Transforming a Mobility Node
In the City of Zwolle

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The railway station is the entrance of the city. It is the first impression a traveller gets of the city. Therefore, the station area should correspond to the identity of the city and should be clearly connected to other parts of the city. However, when it comes to user-friendliness and the relations to the city centre, a lot of station areas need improvement.

The station area is a place where many actors and spatial elements of different scales come together. This is why I chose to work on the transformation of a station area as my graduation project. The station area of Zwolle has a lot of potential. By improving the connection between the station and the city centre on one side and the growing campus Windesheim on the other side, the station area will become a more attractive and more live place in the city. The aim of this graduation project is to transform the station area of Zwolle into an inviting, user-friendly and well-connected part of the city. The final product is this booklet in which both the research and the design are discussed.
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PART I
PROBLEM DEFINITION
1.1 MOTIVATION

The station and the traveller
Stations of old fortified cities, like Amersfoort, Breda and Haarlem, are usually located outside the old city centre. Once you get out of the station it is hard to orient yourself. The identity of the area does not relate to the identity of the city. It is a chaotic place with mostly office buildings and all sorts of traffic trying to find their way on the ground level. You could be anywhere.

From this starting position it is hard to find your way to the city centre. Walking alongside the main road, following bus routes, should lead you in the right direction. Nevertheless, there must be shorter and more attractive ways to walk (or cycle) to the city centre.

In short: the attractiveness and pedestrian-friendliness off station areas need improvement. This is remarkable, because pedestrians are the most important group of users of the railway station; all travellers are pedestrians in about the first 100 meters from the train.

Above all, the station area should be a functional area for this group. As the first impression a traveller gets of the city, the station area should be a clarifying, safe and well-connected part of the city. Its identity should correspond to the identity of the city it is located in.

*identity*
“Definition: the individual characteristics by which a thing or person is recognized or known” ([http://ardictionary.com/identity/239](http://ardictionary.com/identity/239))

*identities*
“i. The collective aspect of the set of characteristics by which a thing is definitively recognizable or known” ([http://www.thefreedictionary.com/identity](http://www.thefreedictionary.com/identity))
Zwolle

New infrastructure often is a trigger for large-scale urban developments. A city obtains a new position in the region, which means potential economical growth. A new railway connection gives the city new opportunities to strengthen both infrastructure and users networks. In the Article ‘De waarde van hogesnelheidstreinstations’ (the value of high-speed railway stations) Mig de Jong (2008) argues that the embedding of the station in the surrounding urban structures, is crucial for the value of the station to the city. He found that new (high-speed) railway connections almost always result in a series of improvements of regional and local connections to the station. Cities alongside the HSL-Zuid track, like Rotterdam and Breda are currently working on the transformation of their station areas. In the coming years a new railway connection between Amsterdam and the north of the Netherlands will lead to transformations of the station areas of Lelystad and Zwolle (figure 1.3). For Zwolle this is the opportunity to transform the station area into a more representative, more pedestrian friendly and better-connected part of the city, than it is at present.
1.2 PROBLEM DEFINITION

1.2.1 Zwolle Context
The city of Zwolle arose in the Middle Ages on a sand ridge between the Overijsselse Vecht and de IJssel, alongside a little river the Aa. In the 15th century the city was already an important trade city and the membership of the Hanze covenant made that position even stronger. The current city centre originated in this period.

Around 1800 Zwolle became the official capital of the province of Overijssel. The city continued to be an important node for (trade) transport. Not only rivers, but also roads and railways now come together in this city. In 1864 Zwolle got connected to the Dutch railway system as one of the stations along the line Utrecht-Zwolle-Kampen. In 1866 the connection with Arnhem and the north of the country was made. Around 1900 railway connections from Zwolle to Ommen and from Zwolle to Almelo were constructed. Later the railway to Almelo was extended to Emmen and Germany.

In the 20th century Zwolle became not only a central position in the Dutch railway network, but also an extraordinary one: The western part of the station was used for the turning of the trains that came from Kampen and went to Utrecht (and vice versa) and in the eastern part of the station the trains from Leeuwarden turned around towards Arnhem. This made the station of Zwolle a double dead-end station. [nl.wikipedia.org]

With 110,000 inhabitants, 80,000 jobs on 111 km² the Zwolle is currently the biggest and most important city in its region. Apart from governmental functions and economic businesses, the city accommodates a lot of education institutes. [Hove, 2005 & www.StudiestadZwolle.nl & www.Zwolle.nl]

Since the 1990’s Zwolle has known major economic, spatial and demographic developments. In the last years the city even had the ‘biggest economic growth of the 25 large cities in The Netherlands’
Transforming a Mobility Node In the City of Zwolle (Municipality Zwolle, 2007a, p.14). The spatial challenges of the city have therefore changed in comparison to the 1990’s.

In 2000 the city has started cooperating with the municipality of Kampen. With the coming of the new high-speed railway line the Hanzelijn in 2012 the position of Zwolle will improve. This offers a perspective of further growth and a stronger competitiveness of the Zwolle in the future. (www.ZwolleKampenNetwerkstad.nl)
The city wants to grow into ‘the independent and versatile centre of the North and East of the Netherlands’ (Municipality Zwolle, 2007a, p.4). To direct the new developments of the city, a new structure plan has been determined in 2007. ‘The structure plan gives an integral representation of the envisaged functions of the city up to 2020’ (Municipality Zwolle, 2007a, p.5).

1.2.2 ‘Structuur Plan’ Zwolle 2020
The development of Zwolle as a centre of the region and as a link between the Randstad and the North and East of The Netherlands, has a central position in the structure plan of the city. To realize this, public transport facilities will have to improve. This comes down to developing the railway station as a central public transport node and improving the existing regional and urban connections. The good connection of Zwolle to the highway A28 has caused the city benefits, but also a lot of automobile traffic. To maintain the good accessibility of the city, slow traffic routes and public transport need improvement and a higher capacity. Public transport should provide a coherent regional and urban network.
The cycle network can be improved and made attractive by combining cycling routes with the green-structure of the city. At the moment the green-structure of the city shows some fragmentation. By combining green elements new corridors can be created which could lead to attractive walking and cycling routes. (Municipality Zwolle, 2007a)

Another main point of the structure plan is densification. Where the city used to look for places outside its boundaries to expand, in the future the city aims to densify. The structure plan points out a few inner-city locations that should densify: ‘the urban centre areas’. These areas will have mixed functions like housing, labour and facilities. The development of urban centre areas is of great importance for the city of Zwolle as a regional centre. (Municipality Zwolle, 2007a)

One of the indicated urban centre areas is the inner city of Zwolle, including the surrounding shell. In this area there will be new shops and catering industry, a new theatre and an increase of dwellings. The new urban centre area of the inner city will be connected to another prospective urban centre area: The railway area, including the Hanzeland behind the station. Because of the favourable position close to the city centre, the future Hanzelijn station and the highway...
Part 1

A28, the area has the potential to develop ‘high-quality facilities on a regional and national scale level, mixed with offices and urban housing typologies’ (Municipality Zwolle, 2007a, p.5).

To strengthen the functionality and the recognisability of the station area, high-rise buildings may be implemented. The public transport node around the station should be optimised.

With the new Hanzelijn the station area of Zwolle has been put on the cities spatial agenda. Therefore this is the opportunity to take a close look at the functioning of this area; and to improve it. Research underpins that non-inviting station areas like this have a negative effect on tourist attraction of a city (see chapter 1.4). At the moment the station area of Zwolle is a chaotic place for a traveller to arrive. It is hard to find the way at the location and there are clear boundaries between the area and other parts of the city.

An uninviting atmosphere at a station area does not only affect the (pedestrian) users of the station, but also the potential for tourist incomes for the city. Research shows that the amount of hours day-trip visitors will stay, and the amount of money the will spend depends on the ‘entrance’ of the city (Van der Spek, 2006). This is further explained in chapter 1.4.

The station area of Zwolle could improve for instance by defining separate routes and spaces for different forms of transport. This way busses, cars, cyclists and pedestrians do not have to be in each other’s way too often. The position of the station in the city could become more clear and attractive by strengthening the structure of green and plazas (Municipality Zwolle, 2007a).

Slow routes and public transport between the station area and other important locations in the city, like the campus on the southside and the old city centre on the northside, have to improve (figure 1.7). The redevelopment of the railway area should lead to attractive walking and cycling routes between the city centre, the station area and the campus.

1.2.3 Aim

The aim of the graduation project is to transform the station area of Zwolle into an inviting, user-friendly and well-connected part of the city.

A short explanation of the used words:

- **INVITING** as a **PLACE** for train travellers but also for inhabitants of Zwolle and its region. The area should relate to the identity of Zwolle. At the moment the Zwolle station area is mainly a node; a connecting element to travel through, but not a destination. Green structures and new facilities like shops and restaurants could improve the attractiveness of the station area as a place.
- **A USER-FRIENDLY** station is a safe and clarifying **NODE** for its users. With this the emphasis is on pedestrians, because all train travellers are pedestrians in approximately the first 100 metres from the train stop. A user-friendly station area should have a clear structure in which even alien people can find their way.
- **A WELL-CONNECTED** station area is well **INTEGRATED** into the surrounding urban fabric. It should connect different parts of the city with each other and with the regional and national transport networks. To make sufficient use of public transport it is important that the city and the region are well-connected to the station area. Because the municipality of Zwolle aims to decrease the use of cars in and around the city, the emphasis is again on slow traffic and public transport,
1.3 ASSIGNMENT

1.3.1 Process
In the beginning of 2007 the city council of Zwolle has formulated an assignment to make an integral vision for the railway area. After formulating the assignment, two phases follow. The first phase consists of strategic exploration. The second phase consists of making a strategic development plan. The most important parties that are involved in making this plan are the municipality of Zwolle, the province of Overijssel, the NS (Dutch railway company) who own most of the ground around the station itself, and Prorail (railway maintenance). This group asked Jo Coenen & Co Architecten to make a strategic exploration for the area. The results of the strategic exploration can be found in the ‘Perspective Spoorzone’. This perspective shows some of the potential and possibilities of the area. However, because it is only an exploration of the area, a lot of important factors like housing demand, accessibility of the railway area for cyclists, pedestrians and cars and parking, were not taken into account. One thing all parties do agree on is the wish to construct a new railway crossing on the Westside of the current station.

Based on research on the demand for offices, dwelling typologies and retail the different parties agreed on a ‘provisional real estate programme’ for the area and a ‘provisional ambition’ (Van Holten, 2009a). Some of the most important subjects currently mentioned in the provisional ambition are:

- A mix of offices, housing, shops and social services;
- A Landmark that makes the station recognisable;
- To realise about 10,000 places for bicycles;
- To relocate the busstation. (Van Holten, 2009b)

Different urban offices have now been asked to continue the urban planning for different parts of the area. The actual redevelopment of the area will start in 2012.
1.3.2 Research
The exact area of this research is a bit different from the area that the municipality calls the ‘Spoorzone’ (figure 1.8). This project will focus on two different scales: The scale of the city concerning the connection of the station area with on the one side the campus and on the other side the city centre. The other scale is the scale of the station itself, concerning the organisation of different traffic flows at the station. These scales are illustrated in figure 1.11 and 1.12.
This research and design project holds on to the railway tracks that are currently used. However, the position of the station is reconsidered, as is the position of other functions connected to the railway, like maintenance and storage areas of the Dutch railway company (NS).

1.3.3 Main research question:
How can the development of the Hanzelijn be used to transform the station area of Zwolle into an inviting, user-friendly and well-connected area in the city?

Sub-questions:
What will the Hanzelijn change about the position of Zwolle in the region?
What influence does this have on developments in the station area of Zwolle?
What possibilities are there for the position of the station in the city?
What changes are needed to make the station less of a barrier in the city?
What changes could contribute to the current network of cycle and walking routes in the city?
What are the limitations of the station area?
What are the qualities of the station area?
What interventions and new functions are needed?
What are the requirements for an inviting, user-friendly and well-connected station area?
What spatial interventions can contribute to an inviting, user-friendly and well-connected station area in Zwolle?
1.3.4 Intended outcome
This project concludes with two types of outcomes: Research outcomes and Design outcomes. The research outcomes of the project should contribute to the general understanding of spatial conditions for a successful station area and for the relationship between the station area and other parts of the city. Hereby emphasis is on the relation between the station area and the city centre, as an important destination for train travellers. Apart from that the project should give insight into how to apply this information in a redesign for an unsuccessful station area, or at for a station area in which not all potentials is being used, like Zwolle.

Therefore the final outcome of the project is a research-based design for the station area of Zwolle in the form of an urban plan. The design focuses on two main scales: The scale of the station area and its surroundings, up to about 1km from the station (figure 1.11), and the very local scale of the station itself, up to about 250m around the actual platforms (figure 1.12). The first scale will show the relation between the station and other parts of the city. The second one will show how the station itself can become a more clear and safe place or its users, than it is at present.

3D-images and pictures of references will visualise the characteristics of the plan. For 3D-images 3D computer program is used. Maps of the area on a larger scale illustrate the most important connections with other parts of the city, and possibly with the region.
1.4 SCIENTIFIC AND SOCIETAL RELEVANCE

1.4.1 Relevance

Since a few years the redevelopment of stations and station areas is high on the agenda of European cities. One of the reasons is the mounting concern about the sustainability. Urban design needs to be less car-dependent and using public transport should be made more attractive and easier for people. (Peek et al., 2006)

Station areas should for instance be attractive and accessible places for cyclists and pedestrians. However, urban designs for station areas are usually based on technical aspects and flows of (larger) vehicles. Patterns and intensities of pedestrian movement are often neglected. (Van der Spek, 2006)

The integration of the station area into its surrounding urban areas is crucial for the livability of the station area. Neglect of the importance of the structural characteristics of urban space can result in failures of a multi-million Euro projects when the ‘expected liveability of the area and an increase in economic value do not occur’ (Kusumo, 2007, p.7).

The hostile atmosphere of station areas does not only affect the (pedestrian) users of the station, but also the potential for tourist incomes for the city. Research shows that the amount of hours day-trip visitors will stay, and the amount of money the will spend depends on the ‘entrance’ of the city. ‘Day-trip visitors usually plan to stay about four hours and spend approximately €150. However, if the arrival is inhospitable and the destination confusing, they will leave after two hours, spending less than €75’ (Van der Spek, 2006, p.3).

Therefore it is useful to develop a strategy to make urban plans for station areas that are not only functional for vehicles, but also functional and attractive for pedestrians.
Apart from that the station area of Zwolle holds a lot of potential that should be used. Once the station area is developed the right way and the walk and cycle routes between this area and other important areas of the city have improved, it can be expected that alongside these new routed new developments will take place too. This way big parts of the city can profit with the new developments in the station area.

1.4.2 National Policy
Apart from the construction of the Hanzelijn, there are also other national decisions that concern the station area of Zwolle. Programma Spoorzone-Ontwikkeling is a programme in which NS, ProRail and the ministries of VROM (housing, planning and the environment) and transport, public works and water management guide municipalities with the of inner-city railway areas. Four municipalities were selected as ‘example projects’ for the programme: Amersfoort, Nijmegen, Groningen and Zwolle (www.vrom.nl). In June 2009 it was announced that minister Eurlings (of transport, public works and water management) will provide a 117 million subsidy for solving the barriers railways cause in 26 cities throughout the country (figure 1.13). While Zwolle is not one of those cities, it is clear that the problem is relevant for a lot of places in the Netherlands.
1.5 METHOD

In the research I make use of different methods, to be divided into two main categories.

1. Literature review. One of the results of literature studies is a paper concerning the integration of station areas in the urban fabric. Apart from that, literature gives an insight in the current theories concerning the functioning of station areas.

2. Spatial Analyses methods. Consisting of:
   A. Methods based on pedestrian oriented design;
   B. Network city analyses;
   C. Space Syntax;
   D. Case Studies.

All methods are shortly explained in this paragraph. The outcomes of the literature review are discussed in paragraph 1.6; while the outcomes of the spatial analyses are discussed in the next chapter.

1.5.1 Pedestrian oriented design

‘Improving the accessibility of transport hubs for pedestrians will increase the use of public transport and the attractiveness of the city centres’ (Van der Spek, 2006, p.9).

Travellers form one of the most important groups that will use a station area. In about the first 100 meters from the train stop these travellers are all pedestrians. Pedestrian oriented design should therefore be taken into account when researching and designing a station area.

In pedestrian oriented design, the experience of pedestrians is the basis for the urban design. In the article ‘Optimising Routing and Safety for Pedestrians’, Van der Spek proposes a method to test accessibility for pedestrians of existing plans: The pedestrian accessibility of a transport hub can be analysed with a ‘logistical
analysis’ (figure 1.15). The aim of this analysis is to identify conflict points between pedestrian movement and other traffic. The flows of traffic can be based on expected use or based on observation, for instance with GPS research. The analysis consists of three steps:
1. Identify the main structural components
2. Map and analyse the use of space
3. Detect conflict points between modes

‘This tool can be used as an instrument to suggest, test or compare transformations. Interventions can be based on routing, logistics, safety and the location of public transport facilities.’ (Van der Spek, 2006, p.4)

1.5.2 Network city analyses
Urban society gets increasingly more mobile. Certain qualities, like physical accessibility, become very important for locations, as well as connections to transportation (and telecommunications) networks at different spatial scales. This is why great potential lies in places where mobility flows interconnect, like station areas. These places should be easy accessible as a node, but also as a place, with different functions. (Bertolini & Dijst, 2003)

In the article ‘Mobility Environments and Network Cities’ Bertolini and Dijst define network cities as: ‘A system of overlapping and complementary functional sub-systems that encompass more spatial scales at the same time, in line with the ‘analytic’ perspective above’ (Bertolini & Dijst, 2003, p.5).

In a network city we can distinguish three levels of networks:
- The spatial (or actual) network consists of the existing landscape and the manmade-landscape, the urban fabric is a part of that landscape;
- The transport (or technical) network consists of streams of human activity. This means the transport of people, goods but also of information. Railways, roads, cables and pipes are part of this network;
- The governance (or functional) network consists of all networks needed for production and consumption. This network feeds our need for resources like money, knowledge and political support. (Hulsbergen & Stouten, 2008 & Oosten, 2000)

Together the three networks make a full geography (Oosten, 2000). Therefore network city concept can be very useful in the study of space. The railway station is both a node and a place. Redevelopments of station areas are related to both the transport network and the spatial network. The position of a station location within the emerging urban networks is [...] a crucial ingredient of its property development potential’ (Bertolini and Spit, 1998, p.39). Designs for stations often are based on the transport network and the use of different motilities. But the spatial network, which represents the station area as a place is just as important (Oosten, 2000).

Tool: By analysing the different networks the structure of the city comes into sight. Where do the networks compete, and where do they complete each other? A new urban plan should work on all three levels. I will define these different networks in the area, on different levels of scale. How will they change by the new developments? How can the networks be balanced and work together?
1.5.3 Space Syntax
One of the aims of this graduation project is to improve the integration of the station area into the urban fabric. Therefore it is important to analyse the spatial network of streets in the area. Space syntax method provides tools to calculate the integration of all different points in the public space through sightlines and axes within the public space. The program Depthmap, developed by the University College of London, can be used for these analyses.

3 concepts for space are used in the Space syntax method:
- Convex space: ‘All points within that space can be joined to all others without passing the boundaries of the space’ (Van Nes, 2009, p.23). This is the space, mostly used for occupation.
- Isovist field: The visualisation of the view of a viewer from a particular standing point.
- Axial lines: Lines that represent the longest and fewest sightlines in the convex space. (A curved street therefore consists of several axial lines). Axial lines represent the space for movement. (Van Nes, 2009)

In this research the vitality of the public space in the area between the campus at the south of the station and the city centre on the northside of the station, will be tested for different design models. The public space here is the public space that can be used by pedestrians and/or cyclists. Therefore water structures and highways are not a part of the public space.

The degree of spatial integration is a strong predictor of pedestrian and traffic flow rates (Van Nes, 2009, p.72). Well-integrated streets are often shopping streets. ‘A shop owner will always look for the most optimal location where he or she can reach most customers. If this optimal location is affected by larger urban changes, he or she will relocate his or her business’ (Van Nes, 2009, p.72).

Less integrated streets are usually found in housing areas. The worst integrated places are urban areas where people feel unsafe to walk through due to high criminality. (Van Nes, 2009)

It should be taken into account that only the integration, which depends on the city structures, is measured with this method. Important factors for a vital public space like programme, the amount of dwellings versus offices, and eyes on the street are not taken into account here.

The Space Syntax analyses can be used to learn more about the current situation of Zwolle, for case studies and to evaluate new urban plans.

1.5.4 Case studies
The redevelopment of stations and station areas is high on the agenda of European cities (Peek et al., 2006). This means that there already are a lot of examples to learn from. At the moment cities linked to the new high-speed line HSL-Zuid, like Rotterdam and Breda are transforming their station areas. The plan of the new area in front of Rotterdam central station aims to make a stronger link between city centre and station area.

Researching such plans could provide suggestions to improve the link between city centres and station areas; and ways to reduce the bounding effects of certain elements, like roads and railway tracks.

While the HSL-Zuid connected cities are now working on the realization of their station-plans, the redevelopment of the station area of ’s-Hertogenbosch was elaborated in the 1990’s. It is one of the most advanced transformation areas in the Netherlands (www.nicis.nl).

In the 1980’s the industrial estate Wolfsdonken (1950’s), on the
backside of ‘s-Hertogenbosch central station started to show signs of physical deterioration. The municipality had to interfere and seized the opportunity to make better use of the potential of the station area. (Peek & Louw, 2007)

With the transformation of this area the municipality wanted to:
- Redevelop the station area from an accommodation for low value businesses, to and accommodation for high value businesses;
- Make room for the accommodation of former centre functions, to create space for new functions in the centre itself;
- Improve the accessibility of both city centre and station area.

The redevelopment of this station area is often referred to as a success story, both as an example of public-private partnership and urban design (www.nicis.nl & Peek & Louw, 2007). Apart from that, this example can give information about the long-term results of station area redevelopments.

A combination of case studies, network city analyses and methods based on pedestrian oriented design should lead to a complete and scientifically underpinned vision for the station area of Zwolle. This vision can be the basis for a new urban design for the transformation of the area into an attractive, representative and well-connected area in the city.

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<tr>
<th>Methods</th>
<th>Sub-Questions</th>
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<td>A Pedestrian</td>
<td>What will the Hanzelijn change about the position of Zwolle in the region?</td>
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<td>B Network</td>
<td>What influence does this have on developments in the station area of Zwolle?</td>
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<td>C Cases</td>
<td>What possibilities are there for the position of the station in the city?</td>
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<td>D Space Syntax</td>
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Figure 1.17 Methods relate to Subquestions (Weeda, 2008)
1.6 THEORY

Apart from spatial analyses a lot can be learned from theory. In this chapter two important subjects are discussed: case studies and more general urban design theories. The first paragraph is an abstract of a literature review about the station areas of Rotterdam, Groningen and Delft, which was made during the graduation project. This paper focuses on the relation between the station area and the city centre. The second paragraph is a short introduction on theory about the experience of public space. It offers different design tools for a successful urban space.

1.6.1 Case Studies

Since a few years the redevelopment of stations and station areas is high on the agenda of European cities. Redevelopments of station areas are not always successful. Kusumo (2007) states that the integration of the station into the existing urban structure and the existing urban flows of the city influences the liveability of an urban area around the station. Therefore it is a crucial factor in (re-) designs for the redevelopment of station areas.

At the moment the station area of Zwolle is not well integrated in the urban fabric of the city. Research on and plans for different station areas provide information about how to improve the integration of a station area in the urban fabric. Focussing on the relation between station and city centre the cities of Groningen, Delft and Rotterdam have been reviewed. In all cases the station area is traditionally separated from the city centre by water or large infrastructural boundaries. Research and new designs suggest solutions for the improvement of the relation between the station area and city centre. To specify the research and to make the cases comparable four topics have been reviewed: Position of the station, Functioning of the station area, Integration of the station area and Proposals from researchers and designers.

When it comes to position, in all cases the station area is located outside the city centre, like in Zwolle. The station of Zwolle however, lies a bit further from the city centre than the stations of the other cities. In Rotterdam the station area has a very eccentric position towards the city centre. This is not the case in the other cities. In Groningen, Delft and Zwolle the station area is more a node than a place. With the new high-speed line on the way, the station of Rotterdam could become more a node than a place. However, plans for a new station area with a lot of programme should prevent that. Bertolini argues that this type of stations has a good opportunity for the development of new facilities and even attracts developers and investors. The case of Rotterdam verifies this.

However, the development of new facilities alone is not enough to make a station area successful. Integration of the station area is crucial, and this exactly is the problem of the reviewed cities.

In Zwolle and in the former situation of Groningen the canal around the city centre is the biggest obstacle between the station and the centre. Bridges therefore need to have strategic positions, providing people a short and clear way from the station to the inner city. In Zwolle and in the former situation of Groningen this is not the case. In Groningen this even led to the neglect of an area in the inner city, close to the station, but not connected by a bridge.

In Rotterdam and Delft, large infrastructure forms the barrier between station area and city centre. In Rotterdam the Weena is not only a dense-traffic infrastructural barrier, but also a mono-functional barrier, with a lot of offices. Visitors would first have to cross this barrier before entering more interesting parts of the city.
Researchers and designers proposed several solutions for the integration of the reviewed station areas.

In the 1990’s a new museum, combined with a new bridge, improved the connection between central station and inner city of Groningen. The new museum/bridge caused a big spin-off in the neglected area across the water, although not in the station area itself.

In Delft plans for putting the railway underground are being developed and researched. Research of Kusumo shows that a long tunnel can provide big improvements for the integration of the station area in the city of Delft. There will be more space for city-centre function above ground and the railway will not be a barrier between the east and the west of the city anymore. However, the large traffic barrier of the road in-between the station area and the city centre will not decrease by the construction of a new railway tunnel. Van der Spek suggests a reconsideration of the location of the station itself.

More research is needed to find out whether this could decrease this last remaining problem.

In front of the Rotterdam station the traffic of the Weena will be put underground, providing a safer and more attractive route towards the city centre. The decentralized position of the station towards the city centre remains. In this situation reconsideration of location of the station may be useful as well.

The found proposals to improve the relation between a station area and a city centre are an inspiration for further research on the integration of other station areas like Zwolle.
1.6.2 Experiencing Public Space

In this paragraph a small explanation is given about basic rules for urban design that can be used in a project like this. It is not the intention to define the different visions on successful urban planning; that would be an entire research itself. This paragraph only contributes to the understanding of urban space and provides tools that can be used in the design later on.

Two articles were used to get more insight in rules for successful urban planning.

- ‘Measuring the Unmeasurable: Urban Design Qualities Related to Walkability’ - Ewing & Handy, 2009

The first article is based on research. Urban design qualities were defined and discussed with the help of a panel of ten urban design and planning experts. The second article is based on important urban design literature, like the writings of Alexander, Cullen, Gehl, Jacobs and Lynch.

The first article is about the relation between physical features and walking behaviour. The writers attempt to ‘comprehensively and objectively measure subjective qualities of the urban street environment’ (p.65).

The way an individual feels about the environment is influenced by three factors:

1. Physical features (street width, building height, water, green)
2. Urban design qualities (human scale, coherence)
3. Individual reactions (sense of safety, level of interest)

Together, these three lead to a level of overall walkability of the public space and therefore to walking behaviour (figure 1.21). To get a better understanding of urban design qualities a range of 51 perceptual qualities were tested. Only five of them appeared to be...
measurable: imageability, enclosure, human scale, transparency and complexity.

Imageability is the quality that makes a place recognisable. A landmark can make a place recognisable. This does not always mean a big civic structure. A landmark may be an orientation point or a point of contrast in the urban setting, like the use of a material or architectural styles. Imageability is closely related to the other four mentioned urban design qualities. If a place rates high on those qualities it is likely to have a good imageability as well.

Enclosure expresses how the public space is defined by vertical elements. ‘An outdoor space is positive when it has a distinct and definite shape, as definite as the shape of a room’ (Alexander, 1977, p.106). Vertical elements can be buildings, but trees and traffic contribute to the visual enclosure of spaces as well.

The level of human scale depends on how much the size, texture and elements in the public space correspond to the size of humans. For instance walking speed and sight should be taken into account. Building details, pavement texture, street trees and street furniture contribute to the experience of human scale.

Transparency is about the ability to see and perceive what lies beyond the edge of the street. This for instance stands for the relation between the public space and the interior of the buildings around it. ‘The ultimate transparency is when internal activities are externalised or brought to the sidewalk’ (p.78). However, a large amount of entrances to a street already contributes to the perception of human activity beyond the street itself.

Complexity expresses the visual richness of a place. To become noticeable the public space needs a certain level of complexity. This results in varying building shapes, sizes, materials, colours, and etcetera. ‘The presence and activity of people add greatly to the complexity of a scene’ (p.80). In a station area both the amount of traffic and people cause a certain level of complexity. Therefore, on
such a location the physical urban design itself may be less complex.

Montgomery defines urban design qualities as well. About ten years before Ewing&Handy he too defined three elements that contribute to a successful urban place:

1. Activity
2. Sensory Experience (image)
3. Physical space (form)

To generate a sense of space quality in these three elements is needed. Activity is the product of vitality and diversity. Vitality is refers to numbers of people in a place at different times during the day and night. Diversity refers to mixed functions (a lot of small scale-businesses) and activity around the clock. The key to sustaining diversity lies in there being, within easy travelling distance, relatively large numbers of people with different tastes and proclivities’ (p.97). Encouraging cafes and restaurants to use the pavement outside their establishments results in activity, people watching and vitality.

The Image represents the meaning of the place. It is a combination of the identity of the place with how a place is perceived. This depends on the activity that is in that place, possibly a symbolic meaning of the place or a landmark. However, more personal aspects like former experiences and a frame of reference contribute to the meaning of a place too. Here imageability and the legibility of the urban place (as mentioned by Lynch) play an important role.

The Writings of Lynch are used to explain what Montgomery means by form. ‘Lynch offers five basic dimensions of city performance: vitality, sense, access, control and fit’ (p.102). The last element (fit) is the one element that may also stimulate the other 2 design qualities that contribute to a successful urban place: Activity and Image. ‘A city with good fit provides the buildings, spaces and networks required for its residents to pursue their projects successfully. In a very real sense, this ‘fit’ will be governed by the type of place and the range and intensity of activity desired’ (p.102). Montgomery finally explains twelve conditions for a good physical form for a city:

1. Development intensity (density and diversity)
2. Mixed use (people attractors and secondary activities)
3. Fine grain (a range of unit sizes)
4. Adaptability
5. Human scale
6. City blocks and permeability (short blocks generate more street life)
7. Streets: contact, visibility, horizontal grain
8. Public realm
9. Movement
10. Green space and water space
11. Landmarks, visual stimulation and attention to detail
12. Architectural style and image

Montgomery’s principles for achieving urbanity can be found in figure 1.24.

Although the two discussed articles were made in very different ways and in different times, there are a lot of similarities. The first article provides 5 measurable design qualities: imageability, enclosure, human scale, transparency and complexity. The second article provides 3 main urban design qualities: activity, image, form. In these qualities there are overlaps. For instance a good urban form means that human scale has been taken into account and activity contributes to the complexity of a space. The different design qualities provide tools that can be used in the design later on.
Part 2
Location analysis
In the second part of this report outcomes of the location analysis are clarified. For these analyses different methods were used. The aim of the analysis of the station area of Zwolle is to find out:
- What are the qualities of the station area?
- What are the weaknesses of the station area?
- What is the relation of the station area and other parts of the city?
- How is the station area used?
- What should stay?
- What new programme is needed in this area?

Analytical drawings help to answer these questions. This chapter contains drawings of the morphology of Zwolle, space syntax analyses, an urban position analysis of the station of Zwolle, network analyses on different scales, and logistical analyses of the station itself. Suggestions for further research are also given.
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2.1 MORPHOLOGY

When working on a spatial plan for an area, it is important to know its history. This helps to understand why the situation is the way it is today. At this moment the station area of Zwolle forms an interruption in the urban fabric of the city. Large infrastructure aggravates the relation between the station area and its surroundings.

The morphology of the city explains a lot about its history (figure 2.1). Looking back at 1849, when there were no railway lines in the Netherlands, the area that is now the station area is still an agrarian landscape. However, as soon as the city got connected to the Dutch railway lines, the area next to the railway line started to urbanise. The railway then became a boundary of the city. In the last 50 years the city of Zwolle grew around the station area, which then became a part of the city. Nevertheless, with another background, other functions and great boundaries around it, the station area functions as an island in the city.

Better integration into the urban structures of the city may lead to a better functioning station area with great development opportunities. The station area also provides a chance for the city to connect other city parts, like the campus in the back of the station with the inner city in front of the station. Therefore, spatial adjustments are needed.

Figure 2.1 Morphology Zwolle through the years (based on: maps from the TUDelft archive)
2.2 SPACE SYNTAX ANALYSIS

For the city centre, including the station area a few Space Syntax analyses have been done. Figure 2.2 shows axial analysis with radius three. The lines in this drawing are sightlines. The figure shows how many other streets are reached after three 'sightline-steps'. It represents the local integration of streets: red is well integrated, and blue is not well integrated.

Figure 2.3 and 2.4 show segment analyses for 100 and 500 meters. It can be concluded that shopping streets and the bridge between the station area and the centre are well integrated locally (2.3). On a higher scale (2.4) the highway and the road in front of the station are well integrated.

From the three analytical drawings together it can be concluded that the area between the city centre and the station itself is not well integrated into the urban structure. This has a negative effect on the liveliness on this area. And even though many people use this space to move from the station to the city centre, the area does not have a lot of facilities. Better integration of the area could improve the potential for new developments and provide a more lively connection between station and city centre, than it is at present.

The next step may be to compare the outcomes of the Space Syntax analysis of Zwolle with a few other cities where the station area is well integrated into the urban fabric, and where there is a good relation between the station area and the city centre. However, due to time limitations, it was not possible to do so within this graduation project.
2.3 URBAN POSITION ANALYSIS

The aim of a position analysis is to get a clear idea of the position of the station in its surrounding areas. The urban analysis consists of three maps that give an insight in the geographical position of the station. The relation between the connector and surrounding infrastructure and urban program are drawn in the scale of the environment of the station (figure 2.5), the agglomeration (figure 2.6) and the region (figure 2.7 & 2.8) (Van der Spek, 2003).

From the urban position analysis the following preliminary conclusions can be drawn:

- Cyclists and pedestrians have to use the same rout between the station and the city centre as cars do. Apart from that the distance between the city centre and the station is more than the preferred 600meter walking distance. Therefore the current situation does not provide an inviting alternative for travelling by car.
- In the area between the station and the city centre apart from housing, there is a park. This park could be used to provide an alternative green route for cyclists and pedestrians.
- On the local scale there is only a very weak connection between the front and the back of the station, which consist of a 200meter long pedestrian tunnel. Cyclists have to cycle rather far to cross the railway.
- The network of busses covers a great part of the city of Zwolle, both north and south of the station area.
- The highway is situated close to the station area of Zwolle.
Figure 2.7 and 2.8 show the reach of the city of Zwolle before and after the construction of the Hanzelijn (2012). The red line indicates the area that can be reached by car in 45 minutes from Zwolle, and the blue line indicates the area that can be covered by train in 45 minutes. It is clear that the Hanzelijn will provide an improvement when it comes to train reach in the area close to the Randstad. Compared to the city of Amsterdam (figure 2.9), there is not a lot of difference in the reach by train or car from Zwolle. This contributes to the attractiveness of travelling by train instead of car.
2.4. FUNCTIONAL AND TRANSPORT NETWORKS

Both the transport and spatial network are important for the development of a station area. Networks can be visualised on different scales. To improve the integration of the station area of Zwolle, the transport network needs to be reviewed on three different scales: the local scale, the scale of the city and the national scale (of the railway network).

The railway station of Zwolle is an important node in the railway network of the Netherlands. The construction of the Hanzelijn even increases the importance of Zwolle in this network (figure 2.10).

The station connects the railway network with the network of destinations in the city. The most important destinations for train travellers in Zwolle are the inner city, and the campus. Because of the wish to reduce car use in the city of Zwolle the municipality also stresses on the park Engelse Werk and the business area Voorsterpoort. From a small analysis (figure 2.11) it can be concluded that Voorsterpoort and Engelse Werk are both located about 1.7km from the station area. These places could preferable be reached by bus or cycle. The campus and the city centre are also further away from the station than the preferred walking distance of 600 meter. A redesign of the station area should provide a shorter route between the three.

A part of the functional network has been visualized in figure 2.13. Only a difference has been made between housing (grey) and other functions (orange) in the station area. This map makes clear that the station area is a mixed function area. However, most functions apart from housing concern work places of the railway company (NS) and local facilities like primary schools. Paragraph 2.7 gives more insight on the exact programme in the station area. In the following paragraphs transport networks on the lower scale will be discussed. The focus is on pedestrians, as the users of the station.
2.5 LAYOUT OF THE STATION

The layout of the station shows how different functions of the station are organised on the location (figure 2.12). In the current situation nearly all functions are located on ground level. The functions on the ground level are spread out rather widely. Busses are located on both sides of the entrance of the station. With a distance of over 100 meters, bicycle parkings are located rather far from the entrance of the station.

On the southside of the station there is a lot of extra space used for train storage and maintenance. This causes a big barrier between the front and the back of the station. Below ground level a 200 meter long pedestrian tunnel connects the front and the back of the station with the platforms. There are no shops or other functions below ground level; this makes the tunnel a rather isolated place.

By using more than just one level, and by reducing the amount of rails behind the station, a more compact layout may be possible in the future.
Figure 2.14 Logistical analysis station of Zwolle (based on: geoloket.tudelft.nl)
2.6 PEDESTRIANS

Because all train travellers are pedestrians in the first 100 meters from the train stop, safety and clarity for pedestrians is one of the main aims of this project. A logistical analysis provides insight in the safety and clarity for the users of the station. With a logistical analysis different traffic flows are visualized in one drawing. On the places were different flows crow a conflict point is indicated. (Van der Spek, 2003)

Figure 2.14 presents the logistical analysis of the station of Zwolle. It can be concluded that busses cause the biggest amount of conflict points in the station area. Apart from that all traffic forms use the same road to access the station. This causes high traffic densities and hold-ups. The pedestrian tunnel between the front and the back of the station is very long: 200 meters. A tunnel for cyclists is located rather far from the actual train station. In short: the bus network needs improvement, as well as the connection between the front and back of the station.

2.7 CHARACTER and PROGRAMME

Apart from technical aspects like flows of vehicles and spatial integration the sphere of a place is very important for its functioning. To capture the sphere of the area around the station, images of the most important streets were collected in a small ‘sphere-catalogue’. The most important findings are summarized in this paragraph.

Very prominent is the difference between the northside and the southside of the station. The built environment on the northside of the station has a traditional appearance, while the southside consists mainly of newly built offices. The northside of the station area is a
residential district with mostly dwellings and some neighbourhood functions like a real estate agent and a dentist. On both sides the amount of programme focusing on the users of the station is very small (figure 2.16). Here lies an opportunity for the area: If more heterogeneous programme is added, the liveliness of the area is likely to increase.

It can be concluded that the character of the station area of Zwolle does not correspond with the character of a regional centre. A first attempt to change the character of the stations surroundings was the construction of the Lubeckplein on the southside of the station, a few years ago. This square has a few terraces and the municipal office is located here. However, the location of the Lubeckplein is not optimal. It is located rather far from the city centre and from the campus. Moreover the square has no relation to the small housing area located next to it.

To make the station area more vital it should become more attractive as a place, with other facilities and a relation to its surroundings. The campus on the southside of the station provides big opportunities for the vitality of the station area. Student housing and student facilities should be stimulated in the area around the station.

Apart from the area in general, the slow traffic routes from the station to the two main attractors, the city centre and the campus, were visualised. The route from the station to the campus mainly consists of a small profile, which can only be used by bicycles and pedestrians. The route passes a lot of backsides and the crossing with the IJsselallee consists of a rather inconvenient tunnel (figure 2.20). Even though large groups of students pass by every day, there is no programme apart from offices and housing alongside this route.

The most common slow traffic route from the station to the city centre is more attractive (figure 2.22). The buildings have a traditional appearance and the streets have a green character. However, all
traffic flows use the same access road to the station, which makes the front of the station less safe for cyclists and pedestrians. Here again, there is hardly any programme that focuses on the large groups of pedestrians and cyclists passing by every day.
2.8 WHAT GOES OUT/WHAT COMES IN?

Industry

Directly alongside the railway track, a number of industrial buildings is located. Most of these buildings will be out of use soon. The municipality of Zwolle plans to demolish them to make way for a new and more appropriate programme for this location near the centre of the city. However, one of the buildings, the Wartsila building, will be maintained (figure 2.25). This building was built for the production of heavy motors for ships. With its heavy foundation, the building is hard to demolish. The Wartsila building has a strong industrial character with an undulating roof; it could become a landmark for the area and a symbolic reminder of the industrial times of the station area of Zwolle. Possibilities to transform the building for new programme like housing or offices are being researched by the NS. Because of the heavy foundation it is for instance possible to build extra floors in and/or on the building.

Platform

The new railway connection Hanzelijn will make use of the existing railway tracks on the location. The Hanzelijn itself will probably stop on the first platform of the current station. However, an extra platform is needed for the trains to Rotterdam and Den Haag, which currently stop at platform 1 (figure 2.24). This platform will be about 200 meters long to begin with (Van Holten, 2009a).

Busses

With the expected increase of train travellers due to the Hanzelijn, it is important to keep the region well connected to the station of Zwolle. Therefore the province of Overijssel wants to improve the bus network and double the amount of bus stops at the station, from 16 to 28 places. This means a lot of extra space is needed for a
new bus station. Whether this station should be on the southside of the station, or on the northside, where it is now, is being researched (Van Holten, 2009a).

Parking
The NS wants to realise parking spaces for about 10,000 bicycles in the area: 3,000 on the southside of the station and 7,000 on the northside (Van Holten, 2009b). Apart from that, new car parks are needed for train travellers and for new programme in the area.

Programme
Moving the industrial programme elsewhere, will provide a lot of new free space to develop, around the station. This is an opportunity to make the area more attractive as a place and to integrate the area into the urban structure.

In the next ten years campus Windesheim expects to grow to nearly the double amount of students they have now. A good relation between the campus on the one side of the station and the city centre on the other side may result in a vital station area. To accomplish this, the campus should ‘grow towards’ the station. Student housing and new student facilities like a library and a sports centre could be realised in the area southwest of the station (figure 2.26).
2.9 CONCLUSION AND DESIGN CRITERIA

From the analyses it can be concluded that the logistical situation of the station area does need improvement. Since a lot of conflict point between traffic flows concern busses, a separation of bus traffic from other transport forms could provide a big improvement when it comes to safety and traffic-density.

The distances between the station and the inner city on one side, and between the station and the campus on the other side are rather long (over 600 meters each). New routes for pedestrians and cyclists should be shorter and more attractive. Therefore the construction of a new bridge across the canal should be considered as well as changing the position of the station itself. The park in between the station area and the inner city provides an opportunity for a green and attractive route for slow traffic.

Criteria for the final design were defined on three different scales: the scale of the station building, the scale of the station location and the scale of the city (Figure 2.29).

The station building itself should be an attractive building for travellers. The shape of the building should have a positive influence on its surroundings and on the relation between the front and the back of the station. Apart from that, the costs of the building have to be taken into account.

The station location should have a clarifying layout for its users. There should be room for all different traffic flows to function without competing too much. Other matters here are social safety, vitality and the overview of the location and its surroundings for travellers.

A design for a new station will change the street pattern of the city. It will have an effect on car-, bus-, cycle-, and pedestrian-routes through the city. It is important that the design improves the routing
for slow traffic and for public transport. The station area should become better integrated into the urban structure of the city. Apart from that the construction of a new station may have an effect on the monumental old station building. Preservation of this building and preservation of the Wartsila building on the southside on the station is desirable.

### Station Building
- Construction of one extra platform
- Improve bus station
- An Attractive building from the perspective of the travellers.
- Influence of the building (shape) on its surroundings
- Costs of the construction of the new station
- Relation between the front and back of the building

### Location
- Social safety
- Vitality
- Minimal amount of conflict points between traffic flows
- Clarifying layout for its users
- Relation between the front and back of the station
  (by cycle; walking; by car)

### City
- Overview on the location and on the city, when you arrive by train
- Overview on the location from the city (is it easy to find the station?)
- The intervention should cause a positive change of routing through the city (focussing on pedestrians and cyclists)
- Improvement of relation between the location and its surrounding urban structures, compared to the current situation?

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**Figure 2.29 Design criteria (Weeda, 2009)**
PART 3
DESIGN
The third part of this report is about the design for the station area of Zwolle. It consists of two main chapters:

3.1 In which the design process is described;
3.2 In which the final design is explained with the help of drawings about routing, programme and more.

Finally both the design and the process are evaluated.
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3.1 DESIGN PROCESS

In the following paragraphs a few different design models are explained. They cover two different station locations and two different station layouts. The models were tested in Space Syntax. After this, one model was selected to be the basis for the final design.

3.1.1 Station Location
Looking at the relation between the station and the two main destinations, the campus and the city centre, two possible locations...
for a new station were selected (figure 3.1):
1. The location at the end of the Parkstraat, about 250 meters west of the current station. The railway crossing should then be an extension of the Parkstraat.
2. The location of the old station building; with a railway crossing at the end of the Stationsweg, about 80 meters west of the of the current tunnel.

The first location seems to be right in the middle between the campus and the city centre. With this location the walking and cycling distances between the station, the campus and the city centre would decrease significantly (figure 3.2). However, the station is currently located somewhere else. It should be tested whether the benefits of moving the station to location 1 are worth the extra money and effort of moving a station.

3.1.2 Station layout
Two alternative station layouts were tested. With the layout of the station it is important that the station becomes a safe and clarifying place for its users, therefore an underground tunnel is out of the question. An underground tunnel does not provide any overview on the city or on the location, from the perspective of a traveller. Apart from that, with stairs at both ends, a tunnel is unlikely to become a vital place, 24 hours a day.

The tested layouts are two layouts that are very common in the Netherlands.
- Pedestrian tunnel on ground level (figure 3.3). To get rid of the ‘tunnel effect’, the level of the railway will rise up to a railway viaduct. This may cost a lot of money, but it will gain a lot too. The construction of a railway viaduct makes it possible to add railway

- Pedestrian bridge (figure 3.4).
crossings anywhere. The street pattern of the city does no longer have to be interrupted by the railway. Apart from that, there is the opportunity to have facilities like shops and restaurants under the railway, alongside the tunnel. Station layouts like this can be seen in a lot of cities across The Netherlands, like Delft, Rotterdam, Amsterdam and Haarlem.

- Pedestrian bridge (figure 3.4). This is a cheaper and more local solution. On scale of the city this solution provides only one railway crossing, and extra crossings may have to be constructed for bicycles, cars, and busses. However, a pedestrian bridge is a lighter and therefore cheaper construction than a railway viaduct and it can work very clarifying for its users. For instance in Den Bosch the station itself gives travellers an overview of the station location and its position in the city (figure 3.5). Other examples of stations in the form of a pedestrian bridge are the stations of Amersfoort, Dordrecht and the new design for the station of Utrecht.

The two possible station locations and the two layouts together make 4 models for a new station area:

1a A station in the form of a pedestrian bridge on a new location about 250meters west of the current station, at the end of the Parkstraat.
1b A station in the form of a pedestrian tunnel on ground level, located at the end of the Parkstraat
2a A station in the form of a pedestrian bridge located directly on the Westside of the current station.
2b A station in the form of a pedestrian tunnel on groundlevel, located directly on the Westside of the current station.

One of these models is the basis for the final design. Urban qualities of the models, like vitality, social safety and integration in the urban fabric were measured with the space syntax method.
3.1.3 Testing Models with Space Syntax

Space syntax provides ways to calculate the integration of different points in the public space, through sightlines and axes within the public space.

3 concepts for space are used in the Space syntax method:
- Convex space: ‘All points within that space can be joined to all others without passing the boundaries of the space’ (Van Nes, 2009, p.23). This is the space, mostly used for occupation.
- Isovist field: The visualisation of the view of a viewer from a particular standing point.
- Axial lines: Lines that represent the longest and fewest sightlines in the convex space. (A curved street therefore consists of several axial lines). Axial lines represent the space for movement. (Van Nes, 2009)

To measure levels of integration of the different design models the models were tested in four different ways, providing four different maps:
- An axial map; showing the amount of sightlines from different points in the public space.
- An agent map; indicating where people are likely to go.
- A step depth analysis; indicating the integration of specific points in the map. In this case the integration of the front and the back of the station were measured.
- A Visual map; measuring the integration of different points by visualising the view of a viewer on these points.

The results of the analyses were compared with a rating system, going from very low integration (- -) to very high integration (++). Since the integration on the northside and the southside of the station differ in most models, the integration on the northside and the southside of the station are rated separately.
The model in figure 3.10 shows the outcome of the ratings. Apart from the four design models a few other models were tested with one or more of these maps as well. For instance a model that shows the results of an extra bridge across the canal. The space syntax method made clear that with only a few adjustments in the current routing, like opening the Hanzeallee (which is now only accessible for cars) for cyclist and pedestrians, a big improvement can be accomplished (figure 3.10).

Overall the models with the station located at the end of the Parkstraat have higher ratings than the models with the station on the current location. The models 1a, 1b and 2a-rotated have the highest scores.

Model 2a-rotated is the design with a pedestrian bridge at the location of the old station. Only in this model the pedestrian bridge is rotated in a way that it forms and extension of the Stationsweg. With this model the integration of the backside of the station would improve a lot. However, there will not be much different on northside of the station. Apart from that it may be difficult to integrate a pedestrian bridge on the location of the old station without damaging or removing the old station building.

Model 1a is the design with a pedestrian bridge at the end of the Parkstraat. This model causes big improvements on both the north and the southside of the station.

Model 1b is the highest rated design. This is the model for a station in the form of a pedestrian tunnel on ground level, located at the end of the Parkstraat. The actual construction of a railway viaduct on this location may be difficult, because it is located very close to a curve and a splitting in the railway track.

Apart from that, model 1b scores only one point higher than model 1a, while the costs for a railway viaduct will be a lot higher than the costs for a station in the form of a pedestrian bridge. Therefore model 1a appears to be the optimal basis for a new station in Zwolle.
Transforming a Mobility Node In the City of Zwolle

<table>
<thead>
<tr>
<th>Current situation</th>
<th>Axial Map</th>
<th>Agents</th>
<th>Step Depth</th>
<th>Visual Map</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation with a few adjustments</td>
<td>++ ± + ± + ± + ±</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>5+ 0</td>
</tr>
<tr>
<td>Model 1a (Parkstraat/pedestrianbridge)</td>
<td>++ ± + ± ± ± +</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>3+ 4+</td>
</tr>
<tr>
<td>Model 1b (Parkstraat/railwayviaduct)</td>
<td>++ ++ + ± + ±</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>5+ 3+</td>
</tr>
<tr>
<td>Model 1b; tunnel2=rotated (tunnel extends Stationsweg)</td>
<td>+ ±</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>8+</td>
</tr>
<tr>
<td>Model 2b (Stationsweg/railwayviaduct)</td>
<td>++ ++ + ± ± ± +</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>6+</td>
</tr>
<tr>
<td>Model 2b; rotated (tunnel extends Stationsweg)</td>
<td>+ ± + ± +</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>3+ 3+</td>
</tr>
<tr>
<td>Model 2a (Stationsweg/pedestrianbridge)</td>
<td>± ± + + ± ± ± +</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>2+ 3+</td>
</tr>
<tr>
<td>Model 2a; rotated (bridge extends Stationsweg)</td>
<td>+ ± ++ + ± ± ± +</td>
<td>++ ±</td>
<td>++ ++</td>
<td>++ ++</td>
<td>7+</td>
</tr>
<tr>
<td>Model 2a; extra bridge (between Stationsweg&amp;centre)</td>
<td>+ + + + ++</td>
<td>+</td>
<td>++ ++</td>
<td>++ ++</td>
<td>7+</td>
</tr>
<tr>
<td>Model 2a; without building x (space for more linear routing)</td>
<td>+ +</td>
<td>++</td>
<td>++ ++</td>
<td>++ ++</td>
<td>7+</td>
</tr>
</tbody>
</table>

Figure 3.10: Results of the Space Syntax analyses [Weeda, 2009]
3.1.5 To Identify with the City

With the station as the key project the working out of the design begins. The most important next step is to define the identity of the station area and the slow routes connecting the station area with the campus and the inner city. One of the aims of the project is that the identity of the station area of Zwolle relates to the city of Zwolle itself. One of the main characteristics of this city is the nature. Zwolle is a very green city. In 2006 Zwolle was even announced to be the greenest city of Europe (figure 3.11).

The green identity of Zwolle should become a guideline for the design task. The station area should become a green and park-like place in the city. The slow traffic routes to the campus and the city centre should have a green character as well (figure 3.13). Trees and plants can be used to achieve this character on the routes.

From here on the design has been elaborated. The next chapters give an insight in the design itself.
Transforming a Mobility Node in the City of Zwolle

Figure 3.12 Europapark Groningen, idea for a park-like station area (duurzaamstadsgroningen.nl, 2009)

Figure 3.13 Green route, green place, green route (Weeda, 2009)
Figure 3.14 Map of the design (based on: geoloket.tudelft.nl)
3.2 DESIGN

In this chapter the design will be explained. The chapter gives an insight in the overall essence of the design; the routing for all sorts of traffic flows in the new station area; and the programme. More detailed information is shown in the cross-sections at the end of this chapter.

3.2.1 Essence of the Design
The design is based on two main principles:
1. The physical principal of connecting the back and the front of the station by a pedestrian bridge located at the end of the Parkstraat.
2. The characterizing principal of a green place, the station, and two green slow traffic routes connecting this place with campus Windesheim and the city centre.

Figure 3.14 shows the difference between the final design and the current situation. Figure 3.15 shows the map of the final design. The southeastside of the plan, where a lot of extra railwaytracks used to be, is now a continuation of the mixed area that is currently located on the southside of the station. This area consists of new building blocks with mainly housing in them. Housing is needed to create a more vital station area. However, to maintain 24-hour liveliness other functions will also be situated here, for instance offices and cafés alongside the streets. References give an impression of what this area could look like (figure 3.16).

The Westside of the station will be an extension of the campus that is located further in the south. Since the campus Windesheim will grow strongly in the coming years, new facilities will be needed. The old Wartsila shed will be the location of a new library with facilities for students in it, like a multimedia centre, workplaces for students...
Figure 3.16 References for blocks (based on: various sources, see Literature)

Rotown, Rotterdam

Waal Drie

De Hofdame, Rotterdam

Dijklaan, Rotterdam

Figure 3.17 References for public buildings (based on: various sources, see Literature)

De Hofdame, Rotterdam

Sportoase, Philipssite, Leuven

MTV Benelux, NDSM-Wharf, Amsterdam

Rotown, Rotterdam

Sportoase, Philipssite, Leuven
The station is the core of the design area. Corresponding to the city of Zwolle, it should have a green character. The station building could for instance have plants growing on the facades and the roof. Plants, flowerboxes and the use of natural materials could provide the platforms with a green character as well.

The station building will be lifted about 4 meters above ground level. This means that the railway tracks would have to sink about one and a half meters under the ground level, at the location of the station.

The station building has squares (also 4 meters above ground level) on both sides. These squares provide an overview on the location and on the routes to the city centre on the one side and to the campus on the other side. Both squares provide space to park bicycles underneath. The square on the backside of the station will be about 120 meters long, rising from ground level towards the level
of the station itself. Figure 3.21 shows the main programme of this square. A good relation between the interior activities of the Wartsila building and the Westside of the square is essential. This could be realised by outside terraces or exhibitions related to for instance the library or the campus. Terraces are desirable on the eastside of the square as well. Apart from that, transparency of the façades is important. The square should provide a clear look on the location and on the route to the campus. The green identity will be expressed on the eastern half of the square. This part should have a park-like character with a lot of trees and people walking from and to the station. Figure 3.22 shows references for the different parts of the square. The shape of the square itself reminds of the Airport City Plaza in Berlin and the station square of Groningen, which also provides room for bicycles underneath. The façade of the Wartsila building should be rather transparent, with terraces in front of it, as shown in the reference of the Zuidas. The green park-like part of the square could look like the Oerliker park in Zurich or the park in Paris, both shown in figure 3.22.
Figure 3.23 Impression slow traffic route
A slow route, with a green character connects the station with the campus and the city centre. A consistent profile should make the route attractive and recognizable. It consists of a 4-meter broad cycling path, a 4-meter broad pavement and trees on both sides. The strips of trees may have different under layers, like grass or pavement whit street furniture like benches and flower boxes. Figure 3.23 is an impression of the profile at the Parkstraat, figures 3.24 and 3.25 are references for this route.
Figure 3.26 Pedestrian routing (based on: geoloket.tudelft.nl)

Figure 3.27 Bicycle routing (based on: geoloket.tudelft.nl)
3.2.2 Routing
The figures in this paragraph show the routing to and from the station for different traffic flows. Figure 3.26 shows the routing for pedestrians. It consists of the new route, but also existing pedestrian areas like the paths in the park that will be used. On the level of the station itself an extra pedestrian bridge on the eastside of the platforms gives an extra possibility to change trains. Since the station itself has a very decentred position towards the platforms, this extra bridge is needed for an optimal timing for transitions at the station. In addition, the pedestrian bridge is accessible from the street level, functioning as an alternative entrance of the station for instance for people who are brought to the station by car.

The new bicycle route is drawn in figure 3.27. A cyclist should be able to take his bike through the station, to continue his route on the other side. However, it will also be possible for cyclists to use the tunnel that is currently used as the main pedestrian tunnel of the station. This improves the distances between the centre and the campus a lot for cyclists (figure 3.28).

Cars should still be able to come close to the station (figure 3.29). However, a few adjustments should reduce the amount of cars that is currently standing in line in front of the station each day. The second entrance of the station, in the form of a pedestrian bridge, should take some weight off the main entrance of the station. Apart from that several roads around the station will become one-way roads.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Current Situation</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Centre to Station</td>
<td>705m</td>
<td>400m</td>
</tr>
<tr>
<td>(Pedestrian and Bicycle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campus to Station</td>
<td>955m</td>
<td>800m</td>
</tr>
<tr>
<td>(Pedestrian and Bicycle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campus to City Centre Walking</td>
<td>1850m</td>
<td>1330m</td>
</tr>
<tr>
<td>Campus to City Centre Cycling</td>
<td>1995m</td>
<td>1330m</td>
</tr>
</tbody>
</table>

Figure 3.29 Distances slow routes (Weeda, 2009)
Figure 3.30 Taxi and Kiss&Ride strips (based on: geoloket.tudelft.nl)

Figure 3.31 Taxi and Kiss&Ride route (based on: geoloket.tudelft.nl)

Figure 3.32 Bus routing (based on: geoloket.tudelft.nl)
The taxi and kiss&ride places are located both on the northside and the southside of the station. On the southside there is a kiss&ride/taxi strip alongside the station square, on the northside the strip is located next to the secondary entrance of the station (figure 3.30). Apart from the distribution of traffic this is also an opportunity for the old stations square to acquire a new function in the city.

The busstation will be a part of the station itself. Like the trainplatforms, the busplatforms are located under the station, and are accessible from the station building. A busstation with about 28 busstops, which the province aims for, would result in very long walking distances. To make the busstation more user-friendly, a separation has been made between a busbuffer and the actual busstops. Busses can follow two separate routes (figure 3.33). The first route goes through the station, where the bus stops to let passengers in and out. The second route first passes the front side of the station to drop off its passengers, after that the bus passes the busbuffer and then the station itself to pick up new passengers. This way only 12 busstops should be enough for the busstation. These stops can be located within a walking distance of about 70 meters from the actual station.
### Table: Parking Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>P Required</th>
<th>P on Location</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building sportcentre</td>
<td>226</td>
<td>300</td>
<td>74</td>
</tr>
<tr>
<td>Wartsia building</td>
<td>158</td>
<td>24</td>
<td>126</td>
</tr>
<tr>
<td>Building 3</td>
<td>95</td>
<td>2</td>
<td>74</td>
</tr>
<tr>
<td>Flat</td>
<td>106</td>
<td>0</td>
<td>106</td>
</tr>
<tr>
<td>Building 5</td>
<td>28</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>Block 1</td>
<td>182</td>
<td>122</td>
<td>50</td>
</tr>
<tr>
<td>Block 2</td>
<td>182</td>
<td>122</td>
<td>50</td>
</tr>
<tr>
<td>Block 3</td>
<td>104</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Block 4</td>
<td>16</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Block 5</td>
<td>37</td>
<td>30</td>
<td>107</td>
</tr>
<tr>
<td>Streetparking</td>
<td>-</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Parking West</td>
<td>-</td>
<td>164</td>
<td>164</td>
</tr>
<tr>
<td>Front building 1</td>
<td>27</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Front building 2</td>
<td>26</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Front building 3</td>
<td>31</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Front building 4</td>
<td>13</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Front building 5</td>
<td>17</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Front building 6</td>
<td>31</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Former station</td>
<td>17</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>For travellers</td>
<td>-</td>
<td>Total P</td>
<td>364</td>
</tr>
</tbody>
</table>

**Figure 3.34 Locations bicycle parking (based on: geoloket.tudelft.nl)**

**Figure 3.35 Locations car parks (based on: geoloket.tudelft.nl)**

**Figure 3.36 Amounts of parking spaces (Weeda, 2009)**
PARKING
Sufficient bicycle parking is essential in a station area. Places for about 8,800 bicycles are included into the design. The bicycle parkings are located under the squares on both sides of the station (figure 3.34&3.38). From these parkings an entrance to the station should be made.

Figures 3.35 and 3.36 show the amount of car parks needed and provided in the area. The following assumptions were made for the demand of parking places:

- Student dwellings: 1 car per 5 students
- Single family dwellings: 1 car per household
- The two public buildings on the Westside of the station: 1P per 150m2
- Offices and other services: 1P per 200m2

Because it concerns a station area, which is easy accessible by public transport, assumptions for required parking spaces are rather low. The design provides about 370 extra parking spaces for the users of the station. However, a part of the parking spaces could be 'double used'. For instance, households can use carparks that are used for offices during working hours, during the rest of the day.

---

Figure 3.37 References bicycle parking (based on: various sources, see Literature)
Figure 3.38 Cross-section bicycle parking (Weeda, 2009)

---

Figure 3.37 References bicycle parking (based on: various sources, see Literature)
Figure 3.39 Current situation, buildings that would have to be demolished to realise the design (based on: geoloket.tudelft.nl)

Figure 3.40 New situation, new buildings (based on: geoloket.tudelft.nl)

Figure 3.41 Design, floors (based on: geoloket.tudelft.nl)

Figure 3.42 Design, square meters built and demolished (based on: geoloket.tudelft.nl)
3.2.3 Programme

Figures 3.39 to 3.46 show the new programme in the area. To accomplish liveliness in the streets, a distinction has been made between programme on the ground floors (figure 3.44) and programme on the floors above (figure 3.45). The density of the area was calculated with the floor space index (FSI). The floor space index can be calculated with the following formula:

\[ \text{FSI} = \frac{\text{gross floor area}}{\text{plan area}} \]

(Berghauser Pont, 2002)

The gross floor area is indicated in figure 3.43; it consists of the surface of all floors of the building, including the ones under ground level. The grey area in figure 3.43 is the plan area. This area is 28,127.8 m². This results in an FSI of 1.3 (figure 4.46).
### 3.2.4 Detailed drawings

Figure 3.47 is an impression of what the northside of the station could look like. The other figures in this paragraph are sections. They give an insight in the proportions of the design.

<table>
<thead>
<tr>
<th></th>
<th>Square meters</th>
<th>Amount</th>
<th>% of added floor area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwellings (110m²)</td>
<td>65,458</td>
<td>539</td>
<td></td>
</tr>
<tr>
<td>Student dwellings (30m²)</td>
<td>6,272</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>Total dwellings</td>
<td></td>
<td>802</td>
<td>32%</td>
</tr>
<tr>
<td>Library</td>
<td>14,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sport centre</td>
<td>15,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student facilities (est campus)</td>
<td>4,612</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other services (shops, conference centre)</td>
<td>16,113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services total</td>
<td>49,725</td>
<td></td>
<td>22%</td>
</tr>
<tr>
<td>Offices</td>
<td>67,591</td>
<td></td>
<td>39%</td>
</tr>
<tr>
<td>Car parking in blocks</td>
<td>11,858</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Bicycle parking under squares</td>
<td>4,140</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Total added floor area</td>
<td>225,044</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Existing buildings in plan area</td>
<td>136,311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demolished floor area</td>
<td>48,368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total m² gross floor area (BVO)</td>
<td>361,355</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan area m² (without railway tracks)</td>
<td>281,278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSI (gross floor area / plan area)</td>
<td>1,3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Figure 3.46 Programme and density
Transforming a Mobility Node In the City of Zwolle

Figure 3.47 Front of the station

Figure 3.48 Section 1, station
Figure 3.49 Section 2, route Parkstraat, 1/200
Figure 3.50 Section 3, route Hanzeallee, 1/200
Figure 3.51 Section 4, residential area

Figure 3.52 Section 5, stations and squares
Transforming a Mobility Node In the City of Zwolle
3.3 EVALUATION

Criteria for the design were defined on three different scales: the scale of the station building, the scale of the station location and the scale of the city (figure 3.57).

In the current situation the station building does not function as a station building anymore. It is only used as an access route for platform 1. Other platforms are accessible via a tunnel that is situated on the eastside of the building. The new station building gives access to both the platforms of the trains and the busses. The shape of the building accentuates the north-south direction, making the railway tracks less of an obstacle.
The location of the station has shifted about 250 meters to the west, from the end of the Stationsweg to the end of the Parkstraat. The layout of the station has improved a lot. Instead of an underground tunnel, the main pedestrian route now consists of a station in the form of a pedestrian bridge. This type of station gives a good overview on the location and on the routing towards the city centre on the one side and towards the campus on the other side.

Figure 3.53 and 3.54 show the logistical analyses of the current situation and of the design. The new solution for the busstation, as a part of the trainstation itself, has solved a lot of conflict points between busses and other traffic flows like pedestrians and bicycles. Because the road in front of the station has now become a one-way road, it will be easier for pedestrians and cyclists to cross this road. The location of the kiss&ride and taxi place at the secondary entrance of the station will take even more pressure off the road in front of the station.

The design does not entirely meet the criteria set up by the municipality, the NS and the province. Instead of parking space for 10,000 bicycles, the plan only offers parking space for about 8,800 bicycles. More research is needed to test whether this amount will be sufficient, or in what way more bicycle parking spaces can be realized. The designed busstation does not provide the 26 busstops that the province aims for. Because of long walking distances, a bus station with 26 busstops, was not found user-friendly. Therefore the design offers a solution with 17 busstops and a busbuffer.

On both sides of the station there will be space for new facilities that will increase the liveliness of the station area. At the southside the square, with public services like a library and terraces alongside it, offers a lot of potential for a vital station area. On the northside there is less space for new urban design. Here the new route through
the Parkstraat should encourage entrepreneurs to start cafes and other small businesses that focus on the groups of people passing by each day. 

With the design the integration of the station area within the urban fabric of the city improved. Figure 3.55 shows the step depth analyses of the current station. The blue area represents the (most vital) area that can be reached within two steps. While this area is not very small, it covers mostly residential areas in the city. In the new situation (figure 3.56) the blue area stretches out to the bridge over the canal that surrounds the city centre. On the southside the blue area stretches out until a distance of about 100meters from the current location of campus Windesheim. The vitality of the space in-between the campus and the city centre has improved a lot. This offers big opportunities for new developments in this area.

Finally the old station building can be preserved. The second entry of the station is situated next to this building, with a place for taxis and a kiss&ride next to it. With facilities like cafés and restaurants on the ground level of the old station building, and an extension of the conference centre (located on the other side of the road) above this building will get a new meaning in the city. The square in front of the old station building will no longer be occupied by busses and contributes to the new function of the old station building.

Overall this design may not be economically feasible. However, it gives solutions for a lot of problems in and around the station of Zwolle and it shows the potential for the inviting, user-friendly and well-connected station area Zwolle could have.

<table>
<thead>
<tr>
<th>STATION BUILDING</th>
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</thead>
<tbody>
<tr>
<td>Construction of one extra platform</td>
</tr>
<tr>
<td>Improve busstation</td>
</tr>
<tr>
<td>An Attractive building from the perspective of the travellers.</td>
</tr>
<tr>
<td>Influence of the building (shape) on its surroundings</td>
</tr>
<tr>
<td>Costs of the construction of the new station</td>
</tr>
<tr>
<td>Relation between the front and back of the building</td>
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<tr>
<th>LOCATION</th>
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<tbody>
<tr>
<td>Social Safety</td>
</tr>
<tr>
<td>Vitality</td>
</tr>
<tr>
<td>Minimal amount of conflict points between traffic flows</td>
</tr>
<tr>
<td>Clarifying layout for its users</td>
</tr>
<tr>
<td>Relation between the front and back of the station (by cycle; walking; by car)</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>CITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview on the location and on the city, when you arrive by train</td>
</tr>
<tr>
<td>Overview on the location from the city (is it easy to find the station?)</td>
</tr>
<tr>
<td>The intervention should cause a positive change of routing through the city (focussing on pedestrians and cyclists)</td>
</tr>
<tr>
<td>Improvement of relation between the location and its surrounding urban structures, compared to the current situation?</td>
</tr>
</tbody>
</table>

Figure 3.57 Design criteria (Weeda, 2009)
Process
The graduation project consisted of two main tasks: the research and the design. The project started with research about station locations in general and about the station area of Zwolle specifically. In the Urban Regeneration studio, which I attended, the contents and the progress of the research was discussed every week. After about half a year of researching, the design criteria could be defined and the design process started.

The second part of the process consisted of both designing and researching. It started with the making of models for the layout and the location of the station. These models were tested in space syntax. Then one model was selected to be the basis for the final design. From here on the design process became less structured. There were a lot of separate ideas and drawings, but no clear structure or general concept. Eventually the station itself, being the key project in this design, appeared to be the right place to start designing. The concept of the station as a green place and two green slow traffic routes connecting this place to the campus and the city center was the second guideline during this process. Problems during the design process were mostly caused by staring too long at certain places in the area. More variation between different scale levels may prevent these problems in the future.

During the second part of the process there was a certain balance between designing and researching, for instance to evaluate certain design decisions. However, during the first part of the process there was no designing involved at all. This resulted in a bit of delay during the start up of the design process. In the future it may be sensible to start designing during the research, at the beginning of a project. This could come down to the making of several drawings of ideas during the research, so that the design has more time to develop.
LITERATURE
Literature


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Oosten, W., 2000, Railway stations and a geography of networks. TRAIL Proceedings No.6, TRAIL Research School, Delft.

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Figure 3.14. Based on: www.geoloket.tudelft.nl, October 2008.

Figure 3.15. Based on: Google Earth, 2009.


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Figure 3.35. 3.36. Based on: Depthmap, 2008.

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