Analysis Document

The analysis document, belonging to the study titled “Reconnecting Rotterdam Port”

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At the faculties of Architecture and Civil Engineering
Delft University of Technology
1. Introduction

This document contains all the relevant analysis executed for the research titled: ‘Reconnecting Rotterdam Port’. A summary of this analysis is included in the main report of this research, with references to this booklet. Also, the different appendixes are included in this document. Furthermore, a CD is added, containing all the digital appendixes.

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2. SWOT analysis

An analysis is made, in order to answer research question nr. 3: What design opportunities can be derived from the functional, spatial and demographic analysis of the scope area? This analysis is executed in SWOT format, based on the five factors important in the port selection process (figure 2.1). Then, strengths and opportunities that may be used to take away the weaknesses and to avoid the threats are analysed. These strengths and opportunities provide the design opportunities for the transportation network, or spatial development resulting from it.

Scheme of Weaknesses and threats

Figure 2.2 shows all weaknesses and threats that I derived from the SWOT analysis. The different elements influence each other, hence the arrows between the elements. I give an example of how the different elements influence each other. Because road traffic is expected to increase, congestion is expected on the A15. This increases the cost of container handling, causes pollution and makes the area less accessible, which makes working in the port less attractive, etc. The scheme shows that the different elements influence each other and therefore, for example, solutions to improve the accessibility may increase the innovative character of the area.

Solutions by making use of strengths and opportunities

Figure 2.3 shows the solutions I derived to turn around the weaknesses and threats. These solutions are listed as socioeconomic design opportunities for the transportation network and the transit oriented development opportunities around the transit stations. The schemes are built up in the following pages.
Pollution is caused by transport and industry

Public transport not available in the port

Safety contours obstruct vulnerable objects

Daily congestion around the port area

Public transport not available in the port

Road traffic is expected to increase

Residual products are hardly exchanged between companies

Low value of land in the port area

Amount of educated employees is insufficient

Connections between leader firms and knowledge institutes are poor

Innovation is limited in the port area

Labour pool is expected to decrease

The Dutch working population will decrease

Inflexible, longlasting contract make port planning difficult

Rotterdam may miss out on new energy products

Many passenger cars on the highways

Miss out on business because of lack of space

Innovation is limited in the port area

Increased costs of cargo handling

Disorderly port development makes co-siting difficult

Low value of land in the port area

Uncertain growth projections

Innovative character

Figure 2.2. Scheme of weaknesses and threats
Pollution is caused by transport and industry. Public transport is not available in the port area, and safety contours obstruct vulnerable objects. Daily congestion around the port area is poor, and the port area is poorly accessible. No amenities for port employees are available. Working in the port area is considered unattractive, and the Dutch working population will decrease.

Innovation is limited in the port area, and the amount of educated employees is insufficient. Connections between leader firms and knowledge institutes are poor. The labor pool is expected to deteriorate. The port area is poorly accessible, and connections between neighborhoods and knowledge institutes are poor. The port area is poorly accessible.

The port relies on oil storage and oil refinery. Hinterland access is limited. Labour force is uncertain, and innovative character is threatened. Sustainability is questionable.

Connections between leader firms and knowledge institutes are poor. The Dutch working population will decrease. The port area is poorly accessible. No amenities for port employees are available. Working in the port area is considered unattractive.

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Hinterland access

Park and Ride facilities are present to remove cars from the highways (figure 2.6).

Public Transport stations with high network value are present in the vicinity of the port (figure 2.7 and 2.8).

Many port companies are willing to organise public transport (figure 2.9 and 2.10).

Creating public transport may reduce car use.

Congestion caused by the high amount of person cars on the surrounding road network. (figure 2.5)

Transport by road is expected to grow (Transumo, 2008)

If the cost of congestion become too high, companies may move to another port to handle their goods.
SWOT Hinterland Access

Weaknesses and threats

The road network around the port area is tormented with daily congestion in both directions. Apart from trucks, many person cars use the A15 (about 70%). The total amount of traffic exceeds the capacity of the road. (Ministry of Transport, Public Works and Water-management, 2007).

Even though the modal split between road, waterway/barge and rail is expected to shift, car transport is expected to continue to grow (Kuipers, 2008). According to Nijdam (2008) total handling costs of containers is increased with 1-3% because of congestion. If congestion increases, the handling costs in the port are will also rise.

Strengths and opportunities

Many Park and ride facilities are present, combinен with public transport they can attract current car drivers, thus reducing traffic and congestion on the surrounding road network. In the existing situation, these facilities are mainly used to enter the city of Rotterdam.

Design opportunities:

Socioeconomic relevance

- Relieve the A15 of cars to give trucks a better passage.

Transit oriented development

- Provide P&R around public transport nodes, to relieve the road network of traffic.

Figure 2.4. Problems and possible design opportunities regarding the Hinterland accessibility of the port of Rotterdam.
Congestion

Legend

- Congestion top 20
  (heavy daily congestion)
- Congestion top 20-50
- Expected congestion in 2030

Figure 2.5, Congestion on the highways surrounding the port area, based on DS+V (2007) and Filetop 50 (Ministry of Transport, Public Works and Watermanagement, 2009)
Figure 2.6. Regional park & ride facilities in the Rijnmond area, based on Municipality of Rotterdam, 2009.
Public transport network

Legend

- High speed train
- Train
- Randstadrail
- Bus lane
- Stop

Figure 2.8. Public transport in the area, with operational speed > 40 km/h
Collective transport

Figure 2.9. Companies offering collective transport and companies interested to offer collective transport. (Port of Rotterdam, 2007)

Restricted to the Port of Rotterdam
Collective transport to ECT

Figure 2.10. Collective transport lines to ECT, running three times per day, a total of eight lines, based on an interview with Vipre (2008)
### Labour force

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| The area has several elements interesting for tourists and visitors. (figure 2.12) | Working in the port area is considered unattractive:  
• The area has a bad image  
• The accessibility of the area is poor because of congestion on the A15 and lack of public transport (figure 2.8)  
• There are no amenities for people working the port. They are difficult to create because of safety contours (figure 2.15). |
| Awareness within the port company to improve the image of the port. | Public transport connections between the different neighbourhoods and the port related knowledge institutes are poor. (figure 2.13) |
| Some areas in South Holland have high density of inhabitants. (figure 2.17 and 2.18) | Providing public transport in the area is difficult, because of spread out employee division. (figure 2.16) |

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>The port is making plans to create amenity clusters in the port area, combining truck parking with basic amenities.</td>
<td>The Randstad performs poor in the attraction of high educated foreigners.</td>
</tr>
<tr>
<td>New neighbourhoods are planned in the area. (figure 2.14)</td>
<td>The amount of working people in Holland is expected to decrease in the future. (figure 2.20)</td>
</tr>
<tr>
<td>High unemployment rate in South Holland gives potential to attract new workers for the port area. (figure 2.19)</td>
<td>If the labour pool for the port of Rotterdam deteriorates, port companies may move to another port.</td>
</tr>
</tbody>
</table>
SWOT Labour force

Weaknesses and threats

Multiple reasons cause problems with the labour pool for the port of Rotterdam. Potential workers (local residents) do not have a good image of the port, and, as a result, the influx of young people is at risk of stagnating in some sectors (Port of Rotterdam et al., 2004). Public transport in the area is poor, making the port area inaccessible for people without a car, like double-income couples and students. The port of Rotterdam conducted a research (2008) among over 200 people working on Maasvlakte about their needs on their working environment. The most important needs were a gas station, basic amenities (Supermarket, lunchroom) and public transport. Amenities are hard to create in the area because of safety problems. An example is the planning of a amenity cluster in Europoor. Just before the tendering phase the project was cancelled because of problems with updated safety contours.

Some port related knowledge institutes are poorly accessible by public transport, like the RDM campus in Waal-Eemhaven. This makes the port related education less likely to be chosen by youngsters. Furthermore, The Randstad does not score well in attracting foreign knowledge workers as compared to other countries, the share of highly skilled workers (those with a tertiary education) in the Netherlands which is foreign, is very low at only 9% (OECD, 2007).

Future prognosis show that the amount of working people will decrease in the future (CBS, 2007), while the total amount of people in Holland will not rise significantly (7% up to 2040) (CBS, 2008). Which means that the total amount of working people will decrease significantly. This in confirmed by the CPB (2008) which states that in 2025 the amount of working people will decrease by 9%.

Strengths and opportunities

The area has several elements interesting for tourists and visitors. If people would visit the area more often, they are more likely to see the area as potential employer. The port sees this opportunity and has provided several bicycle routes and scenic walks. The port company is also planning amenity clusters in the port area, proving parking spaces for trucks and basic amenities for port employees. Truckplaza on Maasvlakte is a successfull example, for which a masterplan is made at this very moment. (IND et al.).

Design opportunities

Socioeconomic relevance

• Connect port employees with their work in the port area. The system should fit the spread out employee division.
• Connect areas with high population density to attract new port employees.
• Improve the connection between youngsters and port related knowledge institutes to attract them as employees.
• Make the port accessible for tourist and visitors, to invite them to experience the port and become more willing to work in the port area.

Transit oriented development

• New neighbourhoods can be created around public transport stations, to ensure good connectivity and prevent car use. While creating new neighbourhoods, the aim should be at the attraction of domestic people combined with (high educated) foreigners.
• Amenities for port employees can be created around stations, like supermarket, lunchrooms and parking for trucks.
• Touristic functions can be created around the nodes, to invite visitors to experience the port and become more willing to work in the port area.
• Safe zones should be allocated, where vulnerable objects can be created.
Figure 2.11. Problems and possible design opportunities regarding the labour force of the port of Rotterdam.
Recreation

Legend

- Regional city center
- Protected townscape
- Beaches
- International attraction: Kinderdijk
- Natural landscape

Figure 2.12. Recreational facilities in the area, based on Nota Belvedere (Feddes, 1999).
Port related knowledge institutes

Legend

饪 University offering port related education
珥 HBO and MBO with port related education

Figure 2.13. Knowledge institutes in the area, offering port related education.
Dwelling programs

Legend
Residential building
- Inner urban
- Outer urban

Figure 2.14. Dwelling programs, based on the existing dwelling stock in 2006 (Atelier Zuidvleugel, 2008)
Safety contours

Figure 2.15. Safety contours, whereas the chance of a fatal accident is over $10^{-6}$ per year. Based on Risicokaart (LBOR, 2009).
Figure 2.16 Job density, based on Bedrijvenregister 2008 (Province of South Holland, 2008).
Low income inhabitants

Legend

Low income inhabitants/hectare

- 34-50
- 13-23
- 8-12
- 3-7
- 2

Figure 2.17, Density of low income inhabitants, between age 15 and 65 (Atelier Zuidvleugel, 2008)
High income inhabitants

Legend

High income inhabitants/hectare

- 10-13
- 7-9
- 4-6
- 2-3
- 1-2

Figure 2.18, Density of high income inhabitants, between age 15 and 65 (Atelier Zuidvleugel, 2008)
Figure 2.19. Unemployment rate in 2003 (Bureau Louter, 2004)
Growth of working population

Figure 2.20. Development of working population between 2009 and 2025, based on CBS, 2005. Working population is defined as people between the age of 15 and 65.
Innovative character

Innovative companies (leader firms) are present in the port area (figure 1.22).

Port related knowledge institutes are present (1.23).

Innovation in the port area is very limited because:
- The education level of the labour pool in the port is low
- Connections between leader firms and knowledge institutes are limited.

Plans are to attract innovative port related companies at the RDM campus, creating a knowledge hub.

Enabling students to take internships and do small projects for companies will improve the relation between knowledge institutes and firms.

The knowledge intensivation in the port provides chances for small and medium sized companies that can adapt to new situations because of their creativity and flexibility.

leader firms could move to another location, leaving a knowledge gap
**SWOT innovative character**

**Weaknesses and threats**

Innovation in the port industry is fairly limited because of two reasons:

- The number of highly educated employees in the industrial sector is relatively low compared to other fields (CBS, 2007)
- Knowledge institutes are not commercial enough, too fragmented and not oriented towards working with smaller enterprises. Therefore collaboration between leader firms and knowledge institutes is very limited (OECD, 2007).

One of the most important reasons to pick a certain location is the availability of qualified employees. If other ports provide a better business climate the leader firm could move, leaving a knowledge gap. (de Langen & Nijdam, 2006)

**Strengths and opportunities**

The port of Rotterdam houses several leader firms. These firms make investments that have positive effects on other companies in the cluster. De Langen & Nijdam (2006) made an analysis on leader firms in the port of Rotterdam, based on size, market position, knowledge and entrepreneurship.

The ministry of economical affairs (2002) made a list of instruments to promote innovation. Internships can be the basis to promote collaboration between research facilities and companies. In order to achieve this mobility between leader firms and knowledge institutes need to be improved.

The knowledge intensification in the port provides chances for small and medium sized companies that can adapt to new situations because of their creativity and flexibility. They can become suppliers for the bigger companies. (TNO, 2006)

**Design opportunities**

**Socioeconomic relevance**

- Improve the connections between leader firms and port related knowledge institutes to stimulate innovation.

**Transit oriented development**

- Attract small and medium sized companies to stimulate innovation.
- Show/share innovation to make it spill over to the rest of the port area.

Figure 2.21. Problems and possible design opportunities regarding the innovative character of the port of Rotterdam.
Leader firms in the port area

Legend

- Terminal
- Chemicals
- Offshore equipment
- Distribution
- Maritime transport

Figure 2.22. Leader firms in the port of Rotterdam, based on Nijdam and the Langen, 2006. They gave the definition of a leader firm as follows: “A leader firm is a company that has the capacity and the incentive to do investments with positive spillover effects to other companies in the cluster, because of their size, market position, knowledge and entrepreneurship”.
Knowledge institutes

Legend

- University offering port related education
- HBO and MBO with port related education

Figure 2.23. Port related knowledge institutes.
### Sustainability

**Sustainable energy sources** are present in the port area (figure 2.26).

**Air pollution** is caused by transportation and industry (figure 2.28).

Few synergies between port companies are present, to make use of residual products.

The Rotterdam climate initiative contains several projects that aim at the reduction of CO₂ emissions (figure 2.25).

Rotterdam and the port company aim to be sustainable by reducing CO₂ emission with 50% up to 2025.

Synergies between companies may reduce emissions.

The world oil production is expected to decrease in the future, which may become a threat for the high amount of oil storage and chemical processing in the port of Rotterdam (figure 2.27).
**SWOT sustainability**

**Weaknesses and threats**

NO₂ emission in the port area are high. At some areas maximum amount of 40 microgram/m³. In these areas no dwelling programs, office buildings or other vulnerable objects are allowed. NOₓ emissions are related to CO₂ emissions and is harmful for the environment (PCT patent, 2005). Few synergies in the port are present to make use of residual products like heat. Since innovation in the port industry is fairly limited (CBS, 2007), these kind of synergies are not easily established.

The world oil production in the world is expected to decrease in the future (A.M. Samsam Bakhtiari, 2004). This may become a problem for the port of Rotterdam, of which most terrain is taken up by oil storage, processing and distribution.

In 1969 an ambitious plan was designed called Plan 2000+. If this plan would have gotten through the port of Rotterdam could have grown to twice the size it is now. Based on social and ecological grounds, the plan was narrowly rejected by the Rotterdam counsel (the voting was 23 to 21). It was the start of an era where action groups finally got a voice and community gained influence on the development of their surroundings. Nowadays, development is significantly influenced by the attitude of the community. (Pinder, 1981)

**Strengths and opportunities**

Many sustainable energy plants are situated in the port area. New ones are being built.

Rotterdam climate initiative is a project that aims at the reduction of CO₂ with 50% in 2025 and making Rotterdam 100% climate neutral in 2025. These projects include CO₂ reduction software, the promotion of synergies between companies to make use of residual products and sustainable leisure facilities.

**Design opportunities**

**Socioeconomic relevance**

- Reduce emissions by offering a sustainable alternative to car transport

**Transit oriented development**

- Stimulate synergies between companies by showing examples of sustainability and attracting innovative companies.
- Improve the image of the area by showing sustainable projects.

**Figure 2.24. Problems and possible design opportunities regarding the sustainability of the area.**
CO₂ reduction projects

Legend

- Sustainable companies
- Sustainable events/attractions
- Plans for CO₂ distribution
- Greenhouses
- Plans for hot water distribution

Figure 2.25. Projects within the Rotterdam climate initiative, to reduce CO₂ emissions (RCI, 2009)
Sustainable energy

Legend

- Biofuels
- Windmills

Figure 1.26. Sustainable energy plant in the port of Rotterdam.
Types of industry

Legend

- New functions
- Containers and breakbulk
- Liquid bulk
- Dry bulk
- Distribution
- Fruit
- Other

Figure 2.27. Different types of industry in the port area (Port of Rotterdam et al., 2004). Most space is taken up by liquid bulk, which consist for the biggest part of oil distribution and processing.
NO$_2$ emissions

Legend

- Permitted NO$_2$ concentration is exceeded
- Permitted NO$_2$ concentration may be exceeded

Figure 2.28. NO2 emissions, maximum is 40 microgram/m$^3$. In these areas no dwelling programs, office buildings or other vulnerable objects are allowed. In the light blue areas more research is needed to estimate the possibilities of vulnerable objects. Based on Risicokäart (LBOR, 2009).
Availability of space

Maasvlakte 2 offers 1000 hectare of new space for port development

Space can be generated by (figure 2.30):
- stimulating underground storage of liquid bulk and containers
- stimulating co-siting of liquid bulk
- stimulating multiple storey distribution
- rearranging the main pipeline corridor

Co-citing can enhance the space productivity of port industry

Densification in the port is not stimulated, because of low rents and old, long last-ign contracts (figure 2.31).

Innovation to improve densification is limited in the port area (page 31).

Disorderly port development does not stimulate co-siting (making use of residual products between companies) (figure 2.27)

Uncertainties of growth make the estimation of future need of space very difficult.

Companies will choose another port if they cannot get space in the port of Rotterdam.
SWOT availability of space

Weaknesses and threats

A lot of contracts in the port are very old and long lasting. Rents are extremely low since the port gains by collecting port dues for each shipment. The result is that several companies rent a certain parcel but they don’t use it (mostly because the soil is polluted). It proves to be cheaper to keep the parcel instead of cleaning the pollution and handing it back to the port authorities. This way, the region misses out on potential income. Also, as research by the Vrije Universiteit of Amsterdam (2007) shows, rents in the port are expected to be low, based on the accessibility of the area.

Availability of space has everything to do with growth projections and the space-efficiency of companies. In an uncertain world it does not suffice to simply extrapolate present growth trends. Scenarios may be used to scan different futures (Schwartz, 1996). In 1995, Junne evaluated the growth projections made up to then. The main uncertainties were about the results of the unification of Europe. He also states, that in to the year 2020, China may become just as important as Japan in terms of trade. Now we know that China has surpassed Japan way before the year 2020 and is expected to grow even more. So in just ten years, growth projections changed completely. In 1996, the CPB has made different forecasts for growth in the port sector. They included three scenarios, all with different growth potentials. In two of these scenarios, the capacity of the second Maasvlakte is exceeded, while the third scenario doesn’t come close to filling the second Maasvlakte. According to the CPB, it is impossible to predict which of the scenarios will prove to be true.

Strengths and opportunities

By improving the space productivity, lack of space can be solved to some extend. Slowly, capacity in the chemical industry is growing because of ‘capacity creep’: A set of small changes to make better use of existing capacity. A study of Chem Systems (2000) shows that

the space productivity of the chemical sector is expected to grow by 22% between 2000 and 2020. As Le-Griffin and Murphy (2006) show, innovations lead to improved capacity of container terminals. The port of Rotterdam aims at densification in three ways: The underground storage of containers and liquid bulk, multiple storey distribution facilities and the rearrangement of the main pipeline corridor.

Design opportunities

Transit oriented development

- Densification can be stimulated around station areas.
- Innovation around station areas can stimulate densification.
- By planning far ahead, space can be reserved for new development
- Co-siting improves space productivity

Figure 2.29. Problems and possible design solutions regarding the availability of space for port development
Densification possibilities

Legend

- Container storage
- Liquid storage
- Distribution
- Main pipeline corridor

Figure 2.30. Densification possibilities in the port area, based on an interview at the port company and google earth.
Duration of contracts

Figure 2.31. Duration of contracts in the port in 2009. Based on SAP database at the port of Rotterdam.
3. Port area analysis

Port area

Maasvlakte:
World class container port

Botlek:
Sustainable energy port

Waal-Eemhaven: Cityport

Structure and characteristics

Type of industry

Legend
- New functions
- Containers/breakbulk
- Liquid bulk
- Dry bulk
- Distribution
- Fruit
- Other

Road structure

Ribbon structure: Port activity along the linear main routes. Only one entrance/exit

Average plot size: 800,000m²

Fishbone:
Main route with secondary routes to reach destination. Couple entrances/exits

Average plot size: 150,000m²

Branches: The main route is outside port area. Multiple entrances/exits

Average plot size: 25,000m²

Plot sizes
Big cranes, container towers megalomane, unhuman

Refineries, oil depots, industrial, clean, low on colour

Mixture of functions, offices, containers, distribution, etc.

The village of Rozenburg is surrounded by trees, to separate itself from the port area

Plans are for urban development to take over the port area.
Knowledge and innovation

Knowledge institutes

Innovation

Sustainability

Space efficiency

Legend

- University offering port related education
- HBO and MBO with port related education

Legend

- Terminal
- Chemicals
- Offshore equipment
- Distribution
- Maritime transport

Legend

- Sustainable companies
- Sustainable events/attractions
- Plans for CO\(^2\) distribution
- Greenhouses
- Plans for hot water distribution

Legend

- Container storage
- Liquid storage
- Distribution
- Main pipeline corridor
Boundary conditions

NO₂ emissions

Safety contours

Duration of contracts

Permited NO₂ concentration is exceeded

Permited NO₂ concentration may be exceeded

Legend

Safety contours make integration between port & city difficult.

Restricted to the Port of Rotterdam

Safety contours cover most of the Botlek

Legend
4.1. GIS analysis, zoning and age distribution

Purpose

In order to create maps and decide which zones to connect, several GIS maps are used. Furthermore the distribution of people in different age classes is needed to estimate the future distribution of port employees and the location of youngsters in the age for higher education.

Data

In order to make a good comparison between maps, the same zoning division is used for all the maps. Some information is best viewed on detailed level, other information should be viewed on regional level. Because population information from the CBS is needed, the municipal zoning division of the CBS will be used for this research (figure 1). Because the scope of the research is the province of South Holland, only the zones from the province are used. Zeeland is added to make a clear distinction between origin and destination (see chapter car drivers on the A15) and the rest of Holland is added to include all data and to know how the numbers in South Holland are in proportion to the rest of Holland.

Since Rotterdam is a very large zone with no division between port areas and city, I choose to split the zone into 10 smaller zones, using autodesk Map (see table 1 and figure 2).

Because population estimations are only available for Rotterdam as a whole, the population should be divided among the 10 zones. The division of the total population now is available on neighbourhood level (CBS, 2009). According to this division, the different age classes now and in 2025 are distributed among the zones, meaning they all share the percentage of

![Figure 1. CBS zoning division (CBS, 2009)](image1)

![Figure 2. Adapted zoning division](image2)
each age class.

Existing districts are used to divide the zones on the regional scale (figure 3): Voorne-Putten, Hoeksche Waard and IJsselmonde are all acknowledged districts. IJsselmonde loses Vondelingenplaat which is considered Port area. The port area excludes Waal-Eemhaven, since the scope states that Waal-Eemhaven is excluded in the regional strategy. All the municipalities attached to Rotterdam North up to the A12 are clustered as Rijnmond North. The remaining area South of The Hague is considered a region as well as Zeeland and Goeree-Overflakkee.

In order to estimate the demographic developments, prognosis data from the CBS (2005) is used.

<table>
<thead>
<tr>
<th>zone</th>
<th>inhabitants 2009*</th>
<th>% of Rotterdam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoek van Holland</td>
<td>9373</td>
<td>1,6</td>
</tr>
<tr>
<td>Hoogvliet</td>
<td>34987</td>
<td>6,0</td>
</tr>
<tr>
<td>Pernis</td>
<td>4742</td>
<td>0,8</td>
</tr>
<tr>
<td>Port Botlek</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Port Europoort</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Port Maasvlakte</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Port Vondelingenplaat</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Port Waal-Eemhaven</td>
<td>1608</td>
<td>0,3</td>
</tr>
<tr>
<td>Rotterdam-Noord</td>
<td>344264</td>
<td>59,1</td>
</tr>
<tr>
<td>Rotterdam-Zuid</td>
<td>187392</td>
<td>32,2</td>
</tr>
<tr>
<td>CBS zone Rotterdam</td>
<td>582366</td>
<td>100,0</td>
</tr>
</tbody>
</table>

Table 1. The division of Rotterdam in ten zones and their share of inhabitants *(CBS, 2009)*

**Results**

The results of this chapter is the zoning of the area as well as the demographic developments in the province of South Holland. The maps are shown on the following pages.
Amount of people between age 0-15
Percentage of total amount in South Holland in 2025

0.0 - 1.0
1.0 - 2.5
2.5 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 50.0
Total = 576,392

Growth of population between age 0-15
Percentage growth between 2009 and 2025

<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10
Total = 576,392

Legend
alleleeftijdengrof
0_15aandee
0.0 - 1.0
1.0 - 2.5
2.5 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 50.0
Legend
alleleeftijdengrof
0_15versch
<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10
Legend
alleleeftijdengrof
0_15versch
<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10

Facebook
Twitter
LinkedIn
Google

Amount of people between age 0-15
Percentage of total amount in South Holland in 2025

Total = 576,392

Growth of population between age 0-15
Percentage growth between 2009 and 2025

<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10
Total = 576,392

Legend
alleleeftijdengrof
0_15versch
<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10
Legend
alleleeftijdengrof
0_15versch
<-10.0
-10.0 - -2.5
-2.5 - +2.5
2.5 - 10
>10

Facebook
Twitter
LinkedIn
Google
Amount of people between age 15-25
Percentage of total amount in South Holland in 2025

Growth of population between age 15-25
Percentage growth between 2009 and 2025
Amount of people of age 65+
Percentage of total amount in South Holland in 2025

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1.0</td>
<td>0.4</td>
</tr>
<tr>
<td>1.0 - 2.5</td>
<td>17.9</td>
</tr>
<tr>
<td>2.5 - 5.0</td>
<td>23.3</td>
</tr>
<tr>
<td>5.0 - 10.0</td>
<td>35.1</td>
</tr>
<tr>
<td>10.0 - 20.0</td>
<td>14.7</td>
</tr>
<tr>
<td>20.0 - 50.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>741.746</td>
</tr>
</tbody>
</table>

Growth of population of age 65+
Percentage growth between 2009 and 2025

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 - 20.0</td>
<td>0.0</td>
</tr>
<tr>
<td>20.0 - 40.0</td>
<td>24.2</td>
</tr>
<tr>
<td>40.0 - 60.0</td>
<td>41.9</td>
</tr>
<tr>
<td>60.0 - 80.0</td>
<td>35.6</td>
</tr>
<tr>
<td>&gt;80.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>741.746</td>
</tr>
</tbody>
</table>

Legend
alsofgebruik
0,0 - 20,0
20,0 - 40,0
40,0 - 60,0
60,0 - 80,0
>80,0
4.2. GIS analysis, Car drivers on the A15

Purpose

The people currently using the congested parts of the A15 have to be found in order to provide an alternative for these people. By doing this, the Hinterland access for trucks on the A15 will increase, as well as a decrease of emission due to congestion.

Data

Origin of port related workers
Kenteken enquête Regio Rotterdam 2007 (Ministery of Transport, Public Works and Water Management, 2007) was used to locate the origin and destination of 1738 people using the A15 between 6.00 and 19.00 on an average day, by using postal codes. Goudappel Coffeng counted 38826 person cars in this time period. They distributed questionnaires among these people and received 1738 usable responses. This being 5% response rate is not great, but it does give a good impression where the people come from. Furthermore they counted 14160 other vehicles, adding up to 52986 vehicles on the A15 in one direction between 6.00 and 19.00 hours.

Figure x shows the location and direction of the survey. Only one direction is measured. Yet, people are asked in the questionnaire whether or not they made the return trip as well, which 87 % of the people answered positively. Therefore I assume that a count in the other direction would have given the same results. The origin and destination data (postal codes) are combined with location data of postcode 4 in ArcGIS.

Time of travel

The Kenteken enquête shows that the response rate in the peak hours was higher than outside these peaks. This would give an uneven image of the distribution of the time of travel. Therefore, the responses are weighted according to the response rate of each time period.

Growth

The distribution of age populations is going to change up to 2025. This, of course will affect the origin and destination on the A15. Yet, I deliberately choose not to change the data according to the changing population, because of the following reasons:
- even though the age distribution changes greatly, the total amount of people does not.
- the ageing in the Voorne-Putten area doesn’t necessarily mean a decrease in A15 drivers. Visits from children and trips to Rotterdam might actually increase the A15 use of people in Voorne-Putten.
- the population prognosis are just prognosis and are already used

Figure 1, Location and direction of the survey, the Botlek tunnel on the A15.
for the future employee pool. Using the same data twice means a
doubling of the fault margin these prognosis include.
Only at one location an adaptation will be made, at Maasvlakte. This
area will grow from 4500 to over 9000 workers between 2009 and
2025. Whether or not it means a doubling of the A15 car drivers to
Maasvlakte is unknown. Therefore a times 2 symbol is added to the
maps on the municipal scale.

Results

In order to make a clear distinction, figure 2,3,10 and 11 show the
origin and destination trips in separate figures, where the totals add
up to 100%. The other figures in this chapter show the characteristics of the trips combined for origin and destination.
Since 87% of the people answered yes to the question whether they also made the return trip, origin and destination may be inter-
changed.

Origin and destination
About 60% of the people on the A15 travel from Voorne-Putten, 30%
comes from the Port area and 10% from Zeeland and Goeree-Over-
flakkee.
About 30% of the A15 drivers travel to Ijsselmonde and another 30% to North Rijnmond. Westland and the Hague account for 13% as well as the rest of Holland.

**Trip characteristics**

Figure 4 shows the purpose of the A15 trips. Most trips are made by commuters, traveling to work and back. This amount is highest in the port area (about 70%). Also interesting is the high amount of recreational traffic from Zeeland and Goeree-Overflakkee. Figure 5 and 6 show that the higher the amount of commuter traffic, the higher the trip frequency and the lower the occupancy rate of the car and vice-versa. This explains the high frequency and low occupancy in the port area, and the opposite in Zeeland and Goeree-Overflakkee.
Checking origin-destination patterns

Since figure 2 and 3 figures show accumulated origin destination data, it is possible that a wrong image is given. For instance, the relation between the Port area and Rijnmond North could be nonexistent, while this cannot be read from the image. Therefore, figure 7 and 8 are created, showing the share of the different origin and destination zones. It shows that the OD proportions do not differ much between zones. Voorne-Putten shows a slightly bigger share towards Rijnmond North and Zeeland, Goeree-Overflakkee and slightly bigger share towards the rest of Holland. This explains the difference in the percentage of cars using the Beneluxtunnel (figure 9). Furthermore, these percentages seem logical. People from Westland and the Hague have no option but to use the Beneluxtunnel, while people from the rest of South Holland have multiple options. I conclude by saying that figure 2 and 3 give a good impression of reality.
Origin and destination of the municipal scale

In order to gain better insight in the origin and destination of people on the A15 the data is shown on municipal level. It shows that Spijkenisse, Hellevoetsluis and Botlek are the biggest generators of traffic on the A15 (together for 48%), while Rotterdam North, Rotterdam South and the Rest of Holland account for most destinations.

Figure 10. Origin of cars on the A15 (Ministry of V&W, 2007)

Figure 11. Destination of cars on the A15 (Ministry of V&W, 2007)
Figure 13 shows the time period in which people travel in Eastern direction through the Botlektunnel. For most regions about one third of the traffic is outside the peak hours. Interestingly, the port area, in which only 1/6th of the traffic is outside the peak hours and about 2/3 is in the evening peak. This shows that the distribution in the port area is very uneven. In the morning peak the East-West direction is dominant, while in the evening peak the West-East direction is dominant.

For the Voorne-Putten area this goes the other way around. Apparently, many inhabitants of Voorne-Putten leave in the morning towards Rotterdam, and return during the evening peak. This means that a system could be designed that brings people from Voorne-Putten to Rotterdam and returns with people from Rotterdam who work in the port area. This way the uneven distribution is neutralized by combining traffic flows.
The top 10 OD pairs are displayed in table x and figure 12. Figure 12 shows that the ten biggest OD pairs have destinations in Rotterdam North and Rotterdam South. Seven of the biggest OD pairs originate in Voorne-Putten and three in the Port area. The most important relation is the one between Spijkenisse and Rotterdam North, followed by the relation between Hellevoetsluis and Rotterdam North.

Table x shows the reasons why these people chose car over Public Transport. The most important reason is a high travel time, followed by low comfort and high costs.

If the amount of trips between the top three origins and top two destinations is combined (from Spijkenisse, Hellevoetsluis and Botlek to Rotterdam North and South, it adds up to 12019 trips which is 31% of the total car trips on the A15 and 23% of the total traffic on the A15.
Conclusions for the design

which zones to connect?
Figure x shows the points awarded to each zone. Figure 12 shows the most important OD pairs making use of the A15. By connecting Rotterdam North and Rotterdam South to Hellevoetsluis, Spijkenisse and Port Botlek, 23% of the total traffic on the A15 could be removed. This number does not include the surrounding zones that will also benefit from this connection, as well as the possibility for people from Voorne-Putten to travel beyond Rotterdam.

what kind of connection?
The three most important reasons not to use public transport for the ten biggest OD pairs are used as criteria for the design of the new public transport line.

59% of the travelers on the A15 don’t use Public Transport because the travel time is too high. 29% of the travelers don’t use the existing public transport because the comfort is too low and 17% don’t use it because the costs are too high. Because the latter is hard to change, since Public Transport companies choose their own fares, the design criteria are as follows:
The system should be fast enough to seduce car drivers to start using public transport. Therefore, the operational speed should be ≥40 km/h and the minimal frequency should be 4 vehicles/hour/direction. Transfers should be avoided as much as possible, therefore I set the maximum amount of transfers for a door-to-door trip at 3. Finally, vehicles should have comfortable seats to ensure a comfortable trip.
4.3. GIS analysis, Labour force

Purpose

The purpose of this chapter is to find out where people live who work in the port area. Providing public transport for these people improves the accessibility and thereby the attractiveness of working in the port. In order to ensure continuity of the port area, it is also important to look at the future labour pool of South Holland. Providing them with better connections can attract people to work in the port area, especially those without a car.

Data

Origin of port related workers

A survey was executed by the Port of Rotterdam and Deltalinqs (2007) about the origin of employees of the port of Rotterdam. A total of 3369 postal codes were obtained of the origin of these workers. The amount of people working in each port area is extrapolated to the total amount of people working in each area (Province of South Holland, 2008). These amounts are shown in table Figure 13 and 14. Appendix A contains the maps of the origin of the employees for each port area separately.

Table 1, Amount of postal codes available of the origin of port employees (Port of Rotterdam & Deltalings, 2007; Province of South Holland, 2008)

<table>
<thead>
<tr>
<th>Region</th>
<th>Respondents*</th>
<th>Total workers#</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vondelingelaan</td>
<td>290</td>
<td>3452</td>
<td>8,40%</td>
</tr>
<tr>
<td>Botlek</td>
<td>1174</td>
<td>12636</td>
<td>9,29%</td>
</tr>
<tr>
<td>Europoort</td>
<td>613</td>
<td>4588</td>
<td>13,36%</td>
</tr>
<tr>
<td>Maasvlakte</td>
<td>1292</td>
<td>4581</td>
<td>28,20%</td>
</tr>
<tr>
<td>Totaal</td>
<td>3369</td>
<td>25257</td>
<td>13,34%</td>
</tr>
</tbody>
</table>

Figure 13, Origin of port employees in 2007, Port of Rotterdam & Deltalings (2007)

Figure 14, Origin of port employees in 2007, Port of Rotterdam & Deltalings (2007)
Demand of port related workers

In order to estimate the amount of employees needed in the future, the decrease in the existing workforce and the growth in employee demand for each port area is estimated (table 2).

The decrease of port related workers is based on prognosis data from the CBS statline (2009), figure 14&15. I assume that when the working population of a certain municipality decreases by 15%, the amount of port related workers (figure 14) also decreases by 15%. The decrease per area is shown on figure 16 and 17. The total decrease for each port area is shown on table 2.

The amount of workers needed for each port area had to be estimated. The total amount of workers on Maasvlakte 1 is calculated to grow up to 5594 in 2015 (Port of Rotterdam, 2009). The amount growth on Europoort is estimated on 200, based on interviews within the port company of Rotterdam.

The amount of employees on Maasvlakte in 2033 is given as 6200. (Maasvlakte 2 projectorganisation, 2007). Because Maasvlakte 2 will gradually be filled between 2013 and 2033, I calculate that in 2020 7/20th part of 6200 and in 2025 13/20th part of 6200 employees should be added for Maasvlakte 2.

Shortage of port related workers

I calculated the shortage of workers for each port area by adding the new workers needed to the decrease because of ageing. The effect of ageing is shown on figure 16 and 17.

<table>
<thead>
<tr>
<th>Port area</th>
<th>Amount of workers needed</th>
<th>Natural decrease</th>
<th>Shortage</th>
<th>Percentage short</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maasvlakte</td>
<td>4581</td>
<td>3183</td>
<td>7764</td>
<td>4733</td>
</tr>
<tr>
<td>Europoort</td>
<td>4588</td>
<td>200</td>
<td>4788</td>
<td>200</td>
</tr>
<tr>
<td>Botlek</td>
<td>12636</td>
<td>0</td>
<td>12636</td>
<td>0</td>
</tr>
<tr>
<td>Vondelingenplaat</td>
<td>3452</td>
<td>0</td>
<td>3452</td>
<td>0</td>
</tr>
<tr>
<td>Totaal</td>
<td>25257</td>
<td>3383</td>
<td>28640</td>
<td>4933</td>
</tr>
</tbody>
</table>

Table 2. Amount of workers needed and shortage in 2020 and 2025, (Maasvlakte 2 projectorganisation 2009; CBS statline, 2009; Province of South Holland, 2008)
Figure 14, Decrease of working population (15-65 years) (CBS, statline)

Figure 15, Decrease of working population (15-65 years) (CBS, statline)

Figure 16, Effect of ageing on the workforce (15-65 years) (CBS, statline)

Figure 17, Effect of ageing on the workforce (15-65 years) (CBS, statline)
Potential of new employees

Figure 20 and 21 show the percentage of working population actually working in the port. About 25% of the working population of Rozenburg works in the port area, which I link to the fact that these people have little choice where to work. In the Voorne-Putten area the percentage is about 10%, but also for this area alternative jobs are limited. Outside the Voorne-Putten and Port area the percentage becomes really low and the port has to compete with other employers for workers.

Even though figure 14 and 15 show a big decrease in working population, figure 24 and 25 show that the total amount of people in each municipality will not decrease accordingly. This has to do with the growth of elderly (figure 26 and 27) which is between 40 and 50% in South Holland. These elders have to be taken care of, taking away the potential workforce.

Because of the above reasons I conclude that the absolute maximum of each municipality working in the port is 10% of its current working population. This is a very optimistic estimation, but otherwise there would be no potential workforce left. The other 90% of the workforce is fixed within the area and the existing economy. If the workforce of a municipality grows, this growth can be additional potential workforce, because no jobs are currently available for them. If the workforce shrinks however, the existing economy still needs this 90% because the total amount of inhabitants will not decrease much. Figure 18 shows how the potential workforce for each municipality is calculated. Figure 22 and 23 show the size of the population between 15 and 65 years of age.

In the project booklet, half of the unemployed are added to calculate total potential workforce. This is done by multiplying the unemployment rate (figure 2.19) with the working population in 2025 (figure 23). It is divided by 2 because not all these people are willing to get a job. In the potential workforce in this chapter the unemployed are excluded, but in the project booklet they are included.

Boundary conditions for port employees to use public transport

I have held several interviews with experts on transportation in (the vicinity of) the port of Rotterdam from the Verkeersonderneming, DS+V, the port of Rotterdam and Vipre.
Results

**Origin of port related workers**

Figure 28 and 29 show the origin of the port employees in 2025. Most employees live in the Voorne-Putten area. Second comes Ijsselmonde with 15.6% of the employees. The figure clearly shows that most employees live in the vicinity of the port. Figure 29 shows that Spijkenisse, Hellevoetsluis and Rozenburg are the municipalities that accomodate most port workers. Appendix B contains maps for each port area seperately.

**Shortage of port related workers**

As figure 28 shows, the expected shortage of port related workers is 7040 which is about a quarter of the total demand in 2025. Table 3 shows the shortage for each port area seperately. It shows that the shortage is biggest on Maasvlakte with about 5000 workers.
Figure 30 and 31 show the future potential labour supply of South Holland. They show that Voorne-Putten has very little potential for the attraction of new workers. This can become a big problem, since it is currently the biggest supplier of port related workers. The biggest potential in South Holland lies in The Hague, Leidschen-dam-Voorburg, Delft, Pijnakker-Nootdorp, Lanseringenland and Rotterdam. The zones are located in the middle of activity, giving the population multiple options for employment, including the green-houses in Westland.

Table 2, Shortage of employees in 2020 and 2025

<table>
<thead>
<tr>
<th>Port area</th>
<th>Shortage</th>
<th>Percentage short</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maasvlakte</td>
<td>3461</td>
<td>5127</td>
</tr>
<tr>
<td>Europoort</td>
<td>518</td>
<td>645</td>
</tr>
<tr>
<td>Botlek</td>
<td>723</td>
<td>1016</td>
</tr>
<tr>
<td>Vondelingenplaat</td>
<td>171</td>
<td>252</td>
</tr>
<tr>
<td>Totaal</td>
<td>4873</td>
<td>7040</td>
</tr>
</tbody>
</table>

Potential of new employees
Boundary conditions for port employees to use public transport

The port operates 24 hours a day, seven days a week. Most port related companies work in shifts. Because of the weekend shifts and the mandatory rest after night shifts, each company requires five pools of workers, i.e. five times a complete occupation. In general, half the employees work in shifts, the other half work from 9 to 5.

Speed

As a rule, Vipre uses travel times of 60 minutes as maximun for their collective transport. If the the 60 minute limit is exceeded, people would prefer to use their car over the collective transport system.

Punctuality

Most of the port related labour (about 90%) is physical. If a crane-driver is not available then the ship is not unloaded and all the consecutive workers are waiting. Being at work on time is therefore crucial.

Connection to time-tables of existing public transport.

In general there are three shifts a day, starting (and ending) around 7.00h, 15.00h and 23.00h. The public transport network should be adapted to these times.

Flexibily to unexpected situations.

If a worker arrives late at a public transport stop this person will be late for work. This is unacceptable (as is stressed under 1.). The system should be very reliable and should be able to adapt to unexpected situations like when the vehicle is delayed, a road is blocked, a vehicle is broken etc.

Delivery inside the industrial plot

Because industrial areas are restricted to company workers and public transport must accept everybody to ride no public transport stops can be situated inside the industrial areas. These areas can easily be five by five kilometers in size. Therefore additional transportation is needed inside the industrial area.

Conclusions for the design

which zones to connect?

Figure 32 show the origin of port related workers in 2025. Spijkenisse, Hellevoetsluis and Rozenburg are dominant, but also zones like Brielle, Hoogvliet, Rotterdam North and South contribute considerably in employees of the port area.

Figure 31 shows the potential workforce of South holland. This potential concentrates around The Hague and Rotterdam. Because Maasvlakte will have the most problems with new employees, Maasvlakte should be part of the network.

What kind of connection?

As the results from the interviews point out, the system should be:
- a maximum of 1 hour travel time
- nearly 100% punctual and therefore flexible to unexpected situations.
- available for people starting around 7.00h and people ending at 23.00 h.
- able to deliver people inside the industrial plots.
Origin of Port employees in 2025
% per region

- Light yellow: 0.0 - 0.1
- Light orange: 0.1 - 2.5
- Orange: 2.5 - 5.0
- Dark orange: 5.0 - 7.5
- Red: 7.5 - 15.0

Legend
nieuweherkomstfijn
nTotaal_
0.0 - 0.1
0.1 - 2.5
2.5 - 5.0
5.0 - 7.5
7.5 - 15.0

30190 Total employees

Shortage
23.3%

7.5 - 15.0

3.7

23.3

Total employees
30190
Potential new workforce
Potential workforce in 2025 to attract to work in the port area

Legend
- potentieelfijn
- potentieel

- 0 - 2000
- 2000 - 5000
- 5000 - 10000
- 10000 - 20000
- 20000 - 100000

Potential new workforce
Potential workforce in 2025 to attract to work in the port area
4.4 GIS analysis, Youth and knowledge

Purpose

Since the amount of youngsters in the port is stagnating, something should be done. By connecting the port related knowledge institutes (figure 1) with the places where the youth lives, these youngsters may be attracted to work in the port.

On the other hand the leader firms in the area benefit from a good connection with the knowledge institutes, in order to stimulate innovation. This way there is a threefold connection between leader firms, knowledge institutes and youngsters.

Data

De Langen & Nijdam (2006) made an analysis on leader firms in the port of Rotterdam. Their location is sought in google earth and added to the maps. The amount of youngsters is based on the prognosis data from the CBS (2005)

Results

Figure 40 and 41 show the youngsters in South Holland in 2025.
Results

Figure 42 shows the location of the port related leader firms in South Holland. Figure 43 shows the amount of employees these firms have. This is important, because generally the larger firms have more innovation power (Langen & Nijdam, 2006). In figure 44 the amount of leader firms and the amount of employees are combined in one figure, where the amount of employees for each firm is divided by 1000.
Appendix A. Utilityfactor iteration

The utilityparameters are unknown for the province of South Holland. Yet, the
behaviour is known for 5100*5100 cases (the amount of zones in the RVMK model). The
utilityparameters that have the best fit for the behaviour cases is estimated with an iteration
program (Appendix I.1). For the iteration, only a selection of RVMK zones is used. OD
(origin/destination) data and skim data from the RVMK model is merged into area data
and exported with Omnitrans (appendix II.1). Zonal data is aggregated into area data in
order to:
- make the iteration possible with less OD pairs
- remove outliers

Since the focus is on regional transit, trips within areas are removed from the itera-
tion. The iteration is weighted, meaning that bigger flows have bigger impact on the calcula-
tion of the utilityfactors.

The following steps are taken in the iteration program:
1. OD data per mode and skim data is imported, starting values for the utilityfactors are
   chosen. The program iterates until it reaches x decimals (predifined by the user).
2. Utility is calculated for each mode and each OD pair
3. The difference between real OD per mode and calculated OD per mode is calculated by
   means of total least squares.
4. One utilityfactor is increased with one iteration step
5. Step 2 and 3 are repeated, if least squares has increased, the utilityfactor is decreased with
   one iteration step.
6. The utilityfactor is increased/decreased as long as the total least squares decreases.
7. Step 2-5 are repeated for the different utility factors 10 times.
8. The iteration step is divided by 10, step 2-6 are repeated
9. After step 7 has passed x times the iteration factor jumps back to it's original state, step
   2-7 are repeated.
10. If step 2-8 are taken without any changes to the leastsquares, the iteration is finished.

Different starting values for the utilityfactors are chosen, in order to make sure the
iteration gives the right results. Figure A.1 shows the results for different starting values. The
amount of decimals is increased with each iteration run, untill the utilityfactors don;t change
anymore.

The results are as follows:
\[ U_{car} = 1 - 0.0779 \times T_{travel\_car} \]
\[ U_{PT} = 0.2967 - 0.0207 \times T_{travel\_PT} - 0.0895 \times T_{wait\_PT} \]
\[ U_{bike} = 1.0861 - 0.0697 \times T_{travel\_bike} \]

Checking the results

Another matlab program is written to check the utility results (Appendix I.2). It
checks how many of the calculated OD per mode fits within 25% of the real OD per mode.
Unweighted (to total OD flow) this is 38,4 %. Weighted this is 68.6%. This means that the
methodology is very unaccurate fro some OD pairs. Therefore, shadow OD calculations are
performed, as described in chapter 4 of the Main booklet.
<table>
<thead>
<tr>
<th>Start values</th>
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<th>$A_{car}$</th>
<th>$A_{PT}$</th>
<th>$A_{bike}$</th>
<th>$B_{car}$</th>
<th>$B_{PT}$</th>
<th>$B_{bike}$</th>
<th>$C_{PT}$</th>
<th>Iterations</th>
<th>Least squares</th>
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<td>1</td>
<td>0.2965</td>
<td>1.0862</td>
<td>-0.0779</td>
<td>-0.0207</td>
<td>-0.0697</td>
<td>-0.0895</td>
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<td>1</td>
<td>0.2967</td>
<td>1.0861</td>
<td>-0.0779</td>
<td>-0.0207</td>
<td>-0.0697</td>
<td>-0.0895</td>
<td>1289</td>
<td>33.194</td>
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<td>0.2965</td>
<td>1.0862</td>
<td>-0.0779</td>
<td>-0.0207</td>
<td>-0.0697</td>
<td>-0.0895</td>
<td>940</td>
<td>33.194</td>
</tr>
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<td>7</td>
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<td>0.2967</td>
<td>1.0861</td>
<td>-0.0779</td>
<td>-0.0207</td>
<td>-0.0697</td>
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<td>1289</td>
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<td>-0.0697</td>
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<td>-0.0207</td>
<td>-0.0697</td>
<td>-0.0895</td>
<td>1289</td>
<td>33.194</td>
</tr>
</tbody>
</table>

Figure A.1. Results from the iteration
Appendix B. Validating RVMK data

Checking origin/destination data

Origin/destination data in the RVMK model is validated based on the survey on the origin of port related employees (Port of Rotterdam and Deltalings, 2007). Figure B.1 shows the origin of Botlek employees in 2025, including a shortage of 8%. Figure B.2 shows the distribution of daily trips to Botlek according to the RVMK data. The maps show big similarities: In both figures Voorne-Putten and Rotterdam provide most trips towards Botlek. The biggest difference is the amount of travelers from the rest of Holland. According to the survey, only 4% of the port employees do not dwell in South Holland or Zeeland. According to the RVMK data, over 9% of the travelers to Botlek originate from the rest of Holland. I assume that the survey data is more accurate, yet since the data is so similar, no changes are made to the RVMK data.

Validating the origin of Maasvlakte employees is more difficult. Between 2009 and 2025, the amount of employees on Maasvlakte is expected to double. Furthermore, the effect of ageing brings about a decrease of current port employees. Therefore, a shortage of port employees of 55% is expected for 2025 (figure B.3). Between 2004 and 2020 in the RVMK model, the amount of trips on Maasvlakte are doubled. Yet very little trips come from the area North of the port where, according to my analysis, the new trips should come from (figure B.5). The data from the RVMK model will not be altered, since the real origin of these new trips is unknown. When simulating the designs, these possible changes in demand patterns should be considered.

For some areas, the original OD data per mode shows very unrealistic values. For instance, on Maasvlakte the amount of public transport entering the area daily is 10 times as high as the amount of people going out of the area. How this problem is solved can be read in appendix C, step 5.
Figure B.3. Origin of Maasvlakte employees in 2025 according to the survey.

Figure B.4. Origin of Maasvlakte employees in 2020 according to the RVMK data.

Figure B.5. Potential port employees density
Fixing existing public transport lines

The RVMK model is very detailed in the vicinity of Rotterdam and abstract in the regions further away. Because of this, some regional buslines in the model have very unrealistic speeds: Operational speeds over 80km/h and no dwell times at stations. Sometimes, the difference in travel time between the model and reality is over 30% (figure B.5). Therefore, the regional buslines are fixed manually in the model to match real travel times.

<table>
<thead>
<tr>
<th>(time in minutes)</th>
<th>lijnnummer</th>
<th>in vehicle time</th>
<th>frequency reality</th>
<th>frequency RVMK</th>
<th>travel time incl. waiting time</th>
</tr>
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<tr>
<td>lijn</td>
<td></td>
<td>rijnomer RET</td>
<td>RVMK</td>
<td></td>
<td></td>
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<td><strong>buses around Waalhaven</strong></td>
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<tr>
<td>RETbus Heijplaat-Zuidplein</td>
<td>stadsbus 68 RET</td>
<td>20</td>
<td>24</td>
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<td>4</td>
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<tr>
<td>RETbus Pernis-Zuidplein</td>
<td>stadsbus 69 RET</td>
<td>39</td>
<td>43</td>
<td>2</td>
<td>2</td>
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<tr>
<td>RETbus Zuidplein-Sluisjesdijkster</td>
<td>stadsbus 72 RET</td>
<td>17</td>
<td>17</td>
<td>4</td>
<td>8</td>
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<tr>
<td><strong>bussen North of the Muese</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>city-regional bus 's-Gravenzande-Schiedam Centrum</td>
<td>31,66</td>
<td>34</td>
<td>22</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>stads-streekbus Hoek van Holland-Den Haag centraal</td>
<td>35,31,30</td>
<td>74</td>
<td>52</td>
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<td>2</td>
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<tr>
<td>stads-streekbus Den Haag centraal-Maassluis (via Delft)</td>
<td>38</td>
<td>74</td>
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<td>2</td>
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<tr>
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<td>41</td>
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<td>7.5</td>
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<tr>
<td><strong>busses in Voorne putten</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snelbus Rockanje-Spijkenisse metro centrum</td>
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<td>4</td>
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<td>106</td>
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</tbody>
</table>

Figure B.5. Difference between real and RVMK travel times of regional busses.
Appendix C. Example of travel behavior calculation

This appendix contains the different calculations used to estimate the travel behavior with different network alternatives. ‘Verkeersmodel RVMK 2.2’ updated in April 2008 is used for these calculations, in the OmniTRANS modeling software.

The existing network, for the year 2020 is used, slightly altered as described in Appendix B. Origin/Destination data for three modalities (car, public transport and bike) is available and used for the year 2020.

**Step 1. Setting up the reference data**

The reference data has to be prepared, in order to estimate the travel behavior with the new network. This includes calculating the skims (step 3), calculating shadow ODs (step 4) and estimating the loads (step 8).

**Step 2. Building the new network**

The new network as designed is created in Omnitrans. When necessary, new infrastructure is created, after which the different transit lines are produced. The operation speeds from chapter 8 of the main booklet are used when fine tuning the transit lines.

**Step 3. Generating new skims**

The new network influences the travel times and waiting times between zones. Therefore, new skims are generated. Three job are written, so that OmniTRANS can output these skims for the different modalities. For each of the 5100x5100 OD pairs, Ttravelcar, TtravelPT, TwaitPT and Ttravelbike are generated jobs used: II.6

**Step 4. Calculating shadow ODs**

As can be read in appendix A, the reference OD data (from the RVMK) and the data calculated with the logit model show significant differences. Weighted, 68.6% of the OD flows per mode are within 25% difference of the real OD flow. Therefore, shadow ODs and a shadow factor are introduced.

For each of the 5100x5100 OD pairs, the percentage of people using car (Pcar), using public transport (PPT) and bike (Pbike) is calculated, using the following formulas:

\[ P_{\text{car}} = \frac{\exp(V_{\text{car}})}{\exp(V_{\text{car}}) + \exp(V_{\text{PT}}) + \exp(V_{\text{bike}})} \]
\[ P_{\text{PT}} = \frac{\exp(V_{\text{PT}})}{\exp(V_{\text{car}}) + \exp(V_{\text{PT}}) + \exp(V_{\text{bike}})} \]
\[ P_{\text{bike}} = \frac{\exp(V_{\text{bike}})}{\exp(V_{\text{car}}) + \exp(V_{\text{PT}}) + \exp(V_{\text{bike}})} \]

with

\[ V_{\text{car}} = 1 - 0.0779 \times T_{\text{travelcar}} \]
\[ V_{\text{PT}} = 0.2967 - 0.0207 \times T_{\text{travelPT}} - 0.0895 \times T_{\text{waitPT}} \]
\[ V_{\text{bike}} = 1.0861 - 0.0697 \times T_{\text{travelbike}} \]

The total travel demand for each OD pair (D_{\text{total}}) is known, so:

\[ D_{\text{car}} = P_{\text{car}} \times D_{\text{car}} \]
\[ D_{\text{PT}} = P_{\text{PT}} \times D_{\text{PT}} \]
\[ D_{\text{bike}} = P_{\text{bike}} \times D_{\text{bike}} \]

jobs used: II.2.1, II.2.2, II.2.3  

**Step 5. Calculating new ODs**

In order to calculate the new ODs, the growth factor of Pcar, PPT and Pbike between the original situation and the situation with the new network has to be calculated. The growthfactor is calculated by dividing the new shadow OD by the original shadow OD:.

The new OD are calculated with the following formulas:

\[ D_{\text{car}} = \frac{D_{\text{car}} \times D_{\text{car}}}{D_{\text{car}} \times D_{\text{car}}} \]
\[ D_{\text{PT}} = \frac{D_{\text{PT}} \times D_{\text{PT}}}{D_{\text{PT}} \times D_{\text{PT}}} \]
\[ D_{\text{bike}} = \frac{D_{\text{bike}} \times D_{\text{bike}}}{D_{\text{bike}} \times D_{\text{bike}}} \]
Dbikenew = Dbikeorg x Dbikeshadownew/Dbikeshadoworg
jobs used: II.2.4, II.2.5 & II.2.6

Step 6. Scaling the OD data

The method I used, by introducing shadowOD data, the total travel demand between zones has changed. This is of course unrealistic, since only the mode choice should change. Therefore, the data is scaled, using the following formulas:
Dcarnew= Dcarnewunscaled * Dtotalorg/Dtotalnew
DPTnew= DPTnewunscaled * Dtotalorg/Dtotalnew
Dbikenew= Dbikenewunscaled * Dtotalorg/Dtotalnew

jobs used: II.4

Step 7. Fixing unrealistic data

For some areas, the original OD data shows very unrealistic values (Appendix B). Therefore, the new ODs should not be based on these original values. Therefore, the shadow calculations from step 4 are directly brought into the final OD matrix for each mode.
jobs used: II.3

Step 8. Calculating loads

The OD data is distributed among the different network paths. Different methods are used for the different modalities

Car loads calculated with the 'Volumeaveraging' method

The most simple way of distributing car drivers over the network is with an all-or-nothing assignment: Drivers are distributed along the lines as though the capacity of each link is infinite, causing each driver to choose the shortest path. Since congestion highly affects the capacity of roads, this effect should be taken into account. Therefore, the Volumeaveraging method is used.

The method is iterative, in this case with 20 iterations. At first, cars are distributed with an all-or-nothing assignment. Link travel times are updated according to the volumes on them and a new all-or-nothing assignment is executed. Then the averaging routine kicks in. An average of link travel times of the last iteration and the second-to-last iteration is taken and a new iteration step is performed. This goes on until this step is repeated 20 times.

Before the car loads are calculated, trucks are distributed among the network with an all-or-nothing assignment. Since trucks are only a small portion of the total loads on the roads, this is an acceptable assumption.

Public transport loads calculated using the 'Parallel' method

For choosing the transit lines to distribute travelers on, the Parallel method in Omnitrans is used. This method takes the line with the highest frequency and calculates the waiting times at the stops based on that frequency. The passengers on the route are distributed over all available lines on that route. This distribution takes places in proportion of the frequencies of the lines.

Bike loads calculated with the ‘All-or-nothing’ method

Cyclists are distributed with an All-or-nothing assignment, since congestion on cycle paths rarely takes place and doesn’t affect the route choice of cyclists.

Jobs used: These jobs are provided by DS+V and distribution is prohibited.

Total trips and kilometers of the different modalities

The amount of people choosing the different modalities for each OD pair is known now. Simply by adding up all the numbers in these tables gives the total trips for each modality.

The distance between zones is estimated with the Omnitrans program (see step 3). By multiplying this distance with the ODs per mode, the total kilometer per modality is calculated for each network alternative.
Appendix D. Benefit/cost estimations

Costs and benefits of the different network alternatives are estimated in this appendix. Figure D.1 shows the excel sheet I used to perform this calculation for the different network alternatives. To make this data readable, only three connections are shown in this image: The connections Rotterdam-Hellevoetsluis, The-Hague-Port area and Spijkenisse-Maasvlakte. The total sheet can be found in Appendix IV.1.

System characteristics

The characteristics of the different public transport systems can be found in chapter 8 of the main booklet and are used to make the benefit/cost estimations.

System design

The amount of vehicles/hour, operational hours/day, total track length and newly built track length are defined in chapter 10 of the main booklet.

Capacity

Capacity/day is calculated as follows:
Capacity/day (two directions)=capacity/vehicle * vehicles/h * operational hours/day * 2 directions

Needed vehicles

The amount of vehicles needed is calculated as follows:
Vehicles needed=(vehicles/h)/operational speed (km/h) * track length (km) * 2 directions * 1,1 (buffer factor). This number is rounded up, since the amount of vehicle needed is always a rounded number.

Timetable hours

The amount of daily timetable hour are needed to estimate the operational costs and are calculated as follows:
Timetable hours/day=track length (km)/operational speed (km/h)* operational hours/day *vehicles /h * 2 directions

Special elements

Special elements are those elements that require additional investments, like bridges, tunnels etc. Each element adds 1 to this number, except for building a new tunnel under the new Waterway, which will be considerable more expensive. Therefore, if this tunnel is proposed, it adds 2,5 to the number of special elements required.

Occupation

The occupation of the system is required to calculate the revenues and the degree of occupation.

Average load

The loads on each transit link are generated by the OmniTRANS program (Appendix C, step 8.) The average load for each transit line is calculated by multiplying the load on each link by the length of the link, adding all these numbers up and dividing it by the total length of the transit line. These loads in two directions are added together.

Degree of occupation

The degree of occupation is calculated by dividing the daily capacity by the average load throughout the day.

Passengerkilometer

The amount of passengerkilometers is calculated by multiplying the average load by the length of the transit line.
Figure D.1: Cost-benefit estimations

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<th>Benefit ($)</th>
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</tr>
<tr>
<td>Railway</td>
<td></td>
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<tr>
<td>Water Body</td>
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<tr>
<td>Port Facility</td>
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<tr>
<td>Light Rail</td>
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<td>Light rail at bus on board</td>
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<td></td>
</tr>
<tr>
<td>Light Rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light rail at bus on board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light rail at bus on board</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Purchase costs
The purchase costs are the initial investment costs to get the system operational.

Infrastructure costs
The infrastructure costs are calculated by multiplying the new km track needed by the investment costs/km for the corresponding transit system.

Additional infrastructure costs
These are the additional bridges and tunnels required. Under system design, the amount of special elements are defined for each transit line. The costs for each special element are estimated at 150 million euro:

Building the metro tube near Benelux tunnel cost 120 million euro back in the year 1992 (Trouw, 1992). With inflation these costs will have risen to 150 million euro.

Vehicle costs
The vehicle costs are calculated by multiplying the amount of vehicles needed with the investment costs/vehicle

Yearly Operational costs
Operational costs consist of operational vehicle costs and operational infrastructure costs and are calculated for one year

Operational vehicle costs
Yearly vehicle cost = timetable hours (hours/day) * operational costs (euro/year) * 365 days/year

Operational infrastructure costs
Yearly infrastructure costs = new infrastructure (km) * operational infrastructure costs (euro/km/year)

Revenues
Revenues are generated by selling public transport tickets. The fare used by Arriva in South Holland is 0,75 euro starting tariff and 0,118 euro/km. These fares are used as basis for the calculation of revenues.

Since some people have public transport discount and students travel for free, I estimate that only 70% of these fares will actually be paid. Since the port operates 7 days a week, the loads as calculated under Occupation count for 365 days a year.

Yearly revenues = 0,118 euro/km * 70% * passengerkm/day * 365 days/year + passenger-trips/day * 0,75 euro/trip * 70% * 365 days/year

Passengerkm is calculated under occupation, yet, the amount of passengertrips are unknown. The amount of trips and kilometers can be generated by the Omnitrans program. When a new network is created, the additional trips divided by the additional passengerkm turn out to be around 30 km/trip for the different network alternatives. Therefore, the formula for calculating revenues becomes as follows

Yearly revenues = 0,118 euro/km * 70% * passengerkm/day * 365 days/year + passengerkm/day / 30 km/trip * 0,75 euro/trip * 70% * 365 days/year

Decrease in revenues
I explain in appendix C how the total public transport kilometer for each modality is calculated for the different network alternatives. The difference between the additional PT kilometers with the new system and the passengerkm on the new transit lines is the passengerkm loss on the existing public transport lines.

Loss on existing lines = PTkmnew - PTkmorg - passengerkmnewtransitlines

Revenue loss is calculated with this loss in PT kilometers as described above.
CO2 reduction

Figure D.2 shows the total CO2 reduction calculation for the different network alternatives.

**CO2 emission production by the new transit lines**

Each type of public transport has a certain CO2 production/passengerkm. Now that the passengerkm on the different transit lines is known, the CO2 production per line can be calculated.

**CO2 emission reduction by car usage reduction**

The reduction in car kilometers is calculated as described in appendix C. By multiplying this reduction by the average emissions of car passenger kilometers (133 gram/passenger km), this CO2 reduction is calculated.

**CO2 reduction on existing public transport lines**

The average CO2 emission for public transport is estimated at 65 gram/passengerkm. The new transit lines attract passengers from existing lines, as described under the sub-chapter ‘Decrease in revenues.’ The emission reduction is calculated by multiplying this reduction of passengerkm with the emissions per passengerkm.

**Total CO2 reduction**

The total CO2 reduction is calculated as follows:

\[
\text{CO2 reduction} = \text{CO2 production on new lines} - \text{CO2 car reduction} - \text{CO2 exiting PT reduction}
\]

By multiplying this number with 365 days/year, the yearly CO2 reduction is calculated.

Figure D.2. CO2 reduction calculations

<table>
<thead>
<tr>
<th>travel km in new system</th>
<th>Port railway</th>
<th>Blankenburgton</th>
<th>Water-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 emission by new system (gram/day)</td>
<td>108,853,000</td>
<td>114,225,000</td>
<td>70,071,500</td>
</tr>
<tr>
<td>carkm difference</td>
<td>-885,350</td>
<td>-1,199,303</td>
<td>-232,828</td>
</tr>
<tr>
<td>CO2 emission by car (gram/day)</td>
<td>-117,751,493</td>
<td>-159,507,347</td>
<td>-30,966,127</td>
</tr>
<tr>
<td>additional PT km in new situation</td>
<td>905,749</td>
<td>1,218,827</td>
<td>235,992</td>
</tr>
<tr>
<td>Additional PT km on existing PT lines</td>
<td>-521,551</td>
<td>-590,573</td>
<td>-238,168</td>
</tr>
<tr>
<td>CO2 emission on existing lines (gram/day)</td>
<td>-33,920,283</td>
<td>-38,387,236</td>
<td>-15,480,918</td>
</tr>
<tr>
<td>total CO2 reduction (gram/day)</td>
<td>-42,818,776</td>
<td>-83,889,582</td>
<td>23,624,455</td>
</tr>
<tr>
<td>yearly CO2 reduction in tonnage</td>
<td>-15,629</td>
<td>-30,539</td>
<td>8,623</td>
</tr>
<tr>
<td>yearly reduction aimed at by the port company</td>
<td>-20,000,000</td>
<td>-20,000,000</td>
<td>-20,000,000</td>
</tr>
<tr>
<td>% CO2 removal with the new system</td>
<td>0,08</td>
<td>0,15</td>
<td>-0,04</td>
</tr>
</tbody>
</table>
Appendix E. Combining socioeconomic data with RVMK model output

In order to calculate the socioeconomic relevance of the different network alternatives, the socioeconomic data (in ArcMap) and the RVMK data (in OmniTRANS) has to be combined. This appendix contains the different steps for

Step 1. Calculating the zones within one hour public transport travel time

A job is written (figure E.1) to find what RVMK zones are within 60 minutes public transport travel time from a certain area (in this instance, Maasvlakte). The station area is closest to centroid 3315, so the travel times from this centroid are calculated. The travel time skim (appendix C) is read and an array is taken, containing the travel times between centroid 3315 and the other centroids. An array (5100*1) is read called ‘fives’, containing 5 for each element. This 5 represents a travel time higher than 60 minutes, as will remain so if it is not replaced in the next part of the job.

For each centroid a 1,2,3,4 is assigned, corresponding to 0-30, 30-45, 45-60 and 60-75 minutes travel time according to the travel time skim. I want to calculate what area are within 0-15 minutes, 15-30 minutes, 30-45 minutes and 45-60 minutes. Why this difference? The transit station is never situated exactly at the location of the centroid. Therefore, OmniTRANS calculates additional travel to walk from the station to the centroid. This time seems to take about 15 minutes on average (before and after the trip).

Finally, the travel time data is implemented in the zonaldata of the matrixcube. jobs used: II.7.1

Step 2. Translating socioeconomic data into RVMK zoning division

The socioeconomic data in the CBS format (figure E.2) has to be translated into the RVMK format (figure E.3).

First of all, the total travelers from/to each zone is calculated (figure E.4). This travel demand is used as a weighing factor to distribute the socioeconomic data among the zones.

Then the zonaldata is distributed among the RVMK zones. Figure E.5 shows the job used for this calculation (in this example about the origin of Botlek employees). Selections are made, containing all the RVMK centroids belonging to its corresponding CBS zone. These selections are made in ArcMap: The RVMK division is exported into a shapefile in ArcMap. Another array is imported, called werknBotlek, containing the amount of Botlek employees of each selection/CBS zone.

The amount of travelers for each RVMK zone is used as weighing factor to distribute the socioeconomic data among the different zones within the selection. The data for each zone is implemented in the zonaldata of the matrixcube. jobs used: II.7.2 and II.7.3

```plaintext
skimPT=sc.get([1,4,2,3,3,1])
skimPTMV=skimPT[[1..5100],3315]
sixty=my_cube.zonalData('fives')

n=5100
for i in 1..n
  if skimPTMV[i]<75 then sixty[i]=4 end
  if skimPTMV[i]<60 then sixty[i]=3 end
  if skimPTMV[i]<45 then sixty[i]=2 end
  if skimPTMV[i]<30 then sixty[i]=1 end
end
my_cube.zonalData('sixty_Maasvlakte',sixty)
```

Figure E.1. job written to calculate what areas are within 60 minute PT travel time from Maasvlakte.
my_selection = Array.new
mc = OtMatrixCube.open
my_cube = OtMatrixCube.new
my_selection[1] = my_network.selection('Rotterdam-Zuid')
my_selection[2] = my_network.selection('Port Maasvlakte')
Etc. for all zones
n=85
totaalreizigers = my_cube.zonalData('totalereizigers')
werknBotlekarray = my_cube.zonalData('zeros')
werknBotlek = [635.028961, 0, 53.816014, etc.]
for j in 1..n
wegingsfactor = totaalreizigers[my_selection[j]]
wegingpotentieel = werknBotlek[j]/wegingsfactor.sum
werknBotlekarray[my_selection[j]] = totaalreizigers[my_selection[j]]*wegingpotentieel
end
my_cube.zonalData('werknBotlek', werknBotlekarray)

Figure E.4. Job written to calculate what areas are within 60 minute PT travel time from Maasvlakte.

my_selection = Array.new
mc = OtMatrixCube.open
my_cube = OtMatrixCube.new
my_selection[1] = my_network.selection('Rotterdam-Zuid')
my_selection[2] = my_network.selection('Port Maasvlakte')
Etc. for all zones
n=85
totaalreizigers = my_cube.zonalData('totalereizigers')
werknBotlekarray = my_cube.zonalData('zeros')
werknBotlek = [635.028961, 0, 53.816014, etc.]
for j in 1..n
wegingsfactor = totaalreizigers[my_selection[j]]
wegingpotentieel = werknBotlek[j]/wegingsfactor.sum
werknBotlekarray[my_selection[j]] = totaalreizigers[my_selection[j]]*wegingpotentieel
end
my_cube.zonalData('werknBotlek', werknBotlekarray)

Figure E.5. Distribution of socioeconomic data among RVMK zones.
Step 3. Calculating the socioeconomic relevance

For each network alternative, the socioeconomic relevance can be calculated. For instance, the amount of port employees that dwell within 60 minutes public transport travel time of Botlek. Now that the zones within 60 minute PT travel time are known (step 1) and the amount of port employees dwelling in each area (step 2) the total amount of port employees dwelling within 60 minute PT travel time from a certain station can be calculated: All the 1,2,3,4 from step 1 are changed into 1 with the replace function in excel, meaning that these areas are within 60 minute PT travel time. All the 5s are replaced by 0. For each zone, the reach (1 or 0) is multiplied by the amount of port employees of the area. By adding all the numbers up, the total amount of port employees within 60 minute travel time is known. Appendix IV.2 contains all these calculations.
Appendix F. Regional public transport after 2020

Figure F.1. Regional public transport after 2020 (Province of South Holland)
Figure D.1 Loads for two network alternatives for the port railway network variant.
Appendix G. Alternative port railway network

The network design for public transport on the port railway connects to Rotterdam Alexander (A) instead of Rotterdam Central station (C). This choice is made, because the system attracts more travelers if A is chosen over C. Figure D.1 shows the difference in loads on the different public transport lines for the different variants. The biggest difference can be seen between Rotterdam and Cityports where A attracts a considerable amount of extra travelers over C. Both the busline between Maasvlakte en Spijkenisse and the metro between Schiedam and Drechtsteden attract some extra travelers in A over C. The only link that has bigger loads in C over A is the hovercraft between Hoek van Holland and Maasvlakte. The lightrail between The Hague and the port area carries the same amount of travelers in A and C. Finally, connecting to Rotterdam Alexander is chosen, because the amount of travelers increases significantly.

Appendix H. Significance of different criteria

The significance of public transport for the different elements is tested with a survey among port specialists. People working at the port company were asked to give their opinion on the relevance of creating public transport to improve any of the 7 issues, as shown on figure C.1. They were given a total of 25 points that they could distribute among the elements. Three people of each of the following departments replied to the survey: Planning, Corporate strategy, Environmental issues and Modalities. Two more people were asked from Contracts and Terrain distribution, because of their contacts with clients. In total 14 people replied.

<table>
<thead>
<tr>
<th>Element Description</th>
<th>Punten</th>
<th>Totaal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achterland verbindingen:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ontlast de A15 om vrachtwagen een betere doorgang te geven</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Werknemers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a. Verbind werknemers met hun werk in de haven</td>
<td>4.9</td>
<td>Totaal werknemers 11.2</td>
</tr>
<tr>
<td>2b. Verbind kernen om nieuwe werknemers vandaan te halen</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>2c. Verbind jongeren met havengerelateerde kennisinstellingen</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>2d. Verbind de haven voor recruten uit Zuid-Holland</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Innovatief karakter:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Verbind leader firms met kennisinstellingen</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Duurzaamheid:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. verminder het autogebruik om congestie te verminderen</td>
<td>3.6</td>
<td></td>
</tr>
</tbody>
</table>

Figure C.1. Significance of different criteria, according to 14 port experts
Appendix J. Future growth projections

In 1996, the CPB has made different forecasts for growth in the port sector. They included three scenarios, Divided Europe, European Coordination and Global Competition, all with different growth potentials. In 2001, they translated this growth into a long term demand for space (CPB, 2001). In 2009, a new balance of the space utilisation is made. In 13 years, port activity expanded with 581 hectares (45 hectares/year). This means that, in order to reach the Global Competition growth scenario up to 2020, port activity will have to grow with 46 hectares/year, about the same growth rate as the period from 1996-2009. Therefore the European Coordination scenario is used a lower bound and the Global Competition scenario as upper bound. The Divided Europe scenario is rejected.

Based on the data from 2009, the growth expectation from 1996 are altered. The total demand for space is kept the same for 2020 and 2035, yet the distribution among the different types of industry is redefined. The growth of distribution and other port activities stayed behind the Global Competition prognosis, while the Liquid and Dry bulk grew ahead of the Global Competition prognosis. Therefore, adaptations are made, as can be seen on figure E.1.

![Figure E.1. Adaptations to the CPB growth scenario's from 1996, based on new insights.](image-url)
Bibliography

Appendix I-IV. CD containing digital data