BRAIN-TRAINS: SCENARIOS FOR INTERMODAL RAIL FREIGHT TRANSPORT AND HINTERLAND CONNECTIONS:
FROM A SWOT ANALYSIS OF THE BELGIAN RAIL PRACTICE TO SCENARIO DEVELOPMENT

Frank Troch
Thierry Vanelslander
Christa Sys
University of Antwerp, Department of Transport and Regional Economics
Christine Tawfik
Martine Mostert
Sabine Limbourg
University of Liège, Research Centre in Quantitative Methods and Operations Management
Angel Merchan
Sandra Belboom
Angélique Léonard
University of Liège, Department of Chemical Engineering, “Products, Environment, Processes”
Vidar Stevens
Koen Verhoest
University of Antwerp, Department of Political Science

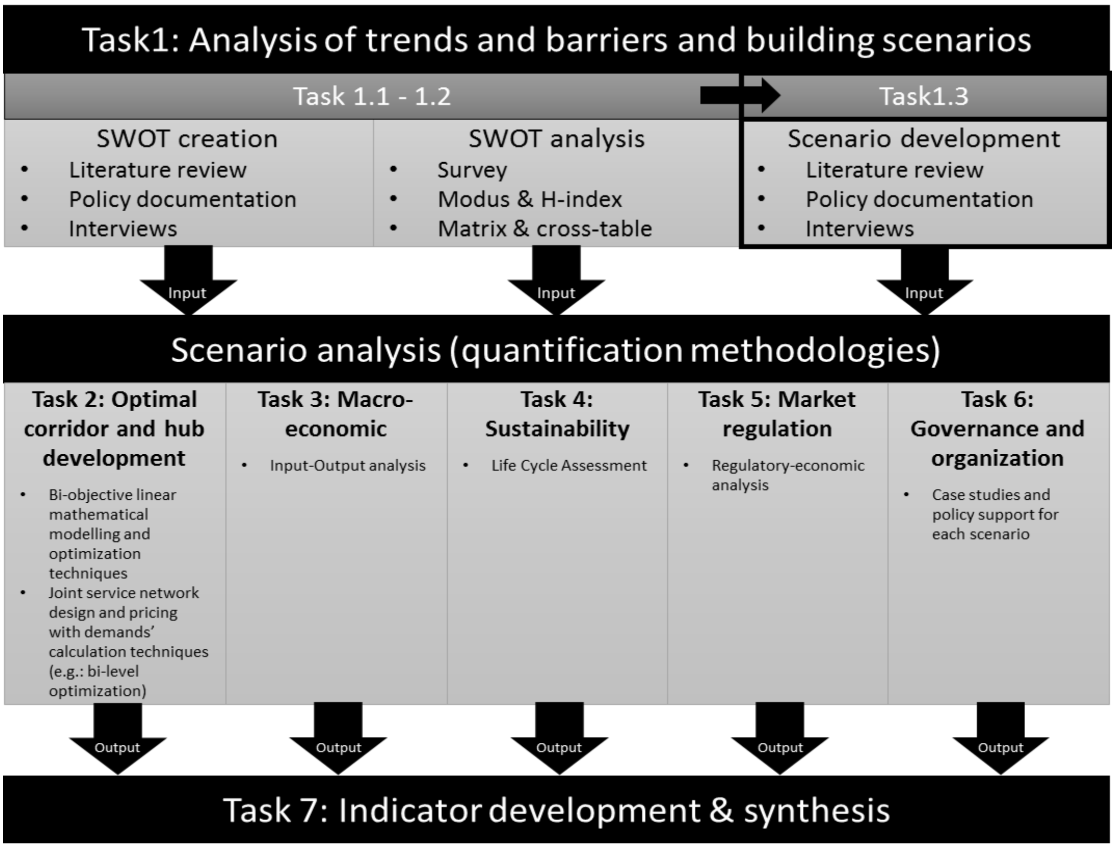
1. INTRODUCTION

Belgium is one of the many member states in the European Union where road transport is claiming the position of most dominant mode of hinterland transport for decades, and is still strengthening this position. With a market share of 64.5% in 2012, measured as a percentage of the total ton-kilometres (tkm), road transport surpasses with ease more sustainable modes of inland transportation, such as inland waterways (IWW) (20.9%), and rail transportation (14.7%) (Meersman et al., 2015). In order to stimulate the use of rail transport and IWW, and therefore breaking the dominant position of road transport, the European Commission (2011) has adopted ambitious goals in its White paper of 2011. By 2030, a 30% shift of the modal share of road transportation over 300 km towards rail and IWW is aspired. This shift is foreseen to go up to 50% by 2050. The White Paper intends reaching these goals by striving for more efficiency and an increased attractiveness of IWW transportation and rail transport, including intermodal rail transport (Gevaers et al., 2012). This should be achieved in the form of a European Single Transport Area, with optimal connections and rail corridors, increasing the possibility of easily shifting from one mode of transport to the other, in a uniform European environment. In the scope of the current paper, intermodal rail transport is defined as the movement of goods in the same loading unit or vehicle, f.ex. containers, which uses successfully several modes of transport, but with the possibility of handling the goods during transhipment between the modes. This is a broad interpretation of the definition defined by Grosso (2011) and includes the assumption of intermediary handling of the goods, required for possible data collection.

The present paper is part of the BRAIN-TRAINS research, which deals with the possible development of rail freight intermodality in Belgium[1]. The main goal of the project is to develop a blue print, including the detailed criteria and conditions for developing an innovative intermodal network in and through Belgium, as part of the Trans-European Transport Network (TEN-T) and the European Single Transport Area. The outcome of the research is an operational framework, linked to various market, society and policy-making challenges, in which effective intermodal transport is successfully established in Belgium. It was found opportune to adopt a transversal approach, starting from the current relatively weak position of intermodal rail freight in Belgium. The research is therefore concentrated around five main subjects, being the *optimal corridor and hub development*, the *macro-economic impact* and *the sustainability impact* of intermodality, the *effective market regulation* and corresponding *governance and organization*. This interdisciplinary approach is important for policy-makers, as the responsibilities for intermodal rail transportation in Belgium are split over different governmental levels (local, regional, federal and European), requiring the need for cooperation in taking decisions towards the same results.

The project is split into seven main tasks. Figure 1 shows the different steps of the process. The present paper focusses on the results of task 1.3, being the development of scenarios of future developments in intermodal rail transport. This is a direct continuation of tasks 1.1 and 1.2, where a profound analysis of the current strengths and weaknesses is documented, together with trends and possible barriers in the future development of intermodal rail transport[2]. This SWOT is the result of a study of existing literature and published studies, as well as of different interviews with a heterogeneous consultation group. In total, 93 different SWOT elements are identified and analysed (Vanelslander et al., 2015). Task 1.3 translates the SWOT into a number of scenarios, containing the most plausible future events affecting the development of intermodal rail transport in Belgium. In the tasks (2 to 6), each of the five subjects will simultaneously use these scenarios, by using, adapting or creating a specific methodology to perform the scenario analysis. These results will then be integrated and will be analysed in task 7, in order to create a framework with indicators to support the users of the model, both governmental and non-governmental. This provides a comprehensive way to measure the impact of possible developments and decisions.

Figure 1: BRAIN-TRAINS project plan



Source: Own composition

The next section will continue from the validated SWOT analysis in tasks 1.1 and 1.2[2]. The scenario development process starts with the selection of final SWOT elements. Afterwards, a number of parameters is carefully chosen for each of the retained elements. In section 3, these parameters are quantified with a reference value, resulting in the reference scenario. Sections 4 to 6 examine the values of the selected parameters for three possible scenarios. The paper ends with conclusions and some discussion on the final scenarios.

2. FROM SWOT ANALYSIS TO SCENARIOS

In this section, the process from SWOT analysis to scenario development will be explained. This is considered the methodology of the paper, although literature research by the authors has learned that no clear existing path or instructions exist for translating a SWOT into scenarios of future development. In addition, scenarios exist in many forms and can have a wide range of objectives. Therefore, sub-section 2.1 defines a scenario as it is used in the scope of the current paper. Sub-section 2.2 highlights the road map that is followed to translate the SWOT into scenarios. Sub-section 2.3 focuses on the element and parameter selection. Sub-section 2.4 finally indicates the chosen scenario characteristics.

2.1. Scenario definition

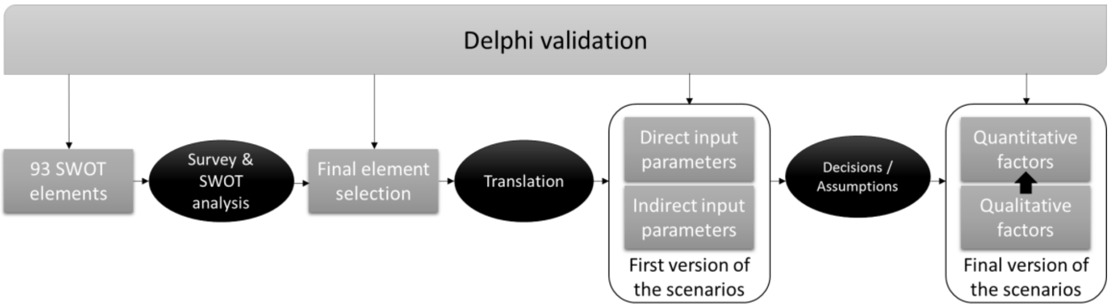
The objective of using scenarios is to research the impact of plausible future developments on intermodal rail transportation in Belgium. Based on the definitions of the European Commission (2007)[3], Lobo et al. (2005)[4] and Kahn & Wiener (1967)[5], a scenario is defined in this project as "An exploration of hypothetical future events, highlighting the possible discontinuities from the present and used as a tool for decision-making". From the definitions, it can be stated that scenarios need to be plausible, consistent and offer insight into the future, without attempting to forecast its exact nature. Scenarios consist of complex interactions by different elements, without attempting to predict the future. In order to do so, assumptions need to be made, which makes them vulnerable to subjective interpretations. As such, it is crucial that key decision makers and external experts with different backgrounds validate the defined scenarios. This will be explained in the next section.

2.2. Road map for scenario development

In order to validate the results of the SWOT and the scenarios, the Delphi technique has been adopted. This is a process where a heterogeneous panel of experts discusses and validates the results presented, until consensus is acquired (Hsu and Sandford, 2007). In the current research, this panel consists of port authorities, rail freight companies, government representatives, academic contributors and private intermodal transport users[6]. In order to converge the different opinions, the 93 final SWOT elements are translated into a questionnaire (Vanelslander et al., 2015). Respondents scored each of the elements on a Likert scale, measuring the impact and the likelihood of happening for each element[7]. The output of this survey is analysed in order to obtain a priority ranking of the elements for each SWOT category.

This SWOT analysis is used as input for the process of scenario development as shown in figure 2. The results of the priority ranking are used together with a consolidation technique based on cross-links, in order to obtain a final selection of SWOT elements. This is done based on the methodology of Crozet (2003), where trends or scenario exploration elements are considered to have a high importance and a weak level of control. The level of impact and the likelihood of happening measured in the questionnaire are related to these factors, in order to obtain a final list of elements. The panel of experts validates these elements with consensus, after which they translate into measurable parameters.

Figure 2: Road map for scenario development from a SWOT analysis



Source: Own composition

Two different kind of parameters are identified. First, there are direct input parameters, which are necessary to execute the different foreseen methodologies for scenario analysis in tasks 2 to 6. Secondly, indirect input parameters are identified, which will require a translation in task 2 to 6, in order to use them in the decided methodologies.

These parameters create a first version of the scenarios. After validation of the parameters, and as such the first version of the scenarios, it is decided which parameters will be taken into account as explorative factors in the final scenarios. This can be either as an actual quantitative value, such as the level of tkm, or as a qualitative factor influencing the other quantitative values, such as a high level of standardization and interoperability, positively affecting the level of tkm.

In the next section, the results of this process will be discussed.

2.3. Element and parameter selection

The SWOT analysis results in a validated selection of 17 final SWOT elements. These elements are shown in figure 3. Within each SWOT category, the most relevant elements are retained. These elements are used to explore possible future events, which will have the highest impact on decisions for the development of future intermodal rail transport.

The next steps of the process translate these 17 elements into clear and measurable quantitative parameters or qualitative factors. A short overview of the final selected quantitative parameters is shown in figure 4[8]. The values of these parameters will be discussed in sections 3 to 6, and they are directly or indirectly influenced by a number of qualitative factors, which are taken into account during the development of the final scenarios[9]. These parameters are also listed in figure 4.

Figure 3: Final selection of 17 SWOT elements.

Selection of SWOT elements	
A. Internal elements (influencable)	
1.Strengths of (intermodal) rail transport	
1.1	Reduced costs and externalities (over long distances)
1.2	Larger capacities and higher payload of containers
1.3	Liberalization of the market
1.4	Relation between GDP and rail transport
2. Weaknesses of (intermodal) rail transport	
2.1	Weak network access and lack of flexibility
2.2	High investments
2.3	High operating costs
2.4	Complex pricing strategies
2.5	Missing (capacity) links
B. External elements (non-influencable)	
3. Opportunities of (intermodal) rail transport	
3.1	Consolidation of flows
3.2	A Single European Market / Transport Area
3.3	Future road taxes
3.4	Standardization and interoperability
4. Threats of (intermodal) rail transport	
4.1	Savings
4.2	Impossibility of consolidating flows and/or low interoperability
4.3	Passenger traffic
4.4	European monopoly or duopoly

Source: Own composition

Figure 4: Final selection of quantitative and qualitative parameters

Quantitative Parameters	Qualitative Parameters
Transport emissions	Level of technical evolutions
Energy consumption	Level of standardization and interoperability
Infrastructure and maintenance cost	Modal split objectives
Noise exposure	Level of flexibility
Market players and company links	Pricing strategies
Rail tonkilometers	Consolidation opportunities
Operational costs	Sufficient network capacity
Road taxes (toll payment per km)	Continuation of subsidies
	Existence of monopoly or duopoly
	Savings policy
	Influence of passenger traffic

Source: Own composition

2.4. Scenario characteristics

Before these parameters are translated into values and final scenarios, the different characteristics of these scenarios need to be defined.

In order to develop the final framework, in which the necessary criteria and conditions for efficient and attractive intermodal rail transport are developed, the choice is made to develop three different scenarios. In order to identify clear differences between these scenarios, a *best-case* scenario, a *medium-case* scenario and a *worst-case* scenario are developed. The heterogeneous panel of experts also validate this set-up.

The *time horizon* of these scenarios is set on 2030, as this is the first milestone in the White Paper of the European Commission (2011).

A *limited set* of elements and parameters is selected, in order to limit the complexity of the scenario analysis, as data is scarce and difficult to obtain. In addition, this approach allows focussing on those elements and parameters that have the highest impact on the future developments of intermodal rail transport and the corresponding decisions that will need to be made.

In order to make the parameters comparable, interpretable and usable in the methodologies of the next tasks, the values will be mostly expressed in a *number per tonkilometer (tkm)*, unless valid reasons exist not to do so.

Parameters will now be quantified for the various scenarios in the next sections.

3. REFERENCE SCENARIO

The selected parameters for the reference scenario are defined with a reference value in this section. These are shown in figure 5. Each value is based on literature documentation and will be briefly explained in this section.

The reference values for the first two parameters, *transport emissions* and *energy consumption*, are based on the study of ECOTRANSIT (2008). Within this study, the average parameter values are calculated for 20 European countries, including Belgium. Also the emission factors for electricity production are taken into account. These values are validated by the TREMOVE study (Ricardo-AEA et al., 2014) and the data available from the European Environment Agency (2013). In order to validate these values for the Belgian case, a spot-check was performed by the authors. This is done by using data of SNCB, the biggest rail operator in Belgium, over the period 2006 to 2012. During this analysis, similar parameter values are calculated[7].

Figure 5: Reference scenario values

Parameters			Reference value	
Transport emissions	CO_2	Road	72	g/tkm
		Rail (electric)	18	g/tkm
		Rail (diesel)	35	g/tkm
	NO_x	Road	0.553	g/tkm
		Rail (electric)	0.032	g/tkm
		Rail (diesel)	0.549	g/tkm
	SO_2	Road	0.090	g/tkm
		Rail (electric)	0.064	g/tkm
		Rail (diesel)	0.044	g/tkm
	NMHC	Road	0.054	g/tkm
		Rail (electric)	0.004	g/tkm
		Rail (diesel)	0.062	g/tkm
	Dust	Road	0.016	g/tkm
		Rail (electric)	0.005	g/tkm
		Rail (diesel)	0.017	g/tkm
Energy consumption		Road	1,082	kJ/tkm
		Rail (electric)	456	kJ/tkm
		Rail (diesel)	530	kJ/tkm
Infrastructure and maintenance costs		Road	0.218	EUR/tkm
		Rail	0.0698	EUR/tkm
		IWW	0.0219	EUR/tkm
Noise exposure	Major road	Lden > 55 dB	250	people/km
		Lden > 65 dB	116	people/km
		Lden > 75 dB	10	people/km
	Major Railway	Lden > 55 dB	321	people/km
		Lden > 65 dB	92	people/km
		Lden > 75 dB	10	people/km
Unlinked active intermodal players			6	(+ 3 linked)
Rail tkm			7,300	mio tkm
Operational costs		Road (long haul)	0.070 - 0.020	EUR/tkm
		Road (short haul)	0.100 - 0.040	EUR/tkm
		Rail	0.025 - 0.019	EUR/tkm
		IWW	0.0076 -0.0381	EUR/tkm
Road taxes			0.11 - 0.14	EUR/km

Source: Own composition

CE Delft et al. (2010) define the parameter value on *infrastructure and maintenance costs* of land transport. Only the cost of building and maintaining the infrastructure is reflected in this value. Other costs such as access charges are not included. It shows from the table that IWW transport has a clear advantage over the other two modes of transport. Road transport carries the highest infrastructure and maintenance cost. On the one hand, this benefits the cost-attractiveness of other modes of transport such as rail transport and IWW transport. On the other hand, it increases the total cost of the logistics chain of intermodal transport, due to the need for pre- and post-haulage by truck.

The value for the parameter *noise exposure* is based on the report of ETC/ATM (2014). As there is only limited data available in terms of noise exposure, a calculation was made based on data of Flanders for the year 2012. This data takes into account the number of people exposed to noise from major roads and major railways. The values are split according to the day-evening-night noise indicator (L_{den}) in decibels (dB). This indicator assesses annoyance during the day and evening period (> 65 dB), and the sleep disturbance during nights (> 55 dB) (European Commission, 2002; Hurtley, 2009).

The number of *active intermodal market players* and the corresponding company links are obtained by interviews and data made available by INFRABEL (2015) and SNCB (2014), respectively the belgian infrastructure manager and the biggest rail operator in Belgium.

The parameter indicating the rail demand, and as such the level of *rail tkm* performed, is one of the most crucial values due to its link with most of the other quantitative parameters and qualitative factors. The current amount of rail tkm performed in Belgium is taken from the statistical pocket book of the European Commission (2014).

The *operational cost* values for road and rail transport are observed in the study of Janic (2008), whilst the IWW values are based on a study of PWC (2003).

Starting from April 2016, the currently used Eurovignet will be replaced by a *road tax* per tkm for trucks heavier than 3.5 tonnes on Belgian highways part of the Eurovignet network (Viapass, 2015). The reference value of road taxes is based on the calculations published in L'écho (2014) and made by Viapass (2015) and is taking into account infrastructure costs and external costs.

The next section will translate the parameters and reference values into the best-case scenario. The ratios applied to the reference values are validated by the heterogeneous panel of experts during the Delphi technique process.

4. BEST-CASE SCENARIO

The best-case scenario fully takes into account the targeted 30% shift by 2030. The rising demand is therefore augmented with the possible results from the efforts taken to realise a shift from road transport over 300 km towards rail, and the growth in demand can also be explained by historical data and the SWOT analysis, showing the increasing trend in transport and rail demand. The values for this scenario are shown in figure 6.

Figure 6: Best-case scenario

	Parameters			Reference value		Scenario value		%
BEST-CASE	Transport emissions	CO_2	Road	72	g/tkm	58	g/tkm	-20%
			Rail (electric)	18	g/tkm	11	g/tkm	-40%
			Rail (diesel)	35	g/tkm	21	g/tkm	-40%
		NO_x	Road	0.553	g/tkm	0.445	g/tkm	-20%
			Rail (electric)	0.032	g/tkm	0.019	g/tkm	-40%
			Rail (diesel)	0.549	g/tkm	0.330	g/tkm	-40%
		SO_2	Road	0.090	g/tkm	0.072	g/tkm	-20%
			Rail (electric)	0.064	g/tkm	0.039	g/tkm	-40%
			Rail (diesel)	0.044	g/tkm	0.027	g/tkm	-40%
		NMHC	Road	0.054	g/tkm	0.043	g/tkm	-20%
			Rail (electric)	0.004	g/tkm	0.002	g/tkm	-50%
			Rail (diesel)	0.062	g/tkm	0.037	g/tkm	-40%
		Dust	Road	0.016	g/tkm	0.013	g/tkm	-20%
			Rail (electric)	0.005	g/tkm	0.003	g/tkm	-40%
			Rail (diesel)	0.017	g/tkm	0.010	g/tkm	-40%
	Energy consumption		Road	1,082	kJ/tkm	975	kJ/tkm	-10%
			Rail (electric)	456	kJ/tkm	365	kJ/tkm	-20%
			Rail (diesel)	530	kJ/tkm	425	kJ/tkm	-20%
	Infrastructure and maintenance costs		Road	0.218	EUR/tkm	0.196	EUR/tkm	-10%
			Rail	0.0698	EUR/tkm	0.0555	EUR/tkm	-20%
			IWW	0.0219	EUR/tkm	0.0198	EUR/tkm	-10%
	Noise exposure	Major road	Lden > 55 dB	250	people/km	175	people/km	-30%
			Lden > 65 dB	116	people/km	81	people/km	-30%
			Lden > 75 dB	10	people/km	8	people/km	-20%
		Major Railway	Lden > 55 dB	321	people/km	225	people/km	-30%
			Lden > 65 dB	92	people/km	64	people/km	-30%
			Lden > 75 dB	10	people/km	7	people/km	-30%
	Unlinked active intermodal players			6	(+3 linked)	10	(+4 linked)	-
	Rail tkm			7,300	mio tkm	17,000	mio tkm	+133%
	Operational costs		Road (long haul)	0.070 - 0.020	EUR/tkm	0.063 - 0.018	EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040	EUR/tkm	0.090 - 0.036	EUR/tkm	-10%
			Rail	0.025 - 0.019	EUR/tkm	0.018 - 0.013	EUR/tkm	-30%
			IWW	0.0076 - 0.0381	EUR/tkm	0.00646 - 0.03239	EUR/tkm	-15%
	Road taxes			0.11 - 0.14	EUR/km	0.132 - 0.18	EUR/km	+20%

Source: Own composition

This scenario is taking into account a number of positive elements to come true by this time horizon. Most of the parameters values are defined in a measure per rail tkm. To identify the total impact of each parameter, it can be multiplied with the explored rail demand in each scenario. The estimated increase of rail demand by 133% is obtained based on the studies of Vandresse et al. (2012) and Islam et al. (2013). Starting point is the reference value for current rail demand in Belgium, indicated by the European Commission (2014), which equals 7,300 million tkm for the year 2012. For the three dominant modes of transport, road, rail and IWW, a rounded total of 50,000 million tkm is taken into account for the year 2012. This results in a current modal split share of approximately 14.7% for rail freight in Belgium, when only the three dominant land transportation modes are taken into consideration (Meersman et al., 2015).

In the best-case scenario, a fixed annual average growth of the GDP by 2% is assumed. Within the study of Vandresse et al. (2012), an average annual growth by 2.4% is foreseen for total transport tkm, corresponding with an average annual growth of the GDP by 1.6%. If the same ratio from the study of Vandresse et al. (2012) is used (1.6%/2.4% = 0.666), the average annual growth of total tkm in Belgium rises in our scenario to 3% (2%/0.666 = 3%). This results in a total transport of approximately 85,000 tkm by 2030. In case the modal split would remain the same, the total number of rail-tkm would rise to 12,495 tkm. This value needs to be increased with the aspired shift of road transport over 300 km towards IWW and rail transportation. This is done by using the study of Islam et al. (2013), where rail demand for Belgium is expected to rise to 16,776 km by 2030, in case the full White Paper goals are aspired, as it is also the case in our current scenario. This number is raised to 17,000 rail-tkm, resulting in an increase of 133% compared to the reference value. This value is also taking into account a number of qualitative parameters as described in section 1.3, such as high level of standardization and interoperability, the execution of all planned investments in order to reach the necessary capacity, little to no impact of savings, the materialisation of consolidation opportunities, an increased level of flexibility and less interference by passenger traffic. Knowing the best-case scenario value for rail demand, the other parameters can be explored.

Rail transport is also expected to lower its direct emissions by 40%, mainly due to innovation and investments in research and development, whilst road transport is becoming cleaner at a less rapid rate (-20%). Nevertheless, as the volume of rail transportation is assumed to increase in this scenario, the total effect should be taken into account by multiplying these values with the total transport measured in tkm. This will be done in future research in tasks 2 to 6 of figure 1.

Within this best-case scenario, also energy consumption of rail transport is dropping at a faster rate compared to that of road transportation. In addition, also infrastructure and maintenance costs are becoming lower by 2030. In this scenario, the cost of rail transportation is dropping at a faster rate than IWW and road transport costs. It is important to notice that cost decrease of road transport will also have an impact on the attractiveness of intermodal rail transportation, where truck transport is often used as a mode of transport for pre –and post haulage. This evolution decreases the total cost of the full logistics chain even further, in case intermodal transport is used. When the comparison for operational costs is made, it shows that for rail transportation, this cost is set to decrease by 30%, whilst road transportation and IWW obtain a decrease by respectively 10% and 15%. This increases the cost-benefit ratio of rail transportation over road transportation, making rail the more attractive main transport option for long distances in an intermodal chain.

In this best-case scenario, it is defined that market competition increases, which is expected to result in an increased efficiency and attractiveness of intermodal rail transportation. Four more independent companies are expected to achieve their licences, and actively use it in the field of intermodal rail transport. This brings the number of intermodal competitors in Belgium to ten. The number of companies operating intermodal rail transport linked to existing operators is set to rise by one. It is clear that a monopoly or duopoly does not exist within this scenario.

Concerning road taxes imposed on trucks, a best-case scenario for rail transport is to consider their increase by 20%, as to render the intermodal rail choices more attractive. Nevertheless, the negative impact through the cost increase of pre- and post haulage is also to be taken into account.

In terms of capacity, the assumption is made that all necessary investments are finished timely within this scenario. Due to the technical developments, it is also assumed that larger capacities and higher payloads will be possible. This implies that no new bottlenecks will arise by 2030, and the rail network and intermodal terminals can handle the rise in rail demand and intermodal transport in general.

5. WORST-CASE SCENARIO

Section 5 turns to the worst-case scenario. This scenario is opposed to the previous scenario, as it is based on the assumption that all parties involved desire to obtain a status quo by 2030. This includes a rise in rail demand in absolute terms, but no additional shift from road tkm towards rail tkm or IWW for distances over 300 km, so contrary to what is intended by the White paper of the European Commission (2011). The values for this scenario are shown in figure 7.

This scenario is taking into account a number of negative elements to come true by the set horizon, such as the lack of investment in standardization, resulting in a continued weak interoperability, increased savings and budget cuts, investments not taking place, resulting in a lack of capacity, and the continuation of passenger train priority. These qualitative factors result in a low flexibility and as such a low attractiveness of intermodal (rail) transport. As it was indicated in section 4, most of the parameter values are expressed in a value per rail-tkm, due to which this parameter is of valuable importance.

Figure 7: Worst-case scenario

	Parameters			Reference value		Scenario value		%
WORST-CASE	Transport emissions	CO_2	Road	72	g/tkm	43	g/tkm	-40%
			Rail (electric)	18	g/tkm	16	g/tkm	-10%
			Rail (diesel)	35	g/tkm	32	g/tkm	-10%
		NO_x	Road	0.553	g/tkm	0.33	g/tkm	-40%
			Rail (electric)	0.032	g/tkm	0.029	g/tkm	-10%
			Rail (diesel)	0.549	g/tkm	0.495	g/tkm	-10%
		SO_2	Road	0.090	g/tkm	0.054	g/tkm	-40%
			Rail (electric)	0.064	g/tkm	0.058	g/tkm	-10%
			Rail (diesel)	0.044	g/tkm	0.040	g/tkm	-10%
		NMHC	Road	0.054	g/tkm	0.033	g/tkm	-40%
			Rail (electric)	0.004	g/tkm	0.004	g/tkm	0%
			Rail (diesel)	0.062	g/tkm	0.056	g/tkm	-10%
		Dust	Road	0.016	g/tkm	0.010	g/tkm	-40%
			Rail (electric)	0.005	g/tkm	0.004	g/tkm	-20%
			Rail (diesel)	0.017	g/tkm	0.015	g/tkm	-10%
	Energy consumption		Road	1	kJ/tkm	755	kJ/tkm	-30%
			Rail (electric)	456	kJ/tkm	410	kJ/tkm	-10%
			Rail (diesel)	530	kJ/tkm	475	kJ/tkm	-10%
	Infrastructure and maintenance costs		Road	0.218	EUR/tkm	0.240	EUR/tkm	+10%
			Rail	0.0698	EUR/tkm	0.0768	EUR/tkm	+10%
			IWW	0.0219	EUR/tkm	0.0241	EUR/tkm	+10%
	Noise exposure	Major road	Lden > 55 dB	250	people/km	150	people/km	-40%
			Lden > 65 dB	116	people/km	70	people/km	-40%
			Lden > 75 dB	10	people/km	6	people/km	-40%
		Major Railway	Lden > 55 dB	321	people/km	290	people/km	-10%
			Lden > 65 dB	92	people/km	83	people/km	-10%
			Lden > 75 dB	10	people/km	9	people/km	-10%
	Unlinked active intermodal players			6	(+ 3 linked)	2	(+ 2 linked)	-
	Rail tkm			7,300	mio tkm	8,000	mio tkm	+10%
	Operational costs		Road (long haul)	0.070 - 0.020	EUR/tkm	0.063 - 0.018	EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040	EUR/tkm	0.090 - 0.036	EUR/tkm	-10%
			Rail	0.025 - 0.019	EUR/tkm	0.030 - 0.023	EUR/tkm	+20%
			IWW	0.0076 - 0.0381	EUR/tkm	0.00912 - 0.04572	EUR/tkm	+20%
	Road taxes			0.11 - 0.14	EUR/km	0.11 - 0.14	EUR/km	0%

Source: Own composition

In the worst-case scenario, an increase by only 10% is foreseen in terms of rail demand. This value is calculated based on the ratios obtained in the studies of Vandresse et al. (2012) and Islam et al. (2013). A fixed annual average growth of the GDP by 0.5% is assumed. This leads to an exploration value of 8,379 rail tkm in Belgium by 2030, when a stable modal split is aspired. Taking into account the negative elements above, as well as a lack in rest capacity, this number is lowered to 8,000 rail tkm. Although still an increase in absolute terms, this results in a decline of modal share for rail transportation by 2030.

For transport emissions, rail transport is expected to lower the values by only 10% in the current scenario. Due to limited innovation and investments in research and development, rail transport is lagging behind, whilst road transport is more rapidly becoming cleaner (-40%). As such, road transportation is becoming almost as clean as or even cleaner than rail transportation by 2030, for each performed tkm. Also in this scenario, the total effect should be taken into account by multiplying these values with the total transport measured in tkm for the different modes of land transport.

Within this worst-case scenario, energy consumption of road transport is also decreasing at a faster rate (-30%) compared to rail transportation (-10%). In addition, infrastructure and maintenance costs are becoming higher by 2030 for all modes of transport. When the comparison with road transport is made, it shows that the operational costs for rail transportation will increase by 20% due to a lack of economies of scale and the lack of standardization and innovation and therefore continuing inefficiencies. Road transportation can benefit from a 10% decrease. This increases the competitive position of road transportation over rail transportation, especially for long hauls. Road taxes are estimated to remain stable; however, the effect of this policy still needs to be taken into account, as this measure will only become effective as of April 2016 and is therefore not incorporated in the reference values.

In the worst-case scenario, it is expected that market competition decreases, which results in a European duopoly, where all remaining operators are heavily linked to two dominant market players. In order to avoid or limit negative consequences for the market, governance and regulation should be implied in order to control this European duopoly.

6. MEDIUM-CASE SCENARIO

Section 6 considers the final scenario for further analysis. This scenario is an in-between scenario, where the goal of a 30% shift by 2030 is only partially carried through. This scenario augments the exogenously expected rise in rail demand with a fractional shift from road transport over 300 km towards rail. The values for this scenario are shown in figure 8.

This medium scenario takes into account a mix of positive and negative qualitative factors, as they were described for the previous scenarios. Correspondingly with these scenarios, the most important parameter is the expression of rail tkm, as it is used to generate the total impact.

Figure 8: Medium-case scenario

	Parameters			Reference value		Scenario value		%
MIDDLE-CASE	Transport emissions	CO_2	Road	72	g/tkm	58	g/tkm	-20%
			Rail (electric)	18	g/tkm	14	g/tkm	-20%
			Rail (diesel)	35	g/tkm	28	g/tkm	-20%
		NO_x	Road	0.553	g/tkm	0.445	g/tkm	-20%
			Rail (electric)	0.032	g/tkm	0.026	g/tkm	-20%
			Rail (diesel)	0.549	g/tkm	0.440	g/tkm	-20%
		SO_2	Road	0.090	g/tkm	0.072	g/tkm	-20%
			Rail (electric)	0.064	g/tkm	0.051	g/tkm	-20%
			Rail (diesel)	0.044	g/tkm	0.035	g/tkm	-20%
		NMHC	Road	0.054	g/tkm	0.043	g/tkm	-20%
			Rail (electric)	0.004	g/tkm	0.003	g/tkm	-25%
			Rail (diesel)	0.062	g/tkm	0.050	g/tkm	-20%
		Dust	Road	0.016	g/tkm	0.013	g/tkm	-20%
			Rail (electric)	0.005	g/tkm	0.004	g/tkm	-20%
			Rail (diesel)	0.017	g/tkm	0.014	g/tkm	-20%
	Energy consumption		Road	1,082	kJ/tkm	920	kJ/tkm	-15%
			Rail (electric)	456	kJ/tkm	388	kJ/tkm	-15%
			Rail (diesel)	530	kJ/tkm	450	kJ/tkm	-15%
	Infrastructure and maintenance costs		Road	0.218	EUR/tkm	0.208	EUR/tkm	-5%
			Rail	0.0698	EUR/tkm	0.0698	EUR/tkm	-5%
			IWW	0.0219	EUR/tkm	0.0219	EUR/tkm	-5%
	Noise exposure	Major road	Lden > 55 dB	250	people/km	200	people/km	-20%
			Lden > 65 dB	116	people/km	93	people/km	-20%
			Lden > 75 dB	10	people/km	9	people/km	-10%
		Major Railway	Lden > 55 dB	321	people/km	290	people/km	-10%
			Lden > 65 dB	92	people/km	83	people/km	-10%
			Lden > 75 dB	10	people/km	9	people/km	-10%
	Unlinked active intermodal players			6	(+ 3 linked)	4	(+ 0 linked)	-
	Rail tkm			7,300	mio tkm	12,000	mio tkm	+64%
	Operational costs		Road (long haul)	0.070 - 0.020	EUR/tkm	0.063 - 0.018	EUR/tkm	-10%
			Road (short haul)	0.100 - 0.040	EUR/tkm	0.090 - 0.036	EUR/tkm	-10%
			Rail	0.025 - 0.019	EUR/tkm	0.022 - 0.017	EUR/tkm	-10%
			IWW	0.0076 -0.0381	EUR/tkm	0.00684 - 0.03429	EUR/tkm	-10%
	Road taxes			0.11 - 0.14	EUR/km	0.121 - 0.165	EUR/km	+10%

Source: Own composition

In the medium-case scenario, an increase by 64% is foreseen in terms of rail tkm. This value is again based on the ratios obtained by Vandresse et al. (2012) and Islam et al. (2013). A fixed annual average growth of the GDP by 1% is assumed. In case the modal split remains the same, the total number of rail tkm would rise to 10,437 tkm. This value is increased with the aspired partial shift of road transport over 300 km towards IWW and rail transportation. Taking into account the study of Islam et al. (2013), this results in a forecast rail transport of 11,712 tkm for 2030 in Belgium. This value is raised in the final scenario to 12,000 tkm, taking partially into account a number of qualitative parameters as described in section 1.3. Within this scenario, a higher level of standardization and interoperability, and the introduction of the Single European Transport Area are achieved, but not fully implemented as planned within the White Paper. Also the execution of all planned investments in order to reach the necessary capacity is only partially met, pressurizing the available rest capacity and maintaining the interference with passenger traffic.

For the emissions and energy consumption, rail transport and road transport are assumed to continue their decline at a similar rate. This implies that both modes of transport are becoming more sustainable, but no additional advantage is gained. The total effect for intermodal transport needs to take into account pre- and post haulage requirements, usually performed by truck.

Within the medium-case scenario, infrastructure and maintenance costs are decreasing by 5%. The rise in rail demand is resulting in economies of scale, lowering the costs, but also in the requirement of more complex and more expensive infrastructure, balancing this benefit to a certain extent. Within this scenario, it is assumed that rail transport is becoming more attractive, but capacity can only partially meet the rising demand. When the comparison with road transport and IWW is made for operational costs, all modes of transport are decreasing at a similar rate. This stabilizes the current cost-benefit ratio of rail transportation over road transportation.

In the medium-case scenario, it is also explored that, due to failures, mergers and acquisitions, the market competition decreases to four dominant active intermodal players. This does not lead to a strict European monopoly or duopoly. In addition, it might result in an increased efficiency and attractiveness of intermodal rail transportation, as competition between these operators still exists, trying to capture the increasing market demand.

7. CONCLUSIONS

"The real voyage of discovery consists not in seeking new landscapes,
but in having new eyes"

(M. Proust)

This research paper is describing the development of three plausible scenarios for the future development of intermodal rail transport in Belgium. The scenarios are based on the analysis of a SWOT, created to indicate the current strengths and weaknesses of rail transport in Belgium, and taking into account possible opportunities and threats for the future. For each selected SWOT element, a number of qualitative and quantitative parameters are defined in accordance with a heterogeneous panel of experts. By applying the Delphi technique, this panel is used to reach a consensus and to validate the parameters and their values. These parameters and values of the three different scenarios are wide in range, in order to identify clear differences between the chosen paths. This results in a best-case, a medium-case and a worst-case scenario. The horizon of these scenarios is 2030, conform to the first milestone in the White Paper of the European Commission (2011).

Each scenario is taking into account a reference value for the selected parameters. As to reflect the interdisciplinary approach, the main parameters are related to five fields of interest, being the optimal corridor and hub development, the macro-economic and the sustainability impact of intermodality, the effective market regulation and the necessary governance and organization. The final parameters defined are transport emissions, energy consumption, infrastructure and maintenance costs, noise exposure, unlinked active intermodal players, rail demand, operational costs and road taxes. For these parameters, the three dominant modes of inland intermodal transportation are explored, being road transport, rail transport and IWW.

The best-case scenario is taking into account a 30% shift of road transportation over 300 km towards rail transport and IWW. Technological developments and investments in research and development are increasing the environmental sustainability of rail transportation, whilst increasing standardization and interoperability are making it more flexible and therefore an attractive alternative for inland transportation.

In the worst-case scenario, transport demand is growing slower than expected and no specific measures are taken to stimulate or develop rail transport and intermodal transportation. As such, road transport is increasing its dominant position. Within this scenario, the possible effects of a European monopoly or duopoly are also investigated.

The medium-case scenario is a possible mix of elements from the previous scenarios, where the two sustainable modes of transport (rail transport and IWW) are capturing a partial shift of road transportation over 300 km.

These scenarios will allow further research to analyse the impact of decisions by developing criteria and conditions that are necessary for an innovative intermodal network in and through Belgium. The outcome of the research is an operational framework that can support policy-makers in devising good intermodal strategies, maximizing benefits to users and society. Through the indicators that will be developed, users of intermodal transport and decision makers will also be supported in measuring this impact of possible developments and decisions.

BIBLIOGRAPHY

CE Delft, INFRAS, Alenium and Herry Consult (2010) External and infrastructure costs of freight transport Paris-Amsterdam corridor – Deliverable 1 – overview of costs, taxes and charges, CE Delft, Delft.

ECOTRANSIT (2008) *Ecological transport information tool – environmental methodology and data*, Heidelberg GmbH.

European Commission (2002) Directive 2002/49/CE of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, *Official Journal of the European Communities*.

European Commission (2014) *EU transport in figures – statistical pocket book 2014*, URL: http://ec.europa.eu/transport/facts-fundings/statistics/doc/2014/pocketbook2014.pdf.

European Environment Agency (2013) Energy efficiency and specific CO2 emissions (TERM 027) – Assessment published Jan 2013, URL: http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-5.

ETC/ACM (2014) European topic centre on air pollution and climate change, URL: http://forum.eionet.europea.eu/etc-sia-consortium/library/noise_database/index_html.

Gevaers, R., Maes, J., Van de Voorde, E., Vangramberen, C. (2012) Vrachtvervoer per spoor, marktstructuur, vervoerbeleid en havens, D/2012/11.528/1, University of Antwerp.

Grosso, M. (2011) Improving the competitiveness of intermodal transport: applications on European corridors, URL: http://www.ua.ac.be/download.aspx?c=thierry.vanelslander&n=9385&ct=005814&e=286358.

Hurtley, C. (ed.) (2009) Night noise guidelines for Europe, WHO Regional Office Europe.

Hsu, C. C. and Sandford, B. A. (2007) The Delphi technique: making sense of consensus, *practical assessment, research & evaluation*, 12 (10), pp. 1-8.

INFRABEL (2015) Our customers, URL: http://www.infrabel.be/en/about-infrabel/our-company/our-customers.

Islam, D. M. Z., Jackson, R., Zunder, T. H., Laparidou, K. and Burgess, A. (2013) Triple rail freight demand by 2050 in EU-27-realistic, optimistic or farfetched imagination?, World congress on railway research.

Janic, M.(2008) An assessment of the performance of the European long intermodal freight trains (LIFTS), *Transport Research Part A*, 42, pp. 1326-1339.

L’écho (2014) Le groupe allemand T-Systems choisi pour gérer la taxe kilométrique belge.

Meersman, H., et al. (2015) *Indicatorenboek 2013-2014 Duurzaam goederenvervoer Vlaanderen*, Universiteit Antwerpen, Departement Transport en Ruimtelijke Economie, Steunpunt Goederen- en Personenvervoer, Antwerpen.

PWC (2003) Faire le choix du transport fluvial: l’avis des entreprises – enquête voies navigables de France, PriceWaterhouseCoopers, France.

Ricardo-AEA et al. (2014) *Update of the handbook on external costs of transport*, United Kingdom.

SNCB (2014) Spoorcafé West-Vlaanderen: NMBS logistics, 14 october 2014.

Vandresse, M., Gusbin, D., Hertveldt, B. and Hoornaert, B. (2012) Vooruitzichten van de transportvraag in België tegen 2030, Federaal Planbureau.

Vanelslander, T., Troch, F., Dotsenko, V., Pauwels, T., Sys, C., Tawfik, C., Mostert, M., Limbourg, S., Stevens, V., Verhoest, K., Mechan, A., Belboom, S. and Leonard, A. (2015) Brain-trains: transversal assessment of new intermodal strategies: deliverable D 1.1 – 1.2 SWOT analysis, Working paper, University of Antwerp, URL: https://www.brain-trains.be.

Viapass (2015) Viapass for heavy Goods Vehicles, URL: http://www.viapass.be//en/about-viapass/viapass-for-hgvs/.

NOTES

[1] The research and its results are subsidised by the federal science policy through contract number BR/132/A4/BRAIN-TRAINS.

[2] The 93 SWOT elements, the analysis and the used methodology can be verified in tasks 1.1 and 1.2 on https://www.brain-trains.be > project results > deliverables

[3] "A scenario is a story illustrating visions of possible future or aspects of possible future. They are not predictions about the future, but used as an exploratory method or tool for decision-making, to highlight the possible discontinuities from the present, in order to reveal choice available and highlight their potential consequences."

[4] "A scenario is an exploration of the possible unfolding of events, based on current social, economic and environmental drivers."

[5] "Scenarios are hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points."

[6] The full list of panel participants can be consulted on https://www.brain-trains.be > Consultation group

[7] Data is available upon request or can be consulted in the project report on https://www.brain-trains.be > project results > deliverables

[8] Whether a parameter is direct or indirect is not indicated. Data on the direct and indirect parameters can be consulted in the project report on https://www.brain-trains.be > project results > deliverables

[9] Data on the qualitative factors can be consulted in the project report on https://www.brain-trains.be > project results > deliverables