching facilities in the city within a walking and cycling distance (Varma, 2017). Areas where there is a viable public transport network, together with a well-designed urban living environment, good walkability and bike-ability are hugely attractive places for people to live, work, play and interact (Suzuki et. al., 2013). Cities with this degree of attractiveness count as an advantage at the national and regional level of the city's economic competitiveness. It also provides a benefit in terms of local emissions and

promotes inclusive development. (Suzuki et. al., 2013). But a condition for this is that the density and diversity is consistent with the accessibility of multimodality to the TOD. This can for example be influenced by certain landscape characteristics, which can be a barrier to multimodality. Accessibility is determined by the supply of public transport around the station. A good framework for a TOD in a station therefore requires a degree of multi-modality, land use adapted to the TOD and pedestrian orientation. In doing so, the station is easily accessible on foot and by bicycle (Vale, Viana & Pereira, 2018).

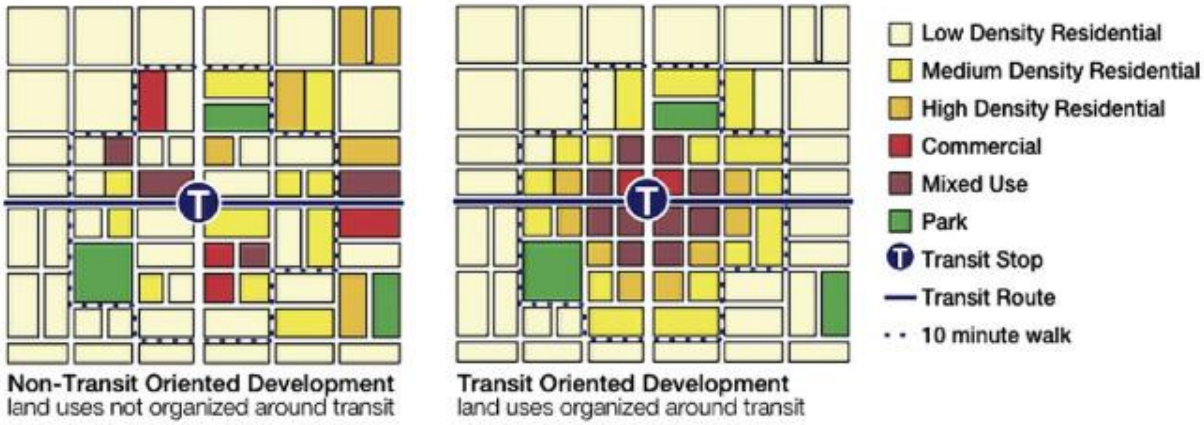

Figure 3. Format of a TOD (Sahu, 2018)

Pillars

To explain TOD, 6 pillars in the form of 6 Ds are identified. These variables are considered very important for achieving the targets set by TOD. They are the foundation for the realization of TOD. (Ogra & Ndebele, 2014 & Translink, 2012). These include:

- **D**ensity: the degree of concentration of households, people and jobs.
- **D**iversity: the presence of different activities and locations in a given area. It involves a characteristic mix of different land uses and functionalities.
- **D**esign: the realization of a "good building environment". This involves opportunities for cycling, walking while simultaneously offering opportunities to sit on public benches or in parks. The essence of the implementation of such features is that they all contribute to a good building environment.
- **D**estination: Transportation systems must ensure that a wide range of locations can be reached so that mobility for people can be increased. It is about effective and efficient transport that makes public transport more interesting and an attractive form of transport in the city.
- **D**istance to transit: Distance has an important role in the viability and effectiveness of a public transport system.
- **D**emand management: Activating methods that counter the use of single vehicle trips by taking action at a specific site, or strategies that take action over a wider area.

A more comprehensive operationalization of the 6 pillars will be further developed in 3.4.

2.5 Urban Growth

In this section, a theoretical background is provided for the sub question dealing with the explanation and exploration of urban growth. The main focus in this section lies on urban growth drivers, growth types and scientific findings that argue for a new kind of urban growth, the smart growth concept. Which is more sustainable and fits with the sustainable ideas of TOD. How urban growth is managed at national and local level in Dutch policy will be further explained in chapter 4.

In the Netherlands, the population of the four major cities is forecasted to continue to grow strongly in the coming decades. Most medium-sized municipalities are also projected to see an increase in population, while many smaller, especially peripheral, municipalities will continue to shrink (PBL, 2019). Below is a map illustrating the growth or shrinkage of each municipality. The thickness of the circle's border indicates growth in absolute terms; the way the circle widens outward indicates shrinkage or growth in percentage terms.

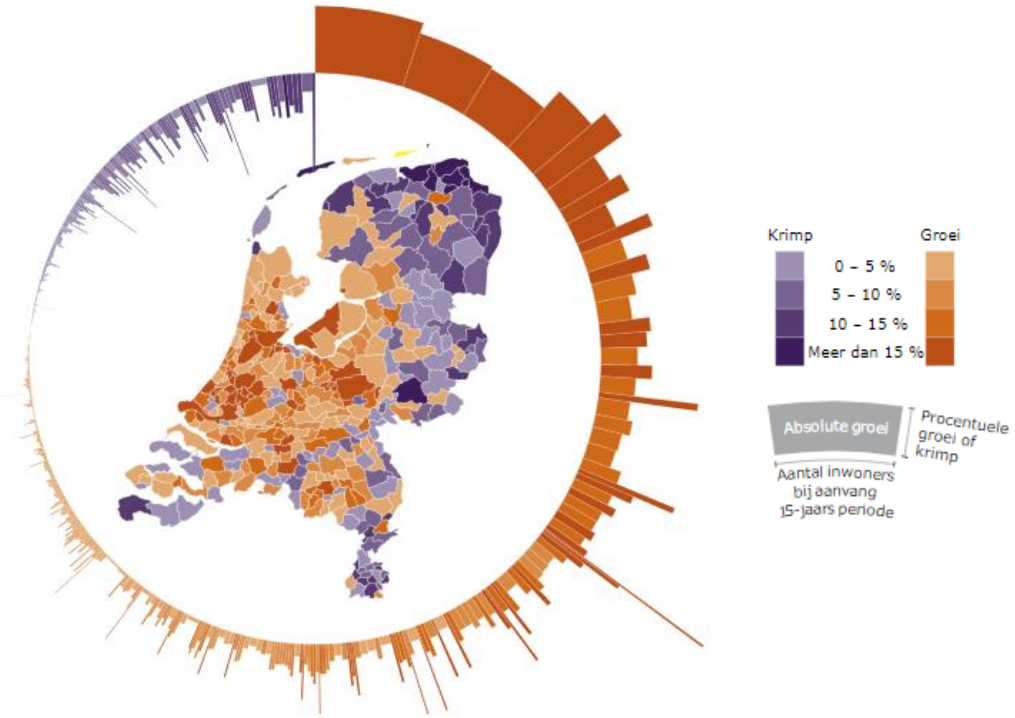

Figure 4. Urbanization Patterns 2018 -2050. (PBL, 2019)

Furthermore, in recent years population growth has mainly focused on municipalities with more than 100,000 inhabitants and in the four large cities. The table below shows what household growth means for municipalities in the Netherlands. In which the blue bars represent the 4 large cities (light blue) and the cities with 100,000 or more inhabitants (darker blue).

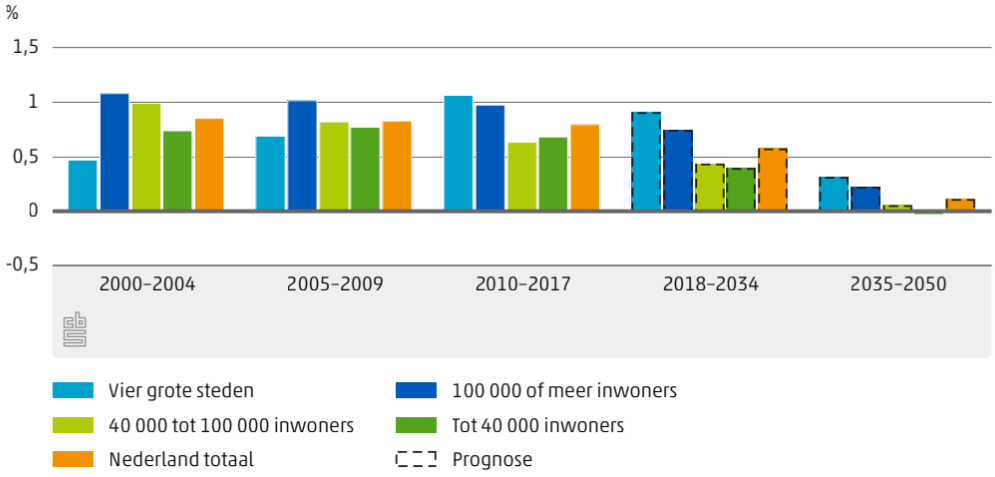

Figure 5. Household Growth in the Netherlands.(PBL, 2019)

Urban growth Drivers

A lot of research has been done to try to explain what lies at the basis of urbanization patterns as key drivers. Based on the report of project SUPER this is distinguished by the following components (Evers, 2020; Evers, van Schie & van Rijn, 2021).

- Demographic drivers: which include population growth, household size, which determine where the growth of urban space is.
- Economic drivers: which translate into Macroeconomic trends, vitality and accessibility
- Societal and technological drivers: the shape of housing demand, transportation preferences and social norms that prevail.

In short, for this research, a primarily focus will be placed on housing, economics and infrastructure drivers of urban growth.

Concerning the steering of urbanization, 3 European urbanization scenarios are described by ESPON in project SUPER (Sustainable Urbanization and Land use Practices in European Regions) guided by a diverse amount of Western sources from planning and environmental disciplines (Evers, 2020). These 3 urban forms are distinguished among compact (usually walkable large dense cities that are dominant in their regions), polycentric (clustered development, usually well-served by public transport) and diffuse (low density car-oriented scattered development).

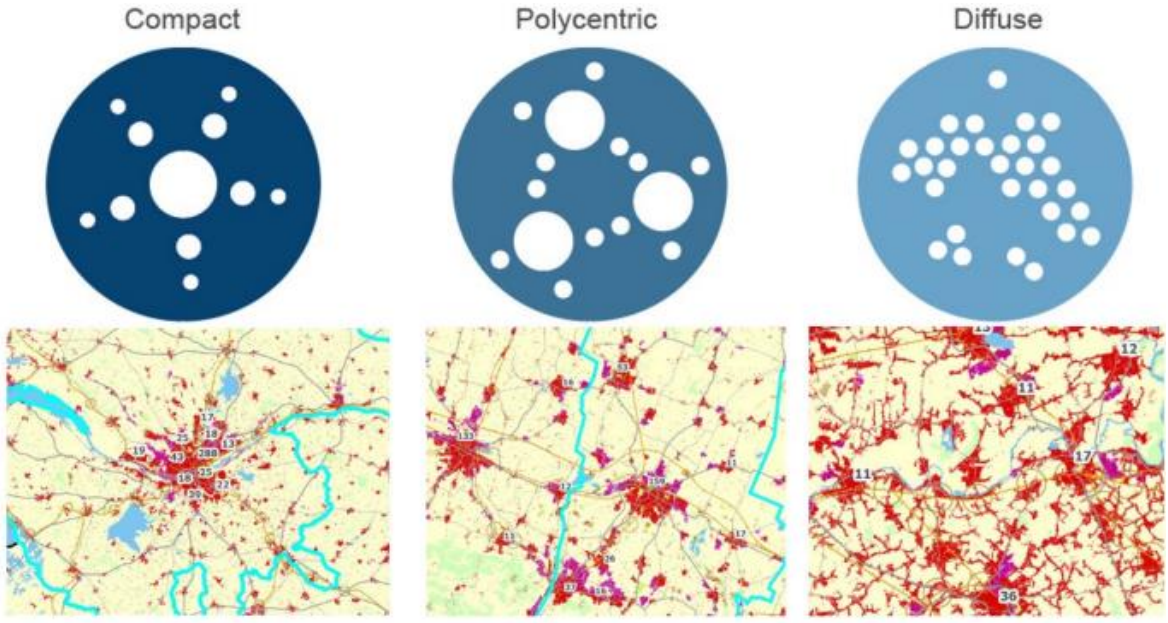

Figure 6.: 3 Types of Urbanization (Evers, 2020)

In figure 6, the top row abstractly shows the extent to which the three forms of urbanization differ from each other. The row below shows in the form of a topographical map how the form of urbanization differs into the landscape. Also, the different urbanization forms can overlap and be combined with each other in some aspects.

In order to make the trade-offs for each urban planning strategy transparent, the SUPER project created an assessment framework for each different form of urbanization. The assessment framework was created based on the usual wide conceptualization of sustainability in economic, environmental and social terms. To create this assessment framework, an extensive literature review was done on the impact of different urbanization types, based on elaborate criteria ordered within these three planes, scoring from very negative (--) to very positive (++). This analysis shows that

compact development is not, as is often assumed, always more sustainable in all areas, and that actually none of the 3 scenarios is a clear "winner" in terms of Sustainability, in its broadest form. Figure 7 shows schematically the extent to which certain forms of urbanization have an effect on sustainability factors in the areas of economy, ecology and the social dimension.

	Compact	Polycentric	Diffuse
Economic sustainability			
GDP, wealth	+/-	++	+
Public finance	+ +	+	-
Jobs	+ +	++	+/-
Accessibility	+/-	++	+/-
Business areas	++	++	+/-
Housing demand	-	+	+
Transportation costs	+/-	+	- -
Energy consumption	+	+	- -
Ecological sustainability			
Reducing mobility (by car)	+ +	+ +	- -
Reducing pollution, including CO2	+ +	+	- -
Green urban areas	-	+	-/+
Biodiversity	+/-	+/-	--
Land consumption	+	+	- -
Natural hazards	-	+	+/-
Climate change	+/-	+	+/-
Consumption of resources	+/-	+	-
Renewable energy	+/-	+/-	+/-
Space for future water retention	+	+	+
Circular economy	+	+	-
Social sustainability			
Health	+/-	+/-	+/-
Affordable housing	+/-	+/-	+ +
Equity/inclusion	+/-	+	- -
Public and recreational space	+/-	+	+/-
Variety (high-rise, suburban, etc.)	+	+	+
Mixed-use areas	+	++	-
Satisfaction with home environment	+/-	+	+

Figure 7. Sustainability of Different Urbanizations (Evers, 2020)

Medium Sized Cities

Bunting et al. (2007) state that for large metropolitan areas, the average modal split for the use of public transport modes is larger than in smaller, less dense cities, the medium-sized cities. From this it can be concluded that only the larger cities have a chance to succeed in upgrading rapid public transport, because car-based travel mainly fits within the mobility policies of lower densities in inner-city areas. Although the identified outcomes of the study of Bunting et. al. (2007), and Stead (2015) argue that a focus on smaller and medium-sized cities is crucial to achieving substantial progress towards more sustainable urban development. Not only because they are home to at least a quarter of the world's population but because they also offer great potential for sustainable transformations (Pojani & Stead, 2015). Over a period of several decades, urban areas around the world have become increasingly dominated by the automobile. Especially in developing countries, cities have experienced a growth in transportation related challenges, which has resulted in a growth in congestion, accidents, public transportation decline. Environmental pollution, climate change and other problems that come to mind when thinking of a sharp increase in automobile use. Instead of megacities, a sustainable potential for urban areas lies mainly in medium-size cities. In these cities a smaller ecological footprint is prevalent and, in principle, due to their size, more flexibility can be found in urban growth that goes hand in hand with the implementation of green modes of transport (Pojani & Stead, 2015).

Calthorpe (1992) and Bonin (2015) distinguish TOD according to 2 scales. A local scale and a neighborhood scale. In this way TOD arises as a multi-scale concept. On a local scale, TOD can be applied to redevelop urban projects around stations. The aim is to increase the density of inhabitants and services from where the station becomes the heart of the secondary center. On the regional scale,

TOD tries to achieve a hierarchy of centers by connecting these secondary centers to each other. In this way, neighborhoods get connected with secondary centers in a larger network.

Urban Growth & Road infrastructure

In the post-war decades, raising the size and number of roads was a common logic approach to filling in congestion and other urban travel problems. In more recent years, there has been a greater understanding that increasing capacity leads to increased demand, as a result of the concept of "induced travel" (Also applicable as latent demand or generated traffic). Past empirical research has not always been clear on distinguishing ‘‘induced travel’’ from ‘‘induced demand’’ (Cervero & Hansen, 2002). Induced travel is the more inclusive term, reflecting all changes in trip-making that are unleashed by a road improvement:

- Newly generated trips (that is, latent demand)
- Longer journeys
- Changes in modal splits
- Route diversions
- Time-of day shifts

Induced demand is more restrictive, encompassing only the first three of these components, thereby representing only newly added vehicle miles traveled (VMT) within a region. (Cervero & Hansen, 2002) In short, by creating new infrastructure, short-term benefits are realized, but the result is that congestion levels quickly return to pre-expansion levels and little travel time savings are realized. Also, road investments have adverse long-term effects on traffic congestion. New roads create new automobile access, which creates trips due to new land use development and possible sprawl.

Smart Growth

The smart growth concept has recently gained attention within the planning area. It represents a response to the growing resentment toward the adverse consequences of current forms of urbanization. These consequences include air pollution, high development costs and a deterioration of the quality of life (Fillion, 2003). Smart growth concepts call for forms of urbanization that are more compact, public transport - and walk friendly city patterns that are beneficial for the quality of life, whereby there is a lower demand for infrastructure and thus a lower environmental impact. Above all, it is for the characteristic notion of "sprawl" that is being tackled within the smart growth movement (Fillion, 2003). And so there are numerous differences to be noted in addressing the differences (Litman, 2017). For example, smart growth is centered on accessibility: The ability of people to reach their desired location, services and activities. While sprawl is generally focused on mobility, physically moving to desired activities, services and other venues. An approach that focuses on smart growth is multimodal, while an approach that focuses on sprawl focuses on longer distances to desired locations, but which are faster to cover. Smart growth, on the other hand, results in short but slower vehicle trips. (Litman, 2017).

2.6 Conceptual Framework

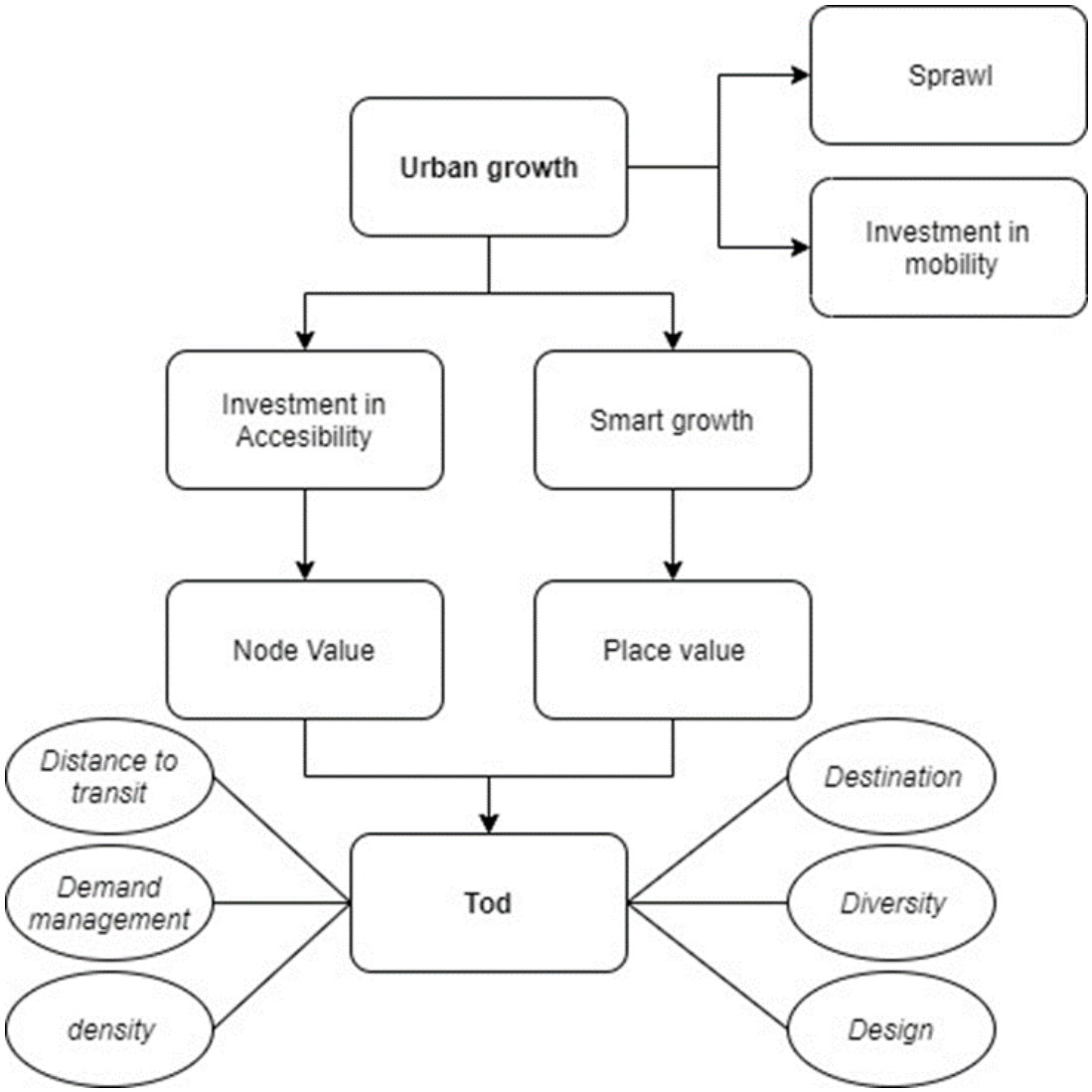

Figure 8. Conceptual Framework (Own elaboration)

Figure 8 illustrates the conceptual model applied in this thesis. The conceptual model can provide a visual interpretation of the theoretical concepts to guide the reader through this research (Yin, 2014) Cities will experience growth in the coming years which, on the one hand, can lead to outward growth, accompanied by investments that improve mobility. This is caused by increasing distances to facilities, housing and jobs. On the other hand, growth can be realized by implementing the concept of smart growth. What goes along with a compact design of urban growth. Due to compactness, transit investments will not necessarily be mobility-enhancing e.g. vehicle miles traveled will not be increased. In contrast, investment in the area of accessibility is considered to be at a higher value. Thus, these developments have an effect on the node and place value of a city. These developments imply that urban developers are adopting concepts of TOD. In addition to compactness and mixed use (which in the scheme are indicated by diversity and density) TOD, is characterized by 4 more D's that underlie such urban development.

3. Methodology

3.1 Research Strategy

The methodology is divided into several parts, each of which is approached at a different stage of the study. During the first phase, desk research is used. During desk research, conceptual aspects are further explored, described, explained and tested. This section of the study has focused on the first sub-question, which addresses the conceptual understanding of TOD. This part will clarify the elements of TOD and attempts to create a general model that will be identifiable by various pillars that have been studied from the literature and previous studies. This phase will also review some literature about urban growth (policy). The second phase of the study has focused on determining urban growth strategies. Again, desk research has been the overall strategy. However, the sources studied are from a different nature. Rather than studies of other academics, the focus during this research has been on growth strategies and agendas of various municipalities and counties on multiple scales that are relevant to this research. Again, this phase of research has an explorative character.

Several policy documents were analyzed. Varying in scale, and varying in topics of interest. The starting point was to analyze Strategies on a national scale. In order to gain a deeper understanding of the state and background of spatial planning, the choice was made to briefly describe the historical path of spatial development. In order to develop an understanding of the years leading up to "modern" spatial development, the focus of the analysis has been primarily on key components of the Vierde Nota Ruimtelijke ordening. Following this, an attempt was made to analyze various components of urban growth in modern spatial planning. Here, the national environmental vision (NOVI) was analyzed, which describes what the desired forms of spatial planning should look like in the coming years. Next, Toekomstbeeld OV 2040 was noted. A deeper understanding of the development of mobility on a national scale, in the Netherlands, emerges through this document. By comparing this document with the NOVI, it should become clear to what extent components mentioned in the NOVI correspond, or clash, with components focused on transportation and mobility development resulting from Toekomstbeeld OV 2040.

The third phase in the study will focus on the third research question. Which is involved in the question of how 6D pillars manifest in mid-sized urban transformations. This is conducted through a multiple case study. According to Yin (2014), the use of multiple cases can ensure that the results that come from the cases can strengthen the evidence. With the implementation of this strategy, municipal documents were used and analyzed as the central form of data collection. This data was supplemented by conducting several interviews. The option to choose 3 totally different cases was taken because of their stage of development. For example, case Den Bosch comprises an already realized station area, and the other 2 cases are at the start of a transformation that will take years. Also the way in which the station is transformed differs in these last two cases. The Achtersluispolder in Zaanstad is going to realize an urban area on a location that currently has no urban structure while the transformation in Nijmegen is mainly aimed at inner-city densification and upgrading of the already existing station area. The similarity that the cases have is that they have relatively similar populations and are examined on the basis of the same units of analysis. Namely, TOD pillars.

The structure of this chapter involves a deeper understanding per case of how housing is arranged, following a deeper understanding of how economic activities are organized and finally at the way infrastructure and mobility relate to the case at hand. When this is completed, the cases are analyzed piece by piece according to the well-known pillars of TOD. Theoretical concepts are also tested against the various interests that will emerge from these interviews.

The final phase focuses on evaluation and reflection of the study conducted. In this phase, the various research results come together upon which an attempt is made to provide a cohesive answer to

the research question. From this, a number of recommendations will emerge that could possibly be adopted by those who are involved in this study.

3.2 Philosophical Perspective

This study reflects on the research question: *"What does Transport Oriented Development of Railway station- areas add to growth policies for mid-size cities?".* To gain a deeper understanding of what a TOD approach contributes to future developments of mid-size cities. In order to answer this question, a couple of qualitative research techniques will be used.

Research paradigms represent the method in which research findings are interpreted and perceived by the society as being true (Van Thiel, 2014). In terms of the epistemology that applies to this research, the question that needs to be asked is whether we can really know what reality is, and in particular, whether there is one reality that is experienced as truth by each and every person?

In line with the open and qualitative character, a constructivism philosophy was chosen for this study. This includes a philosophic approach in which a relative consensus is reached among those concerned with the studied project (Guba & Lincoln, 1994). These truths can differ because they are based on social, political, cultural and economic values. As a researcher, it is necessary to engage with respondents and explore what reality is (Guba & Lincoln, 1994). When it comes to this philosophical approach, the epistemological principles rely on transactional, subjectivist findings. Meanwhile, as far as ontology is concerned, the question can arise: What the value of facts in this study is? The ontological approach will be based on relativist principles. A subjective view of relativity applies to this research (Guba & Lincoln, 1994). The strategy used is a deductive approach. The theory is first analyzed. Then the findings made from interviews and analysis of cases are observed (Bryman, 2016).

3.3 Methods of Data generation

The aim of this research was to gain more insight into the implementation of TOD in a specific- real-world context rather than gathering generalizable knowledge. As this research attempts to explore what TOD can achieve for growth strategies in medium-sized cities, different research techniques will be used to create an in-depth understanding. The exploratory part of this research consists of understanding and mapping whether specific development of (spatial) characteristics will lead to a reduced use of the car, an increase in use of public transport and other green modes of transport and improvement of walkability in order to realize robust urban expansion. This involvement will be studied, especially from a specific threesome of medium sized Cities' experience. By systematically adding, applying and recording multiple qualitative methods, the validity and reliability of the research will be strengthened. The next section will elaborate on the research methods to be used.

1. First, a Content analysis will be conducted in which the content of relevant documents will be further analyzed in a textual analysis. The underlying premise of using these documents is to identify characteristics of spatial planning in the coming years. This is specifically limited to local and national documents. Analyzing documents can provide a stable and primary form of result generation in a case study research (Yin, 2014).
2. Second, semi-structured Interviews help to create a deep understanding of strategists and developers. By using this method, it should become clearer how land use development strategies today are interrelated with transit. Based on these interviews, a more complete understanding is created of how spatial policy is implemented in practice. For this, relevant actors, who have had influence on, or (have been) involved with the spatial development of the case in question, are approached. This will all be done in a multiple case study. Interviews can provide more specific detailed insights and can therefore help as confirmation for the results generated from the documents analyses (Yin, 2014). The interviews therefore serve as additional evidence. The following is the list for the approached

respondents for the semi-structured interviews. Each of interviewees is involved in transformations of the selected cases.

Name	Function	Organisation	Date	Reference
R. Severens	Former project manager	Gemeente Den Bosch	30-11-2021	Interview I
I. van Ophem	Area Development Team	AT Osborne	26-11-2021	Interview II
M.Veilinga	Landscape Architect	Gemeente Nijmegen	25-05-2022	Interview III
E. Jongen	Urban Planner	Gemeente Nijmegen	25-05-2022	Interview III

Table 3. List of Interviewees (Own elaboration)

3.4 Operationalization

3.4.1 TOD components and criteria.

This section will look at what criteria are important to consider when elements of Transport Oriented Development will be further scrutinized.

3.4.1.1 Density

From our urban beginnings, density has never been simply a number, and never neutral, but defined and connected to a shifting set of social, economic, political, and ecological relations.
Density substitutes for a wide variety of terms, many of which carry distinct spatial and political connotations: crowded, congested, centralized, concentration, agglomeration, overpopulated, thickly populated, clustering, ghetto, and so on (McFarlane, 2016).
New urbanism is a reaction to both modernist high-rise urbanism and suburbanization, and seeks to pick up on the tradition of mixed urban social densities. Density returns as a social value derived from a mixture of people, income types, housing, work, shops, civic buildings, and parks in pedestrian-friendly neighborhoods (McFarlane, 2016).

In order to make density measurable, two types of density can be distinguished. On the one hand, there is residential density, which can be described as the number of dwellings, bedrooms or habitable rooms per square meter. While building density can be described as plot area, floor area or ratio of open to built-up space. While density is a well-used and complex concept, there is no consensus on what definition should be used. This is why different definitions are used worldwide (Dempsey, Brown, & Bramley, 2012). In addition, a distinction must be made between actual and perceived density. Churchman (1999) discusses the difference between spatial density and social density. The former is described as the actual number of people in a given space, whereas the latter is "created" by people in the space, which can be interpreted differently by different people. She describes perceived, or social, density as ‘an individual’s perception and estimate of the number of people present in a given area, the space available, and the organization of that space’. For example, when an individual considers density to be too high (regardless of the actual density), one may conclude that a space is (over-) crowded: this is the result of a subjective and qualitative assessment of how the relationship between people and the space they are in is perceived (Dave, 2010).
Developing high density buildings around transportation hubs, facilities and workplaces will increase convenience and therefore sustainable modes such as public transport and walking will be used in higher frequencies. The significance of urban density is that the more people living and/or working in close proximity to transit, the greater the likelihood the service will be used (Ogra & Ndebele, 2014). While high density building is not necessarily a driver of overcrowding, it does provide identifiable opportunities that overcrowding can occur. Overcrowding can lead to loss of privacy at a level that is

less desirable (Stokols, 1976). Thus, effects of high density building do not necessarily result in positive effects. Absolute figures for what an ideal level of density should entail are therefore not available. This is location specific and depends on various factors (Dempsey et. al., 2012).

3.4.1.2 Diversity

Diversity and design should actually be approached simultaneously. In line with density, the requirement for a good building environment consists of a diverse, land-use mix. A diversity of living, working, retail and leisure land uses creates differences in peak and off-peak periods during the day. This results in differences in the amount of traffic on site, but also in differences in the flows to and from the location in question (Gutierrez, 2011). In Sahu (2018), the degree of diversity is expressed as a percentage.

3.4.1.3 Design

Building environment dimensions play an important role in public transport ridership, which consist of 3 dimensions: The two mentioned above: density and diversity, and the third: Design. Design implies: "carefully articulated land-use mixtures; safe and smooth accessibility to transit stations (enabled by foot paths, cycle paths, and street lights, for example); and amenities such as benches, parks, landscaping, and libraries - all of which contribute to the development of a good built environment" (Suzuki et. al., 2013 P.13). Measures that influence the design of a site, which ensure that negative externalities of transit are eliminated, or at least reduced (such as noise barriers, pedestrian fly-overs, or other context sensitive designs) ensure that it has an effect on where people live, how they travel, and which helps to improve the quality of l
ife at streets. This may cause it to attract people to live in these places, which causes a greater number of people to consider the choice of using public transport at these locations. In addition, design reflects the quality of the walking environment. Neighborhoods that are more walkable favor access to stations on foot and increase transit ridership. One variable that can be used to measure walking quality is to add the ratio of sidewalk length to motorized traffic lanes (Cervero, 2002).

3.4.1.4 Destination

Concerning pillar destination is understood to be destination accessibility. It is achieved by reducing the relative distance of urban activities. This is not done by physically clustering these activities, but by transferring people between these destinations in a more efficient manner (Ogra & Ndebele, 2014). Measuring destination accessibility therefore requires calculating a relative distance for the accessibility of different locations. This then includes the accessibility of business, the nearest store, recreation, and the accessibility of residences. Destination accessibility can be improved by designing the transportation system in a way that a wide variety of destinations can be reached. Urban design and street patterns play a role in this, as does the frequency and ability to get on and off bus and tram lines (Suzuki, 2013).

3.4.1.5 Distance to Transit

In addition to destination accessibility, distance to transit applies. Which counts as an important factor for the effectiveness and viability of a public transit system. Measurements of public transport accessibility are important for evaluating a transport system and for re-evaluating or upgrading a transport system. Land use developments depend on this data (Ogra & Ndebele, 2014). Many of the ways to measure transit ridership are measured by trip frequency and distance to a station in a given area. What is less considered is the overall coverage of the trip, i.e., whether a public transportation mode is available for a specific trip or destination. A measurement that integrates the entire trip and its spatial and frequency-dependent components therefore provides a stronger and more precise

description of the quality of a public transportation service, the transport opportunity index (TOI) (Mamun, 2013). It helps to quantify the level of access provided by the service and the ability of this service to make trips from origin to destination. In Sahu (2018), distance to transit is expressed in meters, but it also applies when it comes to facilities that can be reached in 10 minutes walking.

3.4.1.6 Demand Management

According to Ogra and Ndebele (2014) demand management is "... any activity, method or program that reduces vehicle trips, resulting in more efficient use of transportation resources" (P. 3). Measures taken are intended to influence people's individual transportation behavior. The challenge of transport demand management is to implement the right set of incentives and disincentives, so that it has an effect on people's "normal" travel behavior (Meyer, 1999). Policy interventions for demand management are two-sided. Policy interventions that are implemented on site (e.g., rideshare programs at an employment site), and policy interventions that apply to a larger area. (e.g., growth management policies for a state or community, or the implementation of an area-wide variable work hours program) (Meyer, 1999).

3.4.2 Locations of Interest

This section will further discuss the research population to be observed. The aim of the research is to identify what transport oriented development of station areas in mid-size add to the city's growth policy. This is done by studying what societal and spatial obstacles are faced by cities during urban development around stations and what TOD features contribute to overcome these obstacles. To realize a sufficient gathering of information, 3 different cases were approached. What they have in common is that they each fall under the umbrella of medium-sized city. Besides the fact that they are different cities, situated in different locations in the country, the following 2 differences guided this study: First, the phase of development: On the one hand, a case is selected in which characteristics of TOD have been realized, on the other hand, this realization will still take place. This involves studying whether TOD has achieved the desired results in one research object and the extent to which this is reproduced or modified in a planned TOD implementation. Second, the presence of a station: On the one hand, large-scale urban development of the case takes place around a station already realized, on the other hand, large-scale development takes place at a location where no station is yet realized. The study done here is on what principles urban planners want to incorporate transportation and mobility flows into physical urban design and how this aligns with TOD principles. By considering these differences for each case, the TOD concept is scrutinized from different perspectives.

A: The First case s'-Hertogenbosch. The focus of this case has been on the project Paleiskwartier. A new part of downtown Den Bosch, which has been transformed from an industrial area to a mixed live/work environment at the backside of the station (Paleiskwartier, Z.d.). It is a station area which is in a more advanced phase than other cases (van der Beek, 2020). The analysis of this case can be used to provide feedback on differences and similarities in development plans between the other 2 cases whose plans are merely ready to be implemented. Den Bosch is situated in Noord Brabant and has 155.490 inhabitants (CBS, 2021).
B: The Second case is Nijmegen. Several plans are ready to make Nijmegen a Hub of the Future. Development plans are already in place and in the starting blocks to get the first physical hands on the design. In addition to changing the design of the station, access to the rear of the station will be improved, making the station more accessible from two sides, thus triggering significant changes to the urban appearance and structure on this side of the station area (van Dinther, 2020). Nijmegen is located in the Province of Gelderland. And counts 177.359 inhabitants (CBS, 2021).

C: The Third case is Zaanstad. This medium-sized city is one of the fourteen large-scale housing locations identified in the NOVI (BZK, 2020; van Heijningen, 2021). Zaanstad is situated on important public transport connections that are given a key role in "Toekomstbeeld OV 2040" (MIW, 2021). The focus for this case has been on the project of Achtersluispolder. An industrial estate that has a lot to offer to companies and in the future to inhabitants as well. In the coming decades, the Achtersluispolder will be redeveloped into a residential and working neighborhood (ZNSTD, Z.d.). Zaanstad is located in the province of North Holland and has 156.109 inhabitants (CBS, 2021).

Figure 9. Map of the Netherlands (Own elaboration)

4. Empirical results

4.1 Framework

The main question in this thesis is: What does Transport Oriented Development of railway station-areas add to growth policies for mid-size cities. The sub-question "What is urban growth and how is urban growth being managed?" attempts to analyze how growth strategies look like and differ over the years. The dimensions used for the analysis of growth strategies are on housing, economic factors and infrastructural developments. From there, a connection is made to the following sub question, which is involved in the analysis of the role and necessity of a station for the city and its surroundings.
For the analysis, various sources are used, each of which provide a different perspective on spatial planning at a particular time. For an understanding of contemporary spatial development in medium-sized cities in the Netherlands, the period from 1988 to 1997 is considered, mainly focusing on the Vierde Nota on Spatial Planning and subsequent policy documents (VROM, 1988). For a more recent and future look into spatial planning in medium-sized Dutch cities, the above components are approached from NOVI (MBK, 2020). An important difference in these approaches is the integral approach that concerns a much more prominent role from NOVI. These national documents and strategies clarify which national policies applied at the time of spatial transformations in the past, and which national policies will apply for future transformations. This chapter will therefore mainly function as background information for the analysis during the case study in chapter 4.3.

4.2 National

4.2.1. Vierde Nota & NOVI

4.2.1.1 Housing

From the fourth Nota onwards, spatial planning was based on 2 principles (Bruinsma, 2018): The national government remains responsible for strengthening the Dutch competitive position within Europe and worldwide and the national government is responsible for the quality of the living environment in the Netherlands. Instead of quantitative shortages in the housing market, there was a qualitative housing shortage. The housing stock was not adapted to family sizes and types of households prevailing at the time. In addition, strong suburbanization had left large parts of cities in a state of disrepair (Bruinsma, 2018).

The Vierde Nota maintained functional urban regions. The daily functional relationships of living, working and recreation should take place within the radius of a central city with the surrounding commuter towns. The Vierde Nota (VROM, 1988) called for the construction of 835,000 homes in the period 1995-2015. This construction task was particularly assigned to the Randstad: 485,000 homes, because most employment and services were concentrated in the Randstad. In the intermediate zone (Gelderland and Noord-Brabant) 240,000 houses had to be built and 110,000 in the rest of the country. It was the first time that the national government indicated the exact location of where to build. Locations were sought within the cities. This meant the return of the compact city, which aimed at densifying station areas around urban nodes (Pojani & Stead, 2018). The NS was a huge advocate of development around the station, due to the large profits it could make. Within the development projects it often took a leading role. In the second phase of the fourth memorandum, the Vinex memorandum (VROM, 1991), building outside the central urban areas was realized. These Vinex houses, developed on brownfield and other urban areas, were mainly recognizable by the homogeneous way of building. In addition, the transport network did not develop fast enough along with the large suburban transformations, so that residents were often dependent on the car to reach necessary destinations (Pojani & Stead, 2018).

The following map shows that 40% of the housing construction was done within urban areas, the remaining 60% at expansion sites, often called VINEX districts.

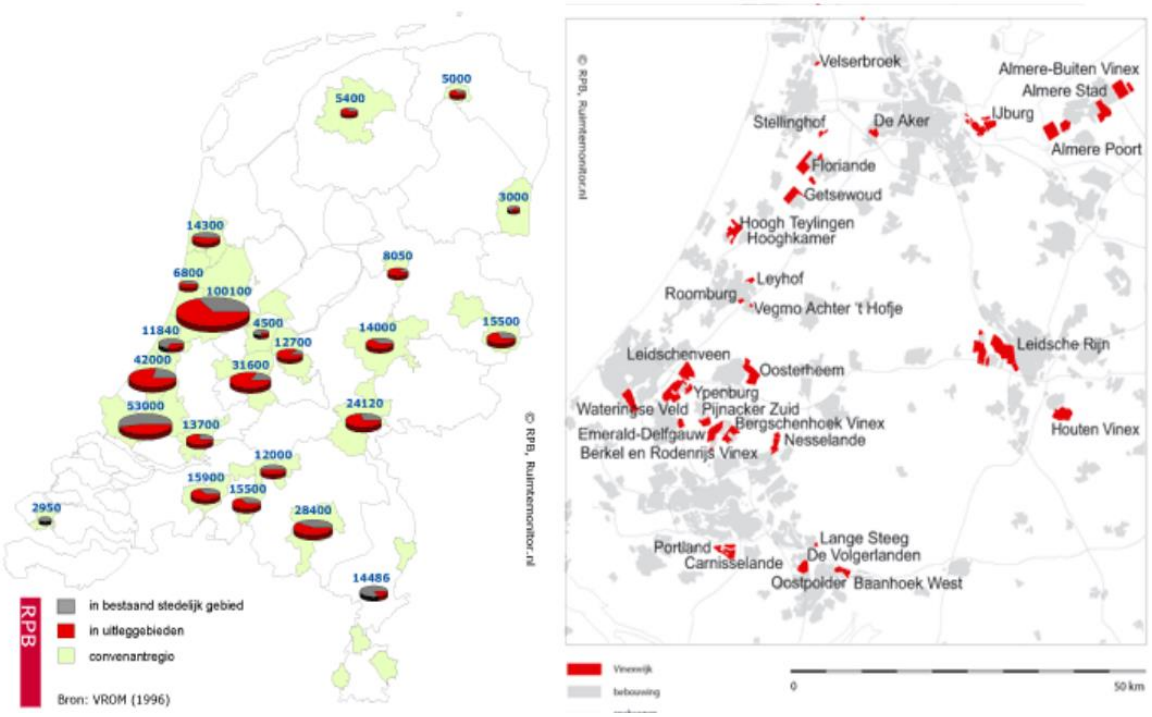

Figure 10. Housing Construction in the Netherlands during 1988-1997 (VROM, 1991)

In NOVI, the urban Network Netherlands is expanded. The development of separate living, working and recreation systems also forms the basis of the current urban network. (MBK, 2020). The national government chooses to set accessibility and environmental quality as the most important conditions with regard to new residential and work locations. With the regions, the national government is looking at the high demand for housing within the central city in combination with the public transport network and good environmental quality, as well as possible locations on the edges of the central city where construction can take place. The primary responsibility for the built environment, the housing stock and livability, lies with municipalities and provinces. The national government has systemic responsibility. The role of the national government is to set the framework, to stimulate, to sanction if necessary and to make resources available where necessary. In addition, the national government is responsible for investments in the main infrastructure, which in many cases are linked to large-scale area development (MBK, 2020).

Referring back to theory, this strategy is addressed by Calthorp (1992) and Bonin (2015), Spatial planning is described by the distinction of TOD Along 2 scales. The neighborhood scale and the local scale. At the local scale, TOD aims to focus on urban projects around some stations, which creates a density of inhabitants and services. Stations become the heart of secondary centers. At the neighborhood scale, TOD aims at implementing a hierarchy of centers around some well-connected key stations. Thus TOD manages to connect areas of different densities in the fringes of the city (Bonin, 2015).

4.2.1.2 Economy & Infrastructure

The national government focused specifically on the Randstad for Dutch international competitiveness (Bruinsma, 2018). Hereby all individual cities were designated with a special function within the urban network. Rotterdam had a harbor and transport function, Amsterdam was the international and

functional center, Den Haag covered the (inter)national administrative functions and Utrecht formed the national business and service center. The remaining regions of the country were themselves responsible for developing European competitiveness. For this purpose, the slogan "Regio's op eigen kracht" was used (Raspe & van Oort, 2007). Regions would have to promote their own unique selling points within Europe. The policy shifted from seeking a geographically balanced distribution of population and economic activities to exploiting the specific potentials of each region individually. Cities that could offer metropolitan facilities on an international level were included in a major urban node. This included Amsterdam, Rotterdam, The Hague, Utrecht, Groningen, the Arnhem-Nijmegen city link and Eindhoven. The Enschede-Hengelo and Maastricht-Heerlen city linkages were designated as urban nodes in their respective EUREGION. Leeuwarden, Zwolle, Breda, Tilburg, Den Bosch and Venlo were designated as regional urban nodes (Bruinsma, 2018). Municipalities were generally left free to create industry and business parks. They were willing and able to provide this. The development of the locations where this took place, however, was unfavorable from the point of of mobility. Namely on the city outskirts and near freeway entrances and exits. The location is easily accessible by car, but poorly accessible by public transport, which led to a sharp increase in commuting traffic which caused congestion. This posed a threat to international competitiveness, and because it was part of the government's core policy in the Vierde Nota, this problem also became part of the national government's responsibilities. This was addressed by introducing an ABC policy. The idea was that the right company should be located in the right place, in order to reduce the pressure on the road network and to maintain the flow on Dutch highways (Jansen, Martens & Schouwenaars, 1997).

A company's mobility profile was defined based on mobility flows to and from the company. A-locations were characterized by good accessibility by public transport and poor accessibility by road. C-locations were well accessible by road and poor by public transport. and B-locations well accessible both by public transport and by car. The policy focused mainly on A-locations. These were intended for office-holding companies. It seemed a well-planned project, but in practice it seemed more difficult to realize. Partly as a result of the restrictive parking policies implemented in A locations, the interest of office-based companies was focused on B and C locations. Also from a competition point of view, the goal and the practice did not seem to match. Thus, there was a clear tension between the interest of the central government and the office-based companies. In addition, switching from car to more environmentally friendly forms of transportation was difficult when people are already used to going to work by car (Bruinsma, 2018). The characteristics of A location types are very similar to certain principles of TOD station locations. Which amounts to a high rate of public transportation modalities, and mixed use of space (Cervero, 2002). However, a factor that emerges here, which is less mentioned in the theory but also passed numerous times in the interviews with interview I and interview II, is the practicality of the regulated designation of certain locations as a car-free zone. What is characterized in interview I by restraint to invest when integrating a station into the residential area. And what in interview II is characterized by restraint in the establishment of offices due to a restrictive parking standard imposed by the municipality and province.

The urban network of the Netherlands is an attempt to link the core economic areas more closely together. This will result in a strengthened urban economic structure (MBK, 2020).
With shorter travel times, economic core areas are better connected and accessible.
The Dutch government has drawn up several goals to develop The urban network. First goal is to Ensure and realize a safe, robust and sustainable mobility system. The overarching (economic and social) interest is served by good accessibility at all levels of scale (more than the national infrastructure network) and for that reason requires assurance at the national level. The national government is (systematically) responsible for this. For certain parts of the network (e.g. the underlying road network and regional public transport) or certain themes (road safety) the elaboration

can be done at the regional level. The government encourages innovations in mobility through cooperation with private, social, scientific and public partners.
Second goal is to maintain and develop the main mobility infrastructure (MBK, 2020). A well-functioning mobility system requires safeguarding and developing the main infrastructure for the transport of people and goods via roads, railroads, air space, sea and waterways. Uninterrupted networks for the whole of the Netherlands and a connection with foreign countries must be guaranteed. This interest transcends territorially the municipal, regional and provincial levels. Third goal is to guarantee and strengthen an attractive spatial-economic business climate (MBK, 2020). A competitive, sustainable and circular economy throughout the Netherlands is the foundation of the Netherlands' prosperity. Part of an excellent business climate is a supply of space that matches demand, including aspects of the physical living environment such as digital connectivity and security, business locations, accessibility and quality of the living environment and nature.

NOVI emphasizes a focus on proximity and accessibility in further urbanization (MBK, 2020 p.31). Accessibility is of great importance for a livable and competitive city or region. Whether abroad or in a neighboring municipality, entrepreneurs and residents value accessibility for different reasons. However, organizing and designing cities and regions in terms of accessibility lead to a lot of long-distance mobility and associated negative effects such as noise, CO_2 emissions and/or degradation of nature and landscape. In contrast, organizing and designing cities and regions in terms of proximity leads to shorter travel distances, more walking, cycling and public transport use.

Some experts also embrace the importance of urban development around the station. "The importance of station areas cannot be stressed enough. It is not just another business park that you are transforming. Always combine this area with public transport and consider the role of this area in the national network." Developing a railroad zone is not just putting up a number of residential towers, you are creating a piece of city, a second heart chamber, which in combination with the other heart chamber, the historic inner city, forms the complete heart of the city " (Stedelijke Transformatie, 2021, 2021). According to Chorus and Bertolini (2011), the way land is organized strongly relates to the way transportation patterns arise, and the other way around. The way these dimensions are interrelated is shown in the Land use transport feedback cycle of Wegener and Fürst (2004). Consider Table 1 and 2 in 2.2 at page 7. These describe the effects that Investments in accessibility generate for different land use dimensions. Investment in high-speed rail links, freeway and airport connections, and railway stations is more attractive for office development. Also, locations that benefit from better accessibility to customers and competing retail companies result in higher land prices and are developed faster. An investment that can be realized based on accessibility, in terms of transportation or proximity, provides a new growth in retail development (Wegener & Fürst, 2004).

Modal split in highly urban area and mid-sized urban area.
The figure below shows the annual figures from 2019 for the average travel pattern divided by city size in the Netherlands and explained based on their modes of transport. These results are calculated by the Central Statistical Office (CBS, 2022). The differences in the number of trips per means of transport are noteworthy. Thus it is visible at a glance that the car in medium-sized cities has a larger share than trips in high-speed areas. Also the public transport: train, bus, tram and metro is used many times more in high urban areas than in medium-sized urban areas.

	Walking	Cycling	Light Rail / Bus	Car (driver)	Train	Oher
Metropolitan Cities	19,3%	31,4%	**6%**	**26,4%**	5,4%	11,5%

Mid-sized cities	13,7%	27%	**1,4%**	**41,1%**	2,5%	14,3%

Table 4. Travel Patterns divided per Transport means in Mid-sized and Metropolitan Cities (CBS, 2022).

4.2.1.3 6D Principles.

According to Wegener & Fürst and Bertolini (1999), the way land is used is strongly related to the demand for transit in a given area. As highlighted in theory (PBL, 2019) and described within national spatial policy (MBK, 2020) , Dutch cities are experiencing growth that affects both the use of land in the cities, as well as the demand of transit within the cities and ideally, around the transport hubs. In order to prevent urban sprawl, NOVI puts a lot of emphasis on building within cities, which brings additional challenges because it will increase the density of people / and facilities, as well as the pressure on mobility (Bertolini, 1999). This study explores whether this inner-city urban growth can be accommodated by the strategy of TOD: Inner-city building around public transport nodes and the accommodation of the increased demand for mobility with public transportation and walkable distances between facilities. TOD can be operationalized using the pillars of Ogra and Ndebele (2014). These variables are considered very important for achieving the targets set by TOD and this is used as an analytical framework in order to formulate an answer to the main question (Ogra & Ndebele, 2014). Density, Diversity, Design, Destination, Distance to transit and Demand management.

Density & Diversity

In the coming years, the Dutch government is putting high priority on densification of the country. In this way, positive externalities associated with density and mixed use of functions are connected. Opportunities for building in high densities are mainly in the inner cities and near public transport hubs (MBK, 2020). Housing types and work environments that require more space will have to be accommodated elsewhere in the urban area, but preferably within the existing built-up area. This does not apply to large business parks that attract few people. These sites are located outside the existing urban are (MBK, 2020 P.113)

Building in high densities has the effect of enabling growth in Public Transport. The significance of urban density is that the more people living and/or working in close proximity to transit, the greater the likelihood the service will be used (Ogra & Ndebele, 2014).

This is also in line with the policy recommendations of Suzuki et. al. (2013), regarding the integration of land use and transport in bullet point 5 in 2.4.2.: "The creation of articulated densities". At the same time it is clear that densification also puts extra pressure on the city and that this effort therefore requires extra attention to the quality of life in the city. Stokols, (1976) labels it as overcrowding. This would also mean that the city would lose its appeal as a healthy and attractive living environment and a good place to work (MBK, 2020). Damo Holt, member of the housing expert team (Stedelijke Transformatie, 2021) also reports that a high building density can have beneficial effects for the functioning of the railroad zone, but that there are limits to this high building density. You can't build higher ad infinitum. At a certain point, it might turn against your plans. The key is to find an optimum that differs per situation.

Design

Suzuki et. al. (2013) emphasizes the importance of creating a good building environment as an element for good land use. A lack of urban design components causes a disconnect between the transportation system and the surrounding environment. According to NOVI: (MBK, 2020) “In addition to the importance of cultural heritage, the architectural quality of buildings and urban planning quality, the human experience of the physical living environment is important.” This includes the spatial and environmental quality of the living environment. More specifically: it includes values

in terms of use, experience and future. Together with noise, odor, air, soil and water quality. This is in line with the Suzuki et. al. (2013) policy recommendations toward integrating land use and transportation. Where urban densities come together with planning design. in bullet point 6 in 2.4.2. The combining of higher densities with diverse land use and pedestrian-friendly design.

Destination (accessibility) & Distance (to transit)
Achieving better destination accessibility is accomplished by reducing relative distance between destinations (Ogra & Ndebele, 2014). The investments made by the Dutch government to reduce relative distance is besides optimizing public transport as a mode of transport, it is also desirable to invest in the first and last mile. Which means that there is also much to optimize within the journey from station or bus stop, to desired location or home address (MIW, 2021). This requires not only an upgrade of the hubs and train connections, but also a qualitative and large-scale jump within the network of modalities, in order to make a transition to a chain of mobility (MIW, 2021). This mobility chain relies on seamless connections, shared mobility and private transport. Good interconnections strengthen the urban network of the Netherlands (MBK, 2020). Also, applications of smart mobility contribute to improving access to public transport, and transfers to other lines (MBK, 2020).

Demand Management
Suzuki et. al. (2013) highlights in bullet point 12 in 2.4.2 of its policy recommendations for integrating demand management with TOD. It also emphasizes that a regulatory framework is needed to apply facets of TOD in the mobility system to incentives and disincentives in bullet points 2 and 3. Transport demand management should enable travelers to become less car-dependent and should diminish energy use, fuel emissions and noise produced by motorized modes. NOVI still provides a rather unclear direction for car restriction measures, which would move society more towards public transport. Measures imposed by the government however, are involved in how the land is planned. The interrelation of land use and transportation, which was cited by Wegener and Fürst (2004) has a steering effect on the use of the automobile. For example, the ABC policy, mentioned earlier (Bruinsma, 2018), is an example of one of these spatial interventions that falls under the umbrella of TDM. However, this did not immediately have the desired effect, because the automobile was strongly embedded in society. Nowadays, many TDM measures are municipality-specific. In terms of car-free zones, parking restrictions and parking.

4.2.1.4 Concluding
With the introduction of the NOVI, the Netherlands will see a lot of new construction in the coming years. Whereas during the Vierde Nota policy document urban growth was fixated on a Vinex transformation, in which the car played a central role in connecting living, working and facilities, in the coming years urban transformations will be realized mainly within the city. This inner-city development will be combined with an upgrade of accessibility, particularly by public transport. The focus on locations for business development also appears to be more broadly focused on station areas. Through the development of the high frequency rail transport program, attempts are being made to bring the urban network Netherlands closer together by running trains in higher frequency between them. Regarding the node place model of Bertolini (1999), increasing the node value, by means of increasing the reachability, means that the place value also demands such development. Which in practice means that these hubs become more attractive for the development of business activities. Whether such station developments can be qualified as TOD will have to be determined by a deeper analysis in 3 specific medium-sized cities that are or have been subject to spatial development. In the multiple case study conducted, 3 assessments are made of their context in terms of housing, economic development and infra structure and to what extent such developments affect the 6 Pillars.

4.3 Case Study

To answer the research question " What does Transport Oriented Development of Railway station-areas add to growth policies for mid-size cities?", this section further explores the sub-question " How do the 6D pillars of TOD manifest in mid-sized urban transformations?" In order to get the best possible understanding of the interrelatedness of TOD in mid-urban transformations, the choice was made to further analyze 3 different cases in the form of mid-size cities. The variety of data is characterized by the different phases of transformations within these cases and the location where the transformation is realized. First Case: Den Bosch, Paleiskwartier. Which has realized a significant upgrading of the station area by opening and transforming a former industrial area on the west side of the station. The development of Paleiskwartier began in the 1980's but is also still under development. Second case: Zaanstad, Achtersluispolder. An upcoming large-scale development of an industrial area that will be transformed into a large live/work area. There is no established train station at this location yet. However, the development of a multimodal hub with or without a rail connection is within the realm of possibilities. Third case: Nijmegen, Spoorzone. An upcoming large-scale development where office and residential space will be added and the possibilities for public transport, cycling and walking will be improved.

4.3.1. 's-Hertogenbosch

4.3.1.1 Housing

From the 1980s onwards, major new building projects are realized. Postwar planning inaccuracies and outdated neighborhoods are renovated or redeveloped. (Verhees, Vos, & Slangen, 2005). From these urban renewals in Den Bosch, the Bosch' Tolbrugkwartier and the station area are good examples of urban renewal. Because a number of sites in the city became available, residential projects could be built in the inner cities after years of decline. The municipality did not want to burden the inner city with large office buildings. From this, the railway station area was indicated as the main location (Verhees et al., 2005). Because the station was chaotically arranged, the station square that ran in front of the station also caused bad traffic situations and there was a considerable spatial degradation going on in the industrial area "De Wolfsdronken", it became possible and also necessary that the railroad zone had to be redesigned (Interview I & Verhees et al., 2005)

A degraded piece of industrial land was upgraded into an area with spacious modern buildings. At first it was doubtful whether there was any interest in living in this area. The area was illustrious because it was used as a location by the illegal circuit for prostitution and the trade in and use of prohibited substances (Interview I). In practice, however, the demand for housing around Paleiskwartier was very much in demand. The municipality was interested in a new station building, a new station Square and the removal of the railway as a physical barrier between the city center and the west side of the tracks. A direct link between De Wolfsdronken and the city center via a new railway station would remove the barrier and enable the municipality to advance its urban center approach (Peek, 2008).

Currently, there are sufficient building sites for the short term to meet the housing needs. After finalizing the last major urban expansion, the residential areas will only be expanded in the coming years through the development of smaller housing locations. For the longer term, the possible shortage will have to be overcome by infill locations (Gem. 's-Hertogenbosch, 2018). For the realization of these large apartments, it is important that it stays in line with the housing demands of the consumers. Thus, the phasing will have to take time. In terms of height a size should therefore be decided carefully and without any rush (Gem. s-Hertogenbosch, 2018).

4.3.1.2. Economy & Infrastructure

For the city council in Den Bosch, it was necessary to establish relevant actors in the station area, during the development of Paleiskwartier. (Back then, the area was still called Wolfsdronken). Buying out current owners was capital-intensive and therefore not desirable (Verheul, Daamen, Heukens, Hobma, & van Zoest, 2019). Through PPP (public-private partnership) the PPP organization was able to make far-reaching agreements on plan functions, quality, phasing and price ranges. Through a PPP, all land is purchased by a public or private party, which makes it much easier to realize a completely new urban planning structure that transcend the boundaries of the plot: Such as integral parking garages and water storage. This also makes it easy to share major costs and risks (Verheul et. al., 2019). The companies approached by the municipality for this PPP were Kondor Wessels, ING Vastgoed and De Nederlandse Investeringsbank (Interview I) .

In practice, it was difficult to attract companies to establish their businesses in the redevelopment area (Interview I). Provincial policy demanded the realization of urbanization around the station. But for many companies the requirement was that this realization should not be at the expense of car mobility. There was a significant parking requirement for many businesses, which did not match the very strict parking standards that were intended to be achieved from the provincial government (Interview I). The company Malmberg was the first organization to settle temporarily on the site. After this period, they liked the location and the proximity of the station so much that they wanted to settle for a longer period. Eventually, the Palace of Justice settled near the Wolfsdronken. Many juridical companies and law firms had the desire to carry out their activities near the Palace of Justice. As a result of this spillover, economic incentives were created (Interview I).

What is key within the transformation of the Paleiskwartier is the never-before-seen form of public-private partnership that developed during the project. Initially, the Dutch Railway only wanted to increase the efficiency of the railway station by adding an extra platform in order to enlarge the network from Den Bosch. The design of the station did not have to be developed at all (Peek, 2008). Ultimately, it was the joint development of the station and its surroundings that ensured that this is generally regarded as a successful transformation.

Now, based on previous research, it can be observed that residents of the Paleiskwartier use the train to a higher extent (Fioreze, de Gruijter, & Geurs, 2019). 17% compared to 7% in other densely populated areas. This higher degree is also visible when the same question is asked to other districts in Den Bosch. It should also be noted that inhabitants of the Paleiskwartier have a lower car ownership rate than other districts in Den Bosch. 0.93 cars per household, compared to 1.34 cars per household (Fioreze et al., 2019). The city center is optimally accessible from all directions by bicycle and public transportation. Bicycles can be used throughout the city center and there are sufficient bicycle parking spaces. Regular public transport no longer drives through the city center, but uses the newly designed inner-city ring and the new large-scale inner-city stops on that inner-city ring. An additional small-scale electric bus runs in the city center. Motorists wishing to visit the city center are primarily referred to transfer points close to the approach roads. In the center, only short-stay parking places will be realized (Gemeente ‘s-Hertogenbosch, 2018).

Modal split Central station

Regarding the travel data known for Station Den Bosch, data about 2019 is used because 2020 and 2021 were not representative due to the global outbreak of Covid19. Den Bosch Central station in 2019 attracted an average of 67.022 travelers per day, for which the modal split of these travelers looks like this (NS, 2019). It is divided into pre-transport: the distribution of the type of transport used to reach the station on an average working day -and post-transport: the distribution of the type of transport used to reach the final destination on a working day. Remaining modes of transport are negligible in this modal split.

	Walking	Cycling	Bus	Car (driver)	Car (Pass.)
Pre-Travel	25%	36%	26%	5%	7%
Post- Travel	57%	16%	15%	3%	8%

Table 5. Modal Split of Travelers from and to Den Bosch Central Station (NS, 2019)

The image below shows an aerial photograph of what the plans for Paleiskwartier second phase came to look like, In which the Paleiskwartier south would act as a pivot between Den Bosch inner City and West. The transformation shown on this aerial photograph is essentially the core of the Palace Quarter development.

Figure 11. Aerial View of Western Railroad Zone 2008 (Interview I)

4.3.1.3 6D principles

Density & Diversity

By having more than 3000 inhabitants in Paleiskwartier on relatively small surface area, it can be concluded that Paleiskwartier involves a strict population density in the built environment. However, density is always relative, as this was also indicated by Dempsey et al. (2012) The diversity of facilities, on the other hand, can be observed objectively, due to several institutes of higher education that are located in the area. Which together provide education to around 20,000 students (Studiekeuze123, Z.d.) In addition, a variety of companies can be found. An increasing number of restaurants and cafes are appearing in the area (Interview I). This great diversity of facilities have positive results on traffic and use of public transport modes by creating differences in peak and off-

peak periods during the day (Gutierrez, 2011). The city council, however, has put a stop to the plans for a large theater in the palace district. The lack of this theater and the still underutilized center function of the Paleiskwartier in the evening is a common criticism that the area sometimes lacks vitality (Vastgoedmarkt, 2018). Mixed-use developments are mostly limited to a mix of housing and offices.

Design

Design dimensions play an important role to what extent a good building environment applies to the area (Suzuki et al., 2013). During the completion of the Palace Quarter, the overarching idea was to connect the historic center with the Paleiskwartier. Thus, there had to be external structures corresponding with the already existing center. The municipality strove for an identity that fitted the urban image of the city: exuberant, somewhat stylish and with a southern exotic touch. This identity should appeal to a certain group of users, contrasting with the working-class inhabitants of surrounding districts on the west side of the railway (Peek, 2008). The design of a station and its surroundings is a key condition for the experience of an area and the journey connected to it. It influences both the choice of whether the traveler continues on foot, or whether the traveler enters the last mile by motorized mode. The introduction of the Ponte Palazzo, which has an enabling function to the city center of Den Bosch is also a meeting and recognition point for the area (Vastgoedmarkt, 2018). In the Paleiskwartier, a primary focus on active mobility applies. This means that the public space is designated with car-free zones in several places (Interview I). In addition to the functional facilities offered in the Paleiskwartier it is also a place where people can meet and temporarily stay. The modern look of the building has in that sense, an appealing look, attracting not only residents and commuters but also small forms of tourism.

Destination & Distance to Transit

The opening of the back to the central station of Den Bosch is an attempt to open up the route to public transport. The central bus station is accessible via the above-ground tunnel, which is kept open and not blocked by little check-in/out portals. Which was a major lobbying effort with Nederlandse Spoorwegen during the realization of the upgraded area. (Interviews I) It is also possible to use various forms of shared transportation in and around Paleiskwartier (Brabants Dagblad, 2021). However, the Bus lines through Paleiskwartier are less extensive than on the center side of the station, so movements within Paleiskwartier are mainly on foot and bicycle (Interview I).

Demand management

Transport demand management should enable travelers to become less car-dependent and should diminish energy use, fuel emissions and noise produced by motorized modes. (Suzuki et. al., 2013) With the strict parking standards implemented by the municipality, an attempt is being made to get visitors and residents of palace quarter to use numerous public transportation modes present in the area (Interview I). However, the construction of a large underground parking facility was a strict condition for the realization of Paleiskwartier . In addition to disincentives to the non-use of the car, more can be done on incentives that ensure that public transport use is encouraged. MaaS (Mobility as a Service) can take care of this. Maas can ensure a more transparent understanding of multimodal travel alternatives, making it easier for customers to use public and shared transport. In fact, when automobile use can be reduced, there is more opportunity for further densification. In the study by Fioreze et al. (2019) It is shown that there is a reasonable amount of curiosity among the residents of Paleiskwartier about the possibilities of MaaS, but that the concept needs to be promoted more because it may still seem too unknown and complicated (Fioreze et. al., 2019).

4.3.1.4 Concluding

Through the Analysis of the characteristics of Den Bosch station and the area Paleiskwartier it is possible to give insight into how densification around the station, combined with a mixed urban infill corresponds with the goals of the new urbanism. The aim of developing the Paleiskwartier was to transform the former industrial area into an urban area, performing as a second heart chamber that together with the inner city could form the center of the city. The vision of Den Bosch is in this respect similar to the national policy in the NOVI in terms of densification, new forms of urbanization and making mobility more sustainable by looking at proximity rather than accessibility.

The development of the station area features which also correspond to the pillars that can be recognized for TOD has led to a different way of looking at mobility in the area. Where in the beginning some companies were still hesitant to settle in an area where mobility is mainly focused on public transport, the commute between home and work by train eventually turned out to be a pleasant experience for the employees. For the daily functioning of the district it is important that in addition to a high density, this density also consists of a diverse package of facilities, in order to see this district truly as an extension of the Den Bosch city center. However, according to several people, the facilities offered in Paleiskwartier are still underutilized, which means that the area lacks some vitality, especially in the evenings. In order to encourage the use of public transport, cycling and walking as much as possible, sharp parking standards have been introduced in Paleiskwartier. This Demand management, however, is way more effective if the focus would be on encouraging public transport rather than prohibiting car usage. All in all, the development of Den Bosch station area has been significantly influenced by certain lines of thought of TOD policy. The access to the train and bus station and city center are mainly focused on walking and cycling routes and also other applicable non - physical standards stipulate that walk and bike-ability is safeguarded.

Paleiskwartier can be qualified as a model for urban sustainability. It shows how infill development realized on underutilized urban sites can help reduce the need for expansion on the outskirts of the city.

4.3.2 Zaanstad

The second case addressed in this study concerns urban development in Zaanstad, exploring the primary opportunities for TOD in the large-scale new project at the Achtersluispolder. The difference with this case is that large-scale urban development is in a different phase than case Den Bosch, the influence on spatial policy due to proximity of a large city like Amsterdam and, thirdly, what should be noted is that the area of the Achtersluispolder does not (yet) contain a "large" railway station. However, the evolution of mobility in the Achtersluispolder requires significant attention, due to the high traffic intensities present, as a result of existing business activity and the future pressure on the area if additional housing is added to the area. Between 2020 and 2040 the municipality will grow by 50,000 inhabitants (ZNSTD, 2020). This has growth implications for mobility, pressure on public space, and increased use of traffic bottlenecks. Because there is a chance that the high-quality public transport- network will be expanded in Zaanstad, on or around the Achtersluispolder, it is relevant to this study whether certain pillars of TOD, which are at the core of this study, can be recognized within the land and transportation policies and where there are still some opportunities.

4.3.2.1 Housing

Zaanstad has rapidly grown from the end of the 19th century and the beginning of the 20th century as a result of strong industrialization and migration flows. For the people working in the factories, in a short time and at a high pace, low quality, wooden laborers' houses were built (Tambach, 2012). The “Woningwet” of 1901 put an end to wooden construction. Brick work houses were built, especially in

the industrial areas along the Zaan. And between 1910 and 1940 many small social houses were added (Tambach, 2012). To overcome the post-war housing shortage, 1000 houses were built per year from the 1960s through to the 1970s. After this period, many housing estates were added all over the city containing many cheap rental houses and between 1975 and 1990 several middle class housing estates were built in the north and west of Zaanstad. From the 1990s onward, construction was on a smaller scale than before and factories along the Zaan were replaced by privately owned and rented apartments. Neighborhoods with a one-sided and poor quality housing stock were restructured (Tambach, 2012).

Now, due to the rapidly recovering economy, previous measures in the housing market and a pent-up demand from people who waited out the great economic crisis, (especially) metropolitan areas with a stressed housing market face considerable challenges. Starters have more problems getting affordable housing, the rental sector lacks a mature middle segment and the supply of affordable housing is very scarce (Rijksoverheid, 2018). The municipality of Zaanstad is also facing these same challenges (ZNSTD, 2018). Where currently 550 newly built homes per year apply, the ambition is to increase the pace of construction to 1000 homes per year. In addition to inner-city construction, many sites will be made available for housing. In the coming years, Achtersluispolder will be redeveloped into an intensive area for living and working, close to Amsterdam. This is where a large part of the housing assignment will land (ZNSTD, Z.d.). The location of the area requires a car-free set-up, with hubs at the edges, optimal bicycle connections between Zaanstad and Amsterdam via Achtersluispolder and especially: Good public transport (ZNSTD, 2021).

4.3.2.2. Economy & Infrastructure

After the Second World War, the need arose to create an area in Zaanstad to accommodate industries. Especially for heavy industry. The first to settle in the area were large wood merchants and the Bührs machine factory (Zaanwiki, Z.d.). The Achtersluispolder was the first industrial area in the Zaanstreek to be developed outside the residential area. Later, the Zaanstreek became an important place for the food and beverage industry. Due to strong migration and urbanisation, the urban appearance of the Zaanstreek changed and it became Zaanstad (Zaanwiki, Z.d.). The work carried out on the site is an important source of employment. Its use has changed in recent years: in its main design the Achtersluispolder was a 'wet business park', with a lot of use of docks. This has shifted over the years towards a 'dry business park' with other types of companies (ZNSTD, 2021b). Due to city formation and ongoing deindustrialization, Zaanstad has nowadays become more and more predominantly a service industry and is of equal importance to employment in the Zaan region as industry (Zaanwiki, Z.d). Since the 2000s, the number of business establishments in Zaanstad has grown by almost 120 percent. Partly due to its location and accessibility in relation to Amsterdam, there are many opportunities for business activity, which mainly focuses on sectors in tourism, sustainable circular economy, technology, healthcare, transport and construction (ZNSTD, 2018). Promoting employment and tourism through a good business climate and more jobs in Zaanstad can provide more balance in the home-to-work commute and also leads to less pressure on the infrastructure towards Amsterdam.

Maintaining and ensuring good traffic flow to and from the Zaan region is essential for the continued functioning and growth of economic activities in Zaanstad and the Achtersluispolder business park. The Achtersluispolder is situated near important routes in the road network such as the highway-tracks A8 and the A10 and the important regional road Thorbeckeweg. These roads are important bottlenecks that need attention and for which robust solutions need to be found. With the development of Achtersluispolder, the municipality wants to focus on high-quality public transport and continue to give priority to cycling and walking. Due to the continued presence of industrial activities, the area must also remain easily accessible to cars and freight (ZNSTD, 2020). To achieve an accessible Achtersluispolder, the feasibility of a new HPT connection is being considered. however,

because the Achtersluispolder project is a built from the foundation, the development of new residential area does not seem to be running parallel to the priority for transit development (Interview II). Research by Arcadis shows that a realized site of 70% is the minimum for attracting the need to build a new HOV line. Developers are also reluctant to simultaneously realize a new public transport network around the Achtersluispolder site, because the return on investment is unclear in a still-to-be-developed residential area (Interview II). With the ex post realization of HPT, the daily travel pattern for residents is already largely determined (Interview II). Parking places have been realized and the daily urban transport structure is focused on car mobility. A modal shift is then spatially, but also mentally more difficult to achieve.

Changing travel behavior is a recurring topic in this study. Setting up additional hubs in Zaanstad will not directly solve the mobility demand with the corresponding resources. Joost van der made (ex-Manager NS stations) states that it is currently difficult to find a better, timesaving journey than taking the car (Spoorcafe, 2022) Creating a (semi) car-free environment where public transport is seen as the most logical means for a specific journey is difficult. Luuk Bos, (D&B), behavioral analyst, also stated during a Spoorcafe meeting on the future of transport, that the message is difficult to spread and behavioral change must take place in small steps (Spoorcafe 2022). In order to see what the opportunities are for upgrading public transport in Zaanstad, it is therefore relevant to look at what the modal split for residents of Zaanstad is at present.

The modal split for Zaanstad strongly indicates that transport is mainly by car. Although Zaanstad is medium-sized, but very close to Amsterdam, one would expect patterns to be similar to Amsterdam. However, this is not the case. The modal split of Zaanstad differs strongly from Amsterdam figures.

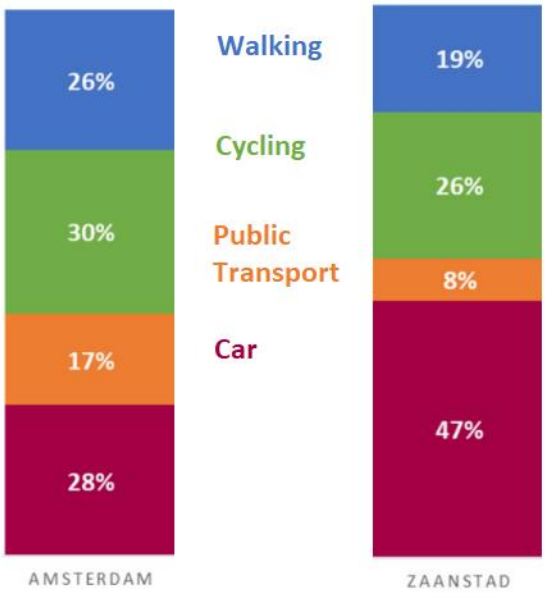

Figure 12. Modal Split Zaanstad (ZNSTD, 2020)

With the upcoming growth of 50,000 inhabitants, the forecast is that with an unchanged policy this will translate into the following growth per modality (ZNSTD, 2020).

Car	Cycling	Public transport	Freight	**Total**
26%	14%	29%	-2%	**22%**

Table 6. Percentual Change of Modal Shift (ZNSTD, 2020)

Bicycle movements are running behind, which means that adjustments are needed to comply with the objectives of the municipality to prioritize active mobility. The further development of hubs, for example, can provide diversification and improve the attractiveness of for businesses, stores, and living because of the proximity of all kinds of facilities (Bertolini, 1999). The prediction is that these adjustments will be made. The municipality chooses to develop mobility hubs where different modalities meet and where mobility services are also offered. This will make it easier to travel multimodally or make use of shared mobility (shared cars, shared bicycles) (ZMP, 2021).

Modal split Central station

Because the area in the Achtersluispolder does not have any railway station, the data is measured from the nearest railway station. Regarding the travel data known for Station Zaanstad, data about 2019 is used because 2020 and 2021 were not representative due to the global outbreak of Covid19. Zaanstad Central station in 2019 attracted an average of 25.020 travelers per day, for which the modal split of these travelers looks like this (NS, 2019). It is divided into pre-transport: the distribution of the type of transport used to reach the station on an average working day -and post-transport: the distribution of the type of transport used to reach the final destination on a working day. Remaining modes of transport are negligible in this modal split.

	Walking	Cycling	Bus	Car (driver)	Car (Pass.)
Pre-Travel	34%	46%	14%	3%	3%
Post- Travel	73%	11%	10%	2%	4%

Table 7. Modal Split of Travelers from and to Zaanstad Station (NS, 2019)

For the development of the Achtersluispolder as a residential and working area, many aspects will be intensified in the coming years. In addition to the large housing assignment, the vision declares that a high-quality transportation line should be realized in the direction of Amsterdam (ZNSTD, 2021). This is of great importance, because the Achtersluispolder, as a major development location, is an indispensable stepping stone for high-quality public transport further into Zaanstad. Without this large-scale development, the chances for a good high-quality public transport axis in Zaanstad are much smaller. Also walking and cycling possibilities, will be made attractive by upgrading ferry connections and bridges in the direction of Amsterdam North (ZNSTD, 2021). At the moment the accessibility of the Achtersluispolder is still insufficient. There is barely enough room for separate bicycle paths, and sidewalks for pedestrians are also lacking in many places. In its present form the road is unsuitable for safely handling residential and commercial traffic together. By public transport the northern part of the plan area, with 3 bus stations it is relatively accessible. The southern part is not accessible by public transport (ZNSTD, 2021b)

The figure below gives a cartographic representation of the interventions currently being designed. In which the double outlined circle indicates where the center hub of Achtersluispolder will be located. Along this Hub the envisaged new high-quality public transport line towards Amsterdam North should run (shown as brown dotted line). Also, the new envisaged bicycle route to Amsterdam (green dotted line) runs from Zaanstad center along the Achtersluispolder.

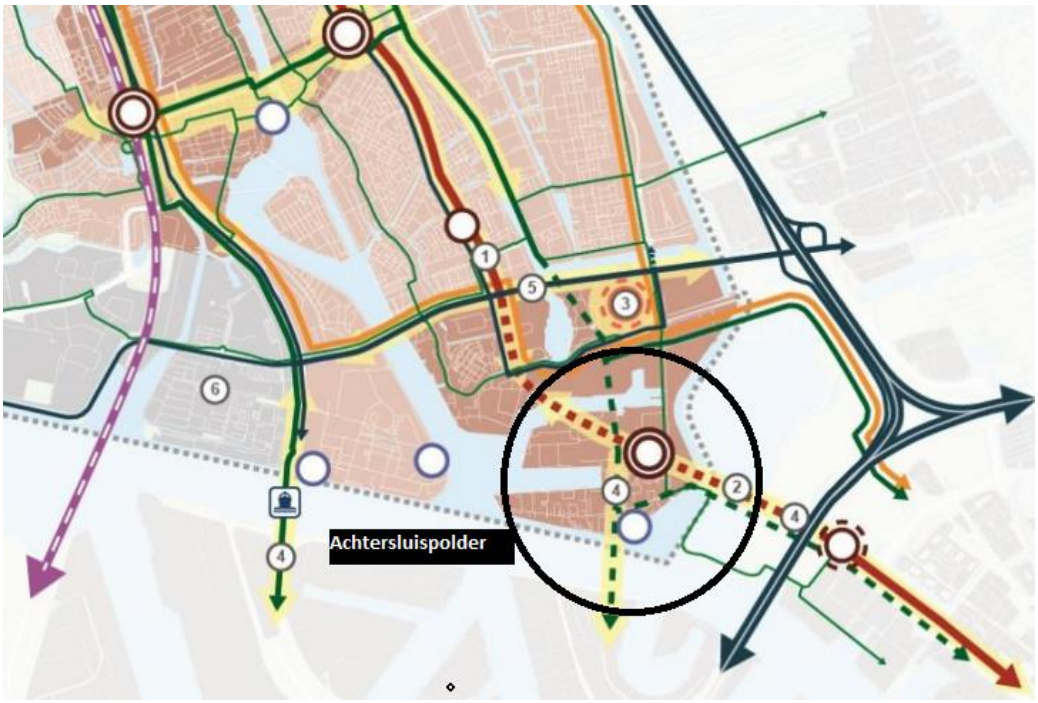

Figure 13. Mobility Plan of Achtersluispolder (ZMP, 2021)

Whether urban expansion based on TOD has a chance of success will be analyzed using the usual 6D pillars, including necessary investments to achieve TOD criteria.

4.3.2.3 6D principles

Density & diversity

In terms of diversity, first of all the unbalanced commute is an important point of attention. In the morning, a large flow goes from Zaanstad and surrounding region to Amsterdam and Schiphol, in the evening it comes back (ZNSTD, 2021) This uneven commute creates problems for the profitability of public transport, for example. If public transport is to be improved, then spatial development should also be aligned with it, as this also triggers a counter-peak hour movement, which Gutierrez (2011) also cites in section 3.4.2.1. The ZMP reports that (ZNSTD, 2021) to 2040 major investments will be made to develop the Achtersluispolder. Where the area currently consists of a pure business park, the transformation over the years will mean that a center hub will be realized where in many ways different modalities can be used. This improved accessibility changes the way land is determined (Wegener & Fürst, 2013). Functions such as living working and providing can be mixed based on 3 levels: From large to small: a shared area, a shared plot, or shared building. The starting point is that the companies currently established in the Achtersluispolder can simply stay. This is an interesting fact because the site currently has large industrial companies that occupy large areas with their activities. Nevertheless, a high density structure will be constructed to fill in the scarce space that remains. There are countless branches of industry that can go well with housing, and that is the basic principle (ZNSTD, 2021b). Because a big piece of land is being developed on a scale of nearly 10,000 dwellings, the social program will also be utilized to determine what facilities are required to allow a residential area of that size to function normally (Interview II).

Design

Furthermore, landscape features in and around the city act as a barrier through rail, water, road and that is a problem in Zaanstad. Cyclists and pedestrians often have to make a detour which creates a repulsive effect. In addition, the public space in many places is not attractive for walking or cycling

(ZMP, 2020). This is why the share of walking and cycling in Zaanstad is somewhat lower and the car share somewhat higher than one would expect when comparing the figures of other mid-sized cities in the other cases and the figures of the neighboring city of Amsterdam. With the development of the Achtersluispolder, plans are being made to build a bicycle road over water to bridge these barriers (ZNSTD, 2021).

Destination (accessibility)
Transportation systems must ensure that a wide range of locations can be reached so that mobility for people can be increased (Ogra & Ndebele, 2014). Highly accessible station areas are essential for TOD success. To determine the destination value, network connectivity, accessibility to jobs and public transportation- accessibility should be considered. The ideas for a second hub for fast and flexible public transport are announced (ZNSTD, 2020). Depending on where the central position of the second axis is going to be, the area on the Achtersluispolder can be connected to a larger network and also to Amsterdam North, which will reduce the relative distance to jobs and facilities with the realization of this axis. With the possible construction of a new mobility hub, the routes to the stations will also have to be made more attractive. Especially the bicycle routes will undergo transformations. By removing obstacles through building bicycle tunnels and adding bridges, new connections will be created and the distance from different angles to the station will be reduced (ZNSTD, 2021b).

Distance (to transit)
There is a need for a new high-quality public transport axis which is supported by bicycle connections to all wind directions. This axis should open up the entire Achtersluispolder. Further, the municipality's ambition is to realize more public transport and to promote the shared use of modalities (ZNSTD, 2020) . For example, in highly urbanized A and A plus areas (Achtersluispolder) there is a target of a maximum of 100 meters walking distance to shared transport over the entire area.

Demand management
The basic idea for traveling remains free choice of mobility, but more measures are going to be taken that are going to attract the traveler to see cleaner transport as an option (ZNSTD, 2021). For example, Achtersluispolder is designated as a high density urban area. This means that the residential area is of highest importance and therefore car transport should be avoided as much as possible. Here it is emphasized that the pedestrian and cyclist are central. The car is welcome, but in the A-plus zone (Achtersluispolder) it is accommodated at the edges as much as possible; in the A-zone parking is possible within the area, but parking at the edge - is made more attractive. However, this can only be achieved if alternative modes of transport can be facilitated.

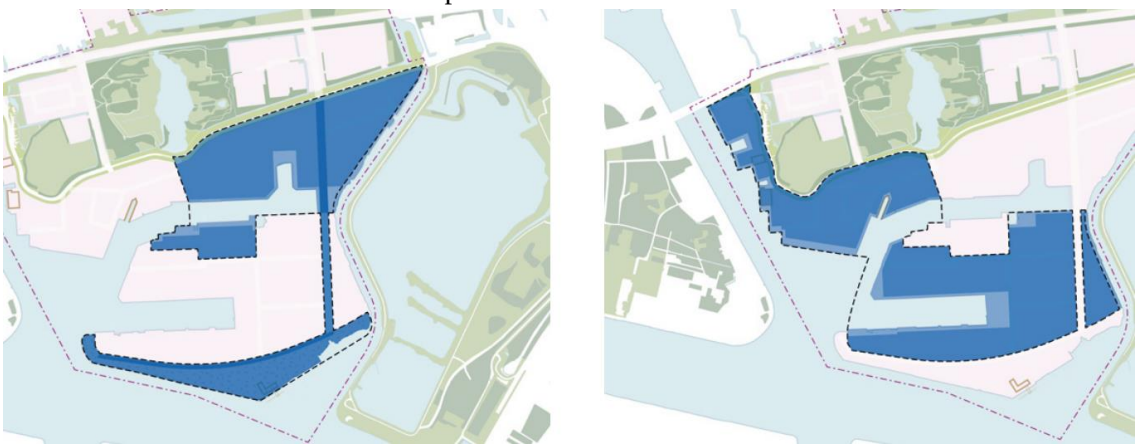

Figure 14. (L) Planning Achtersluispolder 2020-2030 (R)2030 – (ZNSTD, 2021b)

4.3.2.4 Concluding

In the coming years Zaanstad will experience strong growth. In order to provide the corresponding inhabitants with housing, sufficient facilities and good accessibility to and from Zaanstad, transformation will take place on a large scale at various locations within the municipality. Besides densification, expansion locations are also being developed, including Achtersluispolder. The important question that can be addressed with this case is whether the pillars set up for recognizing TOD are met in certain domains. First of all, the Achtersluispolder in its current form is far from being a TOD structure. It is a poorly accessible area for pedestrians, cyclists and public transport passengers. With the new vision for the future however, this industrial area will be transformed into a large urban center area, where mixes of living, working and leisure will be the norm. The development of the Achtersluispolder will be combined with major developments for mobility in the area. These were also necessary because the prediction was that without investments people would travel by car 26% more often and by bike only 14% more often. This difference is partly due to the poor bicycle connection to Amsterdam. A summing up of the spatial investments (building a transport axis and cycling highway, adding cycling tunnels and bridges and guaranteeing walkable access to a public transport boarding point) says that the opportunities of travelling without a private car will improve significantly. Looking at the pillars of TOD, the arrangement based on the intended transformation scores significantly better in each area than the way the area is currently arranged. The major difference with the Den Bosch case is that the emphasis of connectivity is different. Instead of the inner city, investments aimed at connecting to the capital are an essential prerequisite. However, the impact of the investments is still suggestive and based on visions and plans, so whether TOD can actually add value to the urban growth of Zaanstad is conceptually positive, but based on realistic data not much can be concluded yet.

4.3.3. Nijmegen

4.3.3.1 Housing

In the past, the city of Nijmegen consisted of the historical inner city and a large town structure around it, connected by a number of avenues. It was surrounded by an enormous wall, which was very oppressive to the expansion of the city and because of this, dirty air (produced by industries) had no room to "leave" the city. After all, free space in the form of greenery lay in the suburbs. After the city walls were pulled down, a chain of parks and avenues were realized, connecting the city parks (Interview III). At the same time, due to the expansion of the city towards the west, there was a large growth in housing. Later, the municipality of Nijmegen focused on strong densification and the creation of a compact city. However, this was simply not practicable. On the one hand this was due to the noise pollution, on the other hand the urban greenery was once again threatened to exist. Building in the city was therefore only possible to a limited extent (Gunterman, 2003). The current station area does not contribute to the goals set by the national government in the NOVI strategy (Gemeente Nijmegen, 2020). It is messy, and with its back turned to the west, while the outskirts right in that direction are most in innovation and growth. At the same time, the Arnhem-Nijmegen's population is growing strongly. Even more rapidly than other regions in the country (Rijksoverheid, 2021). The forecasts show that this growth will continue, which will bring new challenges in terms of housing and accessibility. For this reason it has been determined in the "Woondeal" Nijmegen-Arnhem that the housing supply in Nijmegen must and may increase significantly (Rijksoverheid, 2021). Densification and transformation within cities is the best way to realize the ambitions with regard to the green profile and the circular region. With the transformation of the station area, 2000 housing units will be added within a maximum radius of 1 kilometer from the station. A substantial part of these dwellings will be affordable for lower and middle incomes and aimed at 1 and 2 person households: The urban target group, people who like to live in the dynamics of the city and everything that comes with it in

terms of travel, work, shopping and entertainment. The area will have a metropolitan look due to high-rise buildings. Also, old buildings, including the old UWV office are converted into living / working locations (Gemeente Nijmegen, 2020). For the realization of new residential units, the following projects are either in the process of development or are already being explored. The named projects are marked with matching letters in the figure below.

A. Metterswane on center side

B. Redevelopment of an area with garage boxes behind van Schaek Mathinsingel, 2 residential blocks owned by Talis and an adjacent office building. Includes the goal to realize 350 residential units in this area.

C. Former UWV Site on Westside: ambition to realize a mixed residential program including a building for 300 homes.

D. Hezelpoort: High rise buildings.

The expansion of the housing supply around the station area is mainly realized at the front of the station, at the backside of the station, where the opening to the west is realized, there is already a large supply of housing. Large residential towers will not be realized there in order to preserve the landscape character (Interview III).

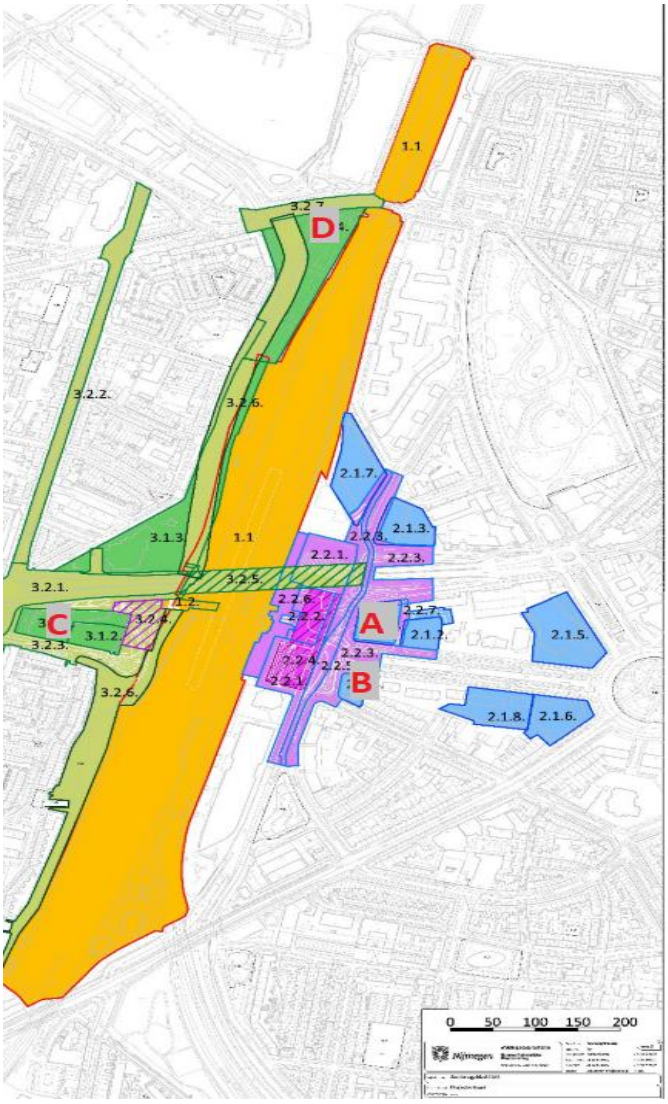

Figure 15. Map of Urban Transformation Station Area (Gemeente Nijmegen, 2022)

4.3.3.2. Economy & Infrastructure

Around the 1920s the future image of urban growth in Nijmegen was mainly centered around Nijmegen west because industry was on the rise and this part of the city was characterized as a future industrial zone. Urban expansion should therefore mainly be realized in this part of the city. Later it turned out that this urban expansion in Nijmegen was mainly focused on the north, the Waalsprong. Nowadays the city government extends over the Waal (Gunterman, 2003). Nijmegen, through its focus on the Arnhem- Nijmegen node, has increasingly become part of the Arnhem-Nijmegen urban network. Which was fully in line with the Vierde Nota. This reinforced connection with Arnhem means that the railway link to Arnhem is being used more intensively. This creates more pressure on the railway network and more movements away and towards the station. For this, as part of the High-Frequency Rail Transport program, work is being done to increase rail capacity by constructing a third platform (MIW, 2021). This will make it possible in the future to have a train running every 10 minutes between Nijmegen and Schiphol. By increasing capacity, accessibility will improve, which in turn will give the area around the station direct land use impulses (Wegener & Fürst, 2004). This jump in scale over the years has also caused problems for the current station area, which arise from only modular adaptations to the growth (Gemeente Nijmegen, 2020). For the upcoming spatial transformation, a more integrated approach will be used to overcome past barriers.

Main problems and things that are missed in the station area that relate to economic and infrastructural deficiencies include: (1) The lack of interesting facilities and functions on the first floor on the city center side, which makes the station area unattractive as a place to stay. This finding will be addressed with the development of a total of 15,000 to 20,000 m2 of space for offices, hotels, stores, social amenities. (2) The lack of direct and representative entrance on the west side. With the new entrance on the west side, the station will occupy a much more central position in the city and the experience of the station will become more diverse. The realization of a new western entrance not only provides the station with a second well-functioning entrance, but also forms the driving force for urban development. (3) Also the connection of the station area with the inner city of Nijmegen is poor due to the unclear and unsafe walking route to the center. The route to the center is marked as unattractive and unclear. Through solid investments in walking routes, the priority of the pedestrian will be revalued. Combined with a massive upgrade of bicycle storage locations, this will improve the attractiveness of cycling to and from the station (Interview III). The figure below shows the current transport conflicts. With the upgrading of each route and a clear split of the position in space between the different modalities, an attempt is made to prevent these conflicts.

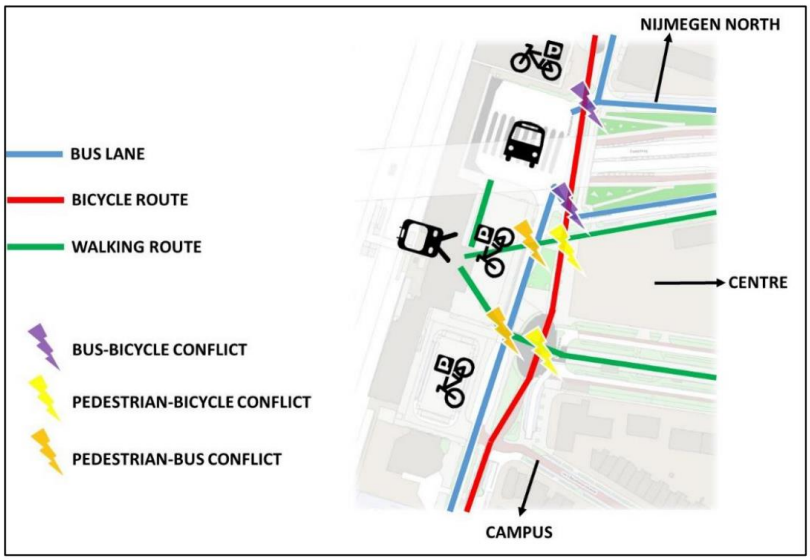

Figure 16. Conflicts between Several Modalities in Front of the Train Station in Nijmegen (Gemeente Nijmegen, 2022c)

The development of the route from the station to the inner city can give an impulse to facilities and businesses on the route to this place. Landscape investments that increase the degree of walkability provide an increase in personal investment and income for the local entrepreneur or restaurant owner (Stedelijke Transformatie, 2021). The transformation is 3-sided, on the east side and west side of the station area, buildings and accessibility will be upgraded. In addition, infrastructural and other transportation innovations in the public space will be implemented. The map below, which is the same as figure 15, but with the sufficient legend, shows in cartographic form at which location what and where will be realized.

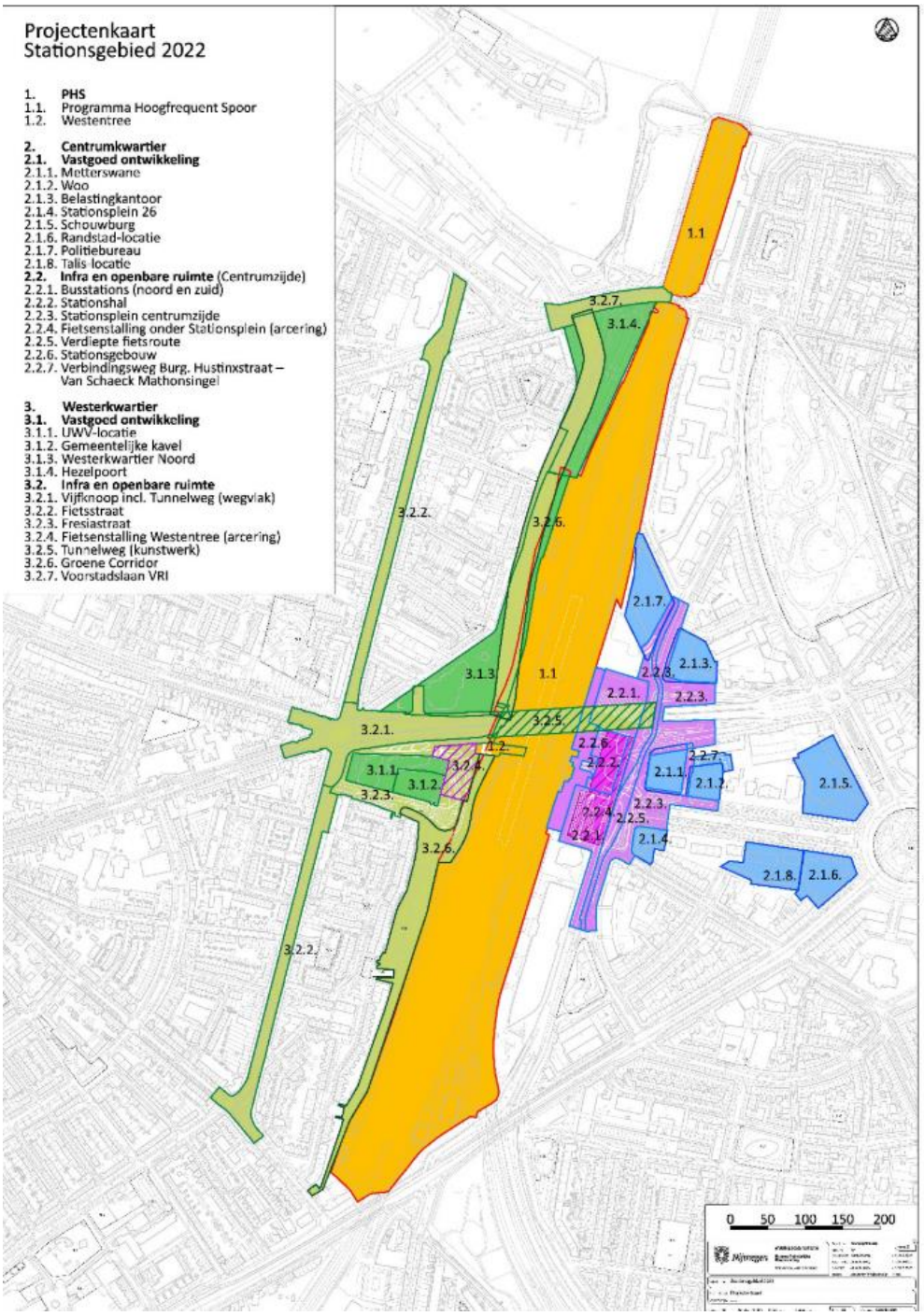

Figure 17. Map of Spoorzone Transformation with Dutch Legend (Gemeente Nijmegen, 2022)

Modal split Central station.

Regarding the travel data known for Station Nijmegen, data about 2019 is used because 2020 and 2021 were not representative due to the global outbreak of Covid19. Nijmegen Central station in 2019 attracted an average of 46.182 travelers per day, for which the modal split of these travelers looks like this (NS, 2019). It is divided into pre-transport: The distribution of the type of transport used to reach the station on an average working day -and post-transport: The distribution of the type of transport used to reach the final destination on a working day. Remaining modes of transport are negligible in this modal split. What is interesting is the large difference in the use of the bus compared to Zaanstad (14% & 10%) and Den Bosch (26% & 15%) and the continuation of the trip on foot (Zaanstad: 34% & 73% , Den Bosch: 25% & 57%) (Table 4 & 6).

	Walking	Cycling	Bus	Car (Driver)	Car (Pass.)
Pre-Travel	18%	46%	30%	1%	5%
Post- Travel	23%	19%	50%	1%	6%

Table 8: Modal Split of Travelers from and to Nijmegen Station (NS, 2019)

4.3.3.3. 6D Principles

Density

The station environment in Nijmegen is aimed at a very exceptional form of densification. It is clear from the interviews (Interview III) that at the front of the station, in the direction of the city, the focus is on a high degree of urbanization: High residential towers, and growth in the supply of facilities. The height that a building like Metterswane will reach on the center side can be up to 60-70 meters. (Gemeente Nijmegen, 2021) On the west side of the station, no large residential towers will be built to preserve the landscape contrast (Interview III). The height of these structures will reach an estimated maximum of about 3 to 4 floors. Also, much space will be retained for green space to create a pleasant and present structure.

Design

The differences in local densification occur from the landscape features in the area. Nijmegen has something no other city has, a very present lateral moraine. This moraine determines height and lowness differences in the landscape. Differences in high and low are in theory no obstacle to the realization of high urbanity, but in order to preserve these differences for the viewer it is not possible to build in the height (Interview III). For the development of the west side it is therefore chosen to guarantee these height differences for the public eye and thus to preserve historical values. It is therefore not possible to realize the same urban structure as can be realized on the center side. High residential towers on the west, obstruct the interesting and typical view from the east.

As far as the design on the inner city side is concerned, there that is a lot of construction going on and a piece of the city being developed that needs buildings to make it noticeable that you are in Nijmegen. The design of the railroad does not yet offer such a degree of recognition value (Interview III). This is partly due to the bus and bike lanes in front of the train station and the urbanity that the city center offers within 10-minute walk.

Diversity

As for diversity, the same contrast applies as for the urbanization and densification assignment in principle density. Great diversity in the field of living, working and realizing facilities and restaurants will be evident for the high urban front (the top of the lateral moraine) and the somewhat low urban area on the west side (the bottom of the lateral moraine) will be more focused on pleasant living: Creating space for public space, mixed with small businesses. It will have a calm, business-like character. By adding small-scale functions to the west side of the building it is intended that this will

create more vitality in the area. This can also ensure social safety. (Gemeente Nijmegen, 2021). An important component that is also closely involved in the spatial plans is the focus on green space (Gemeente Nijmegen, 2022b) For example: With the development of the station area, a green corridor will be realized that runs around the city center. Interview III says "We want to urbanize very intensively, but in a forest kind of city".

Distance (to transit)
Residential towers and office facilities will be built close to the station, with the fact that users of these residential facilities will make their daily trips mainly by public transport (bus/train) or bicycle and on foot, within the plans for urbanization there is no room for facilitating and providing parking facilities (Gemeente Nijmegen, 2022c). Building economic facilities and residential units closer to the station will create a high-density district so that people no longer experience the perception that they have to walk to the city, but rather that at the station you already feel like you are in the city.

Destination (accessibility)
By extending the station tunnel, the opening to the station from the west side will be realized. Travelers will no longer have to pass through the car tunnel to enter the station through a full-fledged entrance. This improves the motivation for travelers to take the train more often. The bicycle transfer point will also be expanded and made more accessible for travelers coming from the west side, and a trench will be realized on the center side separating cyclists from the bus lane and pedestrians accessing the bicycle transfer point will be made easier (Interview III). As a pedestrian it is no longer necessary to walk through the tunnel, which many people, especially in the evening, find unpleasant and unsafe. The capacity of the bus station will also be expanded. It is currently too small for the number of buses that make use of the station. Due to the limited space at the center side, this intervention must be integrated with the cycling and walking routes to ensure a successful upgrade of the bus station that also reduces modality conflicts as mentioned in figure 16 To make this possible an underground cycle route will be realized. This has positive effects for cyclists to arrive more barrier-free at their desired destination, and also has positive effects for bus passengers to reach their desired bus route (Gemeente Nijmegen, 2022c).

Demand management
With the development of the space around the station, planners are trying to minimize the number of parking spaces within the spatial plans. After all, continuing to facilitate parking places encourages the use of the car in the city center. However, taking the first step towards an urban structure that is different requires investment courage, but the elaboration can have a stimulating effect. after all, if there are no more parking possibilities, the modal consideration is no longer needed at all (Interview III). Also the state province and municipality are looking at making parking policy more flexible by building up knowledge of smart solutions, such as sharing systems supported by smart digital means (Rijksoverheid, 2021).

4.3.3.4 Concluding
The Arnhem-Nijmegen region is experiencing strong growth. In order to facilitate this growth, major additional construction will take place in the coming years at various locations in the city, as well as large-scale development of the station environment. Simultaneously, the construction of a third platform at Nijmegen station will enable high frequency travel between Schiphol and Nijmegen. The improved accessibility of Nijmegen has an effect on the activities that will take place around the station. In order to optimize this important area, various transformations will be implemented for the land use. The question arises of how these investments affect the various pillars on which TOD rests

and whether such investments promote walkability, bike-ability, and use of public transportation. There are a number of noteworthy findings that emerge from the analysis of the case. One is that there is a high commitment to strongly urbanize the front of the station. This was necessary because the urban activities and buildings that shape the "city of Nijmegen" are relatively far located from the central station and the station that functions as the physical entrance to the inner city was in fact not there. By building large mixed-use towers and creating pleasant infrastructure, the inner city and the transport network become more interconnected.

At the same time there is a remarkable contrast with the back of the station. Due to an absent access to the train station, the proximity has never really led to major urban activities. Extending the station tunnel will allow for a similar high-rise urban structure in the future as at the front. However, this jump in scale will not occur in the coming years. The landscape features resulting from the existing moraine on which the station is located act as an important identity for Nijmegen, and these considerations weigh heavily. For the west side of the Central Station, the planning infill will be primarily focused on pleasant living, along with maintaining a large public space. also, the integration of greenspace will be prioritized in the area. The development of the station area also prioritizes the first and last mile to the station. Bicycle and pedestrian access to and from the city will be improved on both sides and by minimizing parking norms as much as possible, bicycle and pedestrian movement can be given priority within the area. By keeping the parking area small, important steps are taken against automobility in the cities. By not facilitating the parking of a car there is no need to consider which mode of transport to use, the choice will automatically not be made in favor of the car.

By assessing the urban transformation in Nijmegen along the 6D pillars, it can be stated that the area is making advances in terms of TOD. However, a structure where the hub acts as the center of a big urban area is not in place. The density of buildings and mixed uses is mainly visible on one side of the station, so maximum utilization of the walkability from the station is not fully exploited.

5. Conclusion

5.1 Conclusion

The aim of this qualitative research was to explore to what extent the strategy of TOD is reflected in the TOD policies of mid-size cities in the Netherlands and whether mid-size cities differ, based on the implementation of TOD. Therefore, the research question of this study was: "*What does Transport Oriented Development of Railway station- areas add to growth policies for mid-size cities?"* To answer this question, this research has been split into several steps and sub-questions, which were addressed during the research by using different methods. The first sub-question, "*what is TOD*?" was covered in the first step by providing a literature review of all the preliminary research on Transport Oriented Development.

The first results of this review showed that land use and transportation are highly interrelated and that good management of both indicators will lead to good spatial planning. It also became clear from the literature that transport oriented development is a strategy to achieve sustainable urban land use that can lead to a reduction in car use and in which the urban layout can act as an incentive for more sustainable forms of transport. The way TOD is implemented depends on 6 (D) pillars. These pillars are used as the analytical framework for measuring TOD in the case study conducted.

The second sub-question addressed in this research was "*What is urban growth & how is urban growth being managed?* " This second step of the research consisted desk research and the aim was to conduct an analysis about what growth policy on a national scale looks like .
To do this, the study looked at the differences between policy in the years from the end of the 1980s onwards, to which the Fourth Policy Document on Spatial Development belongs. For recent and future policy, an analysis was made of policy in NOVI. In addition, the national mobility vision was also reviewed. The analysis of national policy in the area of urban growth shows that as a result of domestic migration and demographic growth significant urbanization will take place in the coming years. An important condition for allowing the city to grow is that it is based on sustainable developments and that space is developed in a way that does not harm accessibility. Smart choices in spatial development must therefore be based on choices that on the one hand ensure growth of the built environment, while on the other hand avoid putting too much pressure on the transport network. In this process, scaling down the car in the urban environment plays a central role. So does scaling up public transport and achieving a modal shift based on walking and cycling.

The third step taken in the process towards answering the main question is by developing a multiple case study. The third step focused on the third sub-question: "*How do the 6d pillars of TOD manifest in mid-sized urban transformations?"* Through conducting semi-structured interviews and analyzing various policy documents, municipal vision documents and other relevant sources, the urban development of Den Bosch, Nijmegen and Zaanstad were evaluated against the 6D framework of TOD. By doing so, an attempt was made to discover the extent to which TOD has been implemented in the transformation. After all, for a Transportation-oriented environment to function well, the conditions are that it is dense and diverse, has a design that matches this, contains short distances to transportation, has access to many destinations, and is controlled through demand management. The results of the case study follows:

The construction of high residential and office towers has increased the density of the Paleiskwartier in Den Bosch. The diversity of functions in the Paleiskwartier can be outlined in the presence of (small)business, housing, education and restaurants. In the evening the Paleiskwartier still lacks some vitality because the supply of facilities in that daytime period is still insufficient. The design of the Paleiskwartier is designed in such a way that it creates an ambience that encourages people to walk. By realizing an entry at the back of the station the access route to public transport is

improved. Additionally, the access to the inner city via the station bridge is free of check-in/out portals so that it is possible to walk obstacle-free. The bus connections through Paleiskwartier are only moderately present in relation to the number of bus connections on the center side. With the realization of a large parking garage it is not attempted to restrict car use because by offering parking facilities the use of a modal shift is not encouraged.

With the development of Achtersluispolder in Zaanstad a new part of the city will be built on a former industrial site. Due to the scarcity of space in the area, housing, facilities and employment will have to be intensively built on a small site, making a high urban structure the basic principle. The remaining businesses, which occupy a relatively large amount of space, will be mixed with housing and complementary facilities. This means that the density and diversity will be intensified, but also that valuable space will be lost to the established business operations. A noteworthy result that emerges from the analysis of the Achtersluispolder design is that the surrounding water around Achtersluispolder forms a barrier that may be an obstacle to the use of active forms of mobility to reach neighboring Amsterdam. In order to overcome this barrier, a fast bicycle path over water to Amsterdam will be realized that can function as an invitation for the use of active forms, instead of automobility. Transport flows from Zaanstad are mainly focused on the connection towards Amsterdam. With the realization of a possible mobility hub, the aim is to reach a public transport boarding point within 100 meters anywhere within the Achtersluispolder, so that after the transformation more destinations can be reached with alternative forms of mobility. From a demand management perspective, by accommodating cars to the edge of the urban neighborhood, an attempt is made to promote transit via alternative modes.

By building high residential and office towers, an attempt is being made to achieve substantial densification around the front of Nijmegen railroad station. At the west side of the station additional buildings will be realized as well, but the emphasis will be on pleasant living in an open character. This contrast is also reflected in the design of the station area. Because the station is situated on a lateral moraine, there are significant differences in height on both sides of the station. These typical features in the landscape function as the identity of the city and should also remain in the urban design. This means that the center side of Nijmegen Station can be characterized as much more highly urbanized than the west side. Also, the set of facilities is more diverse on the center side than on the west side. Also, the addition of green space in the developing area results in a lower density of planning, but on the other hand, may in practice invite more walking trips due to the attractive environment. Regarding distance to transit and destination accessibility, adding a proper entrance on the west side will improve access to and promote the convenience of using public transportation. Achieving a low parking standard will create more available space to be built on and reduce the demand for automobility for new residents, customers and employees working in the station area.

With an expected increase in population and migration, cities will experience growth in the coming years. The answer to the second sub-question in this study, which is concerned with how this urban growth will be managed is, based on NOVI: By shifting the focus to strong infill development, combined with a public transport system that matches it. Here, proximity is an important factor in maintaining accessibility. As has been shown in this research, by answering Sub-question 1: "*What is Tod?"* It has become clear that following a TOD strategy can give substance to this compact transport-land use connection as explained in NOVI and that the way in which this form of land use and transport planning is subdivided is based on 6 D pillars. The answer to the third sub-question : "*How do the 6d pillars of TOD manifest in mid-sized urban transformations*?" Forms the starting point for the answer of the main question. For each case, it can be stated that based on the transformation to be realized or achieved, influence is exerted on either density, diversity, design, distance to transit, destination accessibility and demand management. Also, the scaling down of car mobility is central to

each transformation and more space is given to bicycle and pedestrian transportation. By answering all the sub-questions, an answer can be formulated to the main question.

Concluding on the analyzed cases, it would be possible to confirm that Transport oriented Development can be of value for growth policies in mid-sized cities. In each case it can be concluded that pillars of TOD in each of these mid-sized urban developments have been realized in actual transformations which can provide serious support for the inner-city growth task. Adding to this, several analyses from national and municipal documents show that an important condition for keeping cities accessible is that car use must be reduced, and that measures are being taken in that regard in terms of land use interventions and transport interventions. By realizing growth for economic activities and housing around the station area, the aim is to develop an urban system where land use is focused on proximity and transport is steered by public transport and bicycle and walking paths.

5.2 Discussion

Thus, by following the strategy of TOD, even in medium-sized cities, efforts are being made to keep cities accessible by reducing the use of the car. The analyses confirm that measures are being taken to support these limitations. Such measures are also identifiable as pillars of TOD, making it possible in this study to answer the research question. However on a critical note it must be said that it can also be observed that the cases analyzed are not being transformed at all cost into high value TODs. Other criteria often play a role in the development of an area. In Nijmegen, for example, only a part of the railroad zone is transformed into a metropolitan area to preserve landscape characteristics, in Den Bosch the preservation of space for the car played a very prominent role in the transformation and in Zaanstad a potentially to-be-urbanized piece of land remains in use for industry. Such observations suggest that the TOD functioning as an independent heart of a city is not being fully utilized, and it is possible that this aspiration for the pursuit of a fully functioning TOD for medium-sized cities is not yet there. At the same time, each interview does mention that implementing a car-free transformation is very difficult. Regarding the priority for constructing HPT or housing first, interview II cites the chicken-or-the-egg dilemma: “If you start by making a business case that is very good for the HPT line and then the area developments, then you wait a very long time before you construct the HPT until the business case is favorable, and then you possibly make all sorts of suboptimal investments in area development. Or would you turn it around, construct your HPT with the risk and possibly the consequence that you will not be running a very good business for a while, and then anticipate your area development?” And in Interview I on the choice of the location of companies: “It takes courage to settle in a location where the car is not desirable." And Interview III on planning considerations: “As planners, you might want something, but the question is whether people want to join you and dare to invest.” Thus, the synergy between land use and transportation development proves more difficult to achieve in practice than in theory.

Although the confirmation of the potential present for medium-sized cities, findings also show that TOD is very context dependent and therefore it is not possible to give an answer that can be generalized for every other medium-sized city. Often, a variety of factors play a role in why certain pillars are not optimally realized. This may be due to physical components of the station area, financial reasons why a public transport system does not achieve the desired returns, or the target group can vary enormously from medium-sized city to medium-sized city, making the feasibility of a public transport and pedestrian-oriented center possible or impossible. This can for example depend on the age and physical condition of the average user. This was also mentioned in “Stedelijke Transformatie” (2021) regarding building density in railway zones: The key is to find an optimum that differs per situation. The great differences between mid-sized cities also becomes clear when comparing the cases. The strategies of the area to be developed can be very different. Where for the case of Zaanstad

an important condition is that mainly facilities can be reached outside 10 minutes walking distance from the hub, due to the important connection with Amsterdam, this is not applicable for the cases of Den Bosch and Nijmegen, where the connection to the city center is used as an important condition for transport development. Nor can this study determine whether the degree to which the analyzed pillars are sufficient to be characterized as TOD. For some of the elements analyzed there is no measure of this, only an observational assessment can be made of how a pillar appears. However, even with such a qualitative observation, it can be assesed that with the addition of high rise buildings, renovations of pedestrian and cycling roads to the station, an upscaling of bicycle parking spaces, and the identification of an increase in mixed-use land (4.3) that facets of TOD can indeed be observed.

5.3 Limitations

The results from this study are reliable because most of the findings come from published documents of municipal governments. However, there are some limitations in this research. For example, the amount of interviews is limited and most interviews did not provide many more new insights. They mostly gave confirmation on what was written in the published documents. Another major limitation is that the findings of 2 of the 3 cases are based on locations that have yet to be developed. For this, visions and plans do not reveal anything about the actual realization of the plans. Nor can anything be said about the functioning of certain transformations because modal shifts, resulting from adjustments in physical space, are based on estimates and ideal presumptions. In addition, the established planning design is only a moment in time, which means that a meaningful conclusion about the results generated can only be drawn at the time of research. These plans, or society, could change fundamentally in the period from the here and now to implementation.

5.4 Further research

What is apparent from interviews and social developments, we are in a transition in terms of modal shift. We are also currently in an energy transition, which is the important factor why people attach less value to the car. In order to keep urban facilities accessible. It would therefore be necessary to take a good look at how far urban automobility should reach in the next few years. This research attempted to explore what the role of transport oriented development can be for mid-sized cities and whether the car can be given a smaller role of significance through landscape interventions. This was accomplished by looking at how pillars of TOD can be recognized in urban transformations. Although the pillars were not measurable in absolute terms, a qualitative observation could be made about differences for each pillar. However, this observation has not resulted in any absolute standards and therefore no model can be developed to serve as a guide for other medium-sized cities to compare whether the presence of a pillar is sufficient. This is because it is very context dependent. Therefore, there are still many questions as to whether these pillars apply to multiple medium-sized cities, or whether there may be different TOD typologies to qualify. Further, what is indicated in the limitations, this study contains a momentary record of plans. Future research could discover if these plans had the proper effect and to what extent TOD was considered during the construction process. In that case, this study could act as a form of reviewing framework.

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7. Appendix

7.1 Interviews guide

Introductie:

Akkoord met opname, niets zonder uw toestemming publiceren. Niet kritisch, wel verkennend.

Ik zal mijzelf even voorstellen, ik ben Niels de Koning ik studeer Spatial planning aan de Radboud Universiteit, ik schrijf mijn thesis over TOD beleid in middelgrote steden. Transport Oriented development. Verwevenheid meten met stedelijke transformaties. 3 cases: Den Bosch, Zaanstad, Nijmegen.

1. Voorstelrondje & Vakgebied.

2. Hoelang wordt er al nagedacht over de ontwikkeling van het stationsgebied?

- Welke partijen worden gehoord? Hoe verloopt het samenwerken tussen meerdere partijen? Traag proces?
- Is er verzet? Bewoners e.d. Waarom?
- Wat is de relatieve verhouding waarin ontwikkeld gaat worden?: wonen, kantoor, voorzieningen.

3. Het centrum, en met name de voorzieningen liggen op redelijke afstand tot het station. In hoeverre speelt de toetreding aan de centrumzijde naar de stad een belangrijke rol in jullie ontwerp?

- Uitbreiding van het centrum naar Station? Grote ketens? Horeca?

4. De achterkant van het station wordt opengemaakt, hoe gaat dat eruitzien?

- Wat voor invloed gaat dat hebben op de stedelijke structuur in west?
- Zichtbaar van ondernemers die zich willen vestigen? Woningbouwprojecten? Huizenprijzen?
- Hoe zal het OV vanuit west verbonden worden met het busstation aan de centrumzijde?

5. Wat is de rol van de auto in het stationsgebied nu?

- Hoe gaat dat eruitzien. wordt deze omgeleid, geweerd, P+R?

6. De toekomst van deelvervoer. Is dit al geïntegreerd in de plannen? Deel autos, laadpalen?

- In hoeverre is dit ontwerp flexibel voor toekomstige (technische en maatschappelijke) ontwikkelingen op het gebied van transport?

7. TOD is herkenbaar aan de hand van een aantal "meetbare" zuilen.

- Density: Woningbouw en kantoorruimte. Hoogte in? Hoe wordt parkeergelegenheid opgevangen? Wie bepaalt deze voorwaarden? Vraag komt niet overeen met aanbod?
- Diversiteit: Sturen jullie in jullie ontwerp ook op bepaalde voorzieningen die er moeten komen? Of bepaalt de markt dat t.z.t. Ontstaat dat vanzelf? Horeca gecentreerd in centrum, ook hier?
- Design: hoe wordt er voor gezorgd dat het design van het station en de route naar het station uitnodigt tot wandel of fietsen?
- Distance to transit: Is het openen van de achterkant van het station een uitnodiging van de bewoners aan deze zijde van de stad om vaker OV te gebruiken als standaard type vervoer.

- Demand management: welke (niet fysieke maatregelen worden er genomen om het nemen van de auto terug te dringen?) Wordt er gesneden in de parkeernorm?

Vragen / tips?

7.2 List of Figures

7.3 List of Tables