Rail Ghent Terneuzen / ZSP10212

Implementation **S**tudy for **O**ptimization of **C**ross-border **R**ail **I**nfrastructure in the **P**ort area Ghent - Terneuzen

Study 7: Cost Benefit Analysis

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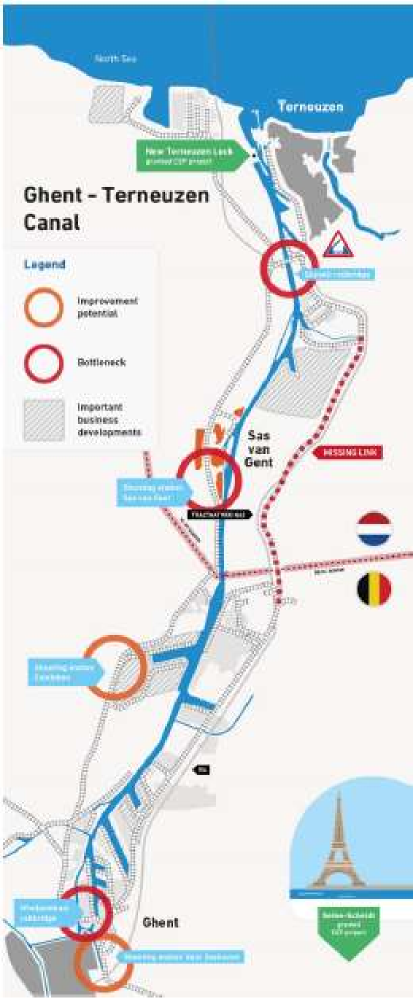
Summary

This document describes the Social Cost Benefit Analysis (SCBA) of possible investments in rail infrastructure within the **Ghent-Terneuzen Canal Zone**. First, we describe the problem. After that, we explore the costs and benefits of the various possibilities from the perspective of society as a whole.

What are the key issues?

The current state of the infrastructure hinders the growth of the rail freight transport in the port, due to the bottlenecks at both sides of the canal.



Trains from and to the east bank of the canal have to pass the Sluiskil bridge. Due to (growing) shipping traffic and number of bridge openings, this route is not always available at the right time. Furthermore, this is a vulnerable route, as its availability can diminish due to maintenance works on the bridge. Moreover, trains from and to the Axelse Vlakte, an industrial area south of Terneuzen, need to turn around in Terneuzen-Zuid. This results in longer journeys and extra costs.

This situation makes the rail freight transport from and to the east bank of the canal vulnerable, relatively expensive, and non-redundant. In future, the number of bridge openings are expected to increase further, as a result of increasing traffic following the opening of the New Lock complex in Terneuzen and the completion of the Seine-Scheldt project.

Companies situated at the west bank of the Ghent-Terneuzen canal can use a direct rail connection to/from Ghent without having to pass a bridge. On these sections of the line, however, there are several other bottlenecks. Tracks on the west bank are used by both freight and passenger trains. Between Wondelgem station and the branch track of passenger line L58 freight trains have to wait for the passenger trains to pass. In addition, the route north of Wondelgem is single track only, which limits its capacity. Furthermore, the connection to the Zandeken train yard is already overloaded according to the operator. Lastly, from the perspective of external safety, it is undesirable that trains with hazardous substances from and to the chemical complex in Terneuzen West have to pass through multiple residential areas.

These bottlenecks put a constraint on the efficiency and potential growth of rail freight within the port area, which has a negative impact on the competitive position of North Sea Port compared to other ports in the Hamburg - Le Havre range.

Goal of the SCBA

The goal of this SCBA is to provide relevant insights into all social costs and benefits of the solutions that are considered for this problem within the Ghent-Terneuzen canal zone. Hence, the project area is limited to this zone and the SCBA does not consider any developments (or possible necessary developments) outside this area.

In this SCBA the following questions are covered: What is the relation between costs and benefits? Which solutions score well in a situation of low growth of the transport demand (= low scenario)? Which solutions are only relevant at a higher growth of the demand (= high scenario)? In answering these questions, we do not only take into account the benefits for the companies as major users of the railway, but also the effects for the local residents (such as changes in air quality or safety), society in general (greenhouse gas emissions such as CO_2), and the economy (changes in employment rate).

Which solutions are being analysed?

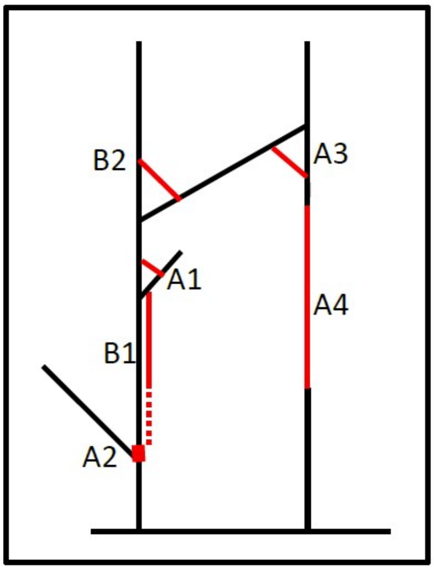
Starting from a base case (reference scenario without new projects), multiple solutions were analysed. The analysis has been conducted for two different growth scenarios: a scenario for low economic growth and resulting transport demand, and a scenario for high economic growth and respective transport demand. The solutions (in SCBA-terminology named 'project alternatives') consist of (a combination of) infrastructure measures (numbered in the table below) which aim at tackling the bottlenecks of the railway infrastructure. Table 1 gives an overview of these measures and their number.

Table 1: Overview of infrastructure measures

Infrastructure measures	*What:*
A1	Northern connection Zandeken, including extension of stabling capacity
A2	Simultaneous passage in Wondelgem
A3	South-east bend at the Sluiskil bridge
A4	Railway connection Axel-Zelzate
B1	Doubling of the track Wondelgem-Zandeken
B2	North-west bend at the Sluiskil bridge

Figure 1 give a schematic representation of the location of the measures. The figure shows that the measures are interrelated. In some cases, a certain measure can trigger the need for other measures further in the network to be strengthened, thus causing logical strings of combinations (for example A2 and B1). In other cases, a measure could induce other measures to have less effect (for example A4 and B1).

Figure 1:Diagram of infrastructure measures



This SCBA includes eight combinations of infrastructure measures. Combinations with B2 (the North-west bend at the *Sluiskil* bridge) have not been studied within this SCBA. This solution was not retained during study 1[1], as the North-West bend does not provide an adequate answer to the challenge (high investment costs of which relatively few trains benefit).

The analysis of the effects of these combinations of measures is largely based on the capacity analysis which was commissioned by North Sea Port and ProRail and conducted by Movares (Movares, 2019)[2]. In close consultation with both parties the results of the capacity analysis were translated to input for the SCBA. In that process, the capacity of the network was defined as the number of trains allowing the transport operators to deliver an 'acceptable' rail product to the transport users. In consultation with ProRail, the 'acceptable' rail product was defined as a maximum expected average delay of 20 minutes, with a 20 minutes spread. In case of delays above 20 minutes, it is impossible to run all trains according to their allocated train paths.

In order for the capacity analysis to serve as an input to the SCBA, the capacity analysis has been translated as follows: (see annex 5 for the information in table form):

Base case: the capacity of the current network amounts to 13 trains from and to the Netherlands (western and eastern bank together) per day, during the day part. At this traffic level the expected delay is 20 minutes (with 20 minutes spread). The majority of trains (85%) are operated during the day part, which runs from 6 AM to 7 PM (Source: Movares, 2019). 10% Of the trains run between 7 PM and midnight, and 5 % between midnight and 6 AM. In the base case, trains from and to the Axelse V*l*akte need to turn around in Terneuzen Zuid, which takes 30 minutes of time. The base case is the same for the low and high traffic scenario due to the capacity limitation.

Project alternatives

A1+A3: This combination concerns the Northern connection Zandeken (A1) and the South-East bend at the Sluiskil bridge (A3). In this project alternative, the network capacity increases to 18

[1] RGT (2018) Studie 1: Vervoersvraag goederen
[2] Movares (2019), Extra capaciteitsanalyses

trains / day part. Because of the bend, trains from / to the Axelse Vlakte do not have to turn around in Terneuzen, leading to a 30 minutes time saving. Next to that, the route is slightly shorter, resulting in a 10 minutes shorter journey time. Altogether, this means a 40 minutes time saving for trains from / to the Axelse Vlakte. The effect of A1 was not covered separately in the capacity analysis. There is no impact of A1 on the expected train delay when the network operates at full capacity. The low and high scenario coincide due to the capacity limitation.

A1+A3+A2: This combination concerns the northern connection Zandeken (A1) +South-East bend at Sluiskil bridge (A3) + a solution for the passing passenger trains (= simultaneous passage Wondelgem – A2). In this situation the network capacity also amounts to 18 trains / day part. For trains from / to the Axelse Vlakte, there is a 40 minutes gain in driving time (see above). According to the capacity analysis, A2 (simultaneous passage Wondelgem) has little added value (1-minute gain in driving time), because freight trains do not operate according to a fixed timetable (Movares, 2019). This is in line with previous observations of Infrabel. There is no impact of A2 on the expected train delays when the network operates at full capacity. The capacity is the same for the low and high traffic scenario.

A1+A3+B1: This project alternative involves the northern connection Zandeken (A1), the South-East bend at Sluiskil bridge (A3), and partially doubling of the track Wondelgem-Zandeken (B1). In this project alternative the network capacity amounts to 21 trains / day part – which is sufficient to accommodate all trains in the low scenario, but not sufficient for the high scenario. For trains from / to the Axelse Vlakte there is a 40 minutes gain in driving time. There is no impact on the expected train delay when using the full capacity (i.e. 20 minutes, same as in the base case).

A4: This project alternative involves a new rail connection between Axel and Zelzate. This measure ensures a direct connection between Ghent and the Dutch part of the east bank. In this alternative the capacity of the network increases significantly. Simulations with the high transport scenario (37 trains per part of the day from and to the Netherlands) indicate that the capacity of the infrastructure is more than sufficient. Thus, traffic in the high scenario can be accommodated at acceptable conditions in this alternative. The average train delay is 5 minutes (11 minutes spread) in the low scenario and 7 minutes (11 minutes spread) in the high scenario for the Dutch trains, well within the acceptable range. Trains from / to the Axelse Vlakte do not have to turn around in Terneuzen, resulting in a 40 minutes gain in driving time. Furthermore, the driving time Terneuzen-Ghent South across the east bank is 6 minutes shorter than across the west bank.

A4+A1: This concerns the combination Axel-Zelzate with the Northern connection Zandeken. According to the capacity analysis, the Northern connection *Zandeken* results in a decrease in delay from 7 to 6 minutes in the high traffic scenario, as well as a 1-minute gain in driving time in both the high and the low traffic scenario (Movares, 2019). The additional contribution of A1 is limited, as fewer trains will use the route on the west bank if Axel-Zelzate is available.

A4+A3: This concerns the combination of the new track Axel-Zelzate and the South-East bend at Sluiskil bridge. As a result of the availability of A4, the capacity limitation of the network disappears (see above). The addition of A3 to A4 ensures that, in case of a network blockage at the east bank, it will be possible to redirect the trains north of the blockage. Rail traffic will have less time delays, being rerouted via the west bank, and more capacity will be available. This results in a more robust network (redundancy). This situation was not simulated separately in the capacity analysis.

The effect of project alternative **A4+A3+A1** (Axel-Zelzate+ South-East bend at Sluiskil bridge + Zandeken) is comparable to that of **A4+A1,** with the additional effect that A3 ensures that, in case of a blockage at the east bank, the trains north of the blockage will be redirected faster and with a larger capacity via the west bank. This situation was not simulated separately in the capacity analysis either.

The effect of the combination **A4+A3+A1+A2** (Axel-Zelzate+ South-East bend at Sluiskil bridge + Zandeken + simultaneous passage Wondelgem) equals that of A4+A3+A1. The analysis of Movares (2019) shows that the addition of A2 does not have any significant effect on the capacity. This situation was not simulated in the capacity analysis.

Based on the capacity analysis, we can conclude that a number of project alternatives have the same expected effects. In practice, this means that six different project alternatives are remaining, apart from the base case. In agreement with the client, however, we chose to show each alternative separately.

Table 2: Overview of investigated and equivalent alternatives

Investigated alternative	**Equivalent alternative**
A1+A3	A1+A3+A2
A1+A3+B1	
A4	
A4+A1	
A4+A3	
A4+A3+A1	A4+A3+A1+A2

What costs and benefits are taken into account in a SCBA?

In a SCBA, the future situation with an investment (project alternative) is compared to the future situation without this investment (base case). The differences between these two situations are the project effects. We distinguish between four groups of project effects:

1. The **direct effects** on the transport system. This concerns savings in transport costs (money and time) for users and their influence on new developments. An important effect of a project is a capacity increase. Capacity increases lead to shorter journey times, reduced waiting times, fewer delays and / or higher reliability. This results in a decrease in costs for rail transport.
2. The **indirect effects** are the effects that occur outside the transport system. These mainly concern the effects on employment and government revenues.
3. The **external effects** are the effects on environment (local residents, nature, agriculture, …) that are not priced. These concern changes in number of road accidents, noise, air quality or greenhouse gas emissions (CO_2) as a result of changes in traffic flows. Despite the fact that these effects are not priced, changes in these types of effects eventually lead to changes in costs for society in general.
4. The **project costs**. These contain the project's investment costs and the effect of the project on the costs of maintenance and management.

Transport prognoses – the major input for the estimation of the direct and indirect effects

This summary does not go into detail about the calculation of the various effects. However, we do take some time to reflect on transport prognoses, as these are an important input to determine both the effects for the user (the direct effects), as well as the external effects.

The transport prognoses are derived from the traffic prognoses for the year 2030, which were drafted in an earlier study[3]. Based on these prognoses, we carried out some additional calculations:

1. First, we updated this prognosis based on discussions with the most important shippers. This analysis does not take the capacity limits into account, and thus reflects the **desired demand** or **non-restricted demand** of the shippers. Given that the prognoses were made for 2030, we assumed that this 'desired demand' remains constant after 2030. In the prognoses we assume that the number of tonnes per train remains constant.
2. Based on the capacity limit of the current network, we determined the transport volume for the base case as a second step. Because the 'desired demand' is bigger than the current capacity, the transport volumes in the base case are lower than the desired volumes.
3. Third, we drew up the prognoses for the various project alternatives. In doing so, we used the change in capacity and the resulting change in (time)costs and expected delays of transport. Using *elasticities*[4] *and growth rates*[5], the increased capacity was translated into changes in transport volumes. Given that the desired demand is higher than the capacity in the base case, we assumed that the demand can increase until either the capacity limit is reached, or the desired demand is reached. This implies that in the project alternatives the demand does keep increasing after 2030, until either the new capacity limit, or the maximum desired demand, is reached.

Figures 2 and 3 show the 'unrestricted demand' (= demand low or demand high = step 1 above), the demand realised in the base case (= step 2), and the demand realised in the project alternatives with higher capacity limits (step 3) in the two scenarios (low and high).

We observe a strong increase in the expected demand, particularly in the later years. This is due to the fact that the prognoses also contain 'new developments'. These developments do not occur in the base case, but can be realised if the conditions (capacity) allow it. As they start off from a 'zero volume', they show a very high yearly growth rate, which results in an exponential increase of demand. They are also responsible for the 'kinks' in the demand curve in the project alternatives. As the capacity within the project alternatives increases, new developments can occur. Shortly after the project alternatives became available, we still observe low volumes and an increase that is caused by a growth in the existing transport. In the longer term, new developments have a growing impact, which results in the kink in the longer term. Within the project alternatives, we always assume a steady internal growth of traffic. In other words, it could take until the year 2042 before all of the extra transport capacity would be used.

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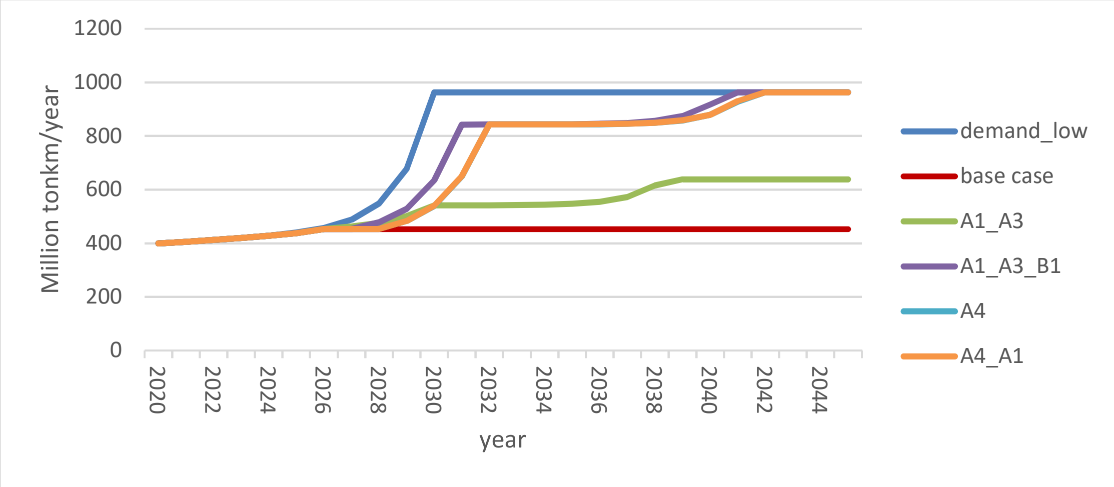
[3] Breemersch, T. (2018), Optimalisatie spoor Gent-Terneuzen. Trafiekprognose spoor – bijlage 2 van ISOCRIP Railontsluiting havengebied Gent-Terneuzen.

[4] An elasticity gives the relation between a change in de cost of a product or service (in this case rail transport) and demand for it.

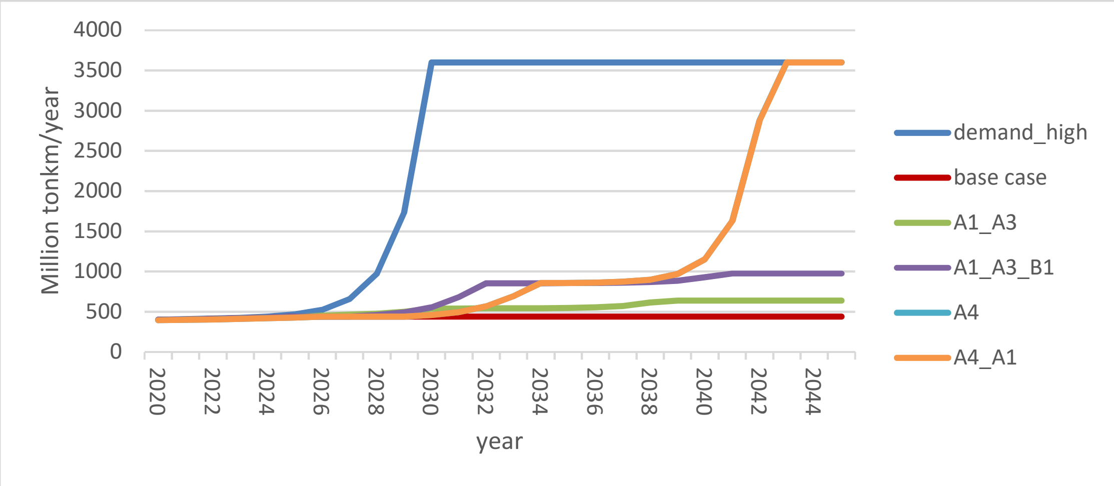
[5] For this that annual growth rates derived in step 1 were used (i.e. the growth between 2016 and 20130 without capacity limits)

Figure 2: Evolution million tonkm/year in base case, project alternatives and unrestricted demand in Terneuzen. Low scenario. A4 coincides with A4_A1



These figures show that the base case does not offer enough capacity to accommodate the desired demand. Figure 2 shows that project alternative A3+A1 does not allow for the potential demand in the low growth scenario to be realised either. Alternative A1+A3+B1 does ensure a sufficiently high expansion of the capacity for the low scenario, but offers insufficient capacity for the high scenario. By contrast, all project alternatives with A4 offer sufficient capacity for the expected demand in both the low as well as the high scenario.

Figure 3: Evolution million tonkm/year in base case, project alternatives and unrestricted demand in Terneuzen. High scenario. A4 coincides with A4_A1.



Results SCBA

This SCBA is consistent with the European standards, as intended by DG Regio (2014). By means of a sensitivity analysis, we illustrate how the results vary if either the Dutch or the Flemish standards respectively are followed.

Tables 3 and 4 show the result for the low and the high scenario for all eight project alternatives. The most important effect are the changes in consumer surplus, followed by the indirect effects. The external effects play a slightly smaller role (benefits resulting from a lower CO_2 (greenhouse gas) emission and NOx (air quality)).

The tables below present an overview of the present value of the costs and benefits over a 30-year time period. The present value is calculated based on a discount rate of 3 percent. The row 'Total' reflects the balance of the present value of costs and benefits, as far as they have been translated into monetary values. In case of a positive Total, the social benefits are higher than the costs at the applied discount rate of 3 percent. Hence, the social return is higher than 3 percent. In case of a negative Total, the return of 3 percent was not achieved.

The BC (benefit cost) – ratio reflects the ratio between the present value of the benefits and the present value of the costs. At a BC-ratio of 1, the benefits just cover the costs.

Table 3: SCBA – Net- present value (30 years, at discount rate 3 %)– low scenario – price level 2018, values VAT exclusive

		Low							
		A1+A3	A1+A3+A2	A1+A3+B1	A4	A4+A1	A4+A3	A4+A1+A3	A4+A1+A3+A2
Project costs	Investment costs	€ -36.93	€ -42.14	€ -45.53	€ -114.87	€ -140.04	€ -126.62	€ -151.79	€ -157.00
	Maintenance costs	€ -7.45	€ -8.52	€ -12.85	€ -24.75	€ -29.53	€ -27.04	€ -31.82	€ -32.83
	Renewal costs	€ -0.15	€ -0.17	€ -0.26	€ -0.50	€ -0.59	€ -0.54	€ -0.64	€ -0.66
	Residual value	€ 0.48	€ 0.55	€ 0.59	€ 1.68	€ 2.01	€ 1.84	€ 2.16	€ 2.23
Consumer surplus		€ 46.40	€ 46.40	€ 101.34	€ 134.67	€ 139.43	€ 134.67	€ 139.43	€ 139.43
Reliability							€ 0.46	€ 0.46	€ 0.46
Indirect effects		€ 5.57	€ 5.57	€ 10.13	€ 16.16	€ 18.13	€ 16.16	€ 18.13	€ 18.13
External Costs	CO2	€ 0.30	€ 0.30	€ 3.53	€ 3.38	€ 3.38	€ 3.38	€ 3.38	€ 3.38
	Nox	€ 1.51	€ 1.51	€ 7.13	€ 6.81	€ 6.82	€ 6.82	€ 6.82	€ 6.82
	PM	€ -0.04	€ -0.04	€ -0.09	€ -0.08	€ -0.08	€ -0.08	€ -0.08	€ -0.08
	Noise	PM	PM	PM	PM	PM	PM	PM	PM
	Safety	€ 0.40	€ 0.40	€ 2.21	€ 2.11	€ 2.11	€ 2.11	€ 2.11	€ 2.11
	Total external costs	€ 2.16	€ 2.16	€ 12.79	€ 12.22	€ 12.23	€ 12.23	€ 12.23	€ 12.23
Total		**€ 10.08**	**€ 3.85**	**€ 66.21**	**€ 24.62**	**€ 1.63**	**€ 11.16**	**€ -11.84**	**€ -18.01**
BC ratio		**1.23**	**1.08**	**2.13**	**1.18**	**1.01**	**1.07**	**0.94**	**0.91**

In the low scenario (see Table 3), the BC ratio of the project alternatives varies between 0,91 (for A4+A1+A3+A2) and 2,13 (A1+A3+B1); in six of the eight cases, the BC ratio is higher than 1. The combination A1+A3+B1 scores best and better than (any combination with) A4. This alternative leads to a substantial increase in capacity, and fully accommodates the projected demand, while the costs are more than halved compared to the costs of the alternatives with A4.

Just like A1+A3+B1, A4 also delivers sufficient capacity to accommodate the transport demand. This alternative shows the highest transport benefits (consumer surplus), albeit at relatively higher costs. By adding the South-East bend (A3) to A4, the robustness of the network improves.

The cheapest alternative (A1+A3) shows a positive balance of costs and benefits, even though it does not succeed in fully accommodating the potential demand. Only the most expensive project alternatives (A4+A1+A3 and A1+A2+A3+A4) do not lead to a net-benefit for society in the low scenario.

At a higher transport demand, as in the high traffic scenario (see table 4), the gain for the users (consumer surplus) is higher. Indeed, the decrease in transport costs effects a larger volume of goods; and next to that we see more new traffic emerging. All project alternatives in this scenario show a net benefit. The BC ratio of some of the alternatives is lower in the high scenario than in the low scenario. This is due to the fact that the demand for additional rail increases significantly in the high scenario resulting in additional negative external effects. Nevertheless, the eventual result is positive in all situations. Note that in A1+A3, the capacity limit is binding in the low and the high scenario. Due to this there is no extra traffic in the project alternative in the high scenario compared to the low scenario, and therefore the result is identical.

Again, alternatives A1+A3+B1 and A4 show the best ratio between benefits and costs. It should be noted that the combination of A1+A3+B1 cannot fully accommodate the transport demand; as opposed to project alternative A4.

Table 4: SCBA – Net-present value (30 years, at discount rate 3%) – high scenario – price level 2018, VAT excluded

		High							
		A1+A3	A1+A3+A2	A1+A3+B1	A4	A4+A1	A4+A3	A4+A1+A3	A4+A1+A3+A2
Project costs	Investment costs	€ -36.93	€ -42.14	€ -45.53	€ -114.87	€ -140.04	€ -126.62	€ -151.79	€ -157.00
	Maintenance costs	€ -7.45	€ -8.52	€ -12.85	€ -24.75	€ -29.53	€ -27.04	€ -31.82	€ -32.83
	Renewal costs	€ -0.15	€ -0.17	€ -0.26	€ -0.50	€ -0.59	€ -0.54	€ -0.64	€ -0.66
	Residual value	€ 0.48	€ 0.55	€ 0.59	€ 1.68	€ 2.01	€ 1.84	€ 2.16	€ 2.23
Consumer surplus		€ 46.40	€ 46.40	€ 103.17	€ 252.03	€ 256.50	€ 252.03	€ 256.50	€ 256.50
Reliability							€ 0.46	€ 0.46	€ 0.46
Indirect effects		€ 5.57	€ 5.57	€ 9.29	€ 22.68	€ 25.65	€ 22.68	€ 25.65	€ 25.65
External Costs	CO2	€ 0.30	€ 0.30	€ 0.32	€ -13.02	€ -13.01	€ -13.02	€ -13.01	€ -13.01
	Nox	€ 1.51	€ 1.51	€ 1.70	€ 2.92	€ 2.92	€ 2.92	€ 2.92	€ 2.92
	PM	€ -0.04	€ -0.04	€ -0.08	€ -1.78	€ -1.78	€ -1.78	€ -1.78	€ -1.78
	Noise	PM	PM	PM	PM	PM	PM	PM	PM
	Safety	€ 0.40	€ 0.40	€ 0.40	€ -2.48	€ -2.48	€ -2.48	€ -2.48	€ -2.48
	Total external costs	€ 2.16	€ 2.16	€ 2.34	€ -14.36	€ -14.35	€ -14.36	€ -14.35	€ -14.35
Total		**€ 10.08**	**€ 3.85**	**€ 56.75**	**€ 121.93**	**€ 99.65**	**€ 108.46**	**€ 86.18**	**€ 80.01**
BC ratio		**1.23**	**1.08**	**1.97**	**1.87**	**1.59**	**1.70**	**1.47**	**1.42**

Results Sensitivity Analysis

Table 5 shows the result of the sensitivity analyses for four project alternatives for the low scenario. We always provide the net present value and the BC-ratio. The first row presents the base result. If the net present value increases, this means that the project performs better than the base result; hence the BC-ratio is also increasing. Table 6 shows the results for the high scenario.

Although the BC-ratio of the alternatives differs quite substantially in the sensitivity analysis, the relative comparison between the project alternatives remains stable. Although the combination A1+A3+B1 scores better than A4 in all situations in the low scenario, the two alternatives are similar in the high scenario.

Table 5: Results sensitivity analysis, Net Present Value (NPV), million euro, prices 2018, VAT exclusive– low scenario

Sensitivity analysis	A1+A3		A1+A3+B1		A4		A4+A1+A3	
	NPV	B/C	NPV	B/C	NPV	B/C	NPV	B/C
Base case	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00
Verbeterd spoor (cost +25 mio)	€ -14.90	0.79	€ 41.21	1.49	€ -0.38	1.00	€ -36.80	0.82
Higher costs (+20%)	€ 2.70	1.05	€ 56.50	1.83	€ 0.97	1.01	€ -42.80	0.80
Lower costs (-20%)	€ 17.90	1.49	€ 76.50	2.59	€ 49.63	1.43	€ 20.90	1.14
2 year shift	€ 7.72	1.18	€ 63.70	2.14	€ 25.56	1.19	€ -9.26	0.95
Lower shift within rail (30% vs 50%)	€ 10.95	1.25	€ 71.33	2.22	€ 29.51	1.21	€ -6.95	0.96
Higher shift witin rail (70% vs 50%)	€ 9.22	1.21	€ 61.10	2.04	€ 19.74	1.14	€ -16.73	0.91
Less inland waterways (15% road, 5% IWW)	€ 11.76	1.26	€ 73.15	2.25	€ 31.25	1.22	€ -5.21	0.97
Option value passenger transport	€ 0.00	0.0	€ 0.00	0.0	€ 0.00	0.0	€ 0.00	0.00
Excluding indirect effect	€ 0.00	0.0	€ 0.00	0.0	€ 0.00	0.0	€ 0.00	0.00
Flemish method	€ 6.74	1.16	€ 57.79	2.01	€ 18.39	1.14	€ -17.73	0.90
Dutch method	€ 5.78	1.13	€ 56.48	1.98	€ 16.92	1.13	€ -19.96	0.89
Discount rate 1,5%	€ 27.73	1.58	€ 113.79	2.62	€ 77.35	1.49	€ 40.60	1.20

Table 6: Results sensitivity analysis, Net Present Value (NPV), million euro, prices 2018, VAT exclusive– – high scenario

Sensitivity analysis	A1+A3		A1+A3+B1		A4		A4+A1+A3	
	NPV	B/C	NPV	B/C	NPV	B/C	NPV	B/C
Base case	€ 0.00	0.00	€ 108.29	0.00	€ 134.67	0.00	€ 139.43	0.00
Verbeterd spoor (cost +25 mio)	€ -14.90	0.79	€ 31.70	1.38	€ 96.93	1.59	€ 61.18	1.29
Higher costs (+20%)	€ 2.70	1.05	€ 47.06	1.69	€ 98.27	1.6	€ 55.20	1.26
Lower costs (-20%)	€ 17.90	1.49	€ 67.08	2.39	€ 146.93	2.28	€ 119.00	1.79
2 year shift	€ 7.72	1.18	€ 54.90	1.98	€ 120.93	1.91	€ 86.86	1.49
Lower shift within rail (30% vs 50%)	€ 10.95	1.25	€ 57.68	1.98	€ 116.19	1.83	€ 80.44	1.44
Higher shift witin rail (70% vs 50%)	€ 9.22	1.21	€ 55.81	1.95	€ 127.67	1.91	€ 91.92	1.50
Less inland waterways (15% road, 5% IWW)	€ 11.76	1.26	€ 58.54	2	€ 128.70	1.92	€ 93.00	1.50
Option value passenger transport	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00
Excluding indirect effect	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00	€ 0.00	0.00
Flemish method	€ 6.74	1.16	€ 49.79	1.87	€ 109.09	1.82	€ 73.40	1.42
Dutch method	€ 5.78	1.13	€ 53.39	1.93	€ 97.35	1.79	€ 60.70	1.35
Discount rate 1,5%	€ 27.73	1.58	€ 103.49	2.62	€ 223.96	2.43	€ 188.30	1.92

The following observations can be made:

- Studies 3, 4, 5 and 6[6] tell show the **uncertainty margin for the costs** estimates for the infrastructure, of -20 and +20%. The effect of this uncertainty is relatively high.
- The cost estimates assume the realisation of a package of measures named "**verbeterd spoor" (improved rail)**. Without "verbeterd spoor", the costs could possibly be 25 million euro higher. It should be noted that the impact of "verbeterd spoor" on the benefits is marginal (small time gain, barely a capacity increase), which is the reason why the benefits are assumed to be constant. Thus, only the costs are increasing, and therefore the BC-ratio is decreasing. This is the only sensitivity analysis in which the project alternative A1+A3 shows a negative balance.
- Lacking information, a number of assumptions were made about what the companies are doing in the base case. A major assumption concerns the **share of rail traffic** that is really new traffic, as opposed to traffic originating from other railway lines (and other ports). The basis assumption is that 50% of the additional transport in the project alternatives concern shifts between railway lines. Within the sensitivity analysis, we take two cases into account: what if 30% would be existing rail transport and what if 70 % would be existing

[6] Rail Gent Terneuzen, Studies 3 t/m 6; Technische studie elementen railinfra. Ontwerprapportage Rail Ghent Terneuzen.

rail transport. The more rail transport is a replacement of existing rail transport, the lower the increase in external costs.

- The assumption concerning the **modal shift**: within the basic calculation, we assume a modal shift of 10% road transport and 10% inland shipping. In the sensitivity analysis, we assume 15% road transport and 5% inland shipping. As the external cost of road transport is higher than the cost of inland shipping, this has a positive impact on the BC-ratio.
- The objective of this SCBA was to focus on the effects on rail freight transport. Nevertheless, the construction of some of the project alternatives (those including A4) also provide the **opportunity to develop passenger transport by rail**. The city of Ghent, the Flemish Government, the municipalities of Zelzate, Evergem, Wachtebeke, Terneuzen and the provinces of Oost-Vlaanderen and Zeeland , Infrabel, North Sea Port, Projectbureau Gentse Kanaalzone, Vegho, Voka, Arcelor Mittal, Volvo, GMF, Samentuin Kouderborn, Bewonersgroepen (local resident associations), Rieme, Hogewege, Muide-Meulestede, Oostakker, Sint-Kruis-Winkel and Terdonk all expressed their support for this line of thought, envisaging the liveability and sustainability of the mobility within this region. Furthermore, passenger transport within the canal zone on L204 is part of the Flemish rail strategy, and financial means have already been reserved in the cooperation agreement between the Belgian Federal Government and the Flemish Government.
  These benefits have been indicatively calculated and have been included in the variants in which the Axel-Zelzate connection (A4) on the east bank is realised. The inclusion of an option value for passenger transport is not possible in case of the alternative without A4. This option results in a significant additional benefit and therefore also in an increase in the BC-ratio. Any detailed research into the additional investment costs and development has not been performed within this study. Note that detailed research into other infrastructural adjustments, such as platforms, is equally necessary to enable passenger transport on line L204.
- The exclusion of **indirect effects** causes a decrease in the BC-ratio. This is due to the fact that these generate relatively high benefits. Note that, according to the European and Belgian standards, the indirect effects are generally not included.
- Differences in **methodology**:
  The Flemish Standard methodology prescribes a discount rate of 4% and an expected lifespan of 40 years. In practice, the results are very similar (slightly more negative) to the calculations according to the European methodology. In the Netherlands, the standard approach differs somewhat with regard to the following points:
  - In the Netherlands, a risk-free discount rate of 0% is being used, plus a risk premium of 4,5% and thus a total discount rate of 4,5%. This leads to a lower value of the benefits.
  - Furthermore, an ‘infinite’ project period is used. In practice, this is operationalised by considering a project period of 100 years starting from the date of first use. In certain cases, a shorter project period can be considered, for instance when investments with a short lifespan are concerned, which is not the case with rail investments. A longer viewing period leads to a higher value of benefits.

- As for CO_2, we observe various valuations for 2020, 2030 and 2050 and for a high or low economic growth scenario[7]. After 2050, we keep the valuations constant. This leads to a higher value of this effect.
- On top of that, "a gradual growth" is used (KiM, 2013). This is based on the argumentation that an hour of travel time gains which is generated during the first years cannot always be fully exploited by the transporter or the shipper. This is due to the fact that his operational processes are not yet well aligned to the new situation. In such case, the value of time might be lower than the factor costs. With regard to rail transport, a ratio of 0.58 is used for the first year starting from the date of installation. Over the years, the transporter and the shipper will become more capable in maximizing the benefit of any gained transport hours. The further in the future the benefits of a project occur, the more the correction grows towards 1. After 10 years, a ratio of 1 is used for all calculations. The application of the ingrowth implies a lower value of the benefits.
- On balance, the difference in result between the Dutch, Flemish and European methodology is negligible, as the differences partly compensate each other.

- If a **discount rate** of 1.5% is being used, the BC ratios are much higher. However, a discount rate of 1.5% is not customary in the reference literature.

Conclusion

The capacity analysis shows that, if the rail connection Axel-Zelzate is built (A4), the expected rail traffic in both the low and the high scenario can be fully accommodated. This measure offers a broad range of growth possibilities to the port. The addition of other infrastructure measures (A1, A3) can help solve local bottlenecks, or improve the robustness of the rail system.

Apart from the project alternatives containing A4, the project alternative that consists of an investment in Zandeken, the South-East bend and the track doubling Zandeken-Wondelgem (A1+A3+B1) also offers a positive outcome, in the low as well as in the high traffic scenario. However, this alternative does not provide sufficient capacity to accommodate the expected transport demand in the high traffic scenario. Consequently, the growth possibilities of the port are limited for this alternative, and part of the cargo will be transported via other ports and routes.

[7] https://www.pbl.nl/publicaties/wlo-klimaatscenarios-en-de-waardering-van-co2-uitstoot-in-mkbas