‘Multimodal location Rotterdam Noordrand’
- Using a Linear Programming model to conduct the optimal strategy for the development of a new central place within the northern part of Rotterdam -

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Master’s Thesis
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I Preface

Throughout my Master studies with the specialisation Real Estate and Housing I encountered many topics, but there were two fields of expertise that caught my attention: project management and urban area development. This Master’s thesis is written within this latter field of expertise and its corresponding graduation lab. Contrary to my expectations during my bachelor in Architecture, the field of urban area development has challenged me in many ways.

This thesis is the result of my research regarding the development of the northern part of Rotterdam, where the City Region Rotterdam and the province of South Holland are developing the North Axis. The North Axis is subject to the comprehensive development of spatial and infrastructural projects. These projects converge in the subarea of Rotterdam Noordrand. I expected that the infrastructural projects, which will interconnect different forms of transportation, would significantly affect their surroundings and provide the area with superb reach ability. However, accessibility alone is not sufficient for area development and a comprehensive approach on an integrated development is in my opinion a necessity.

During my twenty-five years I have been fascinated by all different ways of transportation. Even though I did not encounter the field of urban area development during my bachelor in Architecture and thus only had concise knowledge of this field, it was the aforementioned correlation that caught my attention and stimulated further investigation in this area. Using Linear Programming as a modelling technique for structuring the large and complex area development of Rotterdam Noordrand has been a real challenge. Not only for getting skilled with this technique, but also in convincing others in believing and using the technique.

Several people have contributed to this Master’s Thesis. First of all I would like to express my gratitude to my supervisors at Delft Technical University, Yawei Chen and Rein de Graaf, for guiding me during my graduation research and supporting me with their knowledge. I would also like to thank my supervisors at the Rotterdam Development Corporation, Dennis Damink and Hans Schutjes, for providing me with an environment which partly enabled the completion of my thesis. During my research I was facilitated with everything I needed and supported by their professional input.

I would also like to thank my family, in particular my (grand)parents, for supporting me during my education and last, but certainly not least, Elisa for her unconditional faith and love.

Tom A. Braakman
Amsterdam, June 24 2010
At the northern part of Rotterdam, the City Region Rotterdam and the province of South Holland are creating possibilities to strengthen the economic structure of the South Wing of Randstad Holland. With the launch of the Spatial Plan Region Rotterdam 2020, efforts towards a comprehensive development of this part of the city are made. The area-oriented programme North Axis embodies these efforts and consists of both spatial developments and infrastructural developments. Rotterdam Noordrand is positioned on the interconnection of these infrastructural developments and has adopted the characteristics of a multimodal location: a location that is connected to both a road network and a public transport network.

Rotterdam Noordrand differentiates itself from other development areas by its superb reach ability. The presence of Rotterdam The Hague is a unique selling point and pins down the area at the international map. These characteristics give the area an accessibility quality that is needed to attract and hold the high-quality businesses of Randstad Holland and should ensure economic growth. However, accessibility alone is not sufficient. The spatial developments must enhance a certain spatial quality in order to provide an attractive establishment environment. The spatial developments in Rotterdam Noordrand are being realised on an individual basis, avoiding the comprehensive character of the Spatial Plan Region Rotterdam 2020. A central place within the area is necessary to establish a connection between the segmented sub developments.

The research that is outlined in this thesis concerns three possible central places. It identifies how these locations are influenced by the scheduled infrastructural developments. Linear Programming is used as a modelling technique to structure the complex process of urban area development and conducts a strategy for these central locations. The model is optimised for market quality, spatial quality, means and organisation, referring to the four key elements of an optimal strategy. Subsequently, the strategy is translated into programmatic elements.

The infrastructural influences differentiate two types of central places: those that are positioned in the west of Rotterdam Noordrand adopt an economically orientated identity, while the one in the east adopts a supraregional orientated identity. Therefore, the optimal strategy provides the area with two central places: one in the subarea Rotterdam Airport Business Park and one in the subarea Hoog-Zestienhoven. The comprehensive development of Rotterdam Noordrand is scheduled from 2005 – 2044 and ensures synergy regarding the spatial developments and infrastructural projects.

In addition to this thesis, the Linear Programming model is made operational for the Rotterdam Development Corporation and ready to use in the planning process regarding Rotterdam Noordrand.
### Abbreviations

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<th>Description</th>
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<tr>
<td>BOA</td>
<td>Built-on Area</td>
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<td>CPNR</td>
<td>Comprehensive Plan Noordrand Rotterdam</td>
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<td>CPT</td>
<td>Central Place Theory</td>
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<td>DA</td>
<td>Development Area</td>
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<td>FSI</td>
<td>Floor Space Index</td>
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<td>GFA</td>
<td>Gross Floor Area</td>
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<td>GP</td>
<td>Goal Programming</td>
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<tr>
<td>GSI</td>
<td>Ground Space Index</td>
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<td>HST</td>
<td>High Speed Train</td>
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<td>HVPT</td>
<td>High Value Public Transportation</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IUAD</td>
<td>Integral Urban Area Development</td>
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<td>LP</td>
<td>Linear Programming</td>
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<td>MCDA</td>
<td>Multi Criteria Decision Analysis</td>
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<tr>
<td>Ministry of Housing</td>
<td>Ministry of Housing, Spatial Planning and the Environment</td>
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<td>MIST</td>
<td>Multi-Year Programme for infrastructure, Space and Transport</td>
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<td>NLP</td>
<td>Non Linear Programming</td>
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<td>OSR</td>
<td>Open Space Ratio</td>
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<td>PM</td>
<td>Preference Measurement</td>
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<td>PPP</td>
<td>Public-Private Partnership</td>
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<td>R&amp;D</td>
<td>Research &amp; Development</td>
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<td>RR</td>
<td>RandstadRail</td>
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<td>SPH</td>
<td>Science Port Holland</td>
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<td>SPR2010</td>
<td>Spatial Plan Rotterdam 2010</td>
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<td>SR2020</td>
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<td>SWAP</td>
<td>South Wing Administrative Platform</td>
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Chapter 1 Introduction

1.1 Background

The region of Rotterdam is located at the intersection of two networks that determine to a large extent the spatial economic development of the western part of the Netherlands: the Rhine-Scheldt Delta (Rijn-Schelde Delta) and Randstad Holland. The Rhine-Scheldt Delta consists of the area starting at the harbour of Rotterdam down to the harbour of Antwerp in the east, going up to Breda and Moerdijk in the west. It is a logistic and industrial network of international importance and an enormous source of employment within the region of Rotterdam. Randstad Holland is the largest urbanised area of the Netherlands and contains the four biggest cities of the country: Amsterdam, Rotterdam, Utrecht and The Hague. It is one of the most important urban concentrations in Europe. The economies of Randstad Holland are strongly driven by knowledge intensive businesses, which is a growing economic sector. Rotterdam is located within the South Wing (Zuidvleugel) of Randstad Holland. Its economic performance is seriously lagging behind in comparison with the North Wing (Noordvleugel) and the eastern part. For example, Amsterdam is developing economic centres in South East Amsterdam and at the South Axis (Zuidas), while Utrecht is developing business location Papendorp towards the west. These developments are positioned at the inner flank of the Randstad Holland network.

Economic growth mainly takes place in knowledge intensive and creative sectors. Due to the dominant position of the Rhine-Scheldt Delta, Rotterdam should focus inter alia on diversification of its economic structure. At the northern part of the city, the position of business services and knowledge intensive businesses could be strengthened, since it is strategically located along the inner flank of Randstad Holland. Especially the presence of Rotterdam Airport could serve as a catalyst for attracting these business sectors to the area.

Already in the 1980s, the Rotterdam city council acknowledged that the current economic structure was not sufficient. For many decades the development of the northern part of Rotterdam has been subject to discussion. These plans will be discussed below.

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1 Projectorganisatie RR2020 2005, p. 11.
2 The most important urban concentrations in Europe consist of (i) Greater London (GB), (ii) the Paris metropolitan area (FR), (iii) Randstad Holland (NL), (iv) the Rhine-Ruhr metropolitan region (DE), and (v) the Flemish Diamond (BE).
3 The South Wing region of Randstad Holland covers the regions around Leiden, The Hague, Rotterdam, Dordrecht and Gouda. The North Wing region of Randstad Holland covers the regions around Haarlem, Zaanstad, Amsterdam, Hilversum and Almere. Utrecht is located at the eastern part of the Randstad Holland network (Otgaar 2008, p. 167).
1.1.1 Comprehensive Plan Noordrand Rotterdam (1972 – 1994)

The first initiative for the development of the northern Part of Rotterdam was in 1972. The Rotterdam city council indicated its wish to reallocate polder Zestienhoven into a building location. Such a reallocation would however increase the risk of closure of Rotterdam Airport, which occupies a great amount of space in the desired development area. In the 1980s the Rotterdam city council recognised the economic importance of the airport which resulted in a dead-end situation since closure of the airport was no longer an option. Consequently, a study on relocating Rotterdam Airport to polder Schieveen, situated north of its current location, started and the Comprehensive Plan Noordrand Rotterdam (Integraal Plan Noordrand Rotterdam, ‘CPNR’) was launched. It consisted of among other things: (i) the relocation of the airport, (ii) the realisation of a new A13/A16 highway in order to extend the highway network surrounding Rotterdam, and (iii) concepts regarding an increase of the awareness of and appreciation for the valuable environmental elements present in the area. In the CPNR, all elements were connected with each other. The runway of the airport would for example serve as a roof for the A13/A16 highway tunnel, leaving the environment unharmed.

The part of the plan that concerned the relocation of the airport was rejected by the Dutch government. The government was of the opinion that Rotterdam did not need an airport with night flights and therefore its current location in polder Zestienhoven would suffice. Furthermore, according to the Ministry of Housing, Spatial Planning and the Environment (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, ‘Ministry of Housing’), an investment of this scale did not outweigh the impacts that it would have on the surrounding environment.

After the new elections of the Rotterdam city council in 1994, the majority of the city council voted against the realisation of a new airport in polder Schieveen. Since all elements were integrated with each other, the voting outcome meant a rejection of the whole CPNR.

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6 This transformation from rural land into built-on land is called ‘greenfield development’.
7 Internet 1.
8 Craenen 2001, p. 6.

In 2001, the Rotterdam city council adopted a new approach for the northern part of the city. This approach was part of the Spatial Plan Rotterdam 2010 (Ruimtelijk Plan Rotterdam 2010, ‘SPR2010’). It embodied the vision of the Rotterdam city council concerning the whole city, with the exception of the harbour area. The northern part of the city – the former CPNR development area – was titled ‘Noordrand’ and was considered to be a strategic area within the spatial plan. As mentioned in the beginning of this chapter, this area is where Rotterdam has the opportunity to establish a connection with the economies of Randstad Holland. The developments within the Noordrand dealt with comparable elements similar to the CPNR, but excluded a relocation of Rotterdam Airport. Furthermore, contrary to the CPNR, all elements could be realised independently. Therefore, if one element would be rejected, the other elements could still be developed. The so-called Noordrand project consisted of four core elements:

1. Polder Zestienhoven: a greenfield development of a new residential area in an attractive green and watery setting in order to attract moderate to high income groups.

2. Rotterdam Airport: a brownfield development of a high-quality office location Rotterdam Airport Business Park. According to the province of South Holland (provincie Zuid Holland), the development of Rotterdam Airport participates in the Science Port Holland (‘SPH’) project. The SPH project, also known as the ‘A13 Boulevard of Knowledge’, enhances the collaboration between the municipalities of Rotterdam and Delft, Rotterdam Erasmus University and Delft Technical University. The universities present themselves as the axis in one of the most powerful concentrations of technological activity and research in Western Europe. The development of SPH is of supraregional importance since the whole economy of the South Wing of the Randstad Holland network will profit of the presence of this leading knowledge infrastructure. The project will be realised in the shape of business parks for (i) Research & Development (‘R&D’) businesses, (ii) Information and Communication Technology (‘ICT’), (iii) innovative business services, (iv) medical businesses, and (v) airport related activities.

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10 Otgaar 2008, p. 177-179.
11 The numbers of these core elements correspond with the numbers in Figure 1.2.
12 The (re)transformation of built-on land is given the expression ‘brownfield development’.
13 Rotterdam Airport Business Park was formerly known as the RTM Airpark.
14 Internet 2. Note that the SPH-website does not indicate Rotterdam Airport Business Park as one of its subprojects (Internet 3).
3. Highway A13/A16: a new highway connection that will run right through the Noordrand and will play an important role in releasing the pressure on the congested highway network surrounding Rotterdam.

4. Polder Schieiveen: a greenfield development of Nature- and business park Schieiveen. This development combines the development of a science & business park (for knowledge-intensive high-quality businesses) with the development of nature reserves. The science & business park Schieiveen is part of SPH.\(^{15}\)

Pursuant to the SPR2010, apart from these four core elements, the area will be connected with the public transport network by creating the new hybrid light rail system RandstadRail ('RR') in the area. Compared to certain present train connections, this hybrid light rail system establishes a faster public transport connection between the cities of Rotterdam and The Hague. Furthermore, the new High Speed Train (Hogesnelheidslijn, 'HST') will cross the polder Zestienhoven. It is a fast connection between Amsterdam, the national airport Schiphol Airport and Rotterdam. It is expected that the HST will in the future replace the Benelux-train\(^{16}\) and lengthen its services to Antwerp and Brussels. At Brussels one can continue to *inter alia* England, France, Germany and Switzerland. The crossing of polder Zestienhoven will be realised by using a tunnel in order to avoid negative influences on the future developments that will take place.\(^{17}\)

1.1.3 *Spatial Plan Region Rotterdam 2020 (2005 – present)*

In 2005, the SPR2010 was replaced with another plan for the northern part of Rotterdam. Different than the two previous proposals, Rotterdam was not the only initiator. This new plan was the joint product of the City Region Rotterdam (Stadsregio Rotterdam) and the province of South Holland. Together they launched the Spatial Plan Region Rotterdam 2020 (*Ruimtelijk Plan Regio Rotterdam 2020*, 'SR2020'). It was formally accepted on the 12\(^{th}\) of October 2005 as the regional structure plan by the regional council of the City Region Rotterdam. The SR2020 comprises five area-oriented programmes, which need to be completed in the upcoming years. One of the programmes is the North Axis ('Noordas') at the northern part of Rotterdam. Compared to the Noordrand within the CPNR and the SPR2010, the development area of this programme covers a much larger area. In addition to the elements of the Noordrand project, the programme includes among other things (i) the project of the highway A4-north, (ii) the reallocation of the Zuidplaspolder (the area between Rotterdam and Gouda) to a residential and business district, and (iii) some small scale projects.\(^{18}\)

\(^{15}\) Otgaar 2008, p. 182-183. Note that science & business park Technopolis Innivation Park Delft is also part of SPH.

\(^{16}\) The train connection between Belgium, the Netherlands and Luxembourg.

\(^{17}\) Gemeente Rotterdam 2003a, p. 1.

1.1.4 Rotterdam The Hague Airport (2010)

During the realisation of this thesis, the name of Rotterdam Airport was amended. As of the 10th of February 2010 the airport was named ‘Rotterdam The Hague Airport’. Both mayors of Rotterdam and The Hague, the manager of Rotterdam Airport and the chief executive officer of Schiphol Group laid down this amendment in a covenant. Apart from the change of name, agreements were made regarding the realisation of a shuttle service between that will connect Rotterdam The Hague Airport with the supraregional RR-stop.\(^19\)

Rotterdam and The Hague work together as Metropolitan Region Rotterdam – The Hague (\textit{Metropoolregio Rotterdam – Den Haag}) in order to strengthen the economic establishment environment in the South Wing region of the Randstad Holland network. The change of name provides a larger part of the region with an international identity and should result in attracting more international industries and organisations.\(^20\)

1.2 Research focus: Rotterdam Noordrand

The research of this thesis is focussed on the former Noordrand project, as described in the previous section. This area is part of the North Axis programme of the SR2020 and in this thesis referred to as ‘Rotterdam Noordrand’. Rotterdam Noordrand will among other things enhance spatial developments within the areas of (i) polder Schieveen, (ii) Rotterdam The Hague Airport, and (iii) polder Zestienhoven. In my opinion, the area of Rotterdam Noordrand is an attractive research area due to large investments that are being made on an infrastructural level, such as.\(^21\)

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\(^{19}\) Two RR-stops will be realised in the northern part of Rotterdam; one will be supraregional orientated and the other will be locally orientated. This will be further elaborated in section 1.2.

\(^{20}\) Internet 4.

• the realisation of the high speed train HST;
• the realisation of the A13/A16 highway connection;
• the reconstruction of parts of the A13 and A20 highways into ‘city highways’;
• the realisation of the light rail system RR as a fast connection between Rotterdam and The Hague;
• the realisation of the bus connection ZoRoBus between Zoetermeer and Rotterdam;\(^{22}\)
• the reconstruction of the N470 G.K. van Hogendorpweg; and
• the reconstruction of the N209 Doenkade.

As stated in the previous section, these investments are made to attract the knowledge intensive businesses of Randstad Holland and SPH. They are supposed to enhance the development potential of the area by its improved reach ability. The A13/A16 highway connection, which will run right through Rotterdam Noordrand, will directly connect the area with the national highway network.\(^{23}\) The presence of the HST and Rotterdam The Hague Airport contributes to the international character of the area. Additionally, the RR and the ZoRoBus connect the area with the other areas of the region.

Rotterdam Noordrand will enhance two infrastructural junctions, both positioned in the subarea Polder Zestienhoven The first is situated in the south of the subarea, surrounding the RR-stop ‘Melanchtonweg’. This junction has adapted a local orientated development strategy. The second junction is located in the north of the subarea and can be described as a supraregional orientated junction.\(^{24}\) This latter junction is located nearby the RR-stop ‘Meijersplein’, on the actual junction of all infrastructural investments within Rotterdam Noordrand. It carries the name of ‘infrastructural junction Rotterdam Airport’. In addition to the presence of Rotterdam The Hague Airport, this junction differentiates itself from other development areas in the Netherlands by its superb reach ability.

In 2007, the developments of polder Zestienhoven were started and the beginning of the development of polder Schieveen is scheduled in 2011.\(^{25}\) The development of the post-war residential area South Schiebroek, which is directly connected to the junction, was already in progress since 2005.\(^{26}\)

A study on relocating the passenger terminal of Rotterdam The Hague Airport towards the eastern side of the airport area was still in progress when the developments of polder

\(^{22}\) During this research the route of the bus line is changed into Zoetermeer-Rodenrijs. At Rodenrijs one can change onto the RR. Coincidently the bus line did not need a name change: Zoetermeer-Rodenrijs (ZoRoBus).
\(^{25}\) During the achievement of this research the developments of polder Schieven were postponed with 5 years.
\(^{26}\) Gemeente Rotterdam 2007b, p. 7. The developments in South Schiebroek only exist of small-scale residential redevelopments; therefore this area is not an object of this research.
Zestienhoven started. The relocation would directly connect the infrastructural junction with the terminal. Furthermore, it was uncertain whether a station of the HST would be realised. Therefore it was decided to develop the actual location of the supraregional junction – the subarea of ‘Hoog-Zestienhoven’ – in 2015. Eventually, the relocation was rejected. Consequently, the terminal will be connected to the public transport system by the use of the shuttle service, as stated in the covenant.

It seemed rather unusual to me that the development of the area where the majority of the people will enter Rotterdam Noordrand by public transportation is scheduled last. Especially since this area could serve as a catalyst for the economic developments and could ensure the most revenues. Furthermore, being a part of the SR2020 programme, the development of Rotterdam Noordrand should follow the rational ideas behind this programme: an integral approach on the fields of environment, economy and the realisation of real estate for both residential, economic and accommodation use. The area surrounding the supraregional junction could serve as the connector between the segmented subprojects. It could fulfil the role of a central place within Rotterdam Noordrand and at the same time result in an integral area development where Rotterdam is craving for.

1.3 Aim and outline of the thesis

After several discussions in relation to the developments within Rotterdam Noordrand with Mr. D. Damink (area manager North Rotterdam, department of Area Development) and Mr. J. Schutjes (staff member, department of Strategy) of the Rotterdam Development Corporation (Ontwikkelingsbedrijf Rotterdam, ‘RDC’), it became apparent to me that the focus of RDC is on the economic aspects of the project: the office and industrial locations of Rotterdam Airport Business Park and science & business park Schieveen. While the initial scope of my research mainly concerned the development of Hoog-Zestienhoven, this discovery broadened my research to the whole development area of Rotterdam Noordrand. This area is in need of a central place that ensures the comprehensive character of the overlapping SR2020-programme. Such a central place should profit as much as possible from all present and future infrastructural projects as described in section 1.2. These specific qualities enormously influence the way in which the area will distinguish itself from other (development) areas. Its ‘unique selling points’ contribute to the identity of the whole Rotterdam Noordrand area and Rotterdam and have led to the aim of this thesis:

27 Gemeente Rotterdam 2003a, p. 2.
28 This concerns the covenant regarding the name change towards Rotterdam The Hague Airport, mentioned in section 1.1.
30 The developments of polder Schieveen, Rotterdam The Hague Airport and polder Zestienhoven are each carried out under supervision of separate project leaders. It was not until 2010 that an overall project leader was installed to integrate the developments with each other apart from the structure plan SR2020 (RDC).
‘Conduct the optimal strategy for the realisation of a new central place within Rotterdam Noordrand. Apart from connecting the segmented developments that are scheduled in the programme, the strategy must take into account all present and future infrastructural projects.’

The expression ‘optimal’ indicates that the strategy eventually intends to take into account (i) market quality; (ii) spatial quality; (iii) available means; and (iv) organisation.31 The optimal strategy will be presented as a phased design that will concern the comprehensive programmes of the Rotterdam Noordrand developments. Due to the fact that the development of the area finds itself in the beginning of the process, the optimal strategy can serve as an instrument for the RDC in the planning and negotiations of Rotterdam Noordrand.32 In addition, the RDC will be presented a Linear Programming model that is theirs to use in further negotiations concerning the area.33

In agreement with my supervisors at Delft Technical University and the RDC, three possible central places for Rotterdam Noordrand were defined:

- The first phase of science & business park Schieveen
- The Landzijde terrain of Rotterdam Airport Business Park
- The area of Hoog-Zestienhoven, surrounding the supraregional infrastructural junction

In order to effectuate the aim of this thesis, it is necessary to analyse the different levels of influence that the infrastructural projects may have on the possible central places; one must identify the possibilities and threats. Therefore, the following research question is of importance:

1. **On which level do the infrastructural projects in Rotterdam Noordrand, which converge at the infrastructural junction Rotterdam Airport, influence the three possible central locations?**

This research question is addressed in chapter 3 (Infrastructure and spatial planning). In this chapter first the government policy on a comprehensive approach on both infrastructural developments and spatial developments will be outlined. Second, a differentiation will be made between types of infrastructural junctions. Rotterdam Noordrand will be identified as a multimodal development location and the contribution of the infrastructural influences to the central places’ identities will be structured. The outcomes of this first research question contribute to the boundary conditions that can be set regarding the content of the central places. Additional boundary conditions have to be determined in order to conduct a realistic development strategy. Consequently, the following research question is of significance:

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31 The definition of ‘optimal strategy’ will be elaborated in chapter 4.
32 The RDC provided me with an internship to carry out this graduation research.
33 The method of Linear Programming will be explained in chapter 5 of this thesis.
2. Which boundary conditions are to be set regarding the Rotterdam Noordrand development area and can the characters of these boundary conditions be distinguished?

This research question is addressed in chapter 4 (Boundary conditions Rotterdam Noordrand). The chapter first provides a definition of integral urban area development and identifies the four key elements of the optimal strategy. Second, an elaboration of the four core elements that represent the framework of urban area development will be given and the four-vertex research model is presented. Generating the optimal strategy for the development area means that each of the four focus elements has to be optimised. Such an optimisation provides the vertexes of the solution space. Hence, the following research question is relevant:

3. What are the cause-effect potentials for the possible central places due to the focus on each single element? And how do these potentials affect the surrounding area?

This research question is addressed in chapters 5 (Usage of modelling techniques) and 6 (Linear Programming model Rotterdam Noordrand). Chapter 5 first introduces a systematic approach and the use of modelling techniques as tools for structuring the complex character of urban area development. Second, the different types of mathematical modelling techniques that could be used in this research are elaborated. Chapter 6 first provides a description of the construction of the Linear Programming model that is used as a method in this thesis. Second, the optimisation conditions are given and the strategy is optimised for the four key elements.
1.4 Research methods used in this thesis

In order to pursue in the aim of this thesis, I will make use of several methods to carry out the research. In the first part of this thesis I will use theoretical analysis to gain clear insight on two elements within the Rotterdam Noordrand development area. First, the current mismatch between infrastructure and spatial planning will be analysed in order to obtain more knowledge of the present problems and potentials of the research area. The analysis will provide a framework wherein the influences of the infrastructure for the area and its new central place can be identified.

Second, theoretical analysis will be used for the complex character of urban area development. In order to set the boundary conditions for the required optimal strategy it is important to explore the literature on this field. Obtaining a clear framework on urban area development is necessary for the development of a research model that can be used during the practical part of this research. For the theoretical analyses I refer to chapters 3 and 4 of this thesis.

For the second part of this research I will make use of the mathematical modelling technique Linear Programming in order to structure the complex characteristics of the Rotterdam Noordrand development area. Information that was relevant for this thesis could be found in policy documents and zoning plans. By transforming this relevant information and applying it on the previously mentioned research model, constraints are determined by the model maker. The eventual optimal strategy that is hidden within the Linear Programming model has to meet these constraints in order to give a credible view of the reality.

The key elements of the optimal strategy can also be transformed into constraints, which the model has to satisfy. This method of using a mathematical model to solve a complex urban area development problem provides a clear and structured overview of the development. In addition, the model is very flexible. A change in the constraints is directly accounted for and therefore it can be very useful as a tool to explore the possibilities of the development of an area. Furthermore, the user of the model can determine its focus. The model can therefore be optimised for a specific variable, over and over again.

However in this context I must state that the use of a mathematical model in order to solve urban area development problems is merely a tool. The model maker cannot directly translate reality or
process subjective elements, but he can structure used the information for creating the model’s constraints.

1.5 Organisation of the thesis

Chapter 2 gives a descriptive overview of the subareas of the Rotterdam Noordrand developments. Their location and current situation are followed by the spatial development plans for each area. Chapter 3 – 6 are briefly described in section 1.3. In chapter 7, general conclusions regarding the aim of the thesis are drawn and the optimal strategy is conducted. Furthermore the usage of Linear Programming for complex urban area development problems is discussed. The chapter ends with pointers for further research. Also note the appendices of this thesis; where necessary, reference will be made to the relevant appendix.
Chapter 2 Development area Rotterdam Noordrand

In section 1.2 I remarked that the development area of Rotterdam Noordrand enhances spatial developments within the areas of (i) polder Schieveen, (ii) Rotterdam The Hague Airport, and (iii) polder Zestienhoven. Taking into account the scope of this research, it is important to carefully describe the contents of the focus area of the thesis. Therefore, in the following sections the subareas are positioned, their initial situation is specified and their future developments are outlined. In this respect, use has been made of zoning plans and location based documents.

2.1 Polder Schieveen

2.1.1 Location and boundaries

Polder Schieveen covers an area of 454 hectare between the urbanised areas of Rotterdam, Berkel en Rodenrijs/Lansingerland and Delft. The development area is located north of Rotterdam The Hague Airport, and is bordered by the (i) the ‘Zwethkade’ (northern border), (ii) the ‘Oude Bovendijk’ (eastern border), (iii) the ‘N209 Doenkade’ (southern border), and (iv) the ‘A13 highway’ (western border).

2.1.2 Initial situation

The area of polder Schieveen is primarily used for agriculture (pastures). The majority of the buildings in the area is positioned at the Oude Bovendijk. Currently, the development area contains approximately 56 residences. These residences are for the greater part not related to agricultural functions. In addition, the development area contains 14 farming estates (husbandry,

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34 A hectare covers an area of 10,000m².
35 The northern border of polder Schieveen is also the municipal border.
gardeners and greenhouses). Some of these farming estates will end their industry due to future developments. Furthermore, a small amount of non-agricultural functions is established in polder Schieveen.

Apart from an urban function, polder Schieveen has a significant ecological function. The polder is, as a breed and foraging area, an important area for meadow birds. It forms a connecting factor in the complex of polders and peat land, which is ‘saved’ from the urbanised network The Hague – Delft – Rotterdam. This complex is one of the three big rural landscapes in the southern part of Randstad Holland. However, due to the upcoming urbanisation and transformation of other types of nature (with a more closed character), the amount of polders and peat land is reducing.

2.1.3 Nature- and business park Schieveen

In polder Schieveen the municipality of Rotterdam develops, in cooperation with several parties, a free accessible nature reserve, a science & business park and a small amount of residences. The cooperating parties are: (i) the Society for Preservation of Nature Monuments (Vereniging Natuurmonumenten); (ii) the province of South Holland; (iii) the City-Region Rotterdam; (iv) the Delfland Water Board (Hoogheemraadschap Delfland); and (v) the sub municipality of Overschie. Not the whole polder will be developed. The final result should cover 200 hectare of nature reserves, 90 hectare of business park and 28 residences. In addition, 12 hectare will be reserved for the realisation of the A13/A16 highway connection. The development is titled ‘Nature- and business park Schieveen’.  

The municipality of Rotterdam positions Nature- and business park Schieveen as the working environment of the future. Its strength is caused by the combination of nature development and accessibility. All large cities within the Randstad Holland network are reachable within one hour by car or public transport. Furthermore, Rotterdam The Hague Airport connects the area with European cities.

The business park aims explicitly for high-quality knowledge intensive businesses and therefore the expression ‘science & business park’ is more appropriate. These businesses are dependent on mutual cooperation and in need of an environment that can attract and hold the

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36 Gemeente Rotterdam 2009, p. 18.
higher educated, enhancing the quality of life. The municipality of Rotterdam is realising such environments within the city, but many of these types of businesses are in search of a green environment. In this respect, science & business park Schieveen provides a high-quality package: a green lay-out, architectural quality and adjacent nature development. Such a science & business park will have a larger component of offices than traditional industrial areas. Schieveen is positioned as a promising area that will strengthen the northern part of Rotterdam regarding economic, ecological and recreational facets. Participation in the SPH collaboration should realise the connection with the Randstad Holland economies, as described in section 1.1.

The total development of science & business park will comprise 600,000m² Gross Floor Area (Bruto Vloer Oppervlak, ‘GFA’). Furthermore, 2,000 full-time employees are expected for the year 2018.

Apart from the science & business park, Rotterdam is in need of nature and recreational space within cycling distance from the city centre. Polder Schieveen is part of the provincial plan Green-blue Swing (Groen-blauwe Slinger), which connects the rural areas of Midden-Delfland and the Green Heart (Groene Hart) with each other. Polder Schieveen will also become an essential link in the Green Carpet (Groene Loper), a recreational and ecological connection from the Bergse Plassen towards the Ackerdijkse Plassen and Midden-Delfland.

### 2.2 Rotterdam The Hague Airport

#### 2.2.1 Location and boundaries

Rotterdam The Hague Airport covers an area of 22 3hectare and is located north of Rotterdam, between the development locations of polder Schieveen and polder Zestienhoven. The airport is actually located in the latter polder but in this research it is considered to be a separate area due to the fact that it has its own zoning plan. The development area of Rotterdam The Hague Airport is bordered by the ‘N209 Doenkade’ as northern border. At the eastern, southern and western side, the boundaries follow the border of the airport terrain as set in the Aviation Act (Luchtvaartwet). At the eastern side this border is located at the ‘Bovendijk’. At the current industrial area ‘Hoog Zestienhoven’, the border shifts towards the west. At the southern side, the

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38 Note that the component of offices in the science & business park is smaller if compared to office parks.
40 The provincial board of South Holland is committed to create unceasing nature and recreational reserves in the S-shaped open space between Rotterdam and The Hague. With the Green-blue Swing, the province intends to keep these areas green and to expand them with nature reserves and recreation. The Green-blue Swing consists of five green subareas: (i) ‘Land van Wijk en Wouden’; (ii) ‘Balij en Bieslandse Bos’; (iii) ‘Groenzone Berkel-Pijnacker en Bergboezem Polder van Oude Leede’; (iv) ‘Oude Leede’; and (v) ‘Midden-Delfland’ (Internet 5).
41 The Green Heart forms the courtyard of the Randstad Holland Network. It is an open space surrounded by big cities such as Amsterdam, Rotterdam, The Hague and Utrecht (Internet 6).
border is located at the canal (positioned in line with the ‘Woensdrechtstraat’). At the western side, the border is located at the ‘Vliegveldweg’ (figure 2.4).

2.2.2 Initial situation

When taking the amount of travellers in consideration, Rotterdam The Hague Airport is the second largest regional airport of the Netherlands after Eindhoven Airport. In its first 50 years of existence, Rotterdam The Hague Airport has been of great importance for the regional economic developments. This was only firstly detected by the city council in the 1980s (section 1.1). In the 1990s the airport profiled itself as a business airport by offering regular services to several European business centres. In addition, there was space for privately owned business air traffic and vacation flights. Due to the increasing popularity of air traffic as a fast, safe, environmental friendly and profitable way of transport, the importance of the airport is expected to increase in the upcoming years. In an international active region such as the South Wing of the Randstad Holland network, accessibility from foreign countries is an important factor. Rotterdam The Hague Airport supports not only international orientated firms, but also (governmental) agencies and organisations in their activities.

The airport is a crucial establishment factor that contributes to the unique selling points of the region. However, in order to attract international and high-quality businesses, the amount of the current buildings is insufficient and their state inadequate.

2.2.3 Rotterdam Airport Business Park

Travelling through Rotterdam The Hague Airport is gaining popularity, which is caused by the benefits of the airport for its customers. ‘Good reach ability’, a ‘rapid handling of passengers and baggage’, ‘parking nearby’, ‘excellent facilities’ and a ‘five star service’ are some advertisement expressions off the airport. Furthermore, acknowledged airline companies offer a broad range of

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Note that Amsterdam Schiphol Airport has been disregarded, as it is a national airport.
European business destinations. These advantages result in developing potentials not only for the airport itself, but also for its surrounding areas.

Rotterdam Airport Vastgoed B.V., a private limited company (besloten vennootschap) which is the collaboration between Rotterdam Airport and Schiphol Real Estate, develops ‘Rotterdam Airport Business Park’ at the territory of the airport. The planning for this dynamic and international business park will be done jointly with the municipality of Rotterdam. The high-quality business park will host over 200,000m$^2$ GFA of offices and industrial space. In the future, both the desired green environment and facilities of the business park will provide a link with Rotterdam.

As stated, these developments will take place at the territory of Rotterdam The Hague Airport, an area with a surface of 223 hectare. The territory is in fact property of Schiphol Real Estate and therefore this actor also has an important position in the developments.

The development area of Rotterdam Airport Business Park is divided into two subareas: (i) ‘Luchtzijde’, an area of 172 hectare where a maximum of 23,500m$^2$ GFA will be realised, and (ii) ‘Landzijde’, an area of 51 hectare where a maximum of 206,500m$^2$ GFA will be realised.

2.3 Polder Zestienhoven

2.3.1 Location and boundaries

Polder Zestienhoven is located at the northern part of Rotterdam within the sub municipality of Overschie. The area is positioned between (i) Rotterdam Airport (north); (ii) the urbanised area of Overschie (east); (iii) the area ‘Overschiese Kleiweg en omgeving’ (south); and (iv) the urbanised areas of Schiebroek and Contramal (west).

Polder Zestienhoven is bounded at the northern side by the first part of the ‘N209 Doenkade’ and subsequently by the border of the Rotterdam The Hague Airport territory. Moving along this border, the northern boundary ends at the ‘N470 G.K. van Hogendorpweg’. Here it is attached with the eastern boundary that is located in the middle of the N470, right at the sub municipal

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43 Rotterdam Airport Vastgoed BV 2005.
borders of Overschie and Hilligersberg/Schiebroek. At the southern side the area is bounded by the water surface north of the ‘Achterdijk’. It crosses the ‘Overschiese Kleiweg’ and runs across the sports fields and allotments (volkstuinen). Subsequently, the border goes west and includes the ‘Achterdijk’. At the lakes of Overschie Plasjes the border is positioned even more to the west and is attached to the ‘A13 highway’. The border is equivalent with the highway until the connection with the ‘N209 Doenkade’ (figure 2.7).

2.3.2 Initial situation

The area of polder Zestienhoven can be divided into four subareas: (i) ‘Overschiese Plasjes en omgeving’; (ii) ‘Laag-Zestienhoven’; (iii) ‘Midden-Zestienhoven’; and (iv) ‘Hoog-Zestienhoven’.

Overschiese Plasjes en omgeving has a primarily green character. Within this green environment, some separate residential enclaves and buildings are positioned. Laag-Zestienhoven consists jointly with Midden-Zestienhoven primarily of (abandoned) sports fields and a park. Many sports fields had to move due to the realisation of the tunnel for the HST, which crosses the area. However, the recreational function is still present in the areas. Apart from the remaining sports fields, the areas contain many allotments. Hoog-Zestienhoven mainly consists of an industrial area. The industrial functions are for the benefit of the heavier industries. For example, a large amount of the area is made available to the Dutch Petroleum Company (Nederlandse Aardolie Maatschappij), the joint venture of Shell and ESSO.

The industrial functions are surrounded by a green area, which is put in to use at the northwest side as a horse riding school. Completely north of the area, attached to the grounds of Rotterdam The Hague Airport, another allotment complex is located.
2.3.3 Park Zestienhoven

The development area within polder Zestienhoven is titled ‘Park Zestienhoven’. It consists of the subareas Laag-Zestienhoven, Midden-Zestienhoven, and Hoog-Zestienhoven that are mentioned in the previous section. Park Zestienhoven covers an area of 200 hectare and the desired programme consists of residences for the moderate to high income groups, industrial functions, green, water and recreational, retail and communal facilities.

Laag-Zestienhoven, an area of 102.4 hectare, will be part of the Green Carpet, and is therefore projected as a low-density rural residential area (villamilieu). Midden-Zestienhoven, an area of 36.3 hectare, is projected as a medium density mixed-use area containing residences, industrial functions and several facilities. Linked to the developments that are going to take place regarding Rotterdam Airport Business Park, a total of 7.5 hectare is reserved for industrial functions.

Hoog-Zestienhoven is projected as a high density mixed-use area. As pointed out in section 1.2, initiatives for the development of this final subarea of polder Zestienhoven are not expected before 2015, when the current zoning plan loses its validation.

It is certain that a new main disclosure road between the supraregional junction and the terminal of Rotterdam The Hague Airport will be constructed. This road, that carries the name

Figure 2.9 Artist impression of Park Zestienhoven
Source: Internet 8

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44 Note that the subarea of ‘Overschiese Plasjes en omgeving’ is not part of the development area.
45 Note that the realisation of residences for the moderate to high income groups follows from the principles regarding the enhancement of quality of life, outlined in section 2.1.3.
46 JM 2007/87.
47 Please refer to section 4.2.2 where it is noted that the generality of a zoning plan is not affected by its time span of ten years. Therefore this subarea is not accounted for in the zoning plans and location based documents and consequently is not linked to a specific programme.
‘Zanderijweg’, divides Hoog-Zestienhoven in two areas. In this thesis these areas are titled (i) Hoog-Zestienhoven South and (ii) Hoog-Zestienhoven North.\textsuperscript{48}

\textsuperscript{48} Note that the Zanderijweg follows the similar route as the projected shuttle service.
Chapter 3 Infrastructure and spatial planning

The future infrastructural activities within Rotterdam Noordrand deserve special attention. Both physical and virtual accessibility has become a crucial development condition for almost all social activities. \(^{49}\) In fact, it is one of the most important conditions for a country’s economic vitality and for the attractiveness of locations, so businesses can be established. In addition, accessibility is dependant on the quality and functioning of the transportation and the spatial allocation of activities. \(^{50}\) One can speak of so-called ‘network economies’ which enhance a growing hyperactivity of people, money and means. Due to this fact, infrastructural projects present their selves at a more centralised position within society. New areas, located outside of existing historic city centres at the intersection of different forms of infrastructure, position their selves as focal points of current urbanisation. They may be identified as new junctions in the network economy. \(^{51}\)

As a geographical entity, these junctions have two basic identities. First of all they are a node: a point of access to different forms of transportation. At the same time, they are a place: a specific section in the city with a concentration of infrastructure and spatial interactions among urban elements, economic activities and people. These junctions are centres of (i) activity, (ii) information, (iii) capital, and (iv) traffic. They can be described as junctions of flows. The relation between traffic flows and flows of activities defines the residential character of the junction and therefore a junction can be defined as a concentration of activities. \(^{52}\) Such a definition leaves the origin of the junction – as a location of exchange of transportation flows – unmentioned. Instead it emphasises the role of the junction in spatial economic development. \(^{53}\)

Government policy recognises the importance of these new junctions on a national, regional and local level. It stimulates developments in their surrounding areas. \(^{54}\) Although the coordination between the spatial policy (regarding flows of activities) and the mobility policy (regarding flows of transportations) is considered to be very important, the different nature of spatial and infrastructural projects causes difficulties. \(^{55}\)

Firstly, the coordination seems complicated due to the compartmentalisation of policies. The fields of spatial planning and mobility are installed in two different ministries. Spatial planning is part of the Ministry of Housing and mobility is part of the Ministry of Transport, Public Works and

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\(^{49}\) Le Clercq 2000.
\(^{50}\) Geurs 2006, p. 227.
\(^{51}\) Provincie Zuid Holland 2002, p. 7.
\(^{52}\) Bertolini 1998, p. 10; Peek 2006, p. 111.
\(^{53}\) Priemus 2003, p. 49.
\(^{54}\) Chair of Area Development 2007, p. 41.
\(^{55}\) Buitelaar 2001, p. 159.
Watermanagement (*Ministerie van Verkeer en Waterstaat*). As a result, two different aldermen with two dissimilar scopes and working fields are involved.

Furthermore, the scale of attuning is different, since it depends on the public bodies having primary responsibility: (i) a regional scale requires responsibility by the municipality and the region, (ii) a supraregional scale demands responsibility by the region and the province, and (iii) a (inter)national scale involves responsibility by the municipality and the national government/European Union.\(^{56}\)

Secondly, spatial planning is aimed at generating plans for geographically set areas while infrastructure goes beyond these areas and lastly, there is an enormous difference in time span between infrastructural developments and the realisation of real estate, which makes it difficult to plan and control a combined area development.\(^{57}\)

At a national level, the connection of the whole infrastructural agenda (entailing more than public transport) and the agenda of spatial planning has become a high priority task. Government and regions have entered into agreements relating to integral development of space and infrastructure. A start has been made with the adaptation of the Multi-Year Programme for Infrastructure, Space and Transport (*Meerjarenprogramma Infrastructuur, Ruimte en Transport*, ‘MIST’). This programme forms the starting point of interconnecting the area of spatial planning with regional mobility matters.\(^{58}\) It leads to a focus on urbanisation programmes concerning infrastructural junctions, including the mentioned new junctions in the network economy.

Furthermore, the MIST ensures a targeted institutional context and administrative support. Research done by Bouwfonds Property Development\(^{59}\) resulted in more guidelines towards a successful integration of infrastructure (public transport) and area development, such as:

- an active local community serving as a solid basis is crucial;
- the realisation of public transport in the early phase of the development;
- availability of public rapid transportation systems, so-called High-Value Public Transportation (*Hoogwaardig Openbaar Vervoer*, ‘HVPT’);
- connecting urban area development with public transportation;
- concentrating spatial developments at regional and city level around infrastructural junctions;\(^{60}\) and
- the creation of transfer junctions between public transportation and car or bike in order to enlarge its importance and effectiveness.

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\(^{56}\) Provincie Zuid Holland 2002, p. 48.

\(^{57}\) Bouwfonds Property Development 2008.


\(^{59}\) Bouwfonds Property Development 2008.

\(^{60}\) Note that area development cannot be entirely independent. It is either connected with the most important junction of the city-region (*Sleutelproject*) or it is part of the central junction (*Hoofdstationsontwikkeling*).
3.1 Selective accessibility

It is however not effective to connect all development areas to all levels of infrastructural projects. Areas need to be made ‘selective accessible’ in order to differentiate from other areas. Furthermore they create specific economic, ecological and residential quality and a better usage of transportation systems.\textsuperscript{61} For example, the South Axis in Amsterdam is connected to many public transport levels and lines and became a new centre within the region due to \textit{inter alia} this differentiation. It turned out to be a popular area for real estate investments, partial due to the fact that other areas are less reachable. Its competitive position is high and focuses on spatial economic developments.

Although the development of the South Axis proceeded successfully, the thought that new junctions automatically attract economic activities should not be treated as a given. In general it is accepted that infrastructural efforts are necessary but not sufficient for economic development.\textsuperscript{62} The financial climate and the innovative potential are equally, if not more important than the aforementioned physical networks.\textsuperscript{63} Development is influenced by the demand for a certain spatial quality. Naturally, infrastructure forms a part hereto and policies concerning selective accessibility provide the government with means to steer this process. In the context of selective accessibility, three types of infrastructural junctions can be distinguished:

- Unimodal junctions within the road system. This type of junction is well accessible by car due to its location nearby a highway, but lacks the opportunity to be easily reached by public transportation. Therefore, unimodal road locations have a mono-functional character and are subject to possible congestions within its network. In addition, it reduces the potential target group of the location.

- Unimodal junctions within the public transport system.\textsuperscript{64} This type of junction is well reachable by public transport, but is not located nearby a highway and lacks the opportunity to be easily reached by car. Different than junctions within the road system, unimodal public transport locations have a less mono-functional character due to the fact that one can reach (almost) any location by car or truck and additionally, it is reachable by public transport and thus accessible to a wider group of people.

- Multimodal junctions. This type of junction is well accessible by both car and public transportation and connects the road and public transport systems with each other. A location is multimodal if the exit of the highway is positioned within a concentric circle of

\textsuperscript{61} Le Clerq 2000.
\textsuperscript{62} Priemus 2003, p. 47.
\textsuperscript{63} Schrijnen 2000.
\textsuperscript{64} The public transport in this case is HVPT and consists of high-quality bus and rail (lightrail) transportation. HVPT sets high standards on passenger flows due to an increase of average speed and is therefore capable to produce differences in accessibility. In addition, HVPT provides its service area with a positive image, which will result in an increase of commercial value (Bouwfonds Property Development 2008).
1,500 meter from the public transport stop. Nowadays multimodal junctions are becoming more and more important for area development, especially due to the fact that they are easily accessible by multiple types of transportation. One could think for example of the aspect of redundancy: once one network is congested, the area is still reachable with the use of another network. This increase of accessibility has a visible effect on the value and quality of facilities and real estate in the areas. Multimodal locations are therefore highly appropriate for mixed-use developments and will be given more attention in the following section.

3.2 Multimodal locations

As described in the previous section, multimodal locations differentiate themselves from other locations due to their accessibility by more than one network. Within the scope of accessibility, the demand for multimodal locations increases rapidly. The spatial development of multimodal areas longs for a comprehensive approach. As indicated in section 1.1, this aspect is a complicated issue. In order to profit during spatial planning as much as possible from the presence of so-called infrastructural ‘unique selling points’, it is important to use a double utilisation strategy. Such a double utilisation strategy refers to a combined search for a mobility concept with a spatial development strategy. The strategy should benefit from the combined development of the space and the mobility network and should result in ‘synergy’.

Different target groups appreciate different types of accessibility. Multimodal junctions respond to these differences and attract multiple target groups, leading to multiple flows of activities due to the presence of flows of transportation. These various flows strengthen the definition of Bertolini regarding infrastructural junctions, which in his opinion relates to the junctions of both flows of transportations and flows of activities. They are urban spaces that can attract socio-economic activities due to the fact that all flows interconnect.

Multimodal locations can transform – if they integrate with the aimed spatial quality – into central places. According to the Central Place Theory (‘CPT’), a central place could be defined by a settlement or a nodal point which serves the area surrounding it with goods and services.  

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65 Again the public transportation is HVPT.
69 Atelier Zuidvleugel 2006, p. 10.
70 Within this thesis the expression ‘synergy’ is used in order to define a development where spatial quality and infrastructural works benefit of each other’s presence (Peek 2006).
71 ABF RESEARCH 2005.
73 Kusumo 2007, p. 28. The CPT is a spatial theory in urban geography, concerned with the size, number, functional characteristics, and spacing of settlements. These settlements are nodal points for distribution of goods and services to surrounding market areas (Malczewski 2009, p. 26)
Within this context it is important to notice that not only the flows of activities at the junction are of importance to the concept of centrality, but flows of activities in the area surrounding it could be of even more importance. One may think of a continuous occupation of the area directly surrounding the junction, caused by diversity in both functions and people: a condition for the liveability of retail activities. This occupation is also influenced by the pattern of flows of people and longs for a multifunctional programme and spatial quality. A mixture of, for example, offices, retail, residences and leisure could lead to a more balanced pattern during the day. This urban liveliness is the product of connecting and integrating the different layers of flows. Multimodal junctions can be seen as locations with urban centre-like activities if they are systematically interconnected to the surrounding area on local, city and regional network scales. In addition due to the new centrality the usage of the HVPT-network will increase. Taking into account these aspects, one could say that they justify large investments in the area.

In respect of centrality it is necessary to consider the primary influence of the infrastructural junction on its surrounding area. This will be outlined in the following section.

3.2.1 Primary influence area caused by an infrastructural junction

The primary influence area is identified as the area that is reachable within approximately 10 minutes from an infrastructural junction. It is dependant of among other things the type of pre-transportation. Research of DHV Consultants provides the following distances regarding the primary influence area: 800 meter by foot, 1,200 meter by bike or car and 1,200-2,500 meter by HVPT that services over 10 times per hour. These latter two cover ¾ of the travellers and therefore a concentric circle is used with a radius of 1,200 meter to cover the influence area regarding pre-transportation.

Taking into account a junction such as the supraregional junction present in Rotterdam Noordrand, which is a potential centre-like facility, a maximum distance of after-transportation between 800 (city) and 1000 (centre-like) meter by foot is prescribed. This maximum distance is valued between 1,200 (city) and 1,500 (centre-like) meter regarding the use of HVPT.

Research of Peek (2006) and Trip (2007) also distinguishes a number of concentric circles surrounding the junction, but they differ on levels of scale. Trip uses a larger scale when he first differentiates the station itself, second the station area defined by the distance of a ‘10 minute walk’ and third the city. Peek uses the same circles but he defines them differently. The station area is defined by a circle with a radius of 300 meter and the influenced area by a circle with a

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74 Trip 2007, p. 71.
75 Kusumo 2007, p. 40.
78 Trip 2007, p. 46. This ‘10 minute walk’ is similar to the maximum distance of after-transportation by foot, as outlined in the previous section.
radius of 1,000 meter – similar to the 10 minute walk. In addition he defines a third in between circle with a radius of 500 meter as the acceptance of the surrounding area as office location.\textsuperscript{79}

Due to the fact that multimodal junctions can result in centre-like activities, and in order to provide a clear and structured framework (regarding the different scales of influence), for this research I distinguished the following scales of primary influence:

- 300 meter: the station area;
- 500 meter: the acceptance of a junction as an office location;
- 1,000 meter: influence area by foot; and
- 1,500 meter: influence area by HVPT.

These scales of influence are projected as concentric circles centred at the supraregional junction. The influence area by car or bike is positioned between the scales of 1,000 and 1,500 meter and will therefore not be separately mentioned.

3.2.2 Influences caused by ‘unique selling points’ in the vicinity of the junction

Apart from the primary influence scale that is caused by the junction itself, other nearby developments influence the location. One can think of the connection that an infrastructural junction could have with other junctions, which could be of high importance within the infrastructural network. Fast transfers between these junctions indirectly improve the accessibility of the location and enlarge its position in the current network economy. In addition, such unique

\textsuperscript{79} Peek 2006, p. 138. Note that both Peek and Trip make no differentiation between pre-transportation and after-transportation.
selling points which differentiate the location from other development locations, add a large amount of value to its identity.

### 3.3 Rotterdam Noordrand: a multimodal development location

As mentioned earlier in this thesis, enormous investments have already been and will be made in Rotterdam Noordrand on the infrastructural level. These infrastructural projects interconnect at the infrastructural junction Rotterdam Airport. In order to provide a clear overview, these particular investments are listed below in order of their contribution to the type of junction:

- the realisation of the A13/A16 highway connection;
- the reconstruction of the N470 G.K. van Hogendorpweg;
- the reconstruction of the N209 Doenkade;
- the realisation of the RR-lighttrail system; and
- the realisation of the bus connection ZoRoBus.

The development area enhances characteristics of both a unimodal junction within the road network and a unimodal junction within the public transport system. Due to the fact that the exit of the future A13/A16 highway connection is positioned within a distance of 1,500 meter from the RR-stop (route Rotterdam – The Hague), the area can be defined as a multimodal junction.\(^80\) This junction largely influences the spatial developments within Rotterdam Noordrand.

In fact, due to the scale of the investments and the presence of the HST and Rotterdam The Hague Airport, the whole Rotterdam Noordrand development area can be defined as a multimodal location. The development area differentiates itself from other multimodal locations by its unique selling points. Apart from its supraregional character, it can position itself on an international level because of the airport. In addition, it is possible to connect to the HST that passes the area in an underground tunnel.\(^81\) These additions to the accessibility of Rotterdam Noordrand will eventually lead to an increase of the competitiveness of the whole city of Rotterdam.\(^82\)

The infrastructural developments that are taking place in the area result in multiple opportunities for the areas of science & business park Schieveen, Rotterdam Airport Business Park and Park Zestienhoven. In this respect it is important to give an outline of the influences that the junction has on the contents of Rotterdam Noordrand and to provide an answer on the first research question of this thesis:

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\(^{80}\) Please refer to the characteristics of multimodal junctions provided in section 3.1.

\(^{81}\) This HST-stop will not be realised now, but future realisation will not be made impossible (Gemeente Rotterdam 2005, p. 13).

\(^{82}\) Trip (2007). Indirectly, these additions to the accessibility of Rotterdam Noordrand will also lead to an increase of the competitiveness of the South Wing of the Randstad Holland network.
1. On which level do the infrastructural projects in Rotterdam Noordrand, which converge at the infrastructural junction Rotterdam Airport, influence the three possible central locations?

3.3.1 Science & business park Schieveen

The sub development of science & business park Schieveen could at first glance be identified as a unimodal location within the road system, since it is directly attached on the A13 highway and the future A13/A16 highway connection. A first step towards becoming a multimodal location is already made by the extension of the bus connection ZoRoBus towards the course Zoetermeer – Rodenrijs – Schiedam. This will result in an additional stop in the science & business park and will connect the area with the RR-stop ‘Rodenrijs’. Furthermore, plans have been made to extent the future shuttle service (mentioned in section 1.1), between the supraregional infrastructural junction Rotterdam Airport and Rotterdam The Hague Airport, towards science & business park Schieveen. This particular infrastructural investment connects the science & business park with the airport and the infrastructural junction. Science & business park Schieveen will transform into a multimodal location and this makes the area even more interesting as an establishment location.

However, if one takes into account the primary influence scale of the infrastructural junction Rotterdam Airport, science & business park Schieveen is located at the far end of the 1,500 meter...
influence scale. The area is therefore influenced by the junction due to after-transportation with HVPT such as the shuttle service. An extension of this service is therefore a necessity for the science & business park to develop itself as a multimodal location. In addition, if one takes into account a network approach, the area is positioned at the end of that most important HVPT-line. With reference to Bertolini’s point of view,\(^\text{85}\) the flows of transportation and activities can be assigned to one particular target group: the future users/employees of the science & business park.\(^\text{86}\) Flows of transportation are supposed to show a peak between 7 and 9 am and 5 and 7 pm, while flows of activities (outside of the real estate) are determined at lunchtime and after working hours.

Noticeably, the presence of Rotterdam The Hague Airport functions as a unique selling point for the area of science & business park Schieveen. As an establishment location it becomes more and more interesting for regional, national and even international companies. It pins down the science & business park on the international map as a centre for knowledge intensive businesses. If made a central place within the Rotterdam Noordrand development area, this place would be specifically economic orientated. Therefore, when taking into account the CPT, such a central place would mainly serve the science & business park with its goods and services as there is no continuous occupation. The central place should be identified as business area and its functions and facilities should strengthen its identity.

### 3.3.2 Rotterdam Airport Business Park

The sub development of Rotterdam Airport Business Park could immediately be identified as a multimodal location. It is directly attached to the A13 highway and will in the future also be linked to the A13/A16 highway connection. The future shuttle service that will connect the business park with the infrastructural junction Rotterdam Airport will provide for the necessary attachment with HVPT, resulting in the multimodality of the location. The fact that the development is located on the territory of Rotterdam The Hague Airport, and is therefore directly connected with this unique selling point, differentiates the business park from other development areas. Due to its direct connection with other important business cities in the west of Europe, it makes the Rotterdam Airport Business Park a very attractive establishment location, especially for national and international companies.\(^\text{87}\)

Taking into consideration the primary influence scale of the infrastructural junction Rotterdam Airport, Rotterdam Airport Business Park is located at the end of the 1,500 meter influence scale. The area is therefore influenced by the junction through after-transportation with HVPT and this

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\(^{85}\) Bertolini 1998.

\(^{86}\) This target group can be added to the future users of the nature developments of polder Schieveen. However, the area has an economic focus and therefore this group of users is not accounted for as these numbers are largely outweighed by the employees of the science & business park.

\(^{87}\) A direct connection with the airport is in general not a necessity for regional companies.
after-transportation will be realized with the future shuttle service. Taking into account a network approach, the business park may be identified as a transfer area. Many flows of transportation and activities interconnected as a result of the airport. They will result in an almost continuous occupation of the area (apart from the nighttimes when the airport is closed).

If made a central place within the Rotterdam Noordrand development area, the central place would mainly be economic orientated. Apart from this orientation, this central place would serve both the business park and to a certain degree the users of the airport with its goods and services. The central place should be identified as a business and/or transfer area and it functions and facilities should strengthen its identity. However, in order to avoid competition between the several business areas within the development, it is important to aim at different target groups. To a certain degree, this has already been done as science & business park Schieven orientates at R&D, ICT and innovative business services, while Rotterdam Airport Business Park orientates at airport related businesses.

3.3.3 Park Zestienhoven

The sub development of Park Zestienhoven can firstly be identified as a unimodal location within the public transport system since it is directly attached to the RR at infrastructural junction Rotterdam Airport. However, the area will be transformed into a multimodal location when the future A13/A16 highway connection is realised.

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88 When observing the CPT.
89 It would not serve all users of the airport because most facilities that serve the direct users of the airport (the passengers and staff) are positioned in [or nearby] the terminal.
Looking at the primary influence scale of the infrastructural junction Rotterdam Airport, the larger part of Park Zestienhoven is located within the 1,000 meter influence scale. The area is therefore influenced by the junction due to after-transportation by foot. The development locations of Hoog-Zestienhoven South and Hoog-Zestienhoven North are directly connected to the infrastructural junction with fast transfers to the cities of Rotterdam and The Hague.

Should the subarea of Hoog-Zestienhoven be made a central place within the Rotterdam Noordrand development area, it would be partially economic orientated. Additional chances are available for regional facilities for the Metropolitan Region Rotterdam – The Hague. Taking the CPT into consideration, such a central place would serve the inhabitants of not only Rotterdam but also, on a smaller scale, the inhabitants of the Metropolitan Region with its goods and services. It would consequently strengthen the supraregional character of the junction.

3.4 Conclusions

The infrastructural projects that converge at infrastructural junction Rotterdam Airport provide for lots of possibilities for the Rotterdam Noordrand development area. Due to the planned realisation of the shuttle service, all areas are provided with a fast connection and position themselves in the primary influence area of the junction.

However, the position of the areas within the whole development area results in identity differentiations. Science & business park Schieveen is positioned at the far end of the influence area and has a specific economic identity. The presence of Rotterdam The Hague Airport in the direct vicinity pins down this subarea on the international map. Rotterdam Airport Business Park is also economically focused but due to its position on the territory of the airport its identity might
shift towards that of a business and/or transfer area and hence serve a broader target group. The subarea of Hoog-Zestienhoven is positioned directly at the infrastructural junction and therefore has the possibility to outgrow its serving area and become a place of regional importance.

As a result, it can be concluded that the future central place in Rotterdam Noordrand could be either economically orientated – if realised at science & business park Schieveen or Rotterdam Airport Business Park – or supraregional orientated – when realised at Hoog-Zestienhoven. These orientations bring along different characters of the central place, and therefore the best match with the area should be determined.

Furthermore, it must be mentioned that the presence of Rotterdam The Hague Airport has a large environmental influence on the development of Rotterdam Noordrand, but at the same time it brings along enormous development potential: It differentiates the area from other development areas in the South Wing of the Randstad Holland network and has the opportunity to attract the economic sectors that are supposed to strengthen its economic structure.90

90 These economic sectors consist of business services and knowledge intensive businesses, as outlined in section 1.1.
Chapter 4 Boundary conditions Rotterdam Noordrand

In order to determine the boundary conditions for answering the second research question of this thesis, it is important to theoretically explore the field of urban area development (‘UAD’). When I refer to UAD in this thesis, I mean to address the transformation of an urban area on both physical and functional level. Within this definition, a differentiation can be made between ‘greenfield development’ transformations and ‘brownfield development’ transformations. Greenfield developments transform rural land into built-on land while brownfield developments (re)transform existing built-on land. Taking into account the Rotterdam Noordrand development area it can therefore be stated that the development contains both greenfield developments (polder Schieveen) and brownfield developments (Rotterdam The Hague Airport). Polder Zestienhoven is a combination of these types of transformation because it contains both rural areas (Laag-Zestienhoven and Midden-Zestienhoven) and built-on areas (Hoog-Zestienhoven). The fact that the research area consists of multiple subareas that have to be interconnected makes the development even more complicated. By providing an answer on the second research question of this thesis, structure should be given to this complex character:

2. Which boundary conditions are to be set regarding the Rotterdam Noordrand development area and can the characters of these boundary conditions be distinguished?

For many years the process of UAD characterised itself by its exclusive focus on urbanism on the one side and financial means on the other side: the so-called bilateral approach. However, at the end of the 1980s the demand for space shifted from quantitative to qualitative. This change was especially noticeable in the adaption of urban areas where essential shifts in future economic, spatial and social-cultural structures appeared such as Rotterdam Noordrand. This could have been an important reason why the Rotterdam city council suddenly recognised the economic importance of Rotterdam Airport.

UAD needed to anticipate on the market conditions and the process of urban development transformed into a trilateral approach. A focus on only one of the aspects leads to a poor development: the current and future UAD task demands alignment and steering on different (i) levels; (ii) policy sectors; and (iii) fields of study. In addition, UAD concerns multiple involved parties. One must think of several public parties, private parties – with or without land position – and the civic society that makes or will make use of the (potential) area. Together with uniting different forms of knowledge, insights and skills, these parties contribute to a complicated framework of development: integral urban area development (‘IUAD’). The expression ‘integral’ is in this case defined as:

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92 Bruil 2004, p. 17.
93 Please refer to section 1.1 of this thesis.
“the way in which (i) several spatial levels; (ii) changes in ownership; (iii) boundary conditions and knowledge from several policy sectors; (iv) interests of involved parties; (v) physical-spatial aspect; and (vi) technical, juridical, political, economical, demographical, ecological and social-cultural restrictions are allied and handled as one project.”

In short, it involves a collaboration or partnership between public and private parties from the commencing of the development of a multifunctional and multilayered programme. They collaborate in order to benefit the most of each other’s qualities and skills.

Furthermore, this collaboration foresees in divisible risks for the project. With this collaboration or partnership a fourth focus can be added to the trilateral approach: organisation, which steers the trilateral alignment process. The process of IUAD can be seen as the realisation of a certain ‘urban quality’. This urban quality is defined by Trip by three key elements: diversity, integration and public space. In this thesis I will interpret urban quality as the product of the market call and spatial quality. Therefore, I will not separately outline urban quality as this chapter will already contain a framework for its two elements.

4.1 Urban area development

As described in the previous section, the process of IUAD consists of the next four elements:

1. Spatial quality
2. (financial) Means
3. The market call
4. Organisation

This thesis is written within the graduation field ‘urban area development’ at the Faculty of Architecture. Known research in this field divides the field of UAD in four core elements:

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94 Bruil 2004, p. 396; Peek 2006, p. 27.
95 Van’t Verlaat 1997, p. 50.
96 Trip 2007, p. 67.
97 The faculty of Architecture, Delft Technical University.
98 Chair of Area Development 2007, p. 33.
These four core elements show an enormous resemblance to the elements established in the previous section of this chapter. In fact, the four core elements are much more comprehensive. The context, for example, consists apart from the market call – dependant on social and economic developments – of all kinds of policies on different scale levels. The content consists, apart from the spatial quality, of several sectoral and facet related aspects. The means consist, apart from financial means, of land policy, knowledge and skills. The actors consist, apart from organisational forms, of public parties, private parties and the civic society.

In the next sections of this chapter these four core elements are described in more detail in order to get insight in the complex character of UAD that is present at the Rotterdam Noordrand development area. All elements are of equal importance to the contribution on a clear framework for this research. This chapter will be finished with the introduction of the ‘four-vertex research model’ that provides the path for the carrying out of my research.

4.2 Context

Multiple aspects influence the context of any UAD. As stated in the previous sections it is of major importance to anticipate to the market call. This market call is the direct result of both economic and social developments.

4.2.1 Market quality

The change in economic developments can be explained by the fast emergence of the ICT. It is obvious to connect this economic change to the economic tendency towards an ever increasing volume of knowledge intensity: ‘the knowledge economy’.99 The stimulation of regional clusters of mutually linked knowledge economies is nowadays one of the important aspects of UAD. Social developments are often coherent with economic changes within an area. An unstable social structure in urban districts can be a limiting factor for urban development.100 This is for instance

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100 Chair of Area Development 2007, p. 37.
the case during extreme decline. The current economic situation could work in that case as a catalyst, resulting in a higher unemployment rate.

Within this setting, the development of an urban area tends to react on the market conditions. Such a reaction goes beyond the tuning of market supply and market demand towards equilibrium. In the last decennia the relations between the parties in the development process have changed due to shifts in the role of the government. Public development companies were founded, presenting their selves as ‘private’ entrepreneurs with market knowledge and development risks. This stimulated the dialogue with private parties. However, the stimulation is not only financially based. Evidently, UAD demands large investments in the early phases of the process and private participation (financing) becomes a crucial factor, but on regional or urban level, these shifts are caused by the changes in the demand for different forms of qualitative real estate. An area should be set within regional perspective and the development of an area seen from an urban point of view. The process of UAD cannot take place without the demand of land and real estate, and these two items are coherent with each other. When developing real estate, the investment costs do not only consist of building and additional costs but also of land costs. The value of the land can therefore be determined in advance; this principle is very relevant to the process of UAD.

4.2.2 Policy at (higher) scale levels

The social developments mentioned in the section above are co-determining for the policy at higher scale levels. In the Netherlands we can speak of policies on the scale levels of (i) European; (ii) national; (iii) provincial; (iv) regional; and (v) municipal. Especially, on environmental and infrastructural level, European policy plays an increasingly important role. National policies should be in line with European legislation. Hence, policies of lower scale levels should not be in conflict with European directives on for example transport of hazardous materials or directives concerning the earlier mentioned HST high-speed train network that crosses several European borders.

On a national level, the government develops planned core decisions (\textit{planologische kernbeslissingen}) that capture the main lines and principles for the long-term spatial policy that needs to be followed. These planned core decisions are listed in the Spatial Memorandum (\textit{Nota Ruimte}). This strategic memorandum outlines the differentiation of responsibilities for the national government and decentralised governments. Apart from national spatial main structures, the national government takes a reserved position. However, plans of decentralised governments or public authorities must fit within the outlines provided in the Spatial Memorandum. With regards to Rotterdam Noordrand, the Spatial Memorandum considers the Randstad Holland network as the economic engine of the Netherlands and stimulates the development of a ‘knowledge-axis’ in the northern part of Rotterdam.\footnote{Chair of Area Development 2007, p. 38.} \footnote{Projectorganisatie RR2020 2005, p. 8.}
As regards to the provincial level, regional plans (streekplannen) can be determined to set the main visions on future development within a certain urban area. The policies on regional level changed in the early 1990s due to a revision of the Law on Spatial Planning (Wet op de Ruimtelijke Ordening), which led to the introduction of the regional master plan.¹⁰³ The general board of a regional public body should, pursuant to section 36c of the Law on Spatial Planning, define a regional master plan for the collaboration area. In this plan the board should give notice of the future developments in that area such as definite policy decisions regarding the location of projects and facilities of regional importance.

The province of South Holland outlined her spatial policy in the Provincial Spatial Structure Opinion (Provinciale Ruimtelijke Structuurvisie.). In this structure opinion, the diverse economic structure of South Holland is given attention, more in particular, the structure deals with the ambition to centralise the provincial core qualities within the Randstad Holland network. Its most important aspects are: (i) The Hague as the centre for government, administration and international law; (ii) Rotterdam as world harbour and maritime logistic cluster; and (iii) stimulate high-quality agrarian clusters (green-ports) and (iv) centres of knowledge within the fields of technology, life science and ICT (knowledge-ports). Apart from technology, the fields of science and creativity represent important sources for innovative skills.¹⁰⁴ In addition, these locations should be connected to important public transport junctions and the airports (Schiphol Airport and/or Rotterdam The Hague Airport). After all, modern infrastructure connects economic clusters to each other and to markets all over the world.¹⁰⁵

At a regional level, the South Wing Administrative Platform (Bestuurlijk Platform Zuidvleugel, ‘SWAP’) is working on a coherent and spatial development plan that covers the South Wing of the Randstad Holland network. It pursues the aforementioned scale levels and underlines that the area must transform into a vital network economy of administration and law, knowledge and logistics. The SWAP has listed numerous top priority projects that they consider to be of great importance for the development of the South Wing. Regarding Rotterdam Noordrand, (i) RR; (ii) the development of the northern part of Rotterdam; and (iii) SPH are considered to influence this research.¹⁰⁶

The zoning plan (bestemmingsplan), a policy on municipal level, is however the most important instrument within the Law on Spatial Planning since it is legally the only direct binding plan for both government and citizens. The zoning plan has a strong instrumental function for the government as it translates their policy. For the citizen it creates the framework that sets the

¹⁰³ De Vries 1994, p. 29.
¹⁰⁴ Note that it is important that these knowledge portals should be established in the Southern part of the Randstad, since they bring along important aspects that contribute to the desired international character of the area.
¹⁰⁵ Provincie Zuid-Holland 2009, p. 103-159.
Each zoning plan has two main functions:

- a planning and program function in order to set the intended governmental spatial policy goals and the way these goals needs to be implemented; and
- a normative or regulating function in order to translate the policy goals that are set regarding the first function. The second function can be divided in a regulatory aspect (to judge the activities of use) and a reviewing aspect (concerning granting or refusing of construction permits).

The binding of the government to the zoning plan is absolute, even if usage or construction regulations are lacking. It can be concluded that in general, the normative working of the zoning plan is stronger for the government than a citizen. In the last decennia the regulation of spatial policy, apart from the zoning plan, has been more and more arranged by private law agreements. This approach, that uses contracts instead of zoning plans, can be questioned. However, the government is free to use private law means in order to manage public interest, provided that this does not cause an unacceptable conflict with public law. Although a zoning plan in principle has a validation of ten years, this time span can not affect its generality.

Apart from these main conditions, note that (i) infrastructure; (ii) juridical peripheral conditions; (iii) administrative peripheral conditions; (iv) technical peripheral conditions; (vi) financial peripheral conditions; and (vii) environmental and safety peripheral conditions could be part of the context of UAD.

4.3 Content

The content of UAD is mainly a direct result from the context and could be defined as the object or product of the area development. In this thesis, the content consists of the three possible central places that are described in section 1.3. The content aims at the (re)creation of spatial constellations wherein various functions and real estate (the programme) can be developed.

4.3.1 Spatial quality

The introduction of this chapter mentioned the shift in market conditions from quantitative to qualitative. The current society demands a higher ‘spatial quality’. This spatial quality can be

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110 Chair of Urban Area Development 2007, p. 42.
111 (i) Hoog-Zestienhoven; (ii) the Landzijde-terrain of Rotterdam Airport Business Park; and (iii) the first phase of science & business park Schieveen.
described as the composition of user value, experience, and future value and relates to the economic, social, cultural and ecological dimensions of the society.\textsuperscript{112} During the last decennia, implications and globalisation of technological developments led to an ever increasing acceptation level of spatial quality.\textsuperscript{113} One can speak for instance of a high user value if the space can safely be used by different functions. These functions should not obstruct each other, but – if possible – rather strengthen each other and be accessible for all layers and groups of society. Experience value plays an important role in the living environment where it enhances (i) cultural awareness; (ii) diversity; (iii) human scale; (iv) presence of identity; and (v) acknowledgement of history and beauty. One has to think in this setting of variety. The expression ‘future value’ captures characteristics such as (i) sustainability; (ii) bio-diversity; (iii) robustness; (iv) adaptation; and (v) flexibility in time – regarding the ability to adapt to new forms of use of cultural and economic significance.\textsuperscript{114} However, this explanation of spatial quality is incomplete and slightly random. In its Spatial Memorandum, the Ministry of Housing indicates this issue as it outlines that the interpretation of the criteria for spatial quality has to be determined by the involved parties for every individual development.

The definitions of spatial quality that are outlined in the previous paragraph may be identified as ‘static’ and characterised in advance of any UAD. Opposite to these static qualities there are some subjective components of spatial quality that cannot, or very difficult, be set in advance such as cultural or esthetical aspects. These aspects are defined and made operational during developments. The way in which the different involved parties share their common quality statement and their chances for the area, sets the measurement conditions for spatial quality.\textsuperscript{115} Governments nowadays pay more attention to the feasibility of their policies concerning spatial quality. This connection between policy and its completion brings along two important visions on policy processes:\textsuperscript{116}

- the analytical-rational vision, which defines spatial quality and makes it operational in advance, carries it out and evaluates the results of the development afterwards; and
- the interactive vision, which sets spatial quality as the result of a process that makes the quality operational throughout the development. In this vision, involved parties are not in hierarchical relation with each other and cooperation seems logical.

This second vision has gained more attention in the last years. Both the already mentioned growing complexity of UAD and the steering on spatial quality crave for an integral and process focused approach.

\textsuperscript{112} Ministerie van VROM 1988.  
\textsuperscript{113} Daamen 2005, p. 70.  
\textsuperscript{114} Ministerie van VROM 2004.  
\textsuperscript{115} Daamen 2005, p. 73  
\textsuperscript{116} Hooimeijer 2001.
4.3.2 Sectoral and facet related aspects

Apart from the spatial quality, other aspects regarding the content are of equal importance. These aspects can be differentiated into sectoral aspects and facet related aspects. Sectoral aspects relate to both general functional sectors such as living, working and leisure, and their sub functions such as shopping, education and making dinner. These sectors represent markets of supply and demand. For the general sectors there is a (i) residential market; (ii) an industrial market; and (iii) a leisure market. Sub sector markets can be distinguished within these general markets. There are for example the market for one-bedroom apartments, the market for offices and the market for retail shops. Similar to the market call, described in section 4.2.1, these markets are sometimes subject of fundamental change due to their context of social developments.\footnote{Chair of Area Development 2007, p. 43.} Which function manifests itself in a certain development area therefore depends on the possibilities and chances that are offered by the sectoral markets. In addition, the aforementioned policy context plays an extremely relevant role as well.

Apart from sectoral aspects, there are facet related aspects noticeable within the content of UAD. These aspects run across all the sectors that are stated in the previous paragraph, but they are seen from a specific facet (point of view). The Chair of Area Development (2007) differentiates the following facets: (i) physical facets; (ii) economic facets; (iii) ecological facets; (iv) social facets; and (v) social-cultural facets.\footnote{Chair of Area Development 2007, p. 44.} These various facets can play an important role in UAD. The success of the development lies within the integral approach that considers all five facets and their interconnections.

4.4 Means

Apart from the context and content, the means that are available for the realisation of UAD – and especially the means of land and money – are of high importance.

4.4.1 Land policy

Understanding the notion of means is positioned within the knowledge field of land policy. Land policy involves in making land available in a timely manner, and facilitates the process of (re)developing that land. It also facilitates the financing of the area development.\footnote{Korthals Altes 2002.} Land policy can be defined as the intervention of the government on the land market in order to realise certain objectives regarding their spatial policy.\footnote{Ministerie van VROM 2001.} These objectives are:

\begin{itemize}
\end{itemize}
- the promotion of socially desired spatial use. This regards the realisation of destinations and goals concerning the government’s policy;
- the rise of the quality of use of space, the opinion of the citizen and the market effects on the land market; and
- the promotion of a justified distribution of both costs and revenues among users, owners, developers and the government.

Realisation of this governmental policy can be supported by law and restrictions, which prescribe the boundary conditions concerning the preparation and realisation of the policy. As stated in section 4.2.2, policies on different scale levels are defined within the Law on spatial planning but the only policy that is juridical binding for both government and citizen is the zoning plan.

The Law on municipal priority rights (Wet Voorkeursrecht Gemeenten), provides a juridical framework for municipalities to have priority when obtaining estates. Its aim is firstly to strengthen the directional position of municipalities in the realisation of a spatial policy. Secondly, it enlarges the insight in the land market and thirdly it gives municipalities the opportunity to control the prices. The law is specifically useful in order to prevent undesired transactions during the planning process.121

The Law on compulsory purchase by the council (Onteigeningswet) is the ultimate juridical mean within the field of land policy. It can only be applied when all other means have failed. Compulsory purchase can be checked on a material base by the presence of public interest, necessity and urgency. On a formal base it can be checked by the presence of terms, deadlines and visions. Compulsory purchase is a difficult item due to the fact that the right of ownership is a European fundamental human right.122 The national government has the intention of assigning this law also to provinces and regional collaborations such as the City-Region Rotterdam, one of the initiators of the overlapping SR2020 structure plan in this research.

Subsidies are already paid out to provinces and regional collaborations within the Policy location determined subsidies (Besluit Locatiegebonden Subsidies). These subsidies should remove financial barriers that are caused by high land costs. The Ministry of Housing has the intention to support developments that do correspond with the national spatial policy, but cannot be obtained without financial support or cannot be realised within the intended spatial quality. The post-war reconstruction of the Netherlands resulted in an active land policy by local governments: first the acquisition and development of land before calculating these within the transaction price of the land. However, due to the increase of the prices of potential building land and the consequences of juridical verdicts, this active land policy became more difficult after the 1970’s. This resulted in a passive or facilitating land policy. Municipalities collaborate or negotiate more often with private parties in order to realise their spatial policy and leave the actual development of the lands – under certain circumstances – to these private parties.

121 Daamen 2005, p. 44.
122 Daamen 2005, p. 45.
4.4.2 Finances

Within land policy, the attention has shifted towards collaboration between public and private domains. This shift easily corresponds with the framework of IUAD. Together, the public and private parties create a land exploitation model for the area development that provides an overview of land costs and development returns.

The land costs can be defined as the costs that are closely linked to the production of land that is ready for building, as long as these costs can be foreseen, are measurable or are inevitable. They can be differentiated in (i) acquisition and clearance; (ii) temporary management and maintenance; (iii) demolition and making ready for building; (iv) making ready for residence; (v) soil clearance and reconstruction; (vi) turnover costs; (vii) machinery costs; (viii) rental costs; and (ix) other peripheral costs.\(^\text{123}\ 124\) The development returns are mainly based on the transactions prices of the developed land that is ready to be built-on with real estate. These prices are differentiated for the future usage of the land. For example, revenues for shops and offices are higher than revenues for industrial real estate and are leading for the land exploitation. Apart from these revenues, the development returns can exist of municipal contributions and specific national contributions and subsidies, such as the previously mentioned Policy location determined subsidies. A marginal comment on this matter is that the sum of costs and returns must be in equilibrium to make the development feasible. But even if the land exploitation can be closed with balanced books before the start of the development, this does not necessarily mean that this will be the case after completion.\(^\text{125}\) One must not forget the long period of duration. Furthermore, a range of developments such as the earlier mentioned market call cannot be predicted on forehand. This can either have positive or negative consequences for the land exploitation and brings along high development risks. Therefore, not only the availability of starting capital, but also the risk capital is an important issue in the process of UAD.

There are two other means that are worth mentioning in this section: firstly the in-house knowledge and skills of specialists, and secondly the organisation. This latter mean will be outlined in the following section.

4.5 Actors

The presence of both public and private parties within the framework of UAD was already stated in the beginning of this chapter. These two types of parties can be subdivided and they support very diverse interests, roles and expectations. Special attention is given in this section on their collaboration concerning area development.


\(^{124}\) The machinery costs consist of preparation, supervision and realisation.

\(^{125}\) Chair of Area Development 2007, p. 52-53.
4.5.1 Public parties

The most important actor within the public parties is the municipality, in whose territory the area development takes place. In UAD, the municipality takes the lead and has a share in public law due to zoning plans and building permits. The municipality can also play an important role in private law within an active land policy. Furthermore, the municipality can reside the role of director of UAD. Various departments can be identified within this public body, for example the municipal real estate department, the traffic and transport department and the department for public works. It is of great importance that all different departments carry out one common scope to keep their trustworthiness towards other parties. Kouwenhoven speaks within this context of the focalisation of goals and interests.\(^\text{126}\) Frequently, multiple municipalities are involved in the development when the area transgresses municipal boundaries. It also occurs that a municipality asks another municipality to participate in order to divide the development risks. Within larger municipalities, sometimes sub municipalities or urban district councils can be found.\(^\text{127}\) If an area development is located inside the territory of such a council then both this council and the overlapping municipality bear responsibilities. Their arrangements differ per municipality. In the Netherlands there is the tendency that, apart from the municipalities, some higher public bodies such as provinces and the national government are participating in the risk bearing. This is often the case when large supra-local infrastructural projects are part of the area development. It enhances so-called combination projects.\(^\text{128}\) These higher public bodies have the opportunity to lay down policies which can be very determining for further development. In addition, city-regional bodies sometimes play an important role, often because financial settlement between concrete area developments within their region can be arranged by means of regional funds.\(^\text{129}\) This is the case for the development of Rotterdam Noordrand, where the City-Region Rotterdam and the province of South Holland are the initiators of the overlapping SR2020 structure plan.

Apart from these important public bodies – national government, province and municipality –, there are more (semi)public bodies active within the framework of UAD such as the Public waterways (Waterschappen), the Service rural areas (Dienst landelijk gebied) and public environmental organisations.\(^\text{130}\)

Furthermore, there are former governmental organisations that have been privatised and sometimes play an important public role. One may think of national railway companies, power companies and public transport companies. In addition, social housing corporations fulfil an important social task.

\(^{126}\) Kouwenhoven 1991, p. 12.
\(^{127}\) Chair of Area Development 2007, p. 49.
\(^{128}\) Canoy 2001, p. 9.
\(^{129}\) Chair of Area Development 2007, p. 49.
4.5.2 Private parties

The private parties that can affect the process of UAD must be divided in two groups: (i) the parties with a land and/or tenancy position and (ii) the parties without a land and/or tenancy position.\(^{131}\) If a private party has such a position, it can intervene in the negotiations concerning the development of the area and reveal its goals or interests. The party can get involved in the development process.

When private parties belong to the first group and maintain a certain position in an area that has the intention of being developed, it is up to the public parties to determine the importance of the private position and to what extent it asks for collaboration. If the private position is weak, the public parties can try to reach an agreement on the acquisition. In the worst case the public parties can use the Law on compulsory purchase by the council as described in the previous section.

When private parties belong to the group without a land and/or tenancy position and do not have a dominant position, it is up to the public parties how to involve them in the area development. This means that private parties on different levels could be asked to participate within different collaboration conditions, in order to create more spatial quality and value. Regarding the development of Rotterdam Noordrand, the private actor Rotterdam Airport Vastgoed B.V. carries out a major influence, being the developer of Rotterdam Airport Business Park.

4.5.3 The civic society

In the case of redevelopment of an area, the interests of the end-users can differ significantly from the current users. In this framework of UAD it is necessary to recognise that there are more users in an area than the citizens who participate in the local elections.\(^{132}\) One must think of (i) entrepreneurs; (ii) the working staff; (iii) people that come to the area to do shopping; and (iv) shop-owners that often have their residence in another area. The organised form of civic society, represented by interest groups, should also be taken into account.

4.5.4 Public-Private Partnership (organisation)

In the beginning of this chapter the expression ‘integral’ is defined. It is the collaboration or partnership between public and private parties from the start of the development of a multifunctional programme in order to benefit the most of each other’s qualities and skills. In addition to this definition, both parties hold on to their own identity and responsibilities, social and commercial, and such collaboration foresees in divisible risks for the project.\(^{133}^{134}\)

\(^{131}\) Wolting 2006, p. 29.

\(^{132}\) Chair of Area Development 2007, p. 51.

\(^{133}\) Kouwenhoven 1991, p. 12.
This collaboration can be given the expression ‘Public-Private Partnership’ (‘PPP’). In this organisational form both parties take the responsibility for the development of one project that enhances both public and private elements.\textsuperscript{135} The spatial problems that need to be encountered at area development frequently ask for enormous investments and therefore both private financial means and private expertise are necessary.\textsuperscript{136} PPP characterises itself by the common responsibility due to the fact that the collaborating parties position their selves as one client. All individual goals must be revised in order to clarify how they can support each other. This common orientation on synergy, caused by the coherence between different development activities from the involved parties in the different phases of the development process, distinguishes PPP in specific from more regular interaction methods between public and private parties.\textsuperscript{137} The collaboration does not only provide in chances for a higher investment return, but also reduces risks due to the mutual dependence.

Within this framework I must state that PPP in the case of the Rotterdam Noordrand development area is very complex due to the presence of all infrastructural projects. The development of infrastructure is mainly arranged within the public domain, in contrary to the development of real estate. In many cases the development of infrastructure is a ‘Public-Public Partnership’, collaboration between two or more governmental bodies since it mostly exceeds municipal borders.\textsuperscript{138}

Instead of the three involved parties that are mentioned earlier in this section – public parties, private parties and the civic society – a separation in four groups can also be made: certain arenas are differentiated by their main issue of discussion.\textsuperscript{139} For example, when it concerns the development of a station area – being an area with infrastructural projects – the following differentiation can be made:

- the public administration arena which is to a large extent the arena in which public policy objectives are defined. It includes public bodies on different levels.
- the real estate development arena which mainly concerns the development of the station area as a place and this is to a large extent dominated by private and semi-public parties.
- the transport arena which is in a sense the counterbalance of the previous arena because it mainly defines the station as a node. This arena includes all kind of transport companies.
- the design arena which among others consists of urban planners, transport planners and architects. Actors in this arena mostly work on commission on behalf of those in the public administration– and real estate development arenas.

\textsuperscript{134} Wolting 2006, p. 14.
\textsuperscript{135} Canoy 2001, p. 34.
\textsuperscript{136} Janssen-Jansen 2001.
\textsuperscript{137} Kouwenhoven 1991, p. 12; Peek 2006, p. 90.
\textsuperscript{138} Kenniscentrum PPS 2004, p. 8
\textsuperscript{139} Trip 2007, p. 53.
In this thesis, this differentiation is kept in mind as a basis for analyzing the different parties that are involved in Rotterdam Noordrand. However, the public administration arena can be linked to the public parties and the real estate development arena to the private parties. The transport arena and design arena are of less importance within the scope of the research.

Gaining insight in the differences in scheduling between public parties and private parties is important. While the government distinguishes development products and a phasing design that contains initiative, definition, design, preparation, realisation and exploitation/management, the market distinguishes less phases. The three phases definition, design and preparation are being replaced by the feasibility-phase.\textsuperscript{140} This difference shows itself first of all in the basic assumption. The government reasons from the public interest and the public tasks and responsibilities, while the market parties reason what they can bring on the market. Also the starting point of calculation differs. For the government this point is positioned at the design phase while for the market parties this point is positioned much earlier in the process at the beginning of the feasibility phase. Finally the go/no go moment for the government is scheduled as early as possible while the market parties prefer this as late as possible. Precise and good agreements have to be arranged regarding these differences as the foundation of a successful PPP that will lead to a successful IUAD.

4.6 The four-vertex research model

The findings in the theoretical analysis that are presented in the previous section are structured and converge in the following research model. The model is titled ‘four-vertex research model’ as it visualises the four vertexes of the solution space wherein the aimed optimal strategy will be positioned. The solution space is in this case narrowed down from UAD into core elements and eventually into focuses towards an optimal solution.

\textsuperscript{140} Wolting 2006, p. 37.
4.7 Conclusions

An integral approach on urban UAD is a complex matter. The presented four-vertex research model gives a simplified image of reality. Every development, and this includes developments of Rotterdam Noordrand, is faced with boundary conditions which can be differentiated within the elements of (i) context; (ii) content; (iii) means; and (vi) actors.

Regarding the context, the boundary conditions that are set for the development area may not be in conflict with policies that are set for the larger area by governmental authorities. In addition, these boundary conditions are dependent on both economic and social developments which are often interrelated and cause a change in programme. Such a change directly influences the boundary conditions that can be set for the content of the development, and consequently result in a change in the spatial quality that especially future users of the developed area will desire. Developers have to respond to these changes, but due to the long planning-period of UAD this brings along high risks: the available means have to be reallocated in order to provide new boundary conditions regarding this element. Furthermore, the development of an area cannot be done by just one party, either public or private. Collaboration in a PPP is necessary and sets boundary conditions that reflect on the involved actors within the area.
Reflection on Rotterdam Noordrand

The aim of this thesis, providing the optimal strategy for a new central place within the Rotterdam Noordrand development area, is emphasised is on the programmatic aspect. The boundary conditions regarding the content have a major influence on the programme and quality of the final result. The context was found in the zoning plans that set these boundary conditions and follow the main principles of higher scale policies.\textsuperscript{141} However, boundary conditions on the market call and spatial quality have to be accounted for in order to provide a realistic strategy.

Boundary conditions regarding the available means can be made by assigning transaction prices to the function-specific GFA’s.\textsuperscript{142} This results in an overview of the revenues that the specific programme enhances. The most important actors in Rotterdam Noordrand are the RDC and Schiphol Real Estate. Boundary conditions that these parties set can be obtained by combining their preferences.

\textsuperscript{141} The zoning plans are in line with the principles of the SWAP (section 4.2.2) and the SR2020 structure plan.

\textsuperscript{142} Note that the boundary conditions concerning the land-costs are not accounted for as the lands have already been obtained by the municipality of Rotterdam (excluded of the grounds of Rotterdam The Hague Airport). Insight in possible revenues is therefore of main importance regarding the available means.
Chapter 5 Usage of modelling techniques

In the previous chapter all main elements of UAD is facing were described. It was also explained that these elements visualise the boundary conditions of the development of Rotterdam Noordrand. In the previous chapter four types of elements were differentiated: (i) context; (ii) content; (iii) means; and (iv) actors.

The Rotterdam Noordrand development area consists of the sub developments Nature- and business park Schieveen, Rotterdam Airport Business Park and Park Zestienhoven. The development is, as concluded in the previous chapters, a complex matter and covers multiple disciplines. When complicated problems need to be solved, one must search for a common language and way of thinking that connects these disciplines: a systematic approach. Therefore, I made use of this approach to provide an answer on the third research question of this thesis:

3. What are the cause-effect potentials for the possible central locations due to the focus on each single element? And how do these potentials affect the surrounding area?

The central tool in this approach is the construction of models. It is necessary to define the expression 'model' within this chapter, before making further comments on this subject.

A model is a simplified rendering of present or future reality, provided that a structural relatedness exists with that reality. In addition, the model is based on a conscious interpretation of that reality. The reality is in a model approached from a certain angle. This angle can be determined by scientific cultural backgrounds or it can be context orientated. It is dependant of the scope of the model maker and according to Klaasen, four types of models can be distinguished. I have positioned them in order of abstraction-level:

- Verbal models: these models consist of words (for example the brief for a residential area).
- Spatial models: these models are spatial renderings of three-dimensional reality on scale (for example the urban design for the residential area).
- Mechanical models: these models are spatial models with real time as a fourth dimension (for example the phasing plan for that residential area).
- Mathematical models: these models consist of numbers or symbols (for example the feasibility study for the residential area).

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143 Peek 2006, p. 57.
The types of models can also be categorised according to their relationship to reality: they can be concrete, conceptual or formal. A concrete model is composed of empirical identities and corresponds to ‘matter’. A conceptual model is composed of conceptual identities and corresponds to ‘comprehension’. A formal model is an un-interpreted system of symbols and corresponds to ‘abstract names’. Verbal models can only be conceptual models. Mathematical models can be both conceptual models and formal models, while spatial and mechanical models can be both concrete and conceptual.

The functions of scientific models may be further classified into five types, but I must state that the first three function types are linked to another and belong to the domain of empirical sciences:145

- Descriptive: a model of an existing situation or process (what probably is the case).
- Explicative: a model that is used to get insight into the case (because of what or why that probably the case is).
- Predictive: a model that indicates what probably will happen, given a specific situation, based on insight into the working process (what probably will be the case).
- Planning: a model for a situation that does not yet exist, requiring one or more specific actions in order to realise the situation (what we have decided that should be the case).
- Explorative: a model wherein a future situation (both desired and undesired) is rendered (what possibly can be the case).

This chapter is gives a theoretical overview of the different modelling techniques that could be used in this research. At the end of the chapter, the choice for using Linear Programming is explained.

5.1 Modelling techniques

5.1.1 Linear Programming

Linear Programming (‘LP’) is a modelling technique that can be categorised within the mathematical models. It is the mathematical translation of verbal models and, under certain restrictions, also spatial models because conditions are notated as equations. Many important management decisions today are made on the basis of LP models that utilise hundreds of variables. The expression ‘programming’ is based on planning and was introduced in the 1940’s by George Dantzig.

A LP model is used as a method to establish an optimum within given boundary conditions. These boundary conditions are set by constraints within a so-called task-function. The constraints are set in advance and are given by linear (in) equalities.146 Any LP model can include ‘greater-

146 Due to the use of linear (in) equalities, the technique is named LP.
than or equal-to’, ‘equal-to and less-than’ or ‘equal-to’ types of constraints. What is desired to optimise, depends on the personal preference of the model maker, and is set in the so-called objective-function. Only one aspect can be optimised, but there can be many constraints.

The mathematical requirements that are represented by the constraints must be satisfied in order to have a feasible solution. Optimisation of the objective-function is secondary to finding a feasible solution that will satisfy all the constraints. When one or more constraints in the model find itself outside or in conflict with the area of feasible solutions, there is an infeasible solution. The optimisation of a LP model can generate four possible outcomes which are explained in the following graphical examples:

The optimisation process can have only one solution, as shown in figure 5.1. The maximisation of the objective-function \(1x_1 + 1x_2\) under the given boundary conditions is the point (3,2) and gives the solution a total value of 5. If the objective function is changed into \(1/6x_1 + 1x_2\), then the optimisation under the same boundary conditions has multiple solutions. This is shown in figure 5.2 where the solutions have values that are positioned at the thick line.

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147 Schniederjans 1995, p. 3.
148 Matoušek 2007, p. 4; Schniederjans 1995, p. 3.
In figure 5.3, when the inequalities are changed, the objective-function $1x_1 + 1x_2$ has no feasible solution space at all, let alone a solution.\(^{149}\) In figure 5.4, the objective function $1x_1 + 1x_2$ has an unbounded solution. This happens when the solution area is open on at least one side.

It is important to continuously readjust the boundary conditions in order to react on changing perspectives and contexts. Suddenly, different objectives can become interesting. Such sensitivity with regard to the context only increases if more boundary conditions (constraints) are taken into account. For example, a LP-problem with $n$ variables and $m$ constraints has $\frac{(m+n)!}{m! \times n!}$ corner points.\(^{150}\) In a case of a problem with 50 variables and 50 constraints a total of $10^{29}$ corner points must be solved. It is not necessary to study all corner points. When one proceeds from an initial solution that obeys all boundary conditions, much fewer corner points need to be investigated in order to find the solution.\(^{151}\) The method that in that case needs to be followed is called the ‘Simplex Method’. This method generates an eventual solution in a finite number of steps by adding so-called ‘slack variables’ or ‘remainder variables’.\(^{152}\)

5.1.2 Goal Programming

Goal Programming (‘GP’) originally began as an extension of LP. In LP models with infeasible solutions, the goal or optimum could be attained by minimizing the absolute deviation and generating the best solution instead of the optimum solution.\(^{153}\) In this case, several solutions could be obtained and the best solution depends on the priority that is associated to each goal.\(^{154}\) The deviation could be minimised of one positioned the variables that represented the deviation directly in the objective-function of the LP model. This allows that multiple, and sometimes conflicting, goals need to be expressed in the model. These multiple and conflicting goals, and the fact that there are no decision variables in the objective-function, are characteristics that differentiate a GP-model from a LP model.\(^{155}\) A debated weakness of a GP-model is the ability to produce solutions that are ‘Pareto inefficient’. A model that is ‘Pareto efficient’ implies that an optimal solution is reached: no individual can get better without other individuals getting worse. When this optimum is not reached and the model is ‘Pareto inefficient’, a change in allocations can be made to ensure that at least one individual gets better without others getting worse. This violates a fundamental concept of decision theory, which is that no rational (decision) model maker would produce solutions that are not ‘Pareto efficient’. In addition it is most likely that the entities of the variables are not equal.

\(^{149}\) Matoušek 2007, p. 4.

\(^{150}\) $m!$ is a mathematical notation for $(m \times (m-1) \times (m-2) \times \ldots \times (m-x))$ and this is similar for $n!$.

\(^{151}\) This is approximately $m+n$.

\(^{152}\) De Jong 2002, p. 223-224.

\(^{153}\) With the expression ‘best solution’ the substitution of the optimum solution by a satisfactory solution is meant.

\(^{154}\) De Oliveira 2003, p. 165.

\(^{155}\) Schniederjans 1995, p. 4-5.
5.1.3 Non Linear Programming

Non Linear Programming (‘NLP’) carries the fundamentals of LP. It is the process of solving a model under boundary conditions or constraints (equalities and inequalities) over a set of unknown real variables. This happens along with the objective-function that has to be optimised (maximised or minimised). Different than in a LP model, some of the constraints of the objective-function are nonlinear. In a NLP model, the sequence generally does not exactly reach the solution point, but converges towards it. In operation, the process of NLP is terminated when a point sufficiently close to the solution point is obtained.\textsuperscript{156} There exists no general solution method for NLP models that always produce the global optimum for any model. A local optimum is conducted and one cannot be sure (in all cases) whether that optimum is the global optimum or not.\textsuperscript{157}

5.1.4 Multi Criteria Decision Analysis

Multi Criteria Decision Analysis (‘MCDA’) is a tool that aims at supporting a decision maker or a group of decision makers. When decisions are being made that involve opinions, these decisions mostly arise under the influence of emotions (a soft variable). Preference is subjective in the sense that when it is measured, the system under measurement includes a person or persons who are supported in choosing the most preferred alternative from a number of decision alternatives.\textsuperscript{158} Usually different properties (decision criteria) of the decision alternatives are taken into account. Therefore it can be stated that MCDA involves the measuring of the decision maker’s preferences per alternative per criteria. It is a measuring process that involves the use of scales. One can distinguish the following scales of measurement:\textsuperscript{159}

- Nominal measurement, which involves assigning numerals to objects as labels or names. This procedure only allows comparisons between objects on equality or inequality.
- Ordinal measurement, which involves assigning numbers to objects to represent the rank order of the measured objects. This procedure allows ‘less than’ or ‘greater than’ comparisons.
- Interval measurement, which involves assigning numbers to objects that have all the features of the aforementioned ordinal measurement, but in addition equal differences between measurements represent equivalent intervals. This procedure allows in scale-independent differences because the zero point is arbitrary.

\textsuperscript{156} Luenberger 2008, p. 6.
\textsuperscript{157} Internet 9.
\textsuperscript{158} Barzilai 2005, p. 173.
\textsuperscript{159} Binnekamp 2006a, p. 65.
• Ratio measurement, which involves assigning numbers to objects in a similar way as the aforementioned interval measurement. This procedure defines a zero point that is non-arbitrary.

According to Barzilai (2005) these scales of measurement are expressed as weak scales due to the fact that operations of additions and multiplication are not applicable to these scales. The purpose of measurement is to enable the application of mathematics to the objects under measurement, and defines such scales of measurement as proper scales. These proper scales, which also enable order and the application of the calculus’ limit operation, are expressed as strong scales. Barzilai developed the method of Preference Measurement (‘PM’) that measures with such strong scales. By measuring the preferences in this correct way, soft variables like emotions or architectural beauty can be accounted for. Together with the Canadian company Scientific Metrics he developed Tetra, a tool that can evaluate measure and make decisions that are based on a pure mathematical basis.

Tetra can support the decision maker by mapping the alternatives and the criteria that they follow. The decision maker can accord the amount of value he wants to give each criterion: one criterion is for example more important than another criterion. Each criterion can be valued differently for each alternative and can therefore influence the total score of each alternative. The next step is to determine the contentment about the whole alternative in relation to the other alternatives. When these data are known and imported in Tetra, the programme will conduct results that translate the preference of the decision maker into a numbers between 0 and 100. The results of this MCDA can be displayed in a final table. This information might be of importance when one is interested why a criterion is valued for example with an eight and not a ten. An eight is a good score when a five is considered unsatisfactory. An eight means also that another criterion scores a ten and outnumbers this criterion.

However, the use of MCDA and PM does not give adequate insight in the influence of a changing preference for a criterion on the total score of the alternative. It is always comparing the alternatives with each other and does not visualise the path to an optimal solution for a decision problem.

5.2 Conclusions

There were four types of modelling techniques that could be used as a tool for the optimal development strategy for Rotterdam Noordrand. GP is not used in this research because it could produce ‘Pareto inefficient’ solutions and violates a fundamental concept of decision theory. No rational decision model maker would want to produce such a solution. Therefore, NLP is also not appropriate for this research as it could produce a local optimum. I cannot be sure (in all cases)

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161 Binnekamp 2006b, p. 281.
162 With the use of algorithmically calculations.
whether that optimum is the global optimum or not. Both MCDA and PM always compare the alternatives with each other and do not visualise the path to an optimal solution for a decision problem. Therefore, these techniques could not be used in my research.

LP optimises the personal preferences of the model maker. When an optimum is derived, one is sure that it satisfies all boundary conditions as the optimisation is secondary to finding a feasible solution. Therefore, LP has been used in this research. A model was constructed and optimised for the focuses that are shown in the four-vertex research model.\textsuperscript{163} \textsuperscript{164}

\textsuperscript{163} This will be outlined in the next chapter.

\textsuperscript{164} The four-vertex research model is denoted in section 3.2.
Chapter 6 Linear Programming Rotterdam Noordrand

In the previous chapter, the choice for using LP as a modelling technique to render the complex development of Rotterdam Noordrand was explained. Chapter 4 provided an outline of all different boundary conditions that the development is facing. This chapter deals with the transformation of these boundary conditions into linear equations that can be positioned in the task-function of the LP model. First, the general construction of the model will be described. Second, an outline of the implementation of the boundary conditions will be given. Such a specification will be followed by the application of the model: how to use it and on which manner was the optimisation of the contents of four-vertex research model carried out? The chapter ends with the results of these optimisations.

6.1 Introduction on variables and their relations

As stated in section 5.1.1, a LP model consists of an objective-function and a task-function. The task-function contains the constraints that are set in advance by linear (in) equalities. These constraints set the relations between the multiple variables that are present within the specific development. Two types of variables can be distinguished:

- **Endogenous variables.** This type of variables is calculated by the model (the so-called unknown variables) and endogenous variables are notated with the use of capital letters.
- **Exogenous variables.** The value of this type of variables is determined by the user of the model and exogenous variables are notated with the use of lowercase letters.

These two types of variables are connected with each other in a constraint. Such a connection results in three possible relations:

1. The unknown endogenous variable is smaller than or equal to the (value that the user has given the) exogenous variable: $ENDOGENOUS\ VARIABLE \leq exogenous\ variable$
2. The unknown endogenous variable is equal to the (value that the user has given the) exogenous variable: $ENDOGENOUS\ VARIABLE = exogenous\ variable$
3. The unknown endogenous variable is greater than or equal to the (value that the user has given the) exogenous variable: $ENDOGENOUS\ VARIABLE \geq exogenous\ variable$
The application ‘What'sBest!’ for Microsoft Office Excel provides a solid basis for the creation of LP models. This section describes the design of a simplified LP-problem with the application.

The endogenous variables are positioned in the columns of the workbook and their values are ‘made adjustable’. This makes them non-fixated and capable of being calculated by the LP model. The constraints are positioned in the rows of the workbook. By providing the cell – a column/row-combination, thus in this case a variable/constraint-combination – with a value, the corresponding variable is accounted for in the constraint. The constraint can enhance multiple variables and relate them with each other. The values of the exogenous variables are positioned at the end of the constraint and are separated from the constraint by the symbol that identifies their relation. Figure 6.1 contains the graphical outline of a simplified LP-problem, containing 7 endogenous variables and 8 constraints:

<table>
<thead>
<tr>
<th>Objective</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>MAX!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. businesspark</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>&lt;= 100000</td>
</tr>
<tr>
<td>Max. offices</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 20000</td>
</tr>
<tr>
<td>Max. communal</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 500</td>
</tr>
<tr>
<td>Max. recreational</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 1000</td>
</tr>
<tr>
<td>Max. catering</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 2500</td>
</tr>
<tr>
<td>Max. retail</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 1000</td>
</tr>
<tr>
<td>Max. industrial</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;= 50000</td>
</tr>
</tbody>
</table>

Fig. 6.1 Graphical example of the starting values of a Linear Programming model

The specific endogenous variable that the model user wants to optimise is provided with the value 1 in the row of the objective-function. The presence of the expression ‘MAX!’ tells that the optimisation is in this case maximisation. After optimizing, the maximum value of the optimised variable, under the given set of constraints, is calculated in the blue cell, as shown in figure 6.2:

---

165 The What’sBest! spreadsheet was jointly developed by LINDO Systems and General Optimisation. Its development completed in 1985 on the first release. The spreadsheet has always specialized in tackling large scale, real world problems. In 1995, What'sBest! became the first spreadsheet add-in application, which was capable of solving large scale nonlinear models. Nowadays, projects under development keep the spreadsheet on the cutting edge of technology (Internet 10).

166 The values of cells that are ‘made adjustable’ are blue-colored in figures 6.1 and 6.2.

167 The possible relations were outlined in earlier in this section.
In this example, the value of the endogenous variable GFA_BUSINESS PARK is maximised towards the value of 75,000 and satisfies all the constraints that are set in the rows of the model. The exact values of the other endogenous variables are automatically calculated in the adjustable cells and can be directly derived from the LP model.

6.2 Constructing a structured and usable LP model for the area

This section describes the construction of the actual LP model for the development area of Rotterdam Noordrand. In chapter 5, the use of modelling techniques for solving complex UAD-problems was explained. However, using such a systematic approach is not an easy method and requires knowledge on this field. Therefore it is very important to design a structured and easy accessible model that can be used by laymen who do not have that particular knowledge. The path that highlights the most important decisions that were taken during the construction of the LP model for Rotterdam Noordrand is described in this section.

6.2.1 General Remarks on the model

6.2.1.1. Application of a standardised notation method

The first step in order to keep the LP model as simplified as possible, the endogenous and exogenous variables are provided with a clear and understandable notation method. A standardised format was applied, using five identity aspects for every variable. The first part of the notation starts with the dimension of the variable, abbreviated as a letter:

---

168 This was actually an extra aim of the research: to provide the RDC with an easy usable model, for them to use in the further planning-process of Rotterdam Noordrand.

---
The dimension ‘area’ is provided with the letter $a$

The dimension ‘number’ is provided with the letter $n$

The dimension ‘percentage’ is provided with the letter $p$

The dimension ‘costs’ is provided with the letter $c$

The dimension ‘revenues’ is provided with the letter $r$

The second part of the notation represents the type of the dimension. One can distinguish for example within the dimension ‘area’ the types of development area (‘da’) or gross floor area (‘gfa’). And within the dimension ‘number’ the types of residences (‘res’) or allotments (‘all’).

The third part of the notation represents the specific sub development. Within this research concerning Rotterdam Noordrand the following sub developments are differentiated:

- ‘Nature- and business park Schieveen’ is provided with the abbreviation $sch$
- ‘Rotterdam Airport Business Park’ is provided with the abbreviation $rtm$
- ‘Park Zestienhoven’ is provided with the abbreviation $16h$

The fourth part of the notation method represents the phase that it is positioned in regarding the Rotterdam Noordrand development phasing.\textsuperscript{169} Therefore, $P1$, $P2$, $P3$ and $P4$ are differentiated.

The fifth part of the notation represents the subareas of each development plan. This item needs some further explanation when it concerns variables regarding Nature- and business park Schieveen. This area consists of three subareas which are entitled ‘Phase 1’, ‘Phase 2’ and ‘Phase 3’. In order to keep the LP model and notation method clear and understandable, the subareas of Schieveen are transformed into the Rotterdam Noordrand development phasing they are in. In this case, the fifth part of the notation method disappears for Nature- and business park Schieveen. For the other development areas within this research, the following subareas are differentiated:

- ‘Rotterdam Airport Luchtzijde’ is provided with the abbreviation $lucht$
- ‘Rotterdam Airport Landzijde’ is provided with the abbreviation $land$
- ‘Park Zestienhoven Laag-Zestienhoven’ is provided with the abbreviation $lz$
- ‘Park Zestienhoven Midden-Zestienhoven’ is provided with the abbreviation $mz$
- ‘Park Zestienhoven Hoog-Zestienhoven South’ is provided with the abbreviation $hz_s$
- ‘Park Zestienhoven Hoog-Zestienhoven North’ is provided with the abbreviation $hz_n$

Following aspects of the notation method are variable-specific and therefore not accounted for in this standardised notation format.

\textsuperscript{169} The phasing-plan of the development of Rotterdam Noordrand will be explained in section 6.2.2.
6.2.1.2 The phasing design

As mentioned in the introduction of section 6.2 it is stated that this section handles the construction of the constraints that are accounted for in the model. Therefore, it can be seen as a technical description. The boundary conditions that can be found in the verbal models – the zoning plans and other location based documents – have to be transformed into measurable entities for the mathematical LP model. For the direct translation of the ‘static’ boundary conditions into variables and constraints, the following zoning-plans were used:170

- Nature- and Business park Schieveen: Gemeente Rotterdam (2009), Ontwerp bestemmingsplan 1e fase Natuur- en business park Schieveen, Rotterdam.171
- Rotterdam Airport Business Park: Gemeente Rotterdam (2004), Voorontwerp bestemmingsplan Rotterdam Airport, Rotterdam.
- Park Zestienhoven: Gemeente Rotterdam (2005), Bestemmingsplan Polder Zestienhoven, Rotterdam.172

It was necessary to analyse whether each of these zoning plans did not have conflicting constraints concerning the programme or layout of the subareas, before generating a general LP model for the whole development area. Such an analysis was carried out by constructing individual models for each of the subareas. Eventually, these sub models were converged into one model. This general LP model was based on a phasing design that contained four phases, each with a time-span of 10 years:

- Phase 1: 2005-2014
- Phase 2: 2015-2024
- Phase 3: 2025-2034
- Phase 4: 2035-2044

This starting point of this phasing design was chosen due to the fact that the developments of Park Zestienhoven were already started in 2005. Furthermore, the development of Nature- and business park Schieveen is postponed with at least 5 years by the RDC. This meant that its development would start at first in 2015. The original phasing of Nature- and business park Schieveen was however kept.173 The development of Rotterdam The Hague Airport was scheduled to take between 10 and 15 years (until 2025) and its development fits in with the abovementioned phasing design.

170 The expression ‘static’ is given to the non-subjective boundary conditions (section 4.3.1).
171 Note that the zoning plan for Nature- and business park Schieveen only covers a detailed description of the first phase of its development.
172 Note that the zoning plan for Park Zestienhoven only covers a detailed description of the subareas ‘Laag-Zestienhoven’ and ‘Midden-Zestienhoven’.
173 This meant that the development of the three phases would be finished in 2044.
6.2.1.3 Maximum building heights

All zoning plans contained several boundary conditions on all kind of aspects. For this research on programme and quality, the conditions on GFA and Built-on Area (‘BOA’) were of importance. These two are directly related to each other as the GFA divided by the maximum number of floors results in the amount of BOA.\textsuperscript{174} The maximum number of floors in each area is dependant of the maximum building height, using the following formula to calculate it:

\[
((\text{maximum height} - \text{height ground floor})/\text{floor-height}) + 1 = \text{maximum number of floors}
\]

The maximum height in science & business park Schieveen was set at 12 meter, while the height of the ground floor was set at 4 meter and the height of following floors at 3 meter. Therefore, the maximum number of floors (for non-industrial functions) was \((12 - 4)/3 + 1) = 3.67 = 3\) floors. Similar, the maximum height in Rotterdam Airport Business Park was set at 45 meter. The height of the ground floor was set at 4 meter and the height of following floors again at 3 meter. Therefore, the maximum number of floors (for non-industrial functions) was \((45 - 4)/3 + 1) = 14.67 = 14\) floors. Finally, the maximum height in Park Zestienhoven was set at 20.5 meter. The height of the ground floor was again set at 4 meter and the height of following floors at 3 meter. Therefore, the maximum number of floors (for non-industrial functions) was \((20.5 - 4)/3 + 1) = 6.50 = 6\) floors.

In this context I must add that the zoning plan of Park Zestienhoven gave a maximum of layers for the residential types of ‘Parkwoningen’, ‘Woningen1’, ‘Woningen2’ and ‘Gemengde Doeleinden’. These were respectively 4 layers, 2 layers, 3 layers and 6 layers. For the residences ‘Hoog-Zestienhoven 2015’, no maximum was set. However, this could not be more than the maximum amount of 6. Because they were situated in a high density area, the amount of 6 floors was used.\textsuperscript{175}

6.2.1.4 The allocation of centre-like functions

Although each zoning plan made an explicit description of the different types of functions that could be realised in each subarea, the scope of this research asked for more diversity. Because of the fact that there were three possible central places in the Rotterdam Noordrand development area, it had to be possible to realise centre-like functions in each of that location even when the zoning plan did not prescribe it. The following centre-like functions (facilities) are differentiated: (i)

\textsuperscript{174} This is however only valid for non-industrial functions. Industrial functions are generally provided with one floor only and in that case the GFA is equal to the BOA.

\textsuperscript{175} The ‘Hoog-Zestienhoven 2015’ residences represent the possible residences in Hoog-Zestienhoven South and Hoog-Zestienhoven North.
communal facilities, (ii) recreational facilities, (iii) catering industry facilities, (iv) hotel facilities, and (v) retail facilities.\textsuperscript{176}

6.2.1.5 Translation towards measurable entities
Because Park Zestienhoven is a primarily residential development, the zoning plan provided values on the amount of residences. The zoning plan does not give exact sizes on the types of residences. Therefore, average sizes were used in order to calculate the usable amounts of GFA and BOA:

- ‘Parkwoningen’ – apartments in a green environment: 100m\textsuperscript{2};
- ‘Woningen1’ – detached residences in low densities: 150m\textsuperscript{2};
- ‘Woningen2’ – attached residences in medium densities: 120m\textsuperscript{2};
- ‘Gemengde Doeleinden’ – apartments in high densities: 80m\textsuperscript{2}; and
- ‘Hoog-Zestienhoven 2015’ – apartments in high densities: 80m\textsuperscript{2}.

Furthermore, the zoning plan of Park Zestienhoven provides values regarding the amount of allotments and sports fields. The average size of an allotment in the municipality of Rotterdam is set at 260m\textsuperscript{2}.\textsuperscript{177} Similar the average size of a sports field is set at 5,000m\textsuperscript{2}.

6.2.2 Transforming static boundary conditions into linear constraints

In this section I will give some examples on the method that is used to derive variables and constraints from the zoning plan of development area Nature- and business park Schieveen.\textsuperscript{178}

Example 1: \textit{The first phase of the science & business park will contain a maximum of 100,000m\textsuperscript{2} GFA.} If it concerns the first phase of the Rotterdam Noordrand development it is notated as:

\begin{itemize}
  \item \textbf{Endogenous variables:}
    \begin{itemize}
      \item A\textsubscript{GFA\_SCH\_P1} \textit{Total Gross Floor Area science & business park Schieveen phase 1 realised (m\textsuperscript{2})}
    \end{itemize}
  \item \textbf{Exogenous variables:}
    \begin{itemize}
      \item a\textsubscript{gfa\_sch\_p1} \textit{Total Gross Floor Area science & business park Schieveen phase 1 (100,000m\textsuperscript{2})}
    \end{itemize}
\end{itemize}

\textsuperscript{176} This resulted in adding much more variables to the LP model, apart from the ‘static’ variables that were derived from the zoning plans.
\textsuperscript{177} Rekenkamer Rotterdam 2006.
\textsuperscript{178} An overview of the derived ‘static’ boundary conditions by analyzing the zoning plans and other location based documents can be found in Appendices A, B and C.
The presence of the word ‘maximum’ identifies the relation between these variables as the endogenous variable being smaller than or equal to the exogenous variable:

Constraints:

\[ A_{\text{GFA}\_\text{SCH}\_\text{P1}} \leq a_{\text{gfa}\_\text{sch}\_\text{p1}} \]

Example 2: A total of 50,000m² of this maximum GFA is reserved for industrial function. The remaining non-industrial floor space (with a maximum of 50% of the total GFA) consists of offices (with a maximum of 50,000m² GFA) and several facilities.

Endogenous variables:

- \( A_{\text{GFA}\_\text{SCH}\_\text{P1}} \): Total Gross Floor Area science & business park Schieveen phase 1 realised (m²)
- \( A_{\text{GFA}\_\text{SCH}\_\text{P1}\_\text{IND}} \): Total Gross Floor Area science & business park Schieveen phase 1 industrial functions realised (m²)
- \( A_{\text{GFA}\_\text{SCH}\_\text{P1}\_\text{N}\_\text{IND}} \): Total Gross Floor Area science & business park Schieveen phase 1 non-industrial functions realised (m²)
- \( A_{\text{GFA}\_\text{SCH}\_\text{P1}\_\text{N}\_\text{IND}\_\text{OFF}} \): Total Gross Floor Area science & business park Schieveen phase 1 non-industrial functions offices realised (m²)
- \( A_{\text{GFA}\_\text{SCH}\_\text{P1}\_\text{N}\_\text{IND}\_\text{FAC}} \): Total Gross Floor Area science & business park Schieveen phase 1 non-industrial functions facilities realised (m²)

Exogenous variables:

- \( a_{\text{gfa}\_\text{sch}\_\text{p1}\_\text{ind}} \): Total Gross Floor Area science & business park Schieveen phase 1 industrial functions (50,000m²)
- \( a_{\text{gfa}\_\text{sch}\_\text{p1}\_\text{n}\_\text{ind}\_\text{off}} \): Total Gross Floor Area science & business park Schieveen phase 1 non-industrial functions offices (50,000m²)
- \( p_{\text{gfa}\_\text{sch}\_\text{p1}\_\text{n}\_\text{ind}} \): Total percentage Gross Floor Area science & business park Schieveen phase 1 non-industrial functions (50%)

The presence of the word ‘maximum’ identifies the relation between these variables as the endogenous variable being smaller than or equal to the exogenous variable:
6.2.3 Implementing the optimisation focuses

Apart from the general constraints that were explained in the previous section, additional constraints must be accounted for in order to execute the optimisation processes. As outlined before in this thesis, the aim towards an optimal strategy is based on the focuses on (i) market quality; (ii) spatial quality; (iii) available means; and (iv) organisation. This section will describe how the boundary conditions are derived from the available verbal models. The transformation towards usable variables and constraints can be found in the appendix section of the thesis.

6.2.3.1 Market quality

Optimisation of the LP model for ‘market quality’ means that certain constraints must to be added to the task-function in order to be sure that the realised amount of space will not exceed the demanded amount of space. After all, market conditions visualise the process of demand and supply of several functions of real estate. Due to the fact that area of Rotterdam Noordrand is economic orientated, the market conditions are specified for (i) industrial space ($m^2$ BOA) and (ii) office space ($m^2$ GFA). In addition, market conditions for (iii) facilities ($m^2$ GFA) regarding the possible centre-like function within the area are needed.

Industrial space Rotterdam Noordrand

A prediction for the market conditions regarding industrial space was made in the ‘Vision working locations Rotterdam 2030’ (Visie werklocaties Rotterdam 2030).\(^{179}\) However, this document only gave figures and numbers for the economic region Groot-Rijnmond and therefore no specific information was provided for the Rotterdam Noordrand area or its subareas.\(^{180}\) I had to make

---

179 Ontwikkelingsbedrijf Rotterdam 2009.

180 Groot-Rijnmond consists of the following subareas: De Waterweg-Noord (Maassluis, Vlaardingen, Schiedam), B-driehoek (Berkel en Rodenrijs, Bleiswijk, Bergschenhoek), Oost (Cappele a.d. IJssel, Krimpen a.d. IJssel), Ijsselmonde.
assumptions based on the figures that were present in the document. The municipality of Rotterdam handles the Global Economy (‘GE’) scenario, set by the CPB Netherlands Bureau for Economic Policy Analysis (Centraal Planbureau, ‘CPB’) and identifies the expected demand for the period until 2020 at an average of 63 hectare per year.\textsuperscript{181} This is equal to an average of 630,000 m\textsuperscript{2} development area per year. The expected demand for the period 2020-2030 is set at an average of 28 hectare per year. This is equal to an average of 280,000 m\textsuperscript{2} development area per year. The Vision working locations Rotterdam 2030 gave the following information about the demand and supply for industrial space in the region Groot-Rijnmond.\textsuperscript{182}

\textbf{Figure 6.3} Market conditions industrial space for the region Rotterdam Groot-Rijnmond until 2030
Source: Ontwikkelingsbedrijf Rotterdam 2009, p. 28

Figure 6.3 shows that the supply of ‘dry working locations’ (overige droge werklocaties) in the municipality of Rotterdam is 137 hectare. The total supply of working locations regarding industrial space in the region Groot-Rijnmond is 876 hectare. This makes the share of dry working locations in Rotterdam (to which the area of Rotterdam Noordrand belongs) 15.6% of the total. Taken into account the previously mentioned GE-scenario, the demand for industrial space at dry working locations could be assumed as follows:

\textbf{Table 6.1 Assumed demand for industrial space on dry working locations in the municipality of Rotterdam until 2030}

<table>
<thead>
<tr>
<th></th>
<th>Demand until 2020 (m\textsuperscript{2}/year)</th>
<th>Demand 2020-2030 (m\textsuperscript{2}/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of industrial</td>
<td>630,000</td>
<td>280,000</td>
</tr>
<tr>
<td>space region Groot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rijnmond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of industrial</td>
<td>98,300</td>
<td>43,700</td>
</tr>
<tr>
<td>space dry working</td>
<td></td>
<td></td>
</tr>
<tr>
<td>locations Rotterdam</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{182} Ontwikkelingsbedrijf Rotterdam 2009, p. 28.
There are 3 locations of dry working locations in Rotterdam where new supply can be created to answer the demand that is stated in table 6.1: (i) the development area Rotterdam Noordrand; (ii) the attention-area Rotterdam Spanse Polder; and (iii) the attention-area Rotterdam North-West. The available area of Rotterdam Noordrand is 110 hectare, while the available area of the two attention-areas is 183 hectare. This makes the share of Rotterdam Noordrand 37.5% of the total. Therefore, the demand for industrial space at Rotterdam Noordrand could be assumed as follows:

Table 6.2 Assumed demand for industrial space in Rotterdam Noordrand until 2030

<table>
<thead>
<tr>
<th>Demand until 2020 (m²/year)</th>
<th>Demand 2020-2030 (m²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of industrial space dry working locations Rotterdam</td>
<td>98,300</td>
</tr>
<tr>
<td>Total of industrial space Rotterdam Noordrand</td>
<td>36,900</td>
</tr>
</tbody>
</table>

For the industrial space, the maximum amount of BOA was set for newly realised areas at 50%. With this fact, an assumption could be made towards the amount of BOA regarding the demand of industrial space in Rotterdam Noordrand. Taking into account the phasing plan of the area, the demand for industrial BOA in the whole development could be assumed as follows:

Table 6.3 Assumed maximum of BOA industrial space in Rotterdam Noordrand, translated according to the phasing plan

<table>
<thead>
<tr>
<th>Demand phase</th>
<th>Demand phase</th>
<th>Demand phase</th>
<th>Demand phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of industrial space Rotterdam Noordrand</td>
<td>369,000</td>
<td>266,500</td>
<td>164,000</td>
</tr>
<tr>
<td>Maximum share of built-on area</td>
<td>184,500</td>
<td>133,300</td>
<td>82,000</td>
</tr>
</tbody>
</table>

The derived endogenous variables, exogenous variables and constraints regarding the market quality of industrial space in Rotterdam Noordrand can be found in E 1.1 (Variables and constraints derived from optimisation focuses – Market quality)

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183 Attention-areas are areas where no large economic growth potential is present. The goal of interventions in these areas is primarily aimed at the (re) functioning of the working locations. In order to keep certain developments manageable, restructuring could be necessary (Gemeente Rotterdam 2009, p. 36).

184 Centrum voor Onderzoek en Statistiek 2006, p. 17

185 Four phases, each with a time-span of 10 years.
Office space Rotterdam Noordrand

Similar to the previous subsection, assumptions had to be made concerning the demand of office space in Rotterdam Noordrand due to the fact that no specific information was given for the area or its subareas. Based on the GE-scenario by the CPB, the demand for office space in the region Groot-Rijnmond was set at 100,000m² GFA per year. A share of 80% of this number will be realised in the municipality of Rotterdam and therefore resulted in a demand of 80,000m² GFA in Rotterdam per year. A share of approximately 19% of this total is newly-build office space. Due to the fact that all real estate in the Rotterdam Noordrand development area will be newly-build, assumptions on the demand for gross floor office space is made. Rotterdam Noordrand is the only ‘development-area’ that will contain office space and therefore the demand for office space could be assumed as follows:\textsuperscript{187}

Table 6.4 Assumption of the share of office space in Rotterdam Noordrand translated according to the phasing plan

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of office space Rotterdam</td>
<td>800,000</td>
<td>800,000</td>
<td>800,000</td>
<td>800,000</td>
</tr>
<tr>
<td>Minimum share of Rotterdam Noordrand (10%)</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Maximum share of Rotterdam Noordrand (15%)</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
</tr>
</tbody>
</table>

The derived endogenous variables, exogenous variables and constraints regarding the market quality of office space in Rotterdam Noordrand can be found in E 1.2 (Variables and constraints derived from optimisation focuses – Market quality).

Space for centre-like facilities Rotterdam Noordrand

The market conditions for the demand for facilities were difficult to identify, as no specific information could be found. Therefore, I used the conclusions that I had drawn considering the possible centrality of each of the subareas in the Rotterdam Noordrand development.\textsuperscript{188}

If the area of the first phase of science & business park Schieveen was given the identity of a central place, the facilities of the area would only serve the users of the science & business park

\textsuperscript{186} Ontwikkelingsbedrijf Rotterdam 2009, p. 30
\textsuperscript{187} The share of Rotterdam Noordrand is calculated between 10% and 15%, assuming that a reasonable share will be newly-realised in existing areas in the municipality of Rotterdam such as the Central Station Area and Kop van Zuid.
\textsuperscript{188} These conclusions were written down in section 3.4.
with their goods and services. The particular zoning plan provides in a total of 23,500m² GFA of facilities on a total of 100,000m² GFA. Assumptions on the share of different facilities could thus be made:

Table 6.5 Assumption of the share of facility-types per centre-like facility-cluster in Rotterdam Noordrand

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>GFA (m²)</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total facilities</td>
<td>23,500m²</td>
<td>100%</td>
</tr>
<tr>
<td>Communal facilities</td>
<td>15,000m²</td>
<td>65%</td>
</tr>
<tr>
<td>Recreational facilities</td>
<td>5,000m²</td>
<td>20%</td>
</tr>
<tr>
<td>Catering industry facilities</td>
<td>2,500m²</td>
<td>10%</td>
</tr>
<tr>
<td>Retail facilities</td>
<td>1,000m²</td>
<td>5%</td>
</tr>
</tbody>
</table>

The amount of facilities was therefore be dimensioned as 23.5% of the total amount of GFA in the area. Thus in this case, per 76,500m² GFA of economic functions, 23,500m² GFA of facilities is realised within the thought of financial strength. Therefore, it is assumed that the share of facilities at an economic orientated central place in the Rotterdam Noordrand development area would be approximately 30% compared with the amount of economic functions. In addition, the central place differentiates itself by the presence of (i) a hotel that enhances different in-house facilities and (ii) parking facilities. In the zoning plans of Nature- and business park Schieveen and Rotterdam The Hague Airport, the total amount of space that is reserved for a hotel was set at 35,000m² GFA and therefore this amount was accounted for.

The derived endogenous variables, exogenous variables and constraints regarding the market quality of centre-like facilities in Rotterdam Noordrand can be found in E 1.3 (Variables and constraints derived from optimisation focuses – Market quality)

6.2.3.2 Spatial quality
Optimisation of the LP model for ‘spatial quality’ means that certain constraints should be added to the task-function. These constraints bound the division of real estate in such manner that it will satisfy the composition of user value, experience and future value. Due to the fact that its interpretation must be determined by the involved parties for every individual development, spatial quality has a subjective character. It could not easily be measured on an objective manner. Composition and architectural quality are for example items that cannot be measured with a LP model. I was aware of this en therefore searched for measurable characteristics of spatial quality.

In this thesis, the expression ‘density’ is used as a scale to measure the spatial quality. It is important to realise that the concept of density can be approached in various ways. Individual

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189 These parking facilities must not be mistaken with transfer-areas where one can switch from the road network onto the public transport network.
190 These were outlined in section 4.3.1.
perception and technical attributes belong to different categories. One cannot analyse in the first category and draw conclusions in the other.\textsuperscript{191} In the Netherlands, the most widely used method of determining density is still ‘the number of homes per hectare’.\textsuperscript{192} This method does not account for the size of homes or the number and size of other functions. Because of the economic character of Rotterdam Noordrand, this method could not be used in this research. The emphasis is on the physical and spatial aspects of density and the following measurable are used characteristics:

- Ground Space Index (‘GSI’). This index translates the relation between the amount of BOA that is realised within a certain Development Area (‘DA’). It expresses the compactness of the development: $GSI = \frac{BOA}{DA}$.
- Floor Space Index (‘FSI’). This index translates the relation between the amount of Gross GFA that is realised within a certain DA. It expresses the intensity of the development: $FSI = \frac{GFA}{DA}$.
- Open Space Ratio (‘OSR’). This index translates the relation between the amount of Gross GFA that is realised and the amount of non-BOA within a certain DA. It expresses the non-built space of the development: $OSR = \frac{(DA-BOA)}{GFA}$.

The index Layers (‘L’) is added to these characteristics because it provides an important link in defining the relations that are outlined above, when one uses BOA or GFA as a source of information:

- $GSI = \frac{BOA}{DA}$ but also $GSI = \frac{GFA}{L}$
- $FSI = \frac{(BOA*L)}{DA}$ but also $FSI = \frac{GFA}{DA}$
- $OSR = \frac{(DA-BOA)/(BOA*L)}{GFA}$ but also $OSR = \frac{(DA-BOA)}{GFA}$

The maximum amount of BOA in science & business park Schieveen was set in its zoning plan. A maximum of 35% was reserved and resulted in a GSI of 0.35. For the other subareas of the Rotterdam Noordrand development area, no specific numbers were provided. However, assumptions could be made and are presented in the following table.\textsuperscript{193, 194}

\begin{itemize}
  \item [191] Berghauser Pont 2004.
  \item [192] Number of residences realised in an area of 10,000m$^2$.
  \item [193] Note that the subarea of Rotterdam Airport Business Park Luchtzijde is not accounted for, as the ground also include the landing strip of the airport and therefore no reasonable assumption can be made: the GSI will always be very low.
  \item [194] Also note that the subareas of Laag-Zestienhoven and Midden-Zestienhoven are not accounted for, as the zoning plan is binding and therefore no eventual changes can be made in the densities.
\end{itemize}
Table 6.6 Assumed GSI for the subareas of Rotterdam Noordrand

<table>
<thead>
<tr>
<th></th>
<th>Maximum Ground Space Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science &amp; business park Schieveen phase 1</td>
<td>0.35</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 2</td>
<td>0.35</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 3</td>
<td>0.35</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 4</td>
<td>0.35</td>
</tr>
<tr>
<td>Rotterdam Airport Business Park Landzijde</td>
<td>0.35</td>
</tr>
<tr>
<td>Park Zestienhoven Hoog-Zestienhoven South</td>
<td>0.45</td>
</tr>
<tr>
<td>Park Zestienhoven Hoog-Zestienhoven North</td>
<td>0.45</td>
</tr>
</tbody>
</table>

The maximum GSI of Rotterdam Airport Business Park Landzijde was set similar to the science & business park because the area is also positioned within SPH. Therefore, a same amount of spatial quality would be required. The maximum GSI of the subareas of Hoog-Zestienhoven was assumed to have the value 0.45 due to the fact that they are presented as the areas with the highest density within Park Zestienhoven.

The numbers that are presented in table 6.6 define the amount of BOA but do not account for the height of the real estate, which is also of influence on the spatial quality of the area. Therefore it was necessary to add maximum FSI’s to the subareas. Again, only for the subareas of science & business park Schieveen, a FSI of 0.80 was provided. Due to the fact that the spatial quality was one of the most important aspects of the Rotterdam Noordrand development area, this value of the FSI was assumed to be the same for the other subareas. These assumptions are presented in table 6.7:

Table 6.7 Assumed GSI and FSI for the subareas of Rotterdam Noordrand

<table>
<thead>
<tr>
<th></th>
<th>GSI</th>
<th>Maximum Floor Space Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science &amp; business park Schieveen phase 1</td>
<td>0.35</td>
<td>0.80</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 2</td>
<td>0.35</td>
<td>0.80</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 3</td>
<td>0.35</td>
<td>0.80</td>
</tr>
<tr>
<td>Science &amp; business park Schieveen phase 4</td>
<td>0.35</td>
<td>0.80</td>
</tr>
<tr>
<td>Rotterdam Airport Business Park Landzijde</td>
<td>0.35</td>
<td>0.80</td>
</tr>
<tr>
<td>Park Zestienhoven Hoog-Zestienhoven South</td>
<td>0.45</td>
<td>0.80</td>
</tr>
<tr>
<td>Park Zestienhoven Hoog-Zestienhoven North</td>
<td>0.45</td>
<td>0.80</td>
</tr>
</tbody>
</table>

The derived endogenous variables, exogenous variables and constraints regarding the spatial quality in Rotterdam Noordrand can be found in Appendix E 2 (Variables and constraints derived from optimisation focuses – Spatial quality).196

6.2.3.3 Means

Optimizing the LP model for ‘available means’, indicates that certain constraints have to be added to the task-function. Taken into account the economic importance of possible revenues for the RDC, optimisation for means is about maximizing the revenues that are gained by the transaction-prices for real estate. Within the LP model this could be done by connecting the amount of GFA per function, and transaction-prices for that specific function. In regard to the specific functions that were differentiated in the model, the following assumptions are made:197

Table 6.8 Transaction-prices per function in the municipality of Rotterdam

<table>
<thead>
<tr>
<th>Function</th>
<th>Transaction-prices in €/m² GFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial function</td>
<td>190</td>
</tr>
<tr>
<td>Office function</td>
<td>600198</td>
</tr>
<tr>
<td>Communal facilities</td>
<td>195</td>
</tr>
<tr>
<td>Recreational facilities</td>
<td>300199</td>
</tr>
<tr>
<td>Catering industry facilities</td>
<td>450</td>
</tr>
<tr>
<td>Hotel facilities</td>
<td>290</td>
</tr>
<tr>
<td>Retail facilities</td>
<td>450</td>
</tr>
<tr>
<td>Airport-supporting facilities</td>
<td>195200</td>
</tr>
<tr>
<td>Residences</td>
<td>275</td>
</tr>
</tbody>
</table>

Such a connection between GFA and transaction-prices adds again to the flexibility of the LP model. Increasing or decreasing transaction-prices directly affect the outcome of the model. The derived endogenous variables, exogenous variables and constraints regarding the revenues in Rotterdam Noordrand can be found in Appendix E 2 (Variables and constraints derived from optimisation focuses – Means)

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196 Note that the variables and constraints are directly made with the use of the existing endogenous variables in the LP model. The GSI- and FSI values can be denoted as exogenous variables (in percentages).
197 The provided numbers are based on Gemeente Rotterdam 2007a, p. 5-6 and Ontwikkelingsbedrijf Rotterdam 2008, p. 9-11.
198 The office locations of Rotterdam Noordrand may be compared with the office location Brainpark which transaction-prices are valued between 590 and 605 €/m² GFA (Ontwikkelingsbedrijf Rotterdam 2008, p. 9.
199 The assumption for the transaction-price of recreational facilities is positioned between the transaction-prices of communal- and retail facilities.
200 These are assumed to be equal to the transaction-price of communal facilities.
6.2.3.4 Organisation

Optimizing the LP-model within the context of ‘organisation’ was a difficult issue. As outlined in section 4.5, one can distinguish many involved actors in the development of an area. It is necessary to clearly identify the most important actors in the Rotterdam Noordrand development area. Consequently, it needs to be determined whether private parties have a large land or tenancy position in the area. The grounds of the subareas of polder Schieveen and polder Zestienhoven are almost totally owned by the municipality of Rotterdam. The grounds of Rotterdam The Hague Airport are however owned by Schiphol Real Estate.\(^{201}\) This actor has therefore a large influence on the development of not only the Rotterdam Airport Business Park, but also on the comprehensive development of Rotterdam Noordrand. The most important public party within the development area is the RDC of the municipality of Rotterdam.\(^{202}\)

Spatial problems that need to be encountered at area development frequently ask for enormous investments. Therefore, both private financial means and expertise are necessary. Within such a PPP, all individual goals must be revised in order to clarify how they can support each other (synergy, as explained in section 3.2). The LP model is able to structure these individual goals by allocating the preferences – per function per subarea – of both public and private parties. The model can include or exclude specific functions in specific subareas. A preference is made by assigning the ‘function-area combination’ the value 2. A dislike is made by assigning the value 0.

When a stakeholder holds a neutral position, the value 1 is assigned. Before assigning preferences/dislikes by each party, the values are standardised and provided with the neutral value 1.

Specific arrangements can be made whether all parties have the same amount of influence. When it considers the Rotterdam Noordrand development area, two parties are of importance: the (public) RDC and (private) Schiphol Real Estate. The influence of RDC is valued higher than the influence of Schiphol Real Estate because the first is the administrator of the development area. In the general LP model their ratio is set at 2:1.\(^{203}\)

The preferences were assigned according to the information that was found in the zoning plans (for the RDC, \(S_1\)) and the website of Rotterdam Airport Business Park (for Schiphol Real Estate, \(S_2\)).\(^{204}\) The differentiation in weight of the preferences between the two stakeholders was generated by the use of a cumulative preference table wherein these differences were accounted for. This was done in this research with the following equation:

\(^{201}\) This explains their commitment in the covenant on the name change in section 1.1.4.

\(^{202}\) On a larger extent the City-Region Rotterdam, the initiator of the whole North Axis development programme, is of influence. Due to the fact that the zoning plans are in line with this overlapping structure plan, the influence of the City-Region Rotterdam can be excluded.

\(^{203}\) This ratio can be altered, provided that the stakeholder 1 outweighs stakeholder 2.

\(^{204}\) At this website, the Rotterdam Airport Business Park is presented as an economic establishment location with industrial space, office space, retail facilities and a hotel (Internet 12).
\[(S_1 \times S_2) \geq 1 + (S_1=2) \times (S_1=0)^{205}\]

The allocation of preferences for the two stakeholders, and the cumulative preference table can be found in Appendix F (Preference identification for stakeholders 1 & 2).

6.3 Using the LP model Rotterdam Noordrand

In section 6.1, the main functioning of a LP model was outlined and at the beginning of section 6.2, the difficult character of such a systematic approach and the use of LP were discussed. For the users of the LP model, other than the model maker, it is not necessary to understand functioning of the model in every detail. Therefore, an explicit differentiation was made between the actual LP model and input-fields that determine the values of the exogenous variables. After all, these values are assigned to the model by the users and contribute to the set of constraints.

In order to keep the interface of the LP model as simplified as possible, the exogenous variables were divided into two groups: (i) programmatic exogenous variables that could be altered; and (ii) hard exogenous variables that were fixed. These two groups and their interfaces are presented in the next sections.\(^{206}\)

6.3.1 Programmatic exogenous variables

This group of exogenous variables reflects directly on the intended programme of Rotterdam Noordrand. Due to the fact that the aim of this research is focused on the programmatic aspect of the area development in the northern part of Rotterdam, the values of these exogenous variables can be altered. The values represent the intended programme of the development. The interface is designed according to the phasing plan and is visualised below in figure 6.4.\(^{207}\) \(^{208}\)

In addition to the input-fields of the programmatic exogenous variables, the interface enhances input-fields regarding the location of the central place and the optimisation constraints. Assigning a 1 to the subarea of the development, implements the realisation of a central place in that specific subarea. Assigning a 1 to the type of optimisation constraint, implements that the LP model will account for the constraints regarding this optimisation focus.\(^{209}\)

\(^{205}\) This equation means that the cumulative preference is accounted for in the model if its value is equal or higher than 3.

\(^{206}\) The expression ‘interface’ represents the linkage of two diverse information processing systems.

\(^{207}\) The phasing design was described in section 6.2.1.2.

\(^{208}\) It is of importance to note the values of the exogenous variables are directly translated from the verbal information that was found in the corresponding zoning plans of the subareas.

\(^{209}\) Note that providing the value 1 to all four focuses would implement the optimal strategy.
6.3.2 Hard exogenous variables

This group of exogenous variables is fixed for the development area. These variables are not likely to be altered during the optimisation process. However, the optimisation outcomes have to satisfy the constraints that are related to these variables. The interface of the hard exogenous variables contains apart from subarea specific values, also input-fields regarding the market quality, spatial quality and revenues. For a visualisation of the corresponding interface, please see Appendix G (Interface for valuing hard exogenous variables).

6.3.3 Assigning preferences to a subarea/function combination

Within this chapter, it is of importance to mention how the stakeholders’ preferences can be allocated within the LP model. As outlined in section 6.2.3.4, a preference is made by assigning the value 2 to a specific subarea/function combination and a dislike by assigning the value 0. Differences in influence by the stakeholders could be accounted for by altering the weight factors. The end value in the cumulative preferences table indicates whether the LP model should account for that subarea/function combination. For a visualisation of the corresponding interface, please see Appendix F (Preference identification for stakeholders 1 & 2).
6.4 Application and results

The LP model was optimised for each of the focuses that contribute to the optimal strategy. The optimal strategy takes into account all four focuses in mutual cohesion. In order to test the validity of the four-vertex research model, the optimisation process was done step-wise.210

6.4.1 Testing the validity of the four-vertex research model

This section will describe the steps that are taken to narrow down the solution space towards the optimal strategy. This process is done for each of the three assigned central places. 211 Due to the fact that this process is carried out on a similar way for these three alternatives, only the process for the science & business park as central place will be outlined.

The first step of the optimisation process was an optimisation without any focus on the elements that would determine the optimal strategy. 212 This optimisation led to an unbounded solution of the LP model. Apparently, the model is in need of more constraints because the solution area is open on at least one side. 213 Adding the focuses of the optimal strategy could ensure these constraints.

Adding constraints that determine the spatial quality of Rotterdam Noordrand, bound the development area on the indexes GSI and FSI. They determine the maximum BOA and GFA that can be realised and result in a final programme that enhances a total of 3,651,105m² BOA and 1,834,528m² GFA. 214

The next step is to optimise these outcomes for the market quality in order to be sure that the amount of floor area will not exceed the market conditions. Optimisation of the LP model results in a final programme that enhances a total of 3,651,607m² BOA and 1,721,035m² GFA.

Subsequently, the preferences of the stakeholders were added to the LP model. However, the following optimisation did not lead to changes in the obtained amounts of BOA and GFA. This could be explained by the fact that the preferences of the RDC and Schiphol Real Estate are in agreement with the division of area that was already prescribed in the zoning plans.

The final step in determining the optimal strategy also takes the possible revenues (means) into account. Optimisation of the LP model results in a final programme that enhances a total of 2,752,162m² BOA and 1,301,065m² GFA. An overview of this process per phase is provided in table 6.9 below:

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210 The four-vertex research model was outlined in section 4.6 and visualized in figure 4.3.
211 As written down in section 1.3 of this thesis.
212 These elements are market quality, spatial quality, available means, and organisation.
213 A visualization of such unbounded solution can be found in figure 5.4.
214 Note that the amount of BOA is so much larger that the amount of GFA due to the fact that the development of nature reserves and the A13/A16 highway – that enhance a total of 2,120,000m² – are added to the amount of BOA. This is done to ensure the comprehensive character of Rotterdam Noordrand.
The solution space is shaped from unbounded towards a global optimum that accounts for the four focuses of the optimal strategy and the findings validate the presented four-vertex research model. For the outcomes of the LP model that were used to validate the research model I refer to Appendix H (Validating the four-vertex research model).

6.4.2 Science & business park Schieveen as central place in Rotterdam Noordrand.

In the previous section, the path towards the optimal strategy was already described. The interface of the LP model visualises the strategy, as presented in figure 6.5 below.

The programme of the actual central place – conducted from figure 6.5 – at science & business park Schieveen results, apart from economic functions, in a facility cluster of 58,077m² GFA. The cluster consists of:

- 15,000m² GFA communal facilities;
- 4,615m² GFA recreational facilities;
- 2,308m² GFA catering industry facilities;
- 1,154m² GFA retail facilities; and
- 35,000m² GFA hotel facilities.
This facility cluster will be realised in the second phase of the development of Rotterdam Noordrand (2015-2044), with the exception of the hotel facilities. The LP model allocates these in the fourth phase, but this is randomly chosen by the model. These could also be allocated in the third phase.\textsuperscript{215}

\textsuperscript{215} The hotel facilities can not be realised in the second phase because the realised amount of GFA would then exceed the maximum that was set for the first phase of science & business park Schieveen.
6.4.3 Rotterdam Airport Business Park as central place in Rotterdam Noordrand

In figure 6.6, presented above, the interface of the optimal strategy is given. This strategy implements that the central place is located at the subarea Landzijde of Rotterdam Airport Business Park. The programme of the actual central place – conducted from figure 6.6 – at the grounds of the airport results, apart from economic functions and the terminal, in a facility cluster of 76,077m² GFA. The cluster consists of:

![Figure 6.6 User interface for central place Rotterdam Airport Business Park](image)
• 26,700m² GFA communal facilities;
• 8,215m² GFA recreational facilities;
• 4,108m² GFA catering industry facilities;
• 2,054m² GFA retail facilities; and
• 35,000m² GFA hotel facilities.

This facility cluster will be realised in the first phase of the development of Rotterdam Noordrand (2015-2044).

6.4.4 Hoog-Zestienhoven as central place in Rotterdam Noordrand

In figure 6.7, presented below, the interface of the optimal strategy is given. This strategy implements that the central place is located at within the subareas Hoog-Zestienhoven South and Hoog-Zestienhoven North:

The programme of the actual central place – conducted from figure 6.7 – at the infrastructural junction results, apart from economic functions, in a facility cluster of 86,825m² GFA. The cluster consists of:

• 33,686m² GFA communal facilities;
• 10,365m² GFA recreational facilities;
• 5,183m² GFA catering industry facilities;
• 2,591m² GFA retail facilities; and
• 35,000m² GFA hotel facilities.

This facility cluster will be realised spread over the second, third and fourth phase of the development of Rotterdam Noordrand (2015-2044). However this allocation is randomly chosen by the model. These facilities could also be allocated in the third phase of the development. Furthermore, a total of 90,000m² GFA is reserved for parking facilities regarding the transferee.216

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216 Note that the character as a mixed-use area is strengthened by the realisation of apartments, which are primarily located in Hoog-Zestienhoven South.
6.5 Reflection and discussion

Taking the conclusions regarding the infrastructural influences into account, one must consider the optimal strategies presented in section 6.4. A differentiation can be made between the possible identities of the central places. A central place in science & business park Schieveen or Rotterdam Airport Business Park is primarily identified as a business area, while a central place in

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217 These conclusions were presented in section 3.4.
Hoog-Zestienhoven could outgrow its serving area and become a place of supraregional importance.

The identities that are outlined in the paragraph above, enquire an approach towards the realisation of two central places in the area. One central place located in the business areas in the east of the development area, and one supraregional central place located in Hoog-Zestienhoven. The first should serve the science & business park Schieveen and Rotterdam Airport Business Park with its goods and services. The latter should not only serve the area surrounding the infrastructural junction, but also to a certain degree the Metropolitan Region Rotterdam – The Hague with its goods and services. The LP model was optimised for the proposed central place combinations and the results are shown in table 6.10 below:

<table>
<thead>
<tr>
<th>Central place:</th>
<th>m² BOA</th>
<th>m² GFA</th>
<th>Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoog-Zestienhoven + science &amp; business park Schieveen</td>
<td>2,757,457</td>
<td>1,332,835</td>
<td>€463,802,544,-</td>
</tr>
<tr>
<td>Hoog-Zestienhoven + Rotterdam Airport Business Park</td>
<td>2,701,661</td>
<td>1,316,385</td>
<td>€462,821,699,-</td>
</tr>
</tbody>
</table>

The combination of one supraregional central place in Hoog-Zestienhoven and one business central place in science & business park Schieveen produces much higher values of BOA and GFA. However, the revenues are almost similar – they differ roughly €1,000,000, which is approximately 0.2% – in comparison with the second alternative that defines the business central place in Rotterdam Airport Business Park: the revenues per realised m² BOA and GFA are higher for this latter alternative. This is shown in table 6.11:

<table>
<thead>
<tr>
<th>Central place:</th>
<th>Revenues per m² BOA</th>
<th>Revenues per m² GFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoog-Zestienhoven + science &amp; business park Schieveen</td>
<td>€168</td>
<td>€348</td>
</tr>
<tr>
<td>Hoog-Zestienhoven + Rotterdam Airport Business Park</td>
<td>€171</td>
<td>€352</td>
</tr>
</tbody>
</table>

Within this context it must be stated that the business areas must not be generalised. In order to avoid inter-competition among the economically orientated sub developments, it is of importance to differentiate their target groups. The science & business park Schieveen should focus on (inter)national R&D, ICT and innovative business services while Rotterdam Airport Business Park should aim for international airport related businesses. Consequently, not every business should be able to establish itself on the territory of these areas. The administrators and developers of
Rotterdam Noordrand need to adopt a selective policy in order to secure the range of thoughts of the Noordrand development.218

6.6 Conclusions

An optimisation for all of the four focuses concerning the optimal strategy provides the most realistic visualisation of reality. The effects of organisation will however be more noticeable when the involved parties have a dissimilar interest in the area. In the case of Rotterdam Noordrand, the preferences of the RDC and Schiphol Real Estate are not conflicting with each other. This could be explained by the fact that the first public party positions itself as a private entrepreneur on the land-market. Taking the constraints on market quality and spatial quality into account, gives the development plan its realistic character and frames the actual space wherein one can shift with the programmatic parts of the strategy. They provide for the framework wherein the potentials are visible. Finally, revenues provide opportunities for the involved parties in the development area. Giving insight in the revenues makes it possible to divide the eventual costs on a sensible manner. In addition, participating parties can identify their financial latitude.

Due to the differentiation of identity between the business areas (in the west) and the supraregional area (in the east), a combination of two central places is advisable. A combination of an economically orientated central place at the territory of Rotterdam The Hague Airport and a supraregional orientated central place at Hoog-Zestienhoven ensures the most revenues per m² BOA and m² GFA. These extra revenues could be (re)invested in their development, resulting in more quality. This quality is a crucial factor in attracting and holding the high-quality businesses and their employees in Rotterdam Noordrand.

In addition, the fact that the economically orientated central place is positioned directly at the international business airport Rotterdam The Hague Airport puts the central place on the international map. A definite outline of the optimal strategy that should stimulate this purpose will be presented in chapter 7 (Conclusions and recommendations).

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218 This range of thought is based on the exclusiveness of the development, being the opportunity to enforce a connection with the economies of Randstad Holland and improve the economic performance of the South Wing.
The developments of the North Axis embody the process of improving the economic performance of the South Wing in the Randstad Holland network. The creation of a high-quality establishment environment combined with excellent reach ability should attract and hold the high-quality businesses and their employees. In order to realise this environment, a comprehensive approach on the area development is necessary. The economic centre of the North Axis is describe in this thesis as ‘Rotterdam Noordrand’, consisting of the sub developments of Nature- and business park Schieveen, Rotterdam Airport Business Park, and Park Zestienhoven. Until 2010, a comprehensive approach was not present, as the developments were each carried out under the supervision of separate project leaders. At the beginning of 2010 an overall project leader was installed by the Rotterdam Development Corporation to integrate the developments with each other and ensure the comprehensiveness of the overlapping SR2020 structure plan.

Rotterdam Noordrand requires a central place that connects the sub developments on an administrative, but also on a spatial level. This thesis is produced to ‘conduct the optimal strategy for the new central place within Rotterdam Noordrand.’ Apart from connecting the segmented developments that are scheduled in the programme, the strategy intends to consider all present and future infrastructural projects. This consideration is of importance to profit as much as possible from the infrastructural developments that improve the reach ability of the environment. Eventually, a combination of spatial development and infrastructure will lead to synergy.

Such an optimal strategy allocates the programmatic parts over the period 2005-2044 in four phases, each with a time-span of 10 years. The expression ‘optimal’ defines that the strategy takes the market conditions, spatial quality, available means, and the allocation of stakeholders’ preferences into account. The urban development process of Rotterdam Noordrand is structured with the use of Linear Programming, a mathematical modelling technique. Optimizing the model towards the optimal strategy provides a simplified and realistic reflection of reality. The following section presents the general conclusions that can be drawn from the research and describes the optimal strategy. Section 7.2 presents the optimal strategy for the comprehensive development of Rotterdam Noordrand. Section 7.3 discusses the usage of Linear Programming as a method for solving complex development problems and section 7.4 gives recommendations for further research.

7.1 General conclusions

Rotterdam Noordrand is a multimodal development location. It is connected to the national road network by the A13 highway and will be connected to the planned A13/A16 highway connection. Furthermore, it is connected to the public transport network by the RandstadRail and the HST. The fact that the international business airport Rotterdam The Hague Airport is located in the
development area contributes to its ‘unique selling points’ and even pins down the area as an international interesting location. The multimodal character of Rotterdam Noordrand provides the development area with major potentials regarding the creation of the desired high quality establishment environment. All possible central locations within the area – located in science & business park Schieveen, Rotterdam Airport Business Park, and Hoog-Zestienhoven – are directly connected with the infrastructural projects. However, their position in respect to the ‘infrastructural junction Rotterdam Airport’ influences its possibilities. Although all locations have an emphasis on an economic function, differences can be made concerning their identity.

A central place that is located at the sub developments of science & business park Schieveen or Rotterdam Airport Business Park will adapt a business orientated identity, due to its position at the far end of the primary influence area of the infrastructural junction Rotterdam Airport. A central place that is located at the sub development of Hoog-Zestienhoven is positioned directly at the infrastructural junction. Therefore, it has the potential to outgrow its serving area and transform into a central place of supraregional importance. This differentiation in identity makes a combination of two central places advisable. As outlined in section 6.5, a combination of an economically orientated central place at Rotterdam Airport Business Park and a supraregional orientated central place at Hoog-Zestienhoven should considered to be the best decision if one takes into account the quality and revenues of the comprehensive development.

7.2 Optimal strategy Rotterdam Noordrand

The optimal strategy for the comprehensive development of Rotterdam Noordrand enhances – as outlined above – two central places: (i) the economically orientated central place at Rotterdam Airport Business Park and (ii) the supraregional orientated central place at Hoog-Zestienhoven. The Linear Programming model provides an optimal developments strategy as visualised in figure 7.1 below.

The economically orientated central place Rotterdam Airport Business Park will serve its direct area with goods and services. The programme provides for a facility cluster of 76,077m2 GFA. The cluster consists of:

- 26,700m² GFA communal facilities;
- 8,215m² GFA recreational facilities;
- 4,108m² GFA catering industry facilities;
- 2,054m² GFA retail facilities; and
- 35,000m² GFA hotel facilities.
These facilities of central place Rotterdam Airport Business Park will be realised in the first phase of the development. The remainder of the sub development should consist of industrial and office space that is focused on international airport related businesses. A distinct differentiation has to be made regarding the economies of science & business park Schieveen, which should be aimed at (inter)national R&D, ICT and innovative business services in order to rule out internal strife. Within this context I must state that the administrators and developers of Rotterdam Noordrand will necessitate a selective policy for these two economic areas in order to secure its range of thought, as mentioned in section 6.5.

**Figure 7.1 Optimal strategy Rotterdam Noordrand**
The second central place, the supraregional oriented central place Hoog-Zestienhoven will serve not only its surrounding area, but to a certain degree the Metropolitan Region Rotterdam – The Hague with goods and services. The programme provides for a facility cluster of 86,825m² GFA. The cluster consists of:

- 33,686m² GFA communal facilities;
- 10,365m² GFA recreational facilities;
- 5,183m² GFA catering industry facilities;
- 2,591m² GFA retail facilities; and
- 35,000m² GFA hotel facilities.

Furthermore, a total of 90,000m² GFA is reserved for parking facilities regarding the transferee. The remainder of the subarea consists of office space and a reasonable amount of apartments.\(^{219}\)

Taking into account its supraregional character, one could think of adding specific facilities to the area. An enlargement of the amount of communal space would be the best option in order to avoid infighting competition with other supraregional areas in the municipality of Rotterdam.\(^{220}\) The facilities will be realised during the second, third and fourth phase of the development. The result of the LP model, visualised in figure 7.1 above, allocates some of the facilities in the fourth phase. This is randomly chosen by the model and these facilities could also be allocated in the third phase of the development.

The optimal strategy enhances a total of 1,316,385m² GFA, which can be categorised in the following functions: industrial functions (328,173m² GFA), offices (433,000m² GFA), facilities (314,602m² GFA), and residences (240,610m² GFA). This identifies the comprehensive development of Rotterdam Noordrand as a mixed-use area.

In addition, the optimal strategy allocates the amount of BOA and GFA over the four phases of the development as shown in table 7.1:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RABP + Hoog-Zestienhoven</td>
<td>m² BOA</td>
<td>m² GFA</td>
<td>m² BOA</td>
<td>m² GFA</td>
</tr>
<tr>
<td></td>
<td>235,565</td>
<td>509,310</td>
<td>940,750</td>
<td>239,500</td>
</tr>
<tr>
<td></td>
<td>m² BOA</td>
<td>m² GFA</td>
<td>m² BOA</td>
<td>m² GFA</td>
</tr>
<tr>
<td></td>
<td>703,414</td>
<td>327,984</td>
<td>821,932</td>
<td>239,591</td>
</tr>
</tbody>
</table>

The revenues are, according to the optimal strategy and the assumed transaction prices (section 6.2.3.3) almost €463million.\(^{221}\)

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\(^{219}\) These apartments are primarily located in Hoog-Zestienhoven South.

\(^{220}\) The future realisation of ‘Stadionpark’ at the southern part of the city aims at recreational facilities and the area of ‘Rotterdam-Alexander’ is aimed at retail facilities.

\(^{221}\) The actual value of the assumed revenues is €462,821,699,-.
7.3 Usage of Linear Programming modelling

The use of a mathematical model has contributed to my research. It gave me the possibility to structure the complex development of Rotterdam Noordrand. By assigning endogenous and exogenous variables and their relations (the constraints within the task-function), a total of 398 variables and approximately 500 constraints were constructed within the Linear Programming model.

I considered the fact that all variables and constraints were related with each other as an enormous positive quality of Linear Programming. Every change directly illustrates its effects on the other elements. As a model, this contributed to the adaptability of the uncertain process of urban area development. With the use of this modelling technique, possible development scenarios could be explored and reduce existing uncertainties. Regarding the flexibility, separate sheets can be used to assign the values of the exogenous variables. This makes the model usable for various development problems without having to alter the whole content: the content stays fixed.

Of course, the use of Linear Programming has some pitfalls. The most important one is that Linear Programming cannot implement subjective conditions. It is a technique that only works with quantitative values. Therefore, I had to transform qualitative information within my research into quantitative usable variables. For example, the stakeholders’ preferences were transformed into the values 0, 1 and 2, and the subjective matter of spatial quality into values of GIS and FIS.

In addition, its use can be time consuming, since one is to get familiar with the programming and must systematically approach variables and constraints. This makes the modelling technique not immediately suitable for laymen concerning the Linear Programming subject. In order to make it understandable for future use by the RDC, I limited the input-fields as much as possible and separated input and output sheets from the actual Linear Programming model.

Although the use of Linear Programming, or any other mathematical modelling technique, is not yet noticeable accepted in the process of urban area development, I believe that it could significantly contribute to a more comprehensible and structured development framework. It could be a useful tool in both the negotiation and planning processes as it has the ability to provide a starting point for further development. In this respect the technique remains a tool, as the reality cannot be captured with quantitative variables only!

7.4 Recommendations for further research

The use of modelling techniques in order to structure development problems is not a well-examined subject. In the current search towards synergy of the fields of infrastructure and spatial planning, additional research could implement an elaboration of the ‘node-place model’ of
Bertolini (1999). This model offers a conceptual framework for the exploration of the (re)development potentials of station areas. In this thesis I identified the amount of economic functions as a basis for the amount of facilities and the centre-like programme. This could be done due to the fact that the whole Rotterdam Noordrand development area has an economical identity and is seen as the working and residential environment for the future. Elaborating the node-place model would result in adding more types of infrastructure to the node-place model and enlarge its application possibilities. If added to the Linear Programming model, such location specific values could differentiate the possible central locations in their optimal programme.

Furthermore, additional research could be carried out in search of an index scale concerning the valuing of architectural quality as a quantitative measurable entity. Such a scale would increase the realistic value of the model and result in a more favourable attitude towards a systematic approach of urban area development.

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222 Bertolini 1999.
References

Books, papers and publications

**ABF RESEARCH 2005**
ABF RESEARCH (2005), *Diversiteit langs de Stedenbaan: vraagverkenning woonmilieus*, Delft

**Atelier Zuidvleugel 2006**

**Barzilai 2005**

**Berghauser Pont 2004**

**Bertolini 1998**

**Bertolini 1999**

**Binnekamp 2006a**

**Binnekamp 2006b**

**Bouwfonds Property Development 2008**
Bouwfonds Property Development (2008), *NAW dossier, gebiedsontwikkeling en openbaar vervoer*, Amsterdam

**Bruil 2004**
Buitelaar 2001

Canoy 2001

Centrum voor Onderzoek en Statistiek 2006
Centrum voor Onderzoek en Statistiek (2006), Inventarisatie bedrijventerreinen regio Rotterdam, Rotterdam

Chair of Area Development 2007
Chair of Area Development & ING Real Estate Development (2007) Urban area development, Delft

Le Clercq 2000

CPB Netherlands Bureau for Economic Policy Analysis 2003
CPB Netherlands Bureau for Economic Policy Analysis (2003), Quantifying Four Scenarios for Europe, Den Haag

Craenen 2001
Craenen, M., Crusio, R., Dankert, R., Donkers, T. (2001), Beleidsreconstructie Integraal Plan Noordrand Rotterdam (IPNR), Breda

Daamen 2005

Gemeente Rotterdam 2001
Gemeente Rotterdam (2001), Ruimtelijk Plan Rotterdam 2010, Meer stad meer toekomst, Rotterdam

Gemeente Rotterdam 2002
Gemeente Rotterdam (2002), Nota van uitgangspunten voor de stedelijke ontwikkelingszone & laag zestienhoven, Rotterdam
Gemeente Rotterdam 2003a
Gemeente Rotterdam (2003), Polder Zestienhoven, stad en tuin van Rotterdam, Rotterdam

Gemeente Rotterdam 2003b
Gemeente Rotterdam (2003), Uitvoeringsplan Stedelijke Projecten Rotterdam, Rotterdam

Gemeente Rotterdam 2004
Gemeente Rotterdam (2004), Voorontwerp bestemmingsplan Rotterdam Airport, Rotterdam

Gemeente Rotterdam 2005
Gemeente Rotterdam (2005), Bestemmingsplan Polder Zestienhoven, Rotterdam

Gemeente Rotterdam 2007a
Gemeente Rotterdam (2007), Jaarverslag Grondprijzen 2006, Rotterdam

Gemeente Rotterdam 2007
Gemeente Rotterdam (2007), Masterplan Schiebroek hoofdrapport, Rotterdam

Gemeente Rotterdam 2008
Gemeente Rotterdam (2008), MER Polder Schieveen – Hoofdrapport 2008, Rotterdam

Gemeente Rotterdam 2009
Gemeente Rotterdam (2009), Ontwerp bestemmingsplan 1e fase Natuur- en business park Schieveen, Rotterdam

Geurs 2006
Geurs, K.T. (2006), Accessibility, land use and transport: accessibility evaluation of land-use and transport developments and policy strategies, Delft

Govers 2009

Groetelaars 2004

Heeling 2002

Hooimeijer 2001
Jacobs 1996

Janssen-Jansen 2001

JM 2007/87

De Jong 2002
Jong, T.M. de, Voordt, D.J.M. van der (2002), *Ways to study and research, urban, architectural and technical design*, Delft

Kenniscentrum PPS 2004

Kouwenhoven 1991

Korthals Altes 2002

Kusumo 2007

Luenberger 2008

Luijten 2009

Matoušek 2007
Matoušek, J., Gärtner, B (2007), *Understanding and Using Linear Programming*, Berlin

Malczewski 2009
Ministerie van VROM 1988

Ministerie van VROM 2001
Ministerie van VROM (2001), Nota Grondbeleid, Den Haag

Ministerie van VROM 2004

De Oliveira 2003

Ontwikkelingsbedrijf Rotterdam 2008
Ontwikkelingsbedrijf Rotterdam (2008), Jaarbericht Grondprijzen, Rotterdam

Ontwikkelingsbedrijf Rotterdam 2009
Ontwikkelingsbedrijf Rotterdam (2009), Werklocaties Rotterdam 2030 – concept-eindversie 13-02-2009, Rotterdam

Otgaar 2008
Otgaar, A., Berg, L. van den, Meer, J. van der, Speller, C. (2008), Empowering Metropolitan Regions through New Forms of Cooperation, Hampshire

Peek 2006
Peek, G.J. (2006), Locatiesynergie. Een participatieve start van de herontwikkeling van binnendstedelijke stationslocaties, Delft

Platform Zuidvleugel 2007

Priemus 2003
Priemus, H., Kloosterman, K., Korthals Altes, W.K. (2003), ICES, stad & infrastructuur, Assen

Projectorganisatie RR2020 2005
Projectorganisatie RR2020 (2005), Ruimtelijk Plan Regio Rotterdam 2020, Rotterdam

Provincie Zuid Holland 2002
Provincie Zuid Holland (2002), Knopen leggen, Van visie naar beleid – Basisrapport, Den Haag

Provincie Zuid Holland 2009
Provincie Zuid Holland (2009), Ontwerp Provinciale Structuurvisie – ontwikkelen met schaarse ruimte, Den Haag
Rekenkamer Rotterdam 2006

Rotterdam Airport Vastgoed BV 2005
Rotterdam Airport Vastgoed BV, EGM architecten BV, Paul van Beek landschappen BNT (2005), *Stedenbouwkundig Matenplan Rotterdam Airport*, Rotterdam

Schniederjans 1995

Schrijnen 2000

Trip 2007

Van ‘t Verlaat 1997

De Vries 1994
Vries, Mr.H.J. de (1994) *De ruimte begrensd*, Deventer

Wolting 2006

Van Zundert 1999

Internet resources

Internet 1
Riek Bakker Advies. Available at June 18, 2009 at:
http://www.riekbakker.nl/html/dsv-05.htm#
Internet 2
Provincie Zuid Holland – Science Port Holland. Available at June 18, 2009 at:
http://www.zuid-holland.nl/index/overzicht_alle_themas/thema_economie_werk/content_
innoveren_en_investeren_2/content_programma_s_en_projecten/content_science_port_holland.htm

Internet 3
Visionary Plan. Available at January 04, 2010 at:
http://www.scienceportholland.nl/vision

Internet 4
Nieuws. Available at March 11, 2010 at:
http://www.rotterdam-airport.nl/nl/generalmenu/Nieuws?path=/News/website_nl/ROTTERDAMAIRPORTWORDTROTTERDAMTHEHAGUEAIRPORT

Internet 5
Provincie Zuid Holland – Groenblauwe Slinger. Available at June 22, 2010 at:
http://www.zuid-holland.nl/overzicht_alle_themas/thema_programma_en_projecten/groenblauweslinger.htm

Internet 6
Province Zuid Holland – Groene Hart. Available at June 22, 2010 at:
http://www.zuid-holland.nl/overzicht_alle_themas/thema_programma_en_projecten/content_groene_hart.htm

Internet 7
Ontwikkeling luxe kantorenlocatie Rotterdam Airport (RTM Airpark) in volle gang. Available at June 23, 2010 at:
http://www.rotterdam-airport.nl/nl/generalmenu/Nieuws/ezine2/rtmairpark

Internet 8
Overschie.nl – Een woning kopen. Available at June 23, 2010 at:
http://www.deelgemeenteoverschie.nl/Wonen___Leven/Huisvesting/Een_woning_kopen/index.aspx

Internet 9
Nonlinear programming. Available at June 18, 2009 at:
http://people.brunel.ac.uk/~mastjjb/jeb/or/nlp.html

Internet 10
Scientific Metrics: Home. Available at May 20, 2010 at:
http://www.scientificmetrics.com

Internet 11
Zuid Holland regio Rijnmond. Available at May 20, 2010 at:
http://www.zuid-holland.nl/overzicht_regios/index_regio_zh-rijnmond.htm

Internet 12
Rotterdam Airport Vastgoed B.V. Available at May 20, 2010 at:
http://www.rotterdamairportbusinesspark.nl/rotterdam%20airport%20business%20park/gebiedsontwikkeling.html