BRAINTRAINS

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Deliverable D1.3

Scenario development

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BRAIN-TRAINS

Transversal assessment of new intermodal strategies

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

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

(M. Proust)

The BRAIN-TRAINS project deals with the possible development of rail freight intermodality in Belgium. 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[1]) and related to different market, society and policy-making challenges. The project will develop an operational framework in which effective intermodal transport can be successfully established in Belgium, with attention to beneficial participation and commitment of all different stakeholders.

This analysis will be built around five different main topics, as shown in figure 1:

- The optimal corridor and hub-development.
- The macro-economic impact of intermodality.
- The sustainability impact of intermodality.
- Effective market regulation for a well-functioning intermodality.
- Effective governance and organization for a well-functioning intermodality.

The present document on Deliverable 1.3 (D 1.3) is the direct continuation of the first deliverable (D 1.1-1.2) in the first work package (WP 1). In that deliverable, a profound SWOT analysis of the current situation is documented, together with trends and possible barriers in the future development of intermodal rail transport. This SWOT is the result of a study of existing literature and published studies, as well as of different interviews with the heterogeneous consultation group (Appendix I). In total 93 different SWOT elements are identified and defined (Vanelslander et al., 2015).

In the current document on D 1.3, the SWOT analysis will be translated into a number of scenarios, containing the most plausible future events impacting on the development of intermodal rail transport in Belgium. In the next work packages (WP 2 – WP 6), these scenarios will be simultaneously used by each of the five mentioned fields of interest, as they will define a specific methodology to perform the necessary calculations and obtain the desired outcomes. These results will be integrated into a model and will be analysed in work package 7, in order to create a framework with indicators, to support the users of the model, both governmental and non-governmental, by providing an easy way to measure the impact of possible developments and decisions.

[1] Trans-European Transport Network refers to a comprehensive network of road, rail, air and water transport. More info: http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/en/abouttent.htm

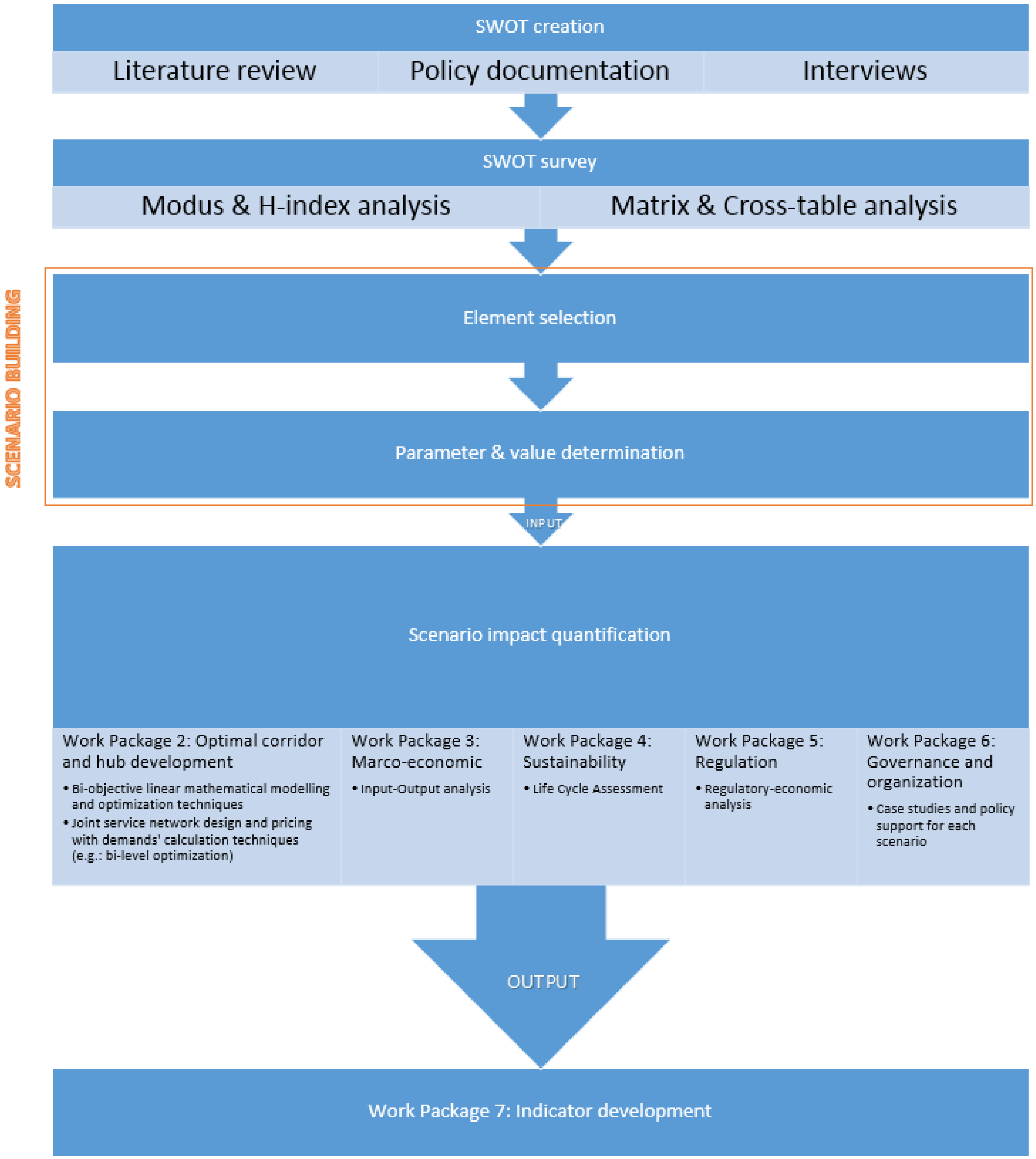
Figure 1: Structure of the BRAIN-TRAINS project

Source: Own composition

Figure 2 shows where the development of the scenarios should be situated in the evolution of the project research plan. In the first chapter of this document, possible definitions for a scenario are defined, the complexity of scenario creation is highlighted, and the chosen methodology is explained. In the second chapter of this document, a final selection is made from the 93 identified elements in the SWOT of deliverable 1.1 - 1.2 (D 1.1 - 1.2). In the third chapter, different measurable parameters and corresponding values are formulated for the different selected SWOT elements. The output is subsequently checked and validated by the heterogeneous panel of experts, according to the Delphi-technique methodology described in the first chapter.

This will eventually lead to the scenario development itself, which is discussed in the fourth chapter of this document.

FIGURE 2: SCENARIO DEVELOPMENT PROCESS AND IMPLEMENTATION IN THE PROJECT PLAN



SOURCE: OWN COMPOSITION

1. SCENARIO DESIGN METHODOLOGY - From SWOT to scenarios

In this chapter, the used methodology to develop the scenarios is described. In a first section, the Delphi technique will be explained, which is used to create the SWOT in D 1.1 and D 1.2, and is continued in the process of scenario development. The second section gives an overview of possible scenario definitions and indicates its complexity. In the last section, the used scenario methodology is briefly highlighted.

1.1 DELPHI-TECHNIQUE

Due to the fact that the creation of the scenarios it is the extension of the process started in D 1.1 - D 1.2, the Delphi-technique will be continued as well. Therefore, the panel of experts continues to be consulted and asked to validate the outcome or results, until a final consensus on the scenarios is reached. In order to understand the context of this process, a short summary of the used Delphi technique in the previous deliverables is stated below.

According to Hsu and Sandford (2007), the Delphi technique is often used to acquire consensus within a heterogeneous panel of experts. The Delphi process consists of a number of iterations, often started with a questionnaire, in which the panellists discuss and rate a number of items related to the subject. The goal is to make the different opinions converge. Within the current research, the panel consists of port authorities, rail freight companies, government representatives, academic contributors and private intermodal transport users. More details about this panel of experts can be found in appendix I. This variety in experts is crucial and renders the sample valid for further analysis.

The SWOT development in D 1.1 - 1.2 started with an extensive review of the existing literature, where both scientific publications, government studies and sector reports are taken into consideration. Kerlinger (1973) validates the use of such a modified Delphi process, as information on the concerned issue is already available and usable. Moreover, Hasson et al. (2000) describe a variation on the Delphi technique process, using important qualitative data retrieved from interviews. These interviews were processed into a draft SWOT version. The results were then taken as an input for the second round, consisting of individual interviews with different specialists and authorities, being part of the panel. A third round consists of a traditional round-table discussion with the full panel of experts, discussing and validating the previous results. This procedure was also followed in this research. Ultimately, a final version of the SWOT was released, containing all identified internal characteristics and possible external trends of intermodal rail freight.

In order to select the most important elements, a survey was created where the panel of experts had to score each of the elements. This could be seen as the fourth round of the Delphi-exercise. The goal of the survey is to obtain the quantification of the impact and likelihood of the different SWOT elements, as validated by the panel at the end of the previous round. In this way, the importance of each element, as well as the level of uncertainty is obtained. The output of the survey is a priority ranking, resulting in a selection of elements to focus on, which will help as an input to build plausible scenarios for further analysis.

This is where the current research document will start from. Over the next sections is shown that multiple rounds of internal and external consultation have taken place, according to the methodology described above.

1.2 SCENARIO DEFINITION

A scenario analysis is a risk analysis technique that can help to explore different assumptions and to reduce uncertainty about the future development of intermodality. To this end, it is important to have a clear definition of a scenario. Scenarios exist in many forms and can have a wide range of objectives. In the current research, the goal of the scenarios is to identify the impact of different plausible situations on the future development of intermodal rail transportation in Belgium. In this respect, the European Commission (2007) identifies a scenario as "*a story illustrating visions of a possible future or aspects of a 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 choices available and highlight their potential consequences*".

Lobo et al. (2005) also indicate that scenario building is not similar to forecasting, neither is it obtaining a future prevision. They describe it as "*an exploration of the possible unfolding of events based on current social, economic and environmental drivers*". In order to come to this description, two important definitions concerning scenarios can be mentioned, as they are closely related to the vision on how scenarios are desired to be reflected during the current research:

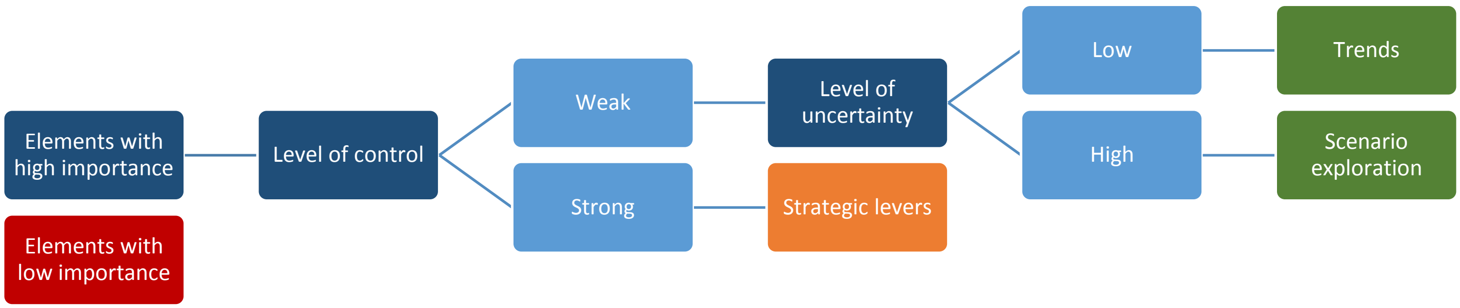
- "*Scenarios are hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points*" (Kahn & Wiener, 1967).
- "*Scenarios are archetypal descriptions of alternative images of the future, created from mental maps or models that reflect different perspectives on past, present and future developments*" (Rotmans et al., 2000).

The definitions above indicate that a scenario needs to be plausible, consistent and offer insights into the future, without attempting to forecast its exact nature. Nevertheless, during the research no clear existing methodology, path or instructions have been found to translate a performed SWOT analysis into a scenario. It is clear that a scenario consists of complex interactions by different elements, without attempting to create a prediction of the future. The nature of a scenario is to establish a view on one possible state of the future, due to which the scenario development process is easily vulnerable to subjective interpretation and requires certain assumptions to be made in advance. Given that scenario analysis has its clear limitations, it remains however crucial that the scenarios are validated by key decision makers and external experts with different backgrounds. This condition is met by the used heterogeneous panel of experts within the BRAIN-TRAINS project, which offers at the same time the opportunity to operate as a sounding board on intermodality issues.

1.3 SCENARIO DEVELOPMENT

Crozet (2003) indicates in figure 3 which variables are crucial to be taken into account when the results of the SWOT survey are used for selection, according to the definitions of a scenario stated above. The figure is showing that elements for scenario development are to have a high importance, determining them as structural elements. Elements with low importance are not recommended to be taken into account for scenario creation. This is indicated in red on figure 3. Secondly, the level of control over these elements needs to be determined. For scenario development, preference is given to elements with a weak level of control. This allows using them during the scenario creation as explorative factors or as identified trends, depending on their level of uncertainty. These elements are indicate in green on figure 3. When the level of control is high, elements are identified as strategic factors or decision makers. These are indicated in orange on figure 3.

FIGURE 3: FRAMEWORK FOR SCENARIO DEVELOPMENT



SOURCE: OWN COMPILATION BASED ON ARCADE (2003) AND CROZET (2003)

This method will be used to translate the results of the SWOT survey into a selection of crucial scenario elements and corresponding parameters and values. The scenario building will start in the next chapter with a selection of the most important SWOT elements, based on their importance as described by Crozet (2003). This selection is a direct result from the SWOT survey and the performed analysis at the end of the created SWOT-document by Vanelslander et al. (2015). This SWOT analysis from D 1.1 - D 1.2 allows to rate the level of importance for each of the 93 identified SWOT elements.

2. ELEMENT SELECTION

The second chapter focuses on the final selection of SWOT elements, as it is difficult to create scenarios that incorporate a high number of different elements. To do this, the research starts from the 93 elements retained from the SWOT developed in the first deliverable of the BRAIN-TRAINS project (D 1.1 - D 1.2). Based on the methodology of Crozet (2003), the Delphi-technique approach, a matrix analysis and cross-link analysis, a final selection of 17 SWOT elements is obtained[2]. These elements are shown in table 1. A number of elements for each category are retained, indicating the most important and most relevant current strengths and weaknesses, and future threats and opportunities. This procedure is described more in detail in appendix II and is taking into account the obtained ratings for the impact or importance of each SWOT element, which is the first step of the methodology described by Crozet (2003). The obtained score on the likelihood of happening can be interpreted as the level of control. The H-index from the SWOT analysis, indicating the level of agreement, is used to determine the level of uncertainty that exists for each of the elements. According to the Delphi-technique described in the methodology above, this list of 17 elements is unanimously approved by the heterogeneous panel of experts and is therefore taken as the main input for the creation of scenarios in the next chapters.

[2] See appendix II for more details on these techniques

Table 1: Final selection of SWOT-elements

Selection of SWOT elements	
A. Internal elements (influencable)	
1.Strengths of (intermodal) rail transport	
1.1	Reduced costs and externalities (over long distanc
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

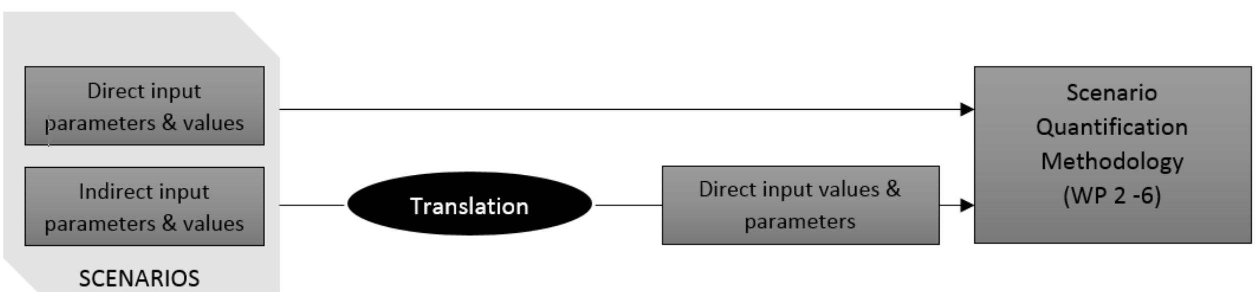
3. PARAMETER DETERMINATION

The next step of the process is to translate the 17 final identified elements into clear and measurable parameters. For each of the defined parameters, a value has to be defined as well, depending on the scenario and the aspired evolution of the parameter in it. This third chapter will explain the context of this procedure, the results of which, that are only intermediary results for this deliverable, can be found in appendix III (required input and output parameters for the scenario analysis methodologies) and appendix IV (first version of the scenarios).

3.1 DIRECT VERSUS INDIRECT PARAMETERS

Each element has been discussed, in order to define the most important parameters that could be identified with each of the specific elements. It is important that these parameters will correspond with the input necessary for each of the different methodologies that will be used during work packages 2 to 6, as described above, in order to quantify and analyse the different scenario impacts. This parameter selection can be done in two extreme ways, either by selecting only parameters that correspond directly with the input parameters required for the planned methodologies, or by selecting parameters that best reflect the selected elements in the previous section, and to translate these alternative parameters into the necessary input parameters for each methodology during the later stages of the project. It is decided by the members of the consortium to select a mix of both options, in order to have the best possible reflection of the selected elements into the different scenarios. This practise is explained in figure 4.

FIGURE 4: DIRECT AND INDIRECT PARAMETER SELECTION IN SCENARIOS



SOURCE: OWN COMPOSITION

As a consequence, the direct input parameters and their corresponding values, necessary for the planned methodologies during the scenario analysis in work packages 2 to 6, are collected by each work package responsible. During an internal discussion round among the authors of this deliverable, a list of possible other indirect parameters is determined as well. This intermediary deliverable result can be found in appendix III.

3.2 CHALLENGES AND COMPLEXITY OF SCENARIO DEVELOPMENT PROCESS

Two challenges are to be mentioned for the scenario development process, one concerning the comparability of the output and one taking into account the risk of running into an endless loop of iterations.

If, during the quantification of the scenarios in the next stage of the project, not all the same parameters and corresponding values of each scenario are used by the different methodologies, the output of the different scenarios might not be comparable, as a different starting point is taken into consideration. Therefore, all values needed in the different scenarios should be taken into consideration by each of the different methodologies, even when they are not crucial for the concerned set-up. In the case that, during the execution of the different methodologies during the next work packages, the need would arise for one of the partners to change one of the values, or to add or delete certain parameters, this should always be done with full agreement of the other work packages, and they need to take this change into consideration as well. In this way, it can be assured that the output of the different work packages can be compared, and a set of integrated indicators can be developed in the final stage of the project.

In addition, if one of the methodologies has an output parameter corresponding to one of the input parameters, it might be the case that the output value does not correspond to the used input value. This means that all calculations would have to be done again, with the newly found value for the parameter. This however might result in an endless loop of iterations, as it is mentioned above. As an example, the modal split can be used. When in scenario 1, a split of 80% road - 15% IWW - 5% rail is taken as an input value for mode share objectives, the bi-objective linear mathematical modelling methodology of work package 2 might give a different result as output for the modal split in scenario 1, for example 75% road – 10% IWW – 15% rail, because of the interference of the other parameters and/or because of actor strategies. Nevertheless, in order to avoid this infinite loop, the conclusion was made that scenarios only reflect a possible or envisaged state of the future, rather than predicting the future itself. Therefore it is decided that input values in the scenarios can be interpreted as goals towards the future. In the example above on the modal split, scenario 1 would take a goal of 80% - 15% - 5%. Together with the other parameter values for scenario 1, this situation would result, according to the model, in an effectively obtained modal split of 75% - 10% - 15%.

3.3 SCENARIO CHARACTERISTICS

The first version of the scenarios can be found in appendix IV. For each of the 17 elements, a full list of **68 possible direct and indirect parameters** and corresponding values are described. As the goal of the project is to develop a framework, in which the different criteria and conditions for an efficient and attractive intermodal rail transport are incorporated, the choice is made to create a **best-case** scenario, a **medium-case** scenario and a **worst-case** scenario. The horizon of the project is set to **2030**, as this is also the first milestone in the White Paper of the European Commission (2011). The final horizon of the White Paper is 2050. However, using this target date would make it even more difficult to define a number of plausible parameters and corresponding values, as a broader time horizon increases the level of uncertainty and volatility. In the next chapter, these scenarios will be referenced as ‘first version of the scenarios’.

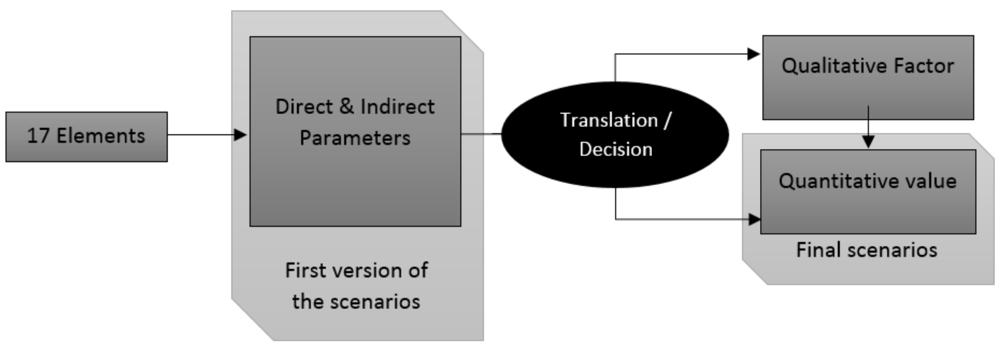
Following the Delphi-technique exercise, these proposals and decisions concerning the first version of the scenarios, the time horizon and the proposed direct and indirect parameters and values selected, were discussed during a round table with the panel of experts. During this meeting, it was asked to the experts whether the parameters for each of the 17 SWOT elements seem to be valid, or if one or more parameters could be omitted. Also the identified values were discussed, whether they seem to be valid for the concerning scenario, or whether other values should be obtained. The output of this meeting is a number of recommendations concerning the continuation of the development of scenarios:

- A general comment during the panel meeting is to **limit the number of parameters**, reducing the current list to a bare minimum. This will simplify the scenario exercise, as only the main elements that define/impact the different scenarios will play a role. For each SWOT element, a target of approximately one or two parameters should be obtained, depending on the input needs for the model, with a validated reference value, as it is explained above.
- The idea of building a **best-, medium- and worst-case scenario** is approved. However, parameters and values in the three scenarios should be **very wide in range**, in order to estimate some real differences when applying the models. Especially for opportunities and threats, the difference between the best-case and the worst-case scenario should be very high, as these elements define the uniqueness of each scenario. This captures the uncertainty of these elements concerning their likelihood of happening and the lower possibility of influencing these elements, as they are happening at an external level.
- The **time horizon 2030** is commonly accepted. This time horizon is also often selected in other rail transport research projects as well.
- A last comment is to always try to work with **parameters 'per tonkilometer (TKM)'**, in order to make them more comparable, interpretable and usable.

4. SCENARIO DEVELOPMENT

The scenario development process allows at this stage transforming the first version of the scenarios from appendix IV and the comments from the panel of experts, into final scenarios. In the first section of this chapter, it is decided for each of the 68 parameters whether will be used in the final scenario. If it is retained, it is also decided whether it will be taken into account as a quantitative parameter with a clear value for each of the three scenarios, or as qualitative factor impacting on other quantitative values. An example of a qualitative factor impacting on a quantitative value can be the standardization and interoperability evolutions taking place, resulting in a rise in the value of rail tkm performed. This selection is done by taking into account the scenario characteristics and the necessary inputs for the different models in the next work packages of the project. The obtained selection of the different quantitative parameters and corresponding values are considered as final scenarios. For each maintained parameter, a final reference value will be given for the period 2010-2015 as well. The full process from the final 17 elements towards the development of final scenarios is summarized in the figure 5.

FIGURE 5: QUALITATIVE FACTORS AND QUANTITATIVE VALUES FOR THE FINAL SCENARIO DEVELOPMENT



SOURCE: OWN COMPOSITION

In the next sections 4.2 till 4.4, the different final scenarios will be explained by the different selected final quantitative parameters. The idea of creating three divergent scenarios will be maintained, and the final scenarios will be directly linked to the goal of the White Paper from the European Commission (2011), identifying the best-, worst- and medium-case scenario:

- The '*best-case scenario*' takes into account a targeted 30% shift by 2030, carried by both government and the private sector. The naturally rising demand is therefore augmented with the shift from road transport over 300 km towards rail. The growth in demand can be explained by historical data and the SWOT analysis, showing that transport is steadily but not equally increasing for all modes of transport. Rail often shows a rather modest growth (Meersman et al., 2013).
- The '*worst-case scenario*' 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 for distances over 300 km.
- The '*medium-case scenario*' is an in-between scenario, where the goal for the 30% shift is carried, but not required to be completely reached by 2030. A partial achievement of the shift is satisfactory for all parties involved. This scenario is augmenting the expected rise in rail demand with a fractional shift from road transport over 300 km towards rail.

4.1 PARAMETER SELECTION AND REFERENCE VALUES

During the continuation of the project, it will be possible for each work package and methodology to perform a sensitivity analysis for each specific scenario, as long as the main final scenarios continue with the same input, in order to be able to compare the different outputs in the last work package.

In this section, the different parameters from the first version of the scenarios will be discussed on their added value. The decision process to retain a parameter in the final version of the scenarios, and whether it will be as a qualitative or quantitative factor, will take into account the comments of the panel of experts. For each selected parameter, a reference value for the period 2010-2015 is stated.

4.1.1 REDUCED COSTS AND EXTERNALITIES

The first element is 'reduced costs and externalities'. For this element, 12 different parameters are identified in the first version of the scenarios. Most of these parameters are too detailed for scenario analysis and can therefore be omitted according to the experts. Taking into account the necessary input for the different methodologies, the experts indicated five parameters to be selected for the final scenarios: CO_2 emissions, other emissions, infrastructure and maintenance costs, energy consumption and noise exposure.

TRANSPORT EMISSIONS

The first and second parameter, CO_2 emissions and other emissions, are combined into the factor 'transport emissions'. The reference value for the CO_2 emissions is defined based on the study of the ECOTRANSIT (2008). 20 European countries are taken into account in this study, including Belgium. On the ECOTRANSIT website, the emissions for each possible route can be calculated by the user. A clear definition for road and rail transport is made within this study, which is used together with a fixed load factor for the different types of cargo, to come to the average emission factors for cargo transport within Europe in table 2. Also the emission factors for electricity production are taken into account in these calculations Table 2 shows that the obtained values are higher than the original parameter values in the first version of the scenarios.

TABLE 2: TRANSPORT CO_2 EMISSIONS

Transport type	European study CO_2 emissions	Belgium case CO_2 emissions
Road traffic *(> 34-40 MT ; Euro 3)*	72 g/tkm	72 g/tkm*
Rail traffic *(electric)*	18 g/tkm	6.18 g/tkm
Rail traffic *(diesel)*	35 g/tkm	41.31 g/tkm

** FOR ROAD TRAFFIC, THE VALUE FROM THE EUROPEAN STUDY IS CONSIDERED TO BE A VALID REFERENCE FOR THE BELGIUM CASE*
SOURCE: ECOTRANSIT (2008), SNCB (2009), SNCB (2013) AND SNCB (2015)

These values are similar to the ones given in the TREMOVE study for the year 2011. The TREMOVE study serves as the basis for the external costs computation of the "Handbook on estimation of the external costs in the transport sector" (Maibach et al., 2008), and "Update of the Handbook on External Costs of Transport" (Ricardo-AEA et al, 2014). A summary of the reference values for CO_2 emissions between 1995 and 2011 can be found on the website of the European Environment Agency (2013).

In an attempt to adapt the value to the recent Belgium case, data provided by SNCB for the period 2006 to 2012 can be used as a valid sample. These calculations can be found in appendix V. It should be noticed that these values are shifting a lot over the years, with a clear, decreasing trend towards 2012. Therefore, it has been decided to keep the values of the ECOTRANSIT (2008) study in the final scenarios, which is a conservative reference value for electric traction (the main traction method for railway transport in Belgium) and an acceptable reference value for diesel traction, taking into account the constant decline over the past decade and especially the years 2009-2012. Nevertheless, the calculations for Belgium will be taken into consideration during the continuation of the project as an additional check.

The study of ECOTRANSIT (2008) can also be used to set a reference value for other emissions. This is done in table 3. These values are estimated to be a valid reference for the Belgium value.

TABLE 3: OTHER TRANSPORT EMISSIONS

Transport type	NO_x	SO_2	NMHC *(Non-Methane Hydrocarbons)*	Dust
Road traffic *(> 34-40 MT ; Euro 3)*	0.553 g/tkm	0.090 g/tkm	0.054 g/tkm	0.016 g/tkm
Rail traffic *(electric)*	0.032 g/tkm	0.064 g/tkm	0.004 g/tkm	0.005 g/tkm
Rail traffic *(diesel)*	0.549 g/tkm	0.044 g/tkm	0.062 g/tkm	0.017 g/tkm

SOURCE: ECOTRANSIT (2008)

ENERGY CONSUMPTION

The third parameter is 'energy consumption'. This parameter's value is estimated within the study of ECOTRANSIT (2008) and shown in table 4. The energy consumption is measured in kiloJoule (kJ) per tkm. The energy consumption during the production process of fuels is also taken into account.

TABLE 4: ENERGY CONSUMPTION

Transport type	European study energy consumption	Belgium calculation energy consumption
Road traffic *(> 34-40 MT ; Euro 3)*	1,082 kJ/tkm	1,082 kJ/tkm*
Rail traffic *(electric)*	456 kJ/tkm	444.83 kJ/tkm
Rail traffic *(diesel)*	530 kJ/tkm	517.02 kJ/tkm

* FOR ROAD TRAFFIC, THE VALUE FROM THE EUROPEAN STUDY IS CONSIDERED TO BE A VALID REFERENCE FOR THE BELGIUM CASE
SOURCE: ECOTRANSIT (2008), SNCB (2009), SNCB (2013) AND SNCB (2015)

In order to adapt the specific energy consumption of rail traffic shown in table 4 to the recent Belgian case, the earlier mentioned data provided by SNCB, from the period 2006 to 2012, can again be used. These calculations can also be found in appendix V. The estimated value for Belgium does not differ much from the average European value. As the calculations performed in appendix V include a trial-and-error process, it has been decided to keep the average European values in the final scenarios. This is also in line with the other selected values concerning transport emissions, in order to maintain stable relations between the different parameters.

Within the first version of the scenarios, only the total oil equivalent was used, which does not capture the real total energy consumption of rail freight, and also contained information about passenger traffic. Therefore, this value is omitted in the final scenarios.

INFRASTRUCTURE AND MAINTENANCE COSTS

The fourth parameter 'infrastructure and maintenance costs' only reflects the cost for building and maintaining the infrastructure. Other costs such as access charges are not included in this parameter. The land value parameter mentioned in the first version of the scenarios is used as an explanatory qualitative factor, to support the changes in the infrastructure and maintenance costs.

For this parameter, table 5 compares the three major modes of land transport, being road, rail, and inland waterways (IWW). Road transport infrastructure is heavily used by citizens, and therefore constructed and maintained by the government, as a public service. Up to now, road freight transport could use this infrastructure without additional charges or investment costs. However, this will change in the future and will be reflected in the different scenarios by the parameter 'road taxes' in section 4.1.13. The values for infrastructure and maintenance costs of land transport are defined by CE Delft et al. (2010). For rail transport an estimated average from base year 2005 is used to define the reference value. For road transport, the highways are taken into consideration.

TABLE 5: INFRASTRUCTURE AND MAINTENANCE COSTS

Transport type	Infrastructure and maintenance costs
Road transport	0.218 EUR/tkm
Rail transport	0.0698 EUR/tkm
IWW transport	0.0219 EUR/tkm

SOURCE: CE DELFT ET AL. (2010)

As rail transport and IWW transport are competitors for sustainable transport, it can be seen from the table above that IWW has an advantage in terms of infrastructure and maintenance costs. The possible evolutions of this advantage will have an effect in the different scenarios. The importance of the infrastructure and maintenance costs for road transport is situated in the necessary use of this mode of transport during the pre-haulage and post-haulage when intermodal rail transport is used. This increases the complexity of the exercise, as high costs for road transport might benefit the cost-attractiveness of other modes of transport such as rail transport or IWW transport, but at the same time it will increase the total cost of the logistics chain of intermodal transport, due to this need for pre- and post-haulage by truck.

NOISE EXPOSURE

The fifth parameter is 'noise exposure'. In order to indicate the total impact of noise exposure, the total number of people exposed to noise is indicated for road transport (cities) and rail transport in the first version of the scenarios. This value is estimated by the available data, measured along the tracks where this exercise is executed. Therefore, this parameter value should be translated into a single unit measure, in order to take into account different levels of volume and tkm in the different scenarios. This can be obtained by expressing a value per tkm.

The Directive 2002/49/EC, also known as Environmental Noise Directive defines environmental noise as being unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity (European Commission, 2002). Road traffic is the main source of noise in Europe and railway is the second most dominant (European Environment Agency, 2014).

Exposure to noise from transport can have negative effects on human health and well-being, on wildlife, as well as a negative economic impact (e.g. reduced possibilities of land use) (World Health Organization, 2011 and European Environment Agency, 2014). The European Environment Agency (2014) considers noise pollution as a major environmental health problem in Europe, and the World Health Organization (2011) estimates that sound pressure levels of 65 dB during the day can create annoyance and sleep disturbance when the noise exceeds 55 dB at night.

The constant restrictions on the emission of noise could become a limiting factor in rail operation due to their impact on time slots and transit zones. Moreover, these restrictions are already introducing additional costs for noise mitigation both in rail equipment (locomotives and wagons) and rail infrastructure (UIC, 2013).

The established Environmental Noise Directive requires the creation of strategic noise maps for all major roads, railways, airports and agglomerations, being available for 2007 and 2012. In Belgium, the development of the strategic noise maps is managed by the regional authorities. In an attempt to calculate the noise impact of rail and road transport in Belgium, these regional strategic noise maps can be used to perform the assessment. Nevertheless, data remains limited.

According to the Environmental Noise Directive definitions, there are two main indicators of noise levels used to determine population exposure. The day-evening-night noise indicator (L_{den}) in decibels (dB) assesses annoyance during day and evening period and the sleep disturbance during night-time, and the night-time noise indicator (L_{night}) which assesses only sleep disturbance and is therefore more limited (European Commission, 2002). Therefore, it has been decided to use the parameter L_{den} for the final scenarios.

To calculate the parameter noise exposure, the data from table 6 can be used, which shows the main results on people noise exposure for major roads, dealing with more than 3 million vehicle passages a year, and major railways, dealing with more than 30,000 train passages per year. These data are split by region according to the data provided by Belgium under the frame of the Environmental Noise Directive. The data corresponds to data reported on strategy noise mapping due by 2012.

TABLE 6: NUMBER OF PEOPLE BY REGIONS INCLUDING AGGLOMERATIONS EXPOSED TO NOISE FROM MAJOR ROADS AND MAJOR RAILWAYS IN 2012 (L_{DEN})

Transport type	Region	Length (km)	Number of people exposed to different noise bands including agglomerations (L_{den})		
			>55 dB	>65 dB	>75 dB
Major roads	Brussels	*	*	*	*
	Flanders	3,531	881,900	408,000	35,000
	Wallonia²	1,544	*	*	*
	Belgium	5,075	881,900	408,000	35,000
Major railways	Brussels³	43	*	*	*
	Flanders	689	221,100	63,500	7,000
	Wallonia³	131	*	*	*
	Belgium	863	221,100	63,500	7,000

*DATA CORRESPONDING TO THE REGIONS OF BRUSSELS AND WALLONIA ARE NOT YET AVAILABLE
²LENGTH 2005: INCLUDES ONLY MAJOR ROADS WITH MORE THAN 6 MILLION VEHICLES/YEAR
³LENGTH 2005: INCLUDES ONLY MAJOR RAILWAYS WITH MORE THAN 60 000 TRAIN PASSAGES/YEAR
SOURCE: ETC/ACM (2014)

The difficulty with the data above is that they do not differentiate noise between freight traffic and passenger traffic. In addition, the data from the Brussels region and the Walloon region is not yet available. Therefore, it has been decided to take the available data of Flanders as a starting point for a reference value in the final scenarios. Based on these data, a value can be calculated indicating the number of people exposed to noise per track km. It can be assumed that this average value, calculated on the limited data available, is a good and sufficiently strict representative for Belgium in general, as this will be lower in reality due to lower population density in Wallonia. The calculated results can be found in table 7.

TABLE 7: ESTIMATED AVERAGE VALUE OF NOISE EXPOSURE (PEOPLE/KM)

Transport type	Number of people exposed to different noise bands including agglomerations (L_{den})		
	>55 dB	>65 dB	>75 dB
Road transport	250 people/km	116 people/km	10 people/km
Rail transport	321 people/km	92 people/km	10 people/km

*DATA CORRESPONDING TO THE REGIONS OF BRUSSELS AND WALLONIA ARE NOT YET AVAILABLE
²LENGTH 2005: INCLUDES ONLY MAJOR ROADS WITH MORE THAN 6 MILLION VEHICLES/YEAR
³LENGTH 2005: INCLUDES ONLY MAJOR RAILWAYS WITH MORE THAN 60 000 TRAIN PASSAGES/YEAR
SOURCE: ETC/ACM (2014)

4.1.2 LARGER CAPACITIES AND HIGHER PAYLOAD

For the element 'larger capacities and higher payload', three different parameters are designed in the first version of the scenarios. No quantitative parameter values are retained. The maximum container payload has the opportunity to increase in the future from 40 Metric Tonnes to 44 Metric Tonnes. The average payload of transported containers can also fluctuate in the different scenarios, as bundling is happening to a higher or lower extent, increasing the volumes transported at the same time. This can avoid small transport volumes, allowing possible economies of scale and as such impacting also on the cost level of rail transport.

The average train statistics are considered to support the changes in the quantification of the other parameter values. The speed and load capacity are directly impacting on the total capacity of the network and on the level of emissions. The total rail demand will be reflected in the parameter of section 4.1.4.

4.1.3 LIBERALIZATION

For 'liberalization', four different parameters are designed in the first version of the scenarios. Only the parameter on market players is selected for the final scenarios, being the number of operational market players, including the number of links between the different players.

This value is indicating the actual level of competition on the Belgian market. According to INFRABEL (2015) and SNCB (2014), twelve companies are currently licensed to operate on the rail freight network in Belgium, of which three have a clear and strong link with other operators, bringing the actual amount of competitors to nine. This is shown in table 8. PKP Cargo is actually not using its license, lowering this amount of active competitors to eight. Finally, not all of these companies are operating in the field of intermodal transport on the Belgian rail network. Currently, Europorte France and CFL cargo are not performing any intermodal rail transport in Belgium. This bring the final number of active intermodal rail competitors to six. Indirect and unfound links between these remaining companies might still exist and are to be taken into account in the different scenarios as well.

TABLE 8: LICENCED RAIL MARKET OPERATORS FOR THE BELGIAN NETWORK

Company	Links	Country of influence
Captrain Belgium NV	Linked to SNCF Fret	France
CFL Cargo	Government-owned corporation (92% Luxemburg, 6% Belgium, 2% France)	Luxemburg
Crossrail Benelux	Parent: Crossrail AG (HUPAC – Switzerland)	Switzerland
DB Schenker Rail Nederland	Linked to Deutsche Bahn	Germany
EuroCargoRail	Linked to Deutsche Bahn	Germany
Europorte France	Parent: Europorte & Eurotunnel (GB Railfreight)	Great-Britain

NMBS Logistics (Incl. IFB)	NMBS (33.3%) – Argos Soditic (66.6%)	Belgium / Switzerland
Railtraxx bvbva	Privately owned railway company	Belgium
Rotterdam Rail Feeding	Parent: Genesee & Wyoming Inc	USA
SNCF Fret	Parent: SNCF	France
TrainsporT AG	Parent: RurTalBahn	Germany
PKP Cargo	Parent: PKP	Poland

SOURCE: INFRABEL (2015), SNCB (2014) AND COMPANY WEBSITES

4.1.4 GDP RELATION WITH TRANSPORT

In order to define the GDP and its relation with transport, nine different parameters are identified in the first version of the scenarios. In the final scenarios, only the value for total rail-tkm will be taken as an input value. The other parameters of this element are used to explore the possible volume of rail demand in Belgium, influencing the selected parameter measured in tkm. As it was mentioned earlier, GDP has an influence on transport, although decoupling is weakening this relationship. As this factor is difficult to predict, this effect will not be taken into account in detail. The total volume transported, the part going by rail, and the total tkm of the main modes of transport in the hinterland of Belgium, being road – IWW – rail, are all directly related to the number of rail-tkm in Belgium. The modal split is used as a goal setting for government policy, and is a direct result of the increase in total tkm and the corresponding changes in the tkm value of the different modes of transport.

In the first version of the scenarios, the number of rail-tkm is calculated based on the study of Vandresse et al. (2012). Within this study, the PLANET model is used to forecast the total transport demand in Belgium by 2030. The average annual growth in Belgium in the reference period is around 0.5% (European Commission, 2014). The total amount of rail tkm in the reference period in Belgium is around 7,300 million tkm (European Commission, 2014). Depending on the source, different levels of modal share for rail transport in Belgium can be found, varying between 9 and 15%. The indicated annual average growth in the study of Vandresse et al. (2012) is used to maintain the same relation between the expected annual growth in GDP and the expected annual growth in tkm (1.6%/2.4% = 0.666). As the annual GDP growth in the first version of the scenarios is set to respectively 2%, 1% and 0.5%, an estimated annual tkm growth could be calculated as 3%, 1.5% and 0.75%. This growth includes influences from all parameters discussed during the SWOT analysis, as well as the selected elements and parameters. When the total annual tkm growth is applied to the obtained total tkm in Belgium, an estimated number of total tkm in Belgium in 2030 for the three scenarios is obtained. The modal split objectives can then be used to calculate the possible effect on the number of rail tkm in Belgium. This is explained more in detail in the different scenarios in sections 4.2, 4.3 and 4.4.

It should be remarked that the above discussion is about rail freight transport in Belgium in general, without making a distinction between intermodal transport, conventional rail transport and single wagon load transport. During an interview with SNCB logistics (2015), it was indicated that for the largest operator on the Belgian Network, SNCB logistics, one third of the traffic is corresponding to these respective categories. Nevertheless, it is extremely difficult to purify the data, obtaining the values for intermodal transport separately from conventional transport and single wagon load transport. Therefore, a broad definition of intermodal transport has to be adopted. Grosso (2011) defines intermodal transport as "The movement of goods in one and the same loading unit or vehicle, which uses successfully several modes of transport without handling the goods themselves in transhipment between the modes". Within the same study, the definition will be opened up to the transport of goods by rail in single units on the Belgian network, which uses successfully more than one mode of transport, accepting the possibility of handling the goods during transhipment between the modes. This is indeed a broad interpretation of intermodal transport. It still assumes the need for more than one mode of transport; however, it allows for the goods to be handled in between these transport moves. As container traffic by rail is often linked to port traffic in Belgium, the adopted definition is allowing to use the identification of intermodal transport for situations such as applied by the chemical sector, where raw materials are received by barge or maritime transport, and distributed by rail after processing.

4.1.5 WEAK NETWORK ACCESS AND LACK OF FLEXIBILITY

The four parameters indicating the element on 'weak network access and lack of flexibility' in the first version of the scenarios will be used as supportive qualitative parameters in the final scenarios. The time to fix a rail path is indicating the level of flexibility, which is reflected in the evolution of the number of rail-tkm. The flexibility in itself is also impacting on the attractiveness of intermodal rail transport, and rail transport in general.

Within the first version of the scenarios, the access charges are also indicated. As this is only a part of the network access cost, other charges for using the network infrastructure should to be taken into consideration as well. It is however difficult to calculate an average total infrastructure charge per tkm, as the tariff structures are not always clear and rather complex. Therefore, it is decided that the earlier mentioned infrastructure and maintenance cost will function as a reference value. During the quantification of the scenarios, it will be taken into account that this parameter, and other parameters as well, will have an impact on the access possibilities and the level of flexibility. This is already quantified in the tkm value for parameter 4.1.4, as will be explained during the three scenarios in section 4.2 to 4.4.

4.1.6 HIGH INVESTMENTS

The added value of taking the fixed cost per year, the capital cost and labour cost in the different scenarios, is rather low, as they will not impact on the different models and the corresponding output. The need for high investments is also reflected in the parameters indicating the level of competition, the value for rail demand in the future and the corresponding need for infrastructure and capacity in general. Hence, none of the values are selected as a quantitative parameter in the final scenarios.

4.1.7 HIGH OPERATING COSTS

Only one parameter is defined for this element, indicating the level of operational costs for rail transport in Belgium. The value of this parameter will be used as an explorative factor in the different scenarios. For the operational costs, rail transport is compared with road transport and IWW. In order to do so, a difference between long haul and short haul is made for road transport. The following ranged reference values in table 9 are obtained based on the cost functions defined by Janic (2008), while the IWW values are based on a study of PWC (2003).

Table 9: Operational costs

Transport type	Operational Costs
Road (long haul)	0.020 – 0.070 EUR/tkm
Road (short haul)	0.040 – 0.100 EUR/tkm
Rail	0.019 – 0.025 EUR/tkm
IWW	0.0076 – 0.0381 EUR/tkm

Source: PWC (2003) and Janic (2008)

4.1.8 COMPLEX PRICING STRATEGIES

The prices and the profit will be an output of the model, and are therefore not selected to build the final scenarios. Nevertheless, some insights about the potential pricing strategies can be provided. Similar to the shipping service classes offered by typical freight carriers, prices can be decided upon in relation to the suggested service quality. For instance, a priority delivery option can be offered with a decent price, in contrast with a normal service with a lower price. The costs associated with each of the service classes need to be carefully regarded.

The congestion level is influencing the flexibility and the quality of the service provided, and is therefore also indirectly influencing the level of rail demand. Within the final scenarios, no quantitative values are therefore mentioned, as it is maintained as a qualitative parameter influencing the remaining values. Nevertheless, reference prices are foreseen to be surveyed in the future phases of the project through connections with the industry. At a first stage, in order to adopt the singular view of the intermodal operator, a monopoly will be considered. When an acceptable profit range is reached, the model can theoretically be extended to handle the mathematical framework of the foreseen intermodal market competition.

4.1.9 MISSING (CAPACITY) LINKS

Capacity is difficult to translate into measurable parameters. It needs to correspond to the level of rail transport in the different scenarios, but should at the same time be plausible in terms of infrastructure creation and management. The level of planned investments is influencing this factor, but is also difficult to predict in terms of values. Therefore, the suggestion is followed to put the capacity as a constraint into each scenario, without quantifying it as such. In this respect, capacity can also be used as a changing parameter in possible sub-scenarios in a later phase of the project. An example can be the question 'what if in the best scenario, not enough infrastructure can be foreseen to meet up with the capacity demand'?

During an interview with SNCB Logistics (2015) and according to De Smedt (2015), it was explained that the capacity of the network in Belgium can be measured in terms of pre-allocated paths (PAPs) and classic rail paths. PAPs are pre-allocated paths through multiple European countries and are coordinated by Railnet Europe (RNE) in cooperation with the national infrastructure managers. These are the paths that are running on the big railway corridors that are corresponding with the Single European Transport Area, as stipulated in the White Paper of the European Commission (2011) and by directive 913/2010. As mentioned in deliverable 1.1 and 1.2, the Belgian network is currently part of corridor 1, corridor 2 and will become active in corridor 8 as from November 2015. Next to these European Rail Paths, the infrastructure manager in Belgium, INFRABEL, is also allocating the regular or classic rail paths for national transport or international transport outside of the European rail corridors. Also paths that require the use of one or more European rail corridor are allocated at this level. The sum of both types of paths results in the current used capacity for freight traffic, as the single wagon load traffic is also using these paths (2). When the use of the network for passenger trains is added, the full capacity use is received. The total capacity is reached when the currently unused capacity is added (1).

Rail network capacity = Rest capacity + Passenger train paths + Freight train paths (1)

Freight train paths = Classic rail freight paths (INFRABEL) + PAPs (RNE/INFRABEL) (2)

However, during the interview, it was made clear that it is difficult to gather this type of data, especially in terms of rest capacity. During the quantification of the scenarios, cooperation from INFRABEL will be requested in order to clearly define capacity and to acquire the necessary data on the Belgium network capacity.

In order to determine the future rail network capacity, as it is mentioned above, the investments should also be taken into account. These investments will directly influence the total capacity, which is used by the passenger train paths, the classic rail freight paths and the PAP's, in order to meet with a possible rise in demand for these different types of rail transport on the Belgian network.

According to Pauwels (2015), the theoretical maximum possible capacity on the Belgian rail network consists of twenty rail paths per hour, per rail track, with a maximum of 18 hours per day.

From an Operations Research point of view, rail capacity can also be evaluated in terms of the number of trains per week. The obtained values can further be incorporated in a functional form, with a number of related parameters, in order to calculate the travel time/cost-associated with a transportation link when the effects of congestion are accounted for. A typical and most commonly used function is given by the Bureau of Public Roads (1964) in the U.S.A. as follows:

$$t = t_0\left[1 + \alpha(V/Q)^{\beta}\right] \tag{3}$$

Where t is the travel time per unit distance (min/km),
t_0 is the travel time per unit distance under free flow conditions,
V is the flow on the link,
Q is the capacity of the link and
α and β are parameters for calibration.

4.1.10 CONSOLIDATION

For the consolidation element, the origin-destination matrix of flows at NUTS3 level will be used in the different scenarios. The other parameters, such as the number of intermodal hubs and their localisation, and the distance of the pre- and post-haulage, are all related and therefore merged into one parameter indicating the intermodal hub effectiveness. This is used as a qualitative parameter in the different scenarios, as it supports the different quantitative factors.

The origin-destination matrix of flows at NUTS3 level is based on the Worldnet database (Newton, 2009). An updated matrix is expected to be generated, on the basis of the economic evolution of the different regions considered under the scope of this research. The economic evolution of the NUTS3 regions can for instance be approximated using forecasts related to the number of companies in the different NUTS. Within the different scenarios, the values of this parameter will be corresponding with the evolution of the other parameters, such as the growth in tkm.

4.1.11 A SINGLE EUROPEAN TRANSPORT AREA

The parameters on the development of a Single European Transport Area have a direct influence on the value of rail tkm and consequently indirectly on the other parameters indicated in a value per tkm as well. Therefore, the Eastern Europe market opportunities, the creation of the European regulator and the TEN-T investments are not included separately in the scenarios, as they are already reflected in the other parameter values.

4.1.12 STANDARDIZATION AND INTEROPERABILITY

Standardization and interoperability have a high impact on the level of sustainability and the level of flexibility of rail transport. As a consequence, this element if often followed by the market, as these parameters are directly influencing the emission factors and the attractiveness of intermodal rail transport, resulting in a higher value of rail tkm.

4.1.13 FUTURE ROAD TAXES

In 2011, it is decided by the Belgian government to introduce road taxes per tkm for trucks heavier than 3.5 tonnes on Belgian highways part of the Eurovignet network, starting from April 2016 as a replacement of the currently used Eurovignet (Viapass, 2015a). In addition, similar actions are under investigation or are already being set up in neighbouring countries. The exact value of the Belgian tax for trucks heavier than 3.5 tonnes has not been definitively fixed by the Belgian government. However, the expected value of road taxes in Belgium can be found in table 10 (L'écho, 2014; Viapass, 2015a).

Table 10: Road taxes on highways in Belgium

Mode of transport	Road taxes
Truck transport	0.11 – 0.14 EUR/km

Source: L'écho (2014)

More details on the expected tariff for the different payloads and the different Euronorms, indicating the environmental classification, can be found in the congestion model of (Viapass, 2015b). This is shown for highways in Belgium in table 11. In Brussels, the road taxes will also need to be paid on other roads than highways, as shown in table 12.

Table 11: Estimated road taxes on highways in Belgium

Mode of transport	Road taxes		
Truck transport	3.5 – 12 t	12 – 32 t	> 32 t
Euro norm 0/1/2	0.146 EUR/km	0.196 EUR/km	0.200 EUR/km
Euro norm 3	0.126 EUR/km	0.176 EUR/km	0.180 EUR/km
Euro norm 4	0.095 EUR/km	0.145 EUR/km	0.149 EUR/km
Euro norm 5	0.074 EUR/km	0.124 EUR/km	0.128 EUR/km
Euro norm 6	0.074 EUR/km	0.124 EUR/km	0.128 EUR/km

Source: Viapass, 2015b

TABLE 12: ESTIMATED ROAD TAXES ON COMMUNAL WAYS IN BRUSSELS

Mode of transport	Road taxes		
Truck transport	3.5 – 12 t	12 – 32 t	> 32 t
Euro norm 0/1/2	0.188 EUR/km	0.263 EUR/km	0.292 EUR/km
Euro norm 3	0.163 EUR/km	0.238 EUR/km	0.267 EUR/km
Euro norm 4	0.132 EUR/km	0.207 EUR/km	0.236 EUR/km
Euro norm 5	0.109 EUR/km	0.184 EUR/km	0.213 EUR/km
Euro norm 6	0.099 EUR/km	0.174 EUR/km	0.203 EUR/km

SOURCE: VIAPASS, 2015B

According to Blauwens et al. (2011), this tax will increase the cost of truck transport with a (partial) trajectory on the Belgium road network, although the effect will be limited for long distance transports as the Belgian network is only a limited part of this trajectory, marginalizing the increased cost of this limited transport part. This needs to be taken into account, as the main advantage of intermodal rail transport is situated at distances over 300 km. Therefore, it can be assumed that the impact of the road taxes currently proposed will be rather limited, and will mainly impact on the national transport traffic. Also the effect on the cost of pre –and post haulages needs to be taken into account, increasing the cost of the total logistics chain of intermodal rail transport, where truck transport is also used. The study also indicates that road taxes will decrease the number of road tkm, due to three effects each accounting for one third of the total effect (De Jong et al., 2010): a higher load capacity for trucks, a decrease in transport demand due to the increased cost and finally a shift towards rail transport and IWW. This also indicates that in the long run, rail transport will only benefit to a limited extent from this measure, so its effect should not be overestimated.

4.1.14 SUBSIDIES AND SAVINGS

The inclusion of savings and subsidies into a model is very complicated. On July 1st, the Belgian government has decided to continue the regulation of subsidies for combined transport and single wagon load transport by rail (Belgische Kamer van volksvertegenwoordigers, 2015). For both 2015 and 2016, 15 million euros will be allocated, with the goal of decreasing truck transport, increasing safety and decreasing the pressure on the environment. Due to their instability over the past years and decades, subsidies currently also have little impact on the decision to use intermodal rail transport in reality. By agreeing on subsidies for a longer period of time (2 years), the goal is to take away part of this uncertainty, and to help companies build a sustainable environment for rail transport in Belgium. Nevertheless, by 2030, subsidies should not be of any importance anymore for intermodal rail transport in Belgium, as it is indicated in the SWOT analysis in deliverable 1.1 and 1.2. Therefore, this parameter will not be used as a quantified factor in the different scenarios.

However, in a worst-case scenario, it might be possible that subsidies to support single wagon transport, or intermodal transport, are still necessary. In addition, it might be the case that savings continue to be requested, putting a high pressure on the flexibility and attractiveness of intermodal rail transport. In this respect, savings and subsidies are also used as a supporting qualitative factor, to indicate the level of tkm in the different scenarios.

4.1.15 PASSENGER TRAFFIC

As indicated in the SWOT analysis, passenger trains currently receive priority over freight trains, even if the first are delayed. In addition, passenger trains are also using the same rail network, and are therefore using part of the total available capacity as mentioned in parameter 4.1.9. In the study of Pauwels (2015), the passenger traffic by rail has been estimated by using the BLTAC-database, which contains all data on public transport. Based on this data, a new matrix can be created, indicating the rail track use of passenger trains between stations, per hour and per type of train (IC, IR, L, P and CR). For each type, a different weight factor is applied. This database can also be used during the quantification of the scenarios in the next phase of the project, when calculating the necessary capacities as indicated in the section above. As this will be part of the model itself, the parameter will not be included as a quantitative factor in the final scenarios, however it will play a significant role in the further stages of the research.

4.1.16 EUROPEAN MONOPOLY OR DUOPOLY

The element 'European monopoly or duopoly' is impacting on all other values and is therefore taken into consideration when creating the value for the different parameters in the final scenarios. This parameter is also taken into the scenarios as the only qualitative factor, expressing whether a European monopoly or duopoly is taking place or not in 2030. In the study of Gevaers et al. (2012), three scenarios are also identified. The first scenario leaves the market structure unchanged, the second scenario indicates a possible and de facto monopoly of DB Schenker Rail and the third scenario assumes a duopoly of DB Schenker Rail and Fret SNCF.

4.1.17 IMPOSSIBILITY TO CONSOLIDATE FLOWS AND/OR LOW INTEROPERABILITY

This element is a direct threat for the opportunities above on consolidation, standardization and interoperability. Thus, the same arguments can be used in order to translate this element in the different scenarios.

In the next sections, the selected parameters and the corresponding values for the reference period, will be translated to the three different scenario cases.

4.2 BEST-CASE SCENARIO

The final best-case scenario in figure 6, takes into account a goal-setting towards a full realisation of the White Paper objectives, as indicated by the European Commission (2011). This means that a 30% shift of road transport over 300 km towards rail or IWW by 2030 is set as a goal by policy makers and intended to be executed by the different actors in the rail sector. This 'high' scenario is taking into account a number of positive elements to come true by this time horizon. As most of the parameter values are expressed in a value per rail tkm, this last parameter value will be of valuable importance. Each parameter value defined in a measure per rail tkm, can be multiplied with the rail demand in each scenario, in order to define the total impact of each parameter. Also qualitative parameters, as defined in the previous section, can still be included in the scenario during the quantification phase in the next round.

FIGURE 6: FINAL BEST-CASE SCENARIO

BEST-CASE

Parameters			Reference value		Scenario value		%
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%
Monopoly/Duopoly			Not present		Not present		-

SOURCE: OWN COMPOSITION

In the best-case scenario, an increase of rail demand by 133% is estimated. This value is obtained based on the studies of Vandresse et al. (2012) and Islam et al. (2013). Starting point is the value for rail demand in Belgium, indicated by the European Commission (2013), which equals 7,300 million tkm for the year 2012. For the three dominant modes of transport together, a total of 50,000 million tkm can be taken into account for the year 2012 (= 7,300 million tkm rail demand + 10,400 million tkm IWW demand + 32,100 million tkm road demand). 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). When calculating the best scenario, a fixed annual average growth of the GDP by 2% is assumed. Within the study of Vandresse et al., 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 retained (1.6%/2.4% = 0.666), the average annual growth of total tkm in Belgium would rise to 3% (2%/0.666 = 3%). This would result 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. In the study of Islam et al. (2013), the rail demand for EU-27 is identified as approximately 320,000 million tkm. The Belgian share in this can be calculated as 2.4%. Within the study, the TRANS-TOOLS model is used to forecast the evolution of the total rail transport in EU-27, which is expected to rise to 699,000 million tkm by 2030 in case the full White Paper goals are aspired. If the same ratio for Belgium compared to the EU-27 is kept, this would result in a rail transport of 16,776 tkm for 2030 in Belgium. This number can be raised to 17,000 rail-tkm, in order to obtain an increase of 133% compared to the reference value. This value is also taking into account a number of qualitative parameters as described in the previous section, such as high level of standardization and interoperability, the execution of all planned investments in order to reach the necessary capacity, an increase due to the opportunities in the Eastern European market.

For the transport emissions, rail transport is expected to lower emissions by 40%, 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 the different models in the next phase of the project.

Within the best-case scenario, energy consumption of rail transport is also 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, these costs are dropping more for rail transportation than for IWW and road transport. Nevertheless, IWW continues to have the lowest cost rates. It is important to notice that the decrease in cost for 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. Therefore, this will decrease the total cost of the full logistic chain even further. When the comparison with operational costs is made, it can be seen that for rail transportation, this cost is estimated to decrease by 30%, whilst road transportation and IWW can count on a decrease by only 10%. This increases the cost-benefit ratio of rail transportation over road transportation, but also in this case IWW retains the lowest cost advantage.

In the best-case scenario, it is expected that market competition increases, which results 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 competitors 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 is not present within this scenario.

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

4.3 WORST-CASE SCENARIO

The final worst-case scenario shown in figure 7, is the complete opposite of the previous section, and anticipates on the situation when the goals of the White Paper, as indicated by the European Commission (2011), are not taken into consideration and no shift is aspired. This means that the 30% shift of road transport over 300 km towards rail or IWW by 2030 is not set as a goal by policy makers and therefore not intended to be executed by the different actors in the rail sector. This scenario is also taking into account a number of negative elements to come true by this horizon, such as the lack of standardization and interoperability, increased savings and budget cuts, investments not taking place resulting in a lack of capacity, the continuation of passenger train priority, etc. As it is indicated in the previous section, most of the parameter values are expressed in a value per rail-tkm, due to which this last parameter will be of valuable importance.

Figure 7: Final 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	0.330	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	1,082	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%
	Monopoly/Duopoly			Not present		Present		-

Source: own composition

In the worst-case scenario, an increase of 10% is foreseen in terms of rail demand. This value is obtained in the same way as described in the previous section, based on the studies of Vandresse et al. (2012) and Islam et al. (2013). A fixed annual average growth of the GDP of 0.5% is assumed in this scenario. Taking the same ratio again gives an average annual growth of total transportation by 0.75%, resulting in 57,000 tkm by 2030. This leads to an estimated (but not forecasted) 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 the need for an increase in capacity, this number can be lowered to 8,000 rail tkm. This will result in a decline of modal share for rail transportation, although it is still an increase in absolute value. Therefore, the government should still conduct a policy in order to be able to manage this rise of 10% in absolute number of tkm.

For the transport emissions, rail transport is expected to lower volumes by only 10%, due to limited innovation and investments in research and development, whilst road transport is becoming cleaner at a more rapid rate (-40%). As such, road transportation is becoming almost as clean as or even cleaner than rail transportation by 2030. Also 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 the different models in the next phase of the project.

Within this worst-case scenario, energy consumption of road transport is also dropping at a faster rate (-30%) compared to that of rail transportation (-10%). In addition, infrastructure and maintenance costs are becoming higher by 2030. This can be explained by the incapacity of consolidation, the remaining or increasing inflexibility, and the lack of economies of scale as no shift to the (currently perceived) sustainable modes of transport is taking place. When the comparison with road transport is made, it can be seen that the operational costs for rail transportation will increase by 20% due to this lack of economies of scale, the lack of standardization and innovation and therefore the continuing inefficiencies, whilst road transportation can count on a decrease by 10%. This increases the competitive position of road transportation over rail transportation, especially for long hauls.

In the worst-case scenario, it is expected that market competition decreases, which results in a European duopoly, where all remaining existing 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. This will be addressed in the models of work package 5 and 6 in the next phase of the project.

For road taxes on truck transport, to adopt a realistic view for rail transport, a worst-case scenario would be for them to remain stable.

4.4 MEDIUM-CASE SCENARIO

The final medium-case scenario shown in figure 8, describes a partial realisation of the White Paper goals, as indicated by the European Commission (2011). This means that a 30% shift of road transport over 300 km towards rail or IWW by 2030 is set as a goal by policy makers, but not with full focus. This results in a low aspiration of the White Paper goals. This medium scenario is also taking into account a mix of positive and negative elements to come true by this horizon. Correspondingly with the other scenarios, the most important parameter is the expression of rail tkm, as it can be used to generate the total impact of a certain parameter value.

FIGURE 8: FINAL WORST-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	0.44	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%
	Monopoly/Duopoly			Not present		Dominant players		-

SOURCE: OWN COMPOSITION

In the medium-case scenario, an increase by 64% is foreseen in terms of rail tkm. This value is obtained based on the earlier mentioned studies of Vandresse et al. (2012) and Islam et al. (2013). A fixed annual average growth of the GDP by 1% is assumed. Taking into account the ratio of 0.666 from the study of

Vandresse et al., an average annual growth of 2% is foreseen for total transport tkm. This would result in a total transport of 71,500 tkm by 2030. In case the modal split would remain the same, the total number of rail tkm would rise to 10,437 tkm. This value needs to be 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), the TRANS-TOOLS model forecasts a rise to 488,000 million tkm by 2030 in case the White Paper goals are only partially aspired. A 1.13% shift from road to rail transport would be obtained according to this study. As it was calculated in the best-case scenario, Belgium has a ratio of 2.4% compared to the EU-27 values. This results in a forecast rail transport of 11,712 tkm for 2030 in Belgium. This number can be raised to 12,000 rail-tkm, in order to obtain an increase of 64% compared to the reference value. This value is also taking into account a number of qualitative parameters as described in the previous section, although only to a partial extent. Within this scenario, a higher level of standardization and interoperability, and the introduction of the Single European Transport Area is reached, 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.

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 for one mode or the other. Nevertheless, also in this scenario, the total effects will be taken into account during further modelling, by calculating the total effect and taking into account pre –and post haulage requirements.

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 maintenance costs, but also in the requirement of more complex and more expensive infrastructure, balancing this benefit to a certain extent. Within this scenario, it can be assumed that rail transport is becoming more attractive, but capacity is not sufficient to meet all the 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 expected that market competition decreases to four active intermodal market players, but this does not lead to a strict European monopoly or duopoly. Instead, it is expected in this scenario that mergers and acquisitions will lead to four independent but dominant players, controlling the market. As a result, no linked companies exist in this scenario. This might lead to increased efficiency and attractiveness of intermodal rail transportation, as competition between these operators still exists, fighting to capture the increasing market due to a rise in attractiveness as a consequence of the above.

As a middle scenario for the above estimated road taxes for trucks, it can be assumed they will increase by 10% compared to the currently estimated value.

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APPENDIX I – Composition of the panel of experts

Organisation	Representative	Competence Domain
ArcelorMittal	David De Rocker	Shipper / Rail user
Belgian Federal Planning Office	Bruno Hoornaert	Research
Belspo	George Jamart	Research
B-logistics	Niels Muys	Operator
B-logistics	Daniel Vanparijs	Operator
B-logistics	Sam Bruynseels	Operator
Brussels Region	Marianne Thys	Public Works
CMA-CGM Benelux	Patrick Kockx	Shipping Company / Rail user
Crossrail	Jeroen Lejeune	Operator / Traction
Ecole Polytechnique Fédérale de Lausanne	Prof. Matthias Finger	Research
European Intermodal Association	Peter Wolters	Network creation / Public Works
Flemish Department of the Economy	Ivo Vanhauten	Public Works
Flemish Department Public Works and Mobility	Ilse Hoet	Public Works
Flemish Department Public Works and Mobility	Reginald Loyen	Public Works
FPS Mobility and Transport	Martine Serbruyns	Public Works
FPS Mobility and Transport	Michel De Vos	Public Works
FPS Public Health and Safety	Lucas Demuelenaere	Public Works
INFRABEL	Els Houtman	Infrastructure Manager
INFRABEL	Heidi Hendrix	Manager Area North-East
InterFerryBoats	Frédéric Buyse	(Terminal) Operator / Consolidator
InterFerryBoats	Johan Gemels	(Terminal) Operator / Consolidator
Logistics in Wallonia	Bernard Piette	Network creation / Public Works
National Bank of Belgium	Georges Van Gastel	Research
Port de Liège	Anne-Sylvie Lonnoy	Port Authority
Port of Antwerp	Koen Cuypers	Port Authority
Port of Ghent	Kate Verslype	Port Authority
Port of Zeebruges	Patrick Vancauwenberghe	Port Authority
Procter & Gamble	Lieven Deketele	Shipper / Rail user
Walloon Department of Mobility	Thibaud Mouzelart	Public Works
Walloon Public Service	Jean-Michel Baijot	Public Works
Walloon Public Service	Pierre Arnold	Public Works

APPENDIX II – Element selection process

Through the SWOT, 93 different elements are identified[3]: 25 strengths, 27 weaknesses, 20 opportunities and 21 threats. In order to create simple and understandable scenarios, a selection of elements is to be made, in order to put focus on the most important and useable factors.

FIRST SELECTION – SWOT ANALYSIS AND RANKING

During the last chapter of the Deliverable 1.1 – 1.2, a SWOT analysis is conducted where the respondents, being a heterogeneous panel of experts in the field of intermodal rail transport, could rate the 93 elements on a Likert scale from 1 to 5, on its impact towards the development of intermodal rail transport in Belgium, as well as on the likelihood that the specific element would (continue to) occur in the future[2]. By calculating the modus and the H-index, indicating the level of agreement between the different respondents regarding the obtained modus, a ranking of the elements is obtained for each SWOT category (strengths, weaknesses, opportunities and threats). The selection criteria are twofold: the elements are firstly sorted by obtained modus (from highest to lowest), followed by a sorting based on the H-index, indicating the level of agreement between the different respondents regarding the obtained modus. In this way, a top 5 can be generated for each category, indicating the most important and most likely elements to happen in the future, with the highest rate of agreement. When combining all the elements that are present in either the top 5 for impact or the top 5 for likelihood of happening, for each of the categories of the SWOT, a reduced list of 33 elements is obtained, including 7 strengths, 10 weaknesses, 9 opportunities and 7 threats.

MATRIX EXERCISE

Next, a matrix is created where the likelihood and impact for each element are compared. This can be seen in figure 9, which is used to put the results of the SWOT analysis in a different perspective. Each element is represented by indicating the category (S-strength / W-weakness / O-opportunity / T-threat), the work package (WP 2 – WP 6) and the element number. Elements in bold, are the 33 elements that are shortlisted by the SWOT analysis described above. This matrix shows that most of the selected elements rated with a high impact, also show a medium or high likelihood of happening. According to the methodology described above, it is important for the creation of scenarios to focus on those elements that have a high impact, as these elements are the drivers of change for the development of intermodal rail transport in the future. These elements are marked in figure 9, in a red box. Depending on the level of uncertainty, which can be derived from the level of agreement between the respondents (H-index), a different role can be defined for each of these impactful elements within the different scenarios, as described by the methodology above. Elements with a high uncertainty, and as such a lower level of agreement concerning the obtained modus for the category 'likelihood of happening', can therefore still be taken into consideration for the scenario analysis. This might seem contradictory, however as these elements can be translated into a wide range of varying values, due to the high level of uncertainty, they can create the unique characteristics of each scenario. According to the Delphi technique, the number of elements selected in this way should be limited, and the selection of these elements should be unanimously agreed upon.

Both the SWOT analysis and the matrix exercise are taken as an input for further selection of the different components, as a group of 33 elements is still complicating the development of clear and simple scenarios.

[3] More details on the original 93 elements and the results of the SWOT analysis can be found in deliverable 1.1 and 1.2: https://www.brain-trains.be

FIGURE 9: MATRIX ANALYSIS OF THE SWOT SURVEY

	LOW LIKELIHOOD	MEDIUM LIKELIHOOD	HIGH LIKELIHOOD
HIGH IMPACT	O-2-5	**S-2-1** **S-3-2** **S-3-3** S-5-2 S-6-2 S-6-4 S-6-9 **W-3-1** W-3-3 W-4-2 W-4-3 W-4-5 **W-6-4** O-2-1 **O-2-2** **O-2-4** **O-3-1** O-3-5 O-4-1 **O-5-1** O-6-2 **T-2-1** T-2-2 T-3-3 T-4-4	**S-2-2** **S-5-1** **W-2-1** **W-2-2** W-2-3 **W-2-4** W-2-5 **W-2-6** W-3-2 **W-5-1** **W-5-2** **W-5-3** W-6-1 W-6-2 W-6-3 W-6-5 **W-6-8** W-6-9 **W-6-10** **O-2-3** O-2-6 **O-3-3** **O-4-4** O-3-6 **T-2-3** **T-2-4** **T-3-1** **T-3-2** T-3-4 T-3-5 T-4-3 **T-5-1** **T-5-2** T-5-3 T-6-1
MEDIUM IMPACT	S-4-3 S-6-1 S-6-6 S-6-8	S-3-1 S-4-5 S-6-3 **S-6-5** S-6-7 **S-6-10** S-6-11 W-4-1 W-6-6 W-6-7 O-3-2 O-3-4 O-4-2 **O-6-1** O-6-3 T-2-5 T-2-6 T-4-1	O-4-3
LOW IMPACT	S-3-4 S-3-5 S-4-1 S-4-4	S-4-2 W-4-4 T-4-2 T-6-2 T-6-3	

SOURCE: OWN COMPOSITION

RETAINED ELEMENTS

During an internal brainstorming session, the consortium panel decided that the six remaining elements of work package 6, regarding the effective governance and organization for a well-functioning intermodality, are not to be taken into account for the development of scenarios. The reasoning behind this decision, is that governance is a field of examination that will follow directly from the scenarios itself, rather than giving input to the scenario creation as such. Therefore, this field will take the different scenarios as an input during the next deliverables, and put its focus on all the different identified SWOT elements in order to determine the required governance and organization for the studied scenario. This decision was also addressed to the heterogeneous panel of experts, and is unanimously approved as a correct way forward, both in terms of the development of scenarios (without further selection of elements of work package 6) as well as for the continuation of the project.

The remaining 27 elements are discussed by the members of the consortium, investigating the relation of each element with other SWOT elements. In this way, it became clear that a number of elements are cross-linked and could therefore be clustered into a more general factor, reflecting the characteristics of all the underlying components. This has led to a final list of 17 elements that was presented to the panel of experts on the 20th of April 2015 at Federal Government Department of Mobility and Transport.

APPENDIX III – Input and output parameters for the five methodologies to be used in the scenario analysis (work package 2 - 6)

WP 2 - QUANTOM - MODEL 1		
INPUT	METHODOLOGY	OUTPUT
Origin-Destination matrix of flows at the NUTS3 lev	Bi-objective linear mathematical modeling (optimization techniques)	Modal split
TEN-T corridor flows		Total costs/emissions
Subsidies		Total costs/emissions per mod
Taxes		
Operational costs		
Transport CO2 emissions		
Transport other emissions (particles, SO2, ...)		
Value of time		
General remark : subsidies, taxes, operational costs, transport CO2 emissions and other emissions are considered for block trains. We do not plan to include the single-wagon trains since they represent a small market share and they are less efficient, in the framework of the promotion of intermodal transport		

WP 2 - QUANTOM - MODEL 2		
INPUT	METHODOLOGY	OUTPUT
Origin-Destination matrix of flows at the NUTS3 lev	Joint service network design and pricing with demands' calculation techniques (e.g.: bi-level optimization)	Intermodal service prices
Subsidies		Transported volumes
Taxes		Modal split
Operational costs		
Transport CO2 emissions		
Transport other emissions (particles, SO2, ...)		
Network capacity		
Infrastructure and maintenance costs (Rail)		
Infrastructure and maintenance costs (IWW)		
Intermodal carriers' profit structure		
Passengers flows at peak hours		

WP 3 - TPR I		
INPUT	METHODOLOGY	OUTPUT
Payments between rail actors	Input-Output Model	Added Value Relationships
GDP		
rail TKM & transported Volume (TEU and MT)		
Available Track length / Bottlenecks (capacity)		
Modal split objectives		
Investments & Savings		
Employment?		
Freight Train delays		
Time to fix a railpath		
Bundling/Hub developments		
Subsidies		

WP 4 - PSD		
INPUT	METHODOLOGY	OUTPUT
Rail operation		Environmental Impact in numerous categories in a tkm
Belgium railway freight characteristics		Climate change
Share of diesel and electricity traction		Ozone depletion
Average energy consumption per train		Eutophication
Direct emissions to air and soil (CO_2, CO, NMVOC,PM10... and Heavy metal)		Acidification
Rail equipment		Human toxicity (cancer and non-cancer related)
Locomotives currently used		Ecotoxicity
Wagons currently used		
Rail infrastructure		
Share between passenger and freight transportation	Life Cycle Assessment	
Materials & energy consumptions for construction, maintenance and disposal of railway track, bridges, tunnels and electrical installations		
Land use Impact Assessment		Land use impact
Land Use (land transformation & land occupation)		Biodiversity & Ecosystem services (biotic production and regulation functions of the natural environment)
Noise impact assessment		Noise impact
Sound power level		
Location		
Time		

WP 5 - TPR II		
INPUT	METHODOLOGY	OUTPUT
# operational market players		
Links between market players		
Persistance of profit		
Fixed cost per year		
Capital cost vs. Labour cost		
Time to enter market		
access charges	Regulatory-economic analysis	
Role of European Regulator		
# parameters per country (language, certification, type of wagons, safety system, voltages, ...)		
# network changes (stops on 1 route for technical reasons)		

APPENDIX IV – First version of the scenarios

	SWOT element	Parameters		Reference (2010-2015)	Best-case (2030)	Medium-case (2030)	Worst-case (2030)
STRENGTHS	Reduced costs and externalities	Transport CO_2 emissions	Road (long haul)	27,440 g/tkm	-10%	27,440 g/tkm	-20%
			Road (short haul)	47,886 g/tkm	-10%	47,886 g/tkm	-20%
			Rail	16,380 g/tkm	-20%	16,380 g/tkm	-10%
		Transport other emissions (particles, SO_2, …)	Road (long haul)	REF	-10%	REF	-20%
			Road (short haul)	REF	-10%	REF	-20%
			Rail	REF	-20%	REF	-10%
		Infrastructure and maintenance costs	Rail	estimated average 0,0698 €/tkm	-10%	0,0698 €/tkm	+10%
			IWW	0,0219 €/tkm	-10%	0,0219 €/tkm	+10%
		Energy consumption		186700 TOE			
		GHG emission rail transport (freight + passanger)		0,1 mio tonnes CO_2 equivalent	0 mio tonnes	0,05 mio tonnes	
		Materials & energy consumption for construction, maintenance and disposal of infrastructure					
		Land use	Land Occupation	11,5 m^2/m*a			
			Land Transformation	2,66E-2 m^2/m			
		Noise exposure (# people exposed)	Lden > 75 dB	9-10 people/km	0 people/km	4-5 people/km	
			Lnight > 70 dB	11-39 people/km	0 people/km	5-19 people/km	
		Location (Urban, Rural, …)					
		Time (day, evening, night)					
		Share of electrified network		85,50%	100%	92,75%	
		Rail traction	Diesel	29,10%	0%	14,55%	
			Electric	70,90%	100%	85,45%	
	Larger capacities and higher payload	Container Payload					
		Average Train	Length	600m	740m	650m	600m
			Length (# railcars)	27			
			Speed	25 km/h	40 km/h	30 km/h	25 km/h
			Gross weight (incl train)	1300	1800	1600	1300
			load capacity	700	1000	850	700
		Total rail demand					
	Liberalization	# Operational market players		13 (10)	18	6	2
		Links between market players		2	3	2	0
		Time to enter market		2 years	1 year	1,5 years	2 years
		Persistance of profit					
	GDP relation with transport	Modal split objectives (market share in tkm)	Road	64,5%	59,0%	64,0%	69,0%
			Rail	14,7%	17,0%	15,0%	13,0%
			IWW	20,9%	24,0%	21,0%	18,0%
		average yearly GDP growth		0,5%	2,0%	1,0%	0,5%
		average yearly MT growth		N/A	2,75%	1,38%	0,69%
		average yearly TKM growth		N/A	3,00%	1,50%	0,75%
		Volume transported by rail (MT / TEU)		39000000 MT	+90%	+30%	+1%
		Intermodal rail transport		*2162 mio TKM (?)*			
		Total TKM (rail-IWW-road)		49660 mio TKM	84542 mio TKM	64922 mio TKM	56809 mio TKM
		Rail TKM		7300 mio TKM	+96,9%	+33,4%	+1,1%
		average yearly rail tkm growth		N/A	5%	2%	0%

	SWOT element	Parameters		Reference (2010-2015)	Best-case (2030)	Medium-case (2030)	Worst-case (2030)
WEAKNESSES	Weak network access & lack of flexibility	Value of time in €/MT or €/tkm					
		Freight (Bloc-)Train Delays (> 30 min)		24%	10%	20%	30%
		Access Charges		2,732672 EUR/km	10% Lower	Index	10% Higher
		Time to fix a railpath		18m	6m	12m	18m
	High investments	Fixed cost per year		REF	- 10%	+ 0%	+ 10%
		Capital Cost		REF	- 10%	+ 0%	+ 10 %
		Labour Cost		REF	- 5%	+ 0%	+ 5%
	High operating costs	Operational costs	Road (long haul)	0,070 - 0,020 €/tkm	-10%	0,070 - 0,020 €/tkm	-10%
			Road (short haul)	0,100 - 0,040 €/tkm	-10%	0,100 - 0,040 €/tkm	-10%
			Rail	0,025 - 0,019€/tkm	-15%	0,025 - 0,019€/tkm	+10%
	Complex pricing strategies	Congestion level		REF	-10%	REF	10%
		Prices		Results of the model (REF)	Results of the model (more profitable)	Results of the model (REF)	Results of the model (less profitable)
		Profit		Results of the model (REF)	Results of the model (+ 10%)	Results of the model (REF)	Results of the model (- 10%)
	Missing (capacity) links	Available track length		3595 km	higher	higher	idem
		Max. # Freight Trains possible per hour, per direction		13	15	13	11
		# bottlenecks		20	0	10	20
		Invesments (planned)		Investeringsplan 2025 = 15,4 billion euros	Executed	Ongoing	None
		Rest capacity: (Capacity + investments - passenger - freight)		< 20% capacity left on a track = RED 20 - 40% capacity left on a track = YELLOW > 40% capacity left on a track = GREEN	Sufficient (all yellow/green)	Minor problems (some red, major yellow/green)	Major problems (same bottlenecks, but with increased traffic)
		Network capacity		# vehicles per convential space unit			

REF = Reference Value to be found at the moment of closing the first version of the scenarios

	SWOT element	Parameters		Reference (2010-2015)	Best-case (2030)	Medium-case (2030)	Worst-case (2030)
OPPORTUNITIES	Consolidation	Origin-destanation matrix of flows at NUTS3 level		(MT)	10%	(MT)	-10%
		# Intermodal Hubs (effect on tkm)		12	16	12	10
		Hub localisation (effect on tkm)		almost optimal	optimal	optimal	not-optimal
		PPH distances		REF	-10%	REF	10%
		Cooperation results in bundling of flows (effect on tkm)			Positive effect	Small effect	No effect
	A Single European Transport Area	TEN-T corridor flows in MT		REF	10%	REF	-10%
		1 European Regulator		NO	YES	IN PROGRESS	NO
		TEN-T investments		215 bio EUR	215 Bio EUR	180 Bio EUR	100 Bio EUR
		Increase due to new market in Eastern Europe	Volume (MT / TEU)	Included in yearly growth of total TKM (see above)			
			TKM				
	Standardization and interoperability	Intermodal carriers profit structure (revenue - cost)					
		# network changes (stop due to technical reason)		REF	REF -90%	REF - 50%	REF
		Locomotives used	Diesel	16,84%	0%	8,42%	
			Electric	83,16%	100%	91,58%	
		# intermodal Wagons used		12821	25000	17000	13000
		Certification, single language, type of wagons, safety system implementation, voltages, …			ECTS implemented	ECTS partially implemented	ECTS not implemented
	Future road taxes	Road tax/km of the Walloon Region		REF	10%	REF	0

	SWOT element	Parameters		Reference (2010-2015)	Best-case (2030)	Medium-case (2030)	Worst-case (2030)
THREATS	Savings	Subsidies	Fixed (between 2 Belgian terminals)	1,5385 €/MT moved	10%	1,5385 €/MT moved	0
			Variable for Belgian terminals seperated by min. 51 km	0,00978 €/tkm	10%	0,00978 €/tkm	0
		Intermodal transport subsidies		17,4 mio	19 mio	17 mio	15,5 mio
		Single wagon subsidies		NO	YES	NO	NO
		Planned investments go through (f.ex TEN-T)		N/A	YES	PARTIALLY	NO
	Passenger Traffic	Passenger flows at peak hours (11-12 and 5-6)		REF	Lower	Idem	Higher
		Network use Market Share (Network occupation in %)	Freight Trains	13,02%	20%	15%	10%
			Passenger Trains	86,98%	80%	85%	90%
	European Monopoly or Duopoly	Will it come true?		NO	NO	DOMINANT	YES
	Impossibility to consolidate flows and/or low interoperability	Does it occur?		N/A	NO	PARTIALLY	YES

REF = Reference Value to be found at the moment of closing the first version of the scenarios

APPENDIX V – Calculation of the Belgium values for energy consumption and CO_2 emission

In order to adapt the specific average European energy consumption of rail traffic from the ECOTRANSIT (2008) study to the recent Belgium case, data provided by SNCB from table 13 could be used. This table contains the data of energy consumption from rail freight in Belgium conducted by SNCB, the main operator on the Belgian network, from 2006 to 2012.

TABLE 13: ENERGY CONSUMPTION OF RAIL FREIGHT IN BELGIUM

Rail Freight - Belgium		1990[3]	2006[1]	2007[1]	2008[1]	2009[2]	2010[3]	2011[3]	2012[3]
Total freight transport (millions tkm)		8,354	8,442	8,148	7,882	5,439	5,729	5,913	5,220
Freight transport by electric traction		?	?	?	?	?	?	?	?
Freight transport by diesel traction		?	?	?	?	?	?	?	?
Energy consumption (TJ)	**Electric traction**	2,794	3,489	3,261	3,382	2,472	2,092	2,248	1,922
	Diesel traction	2,268	1,450	1,339	1,282	739	721	582	465
	Total	5,062	4,939	4,600	4,664	3,211	2,813	2,830	2,387
Specific energy consumption (kJ/tkm)		606	585	565	592	590	491	479	457

SOURCES: SNCB (2009)[1], SNCB (2013)[2] AND SNCB (2015)[3]

With the data from table 13, the specific energy consumption for the SNCB rail freight transport in Belgium can be calculated as 457 kJ/tkm in 2012. However, no differentiation can be made between electric and diesel traction. In order to obtain the specific energy consumption of electric and diesel traction separately, the amount of freight transport moved by either electric and diesel traction would be needed. Although the total electric and diesel energy consumption are available in Tj, these values cannot be distributed proportionally, neither can the amount of freight be distributed according to these values, as the electric and diesel traction have different specific energy consumptions as shown in table 4. Nevertheless, the amount of freight transport moved by electric and diesel traction can be estimated separately by using the reference value for the energy consumption obtained in the ECOTRANSIT (2008) study. These values for the energy consumption are defined based on the study of 20 European countries, including Belgium. Thus, these values are a European average and it can be supposed that the Belgium value will be close.

To obtain the amount of freight transport moved by electric and diesel traction in Belgium during the observed period, the following equation can be used:

$$Freight\ transport\ (millions\ tkm) = \left[\frac{Energy\ consumption\ (TJ)}{Specific\ energy\ consumption\ \left(\frac{kJ}{tkm}\right)}\right] * 1{,}000 \qquad (4)$$

Therefore:

$$Freight\ transport\ by\ electric\ traction\ (millions\ tkm) = \left[\frac{Electric\ energy\ consumption\ (TJ)}{Specific\ electric\ energy\ consumption\ \left(\frac{kJ}{tkm}\right)}\right] * 1{,}000 \quad (5)$$

$$Freight\ transport\ by\ diesel\ traction\ (millions\ tkm) = \left[\frac{Diesel\ energy\ consumption\ (TJ)}{Specific\ diesel\ energy\ consumption\ \left(\frac{kJ}{tkm}\right)}\right] * 1{,}000 \quad (6)$$

To explain the procedure, the data from 2012 can be used as an example.

$$Freight\ transport\ by\ electric\ traction\ (millions\ tkm) = \left[\frac{1{,}922\ TJ}{456\ \frac{kJ}{tkm}}\right] * 1{,}000 = 4{,}214\ millions\ tkm$$

$$Freight\ transport\ by\ diesel\ traction\ (millions\ tkm) = \left[\frac{465\ TJ}{530\ \frac{kJ}{tkm}}\right] * 1{,}000 = 877\ millions\ tkm$$

$$Total\ freight\ transport\ calculated\ (Electric\ +\ diesel) = 5{,}091\ tkm$$

Finally, 5,091 million tkm is computed as total freight transport, when the average European values are used. This is not the same value provided in the original table, being 5,220 million tkm. Thus, with a trial-and-error approach the values of 456 kJ/tkm and 530 kJ/tkm can be adjusted until the correct value is obtained. By doing so, it can be found that with an adjustment of -2,45% in the specific energy consumption values, the total freight transport value of 5,220 million tkm can be obtained. This leads to a specific electric and diesel traction energy consumption value of 444,828 kJ/tkm and 517,015 kJ/tkm.

As a consequence of the previous calculations, also the share of freight transport between electric and diesel traction can be obtained. In 2012, 5,220 tkm was performed by rail, out of which 4,321 tkm was moved by electric traction (83% of total) and 899 tkm by diesel traction (17% of total). Table 14 shows the values for several years. Therefore, this table can now be completed as shown below.

TABLE 14: CALCULATED ENERGY CONSUMPTION OF RAIL FREIGHT IN BELGIUM

Rail Freight - Belgium		1990	2006	2007	2008	2009	2010	2011	2012
Total freight transport (millions tkm)		8,354	8,442	8,148	7,882	5,439	5,729	5,913	5,220
Freight Transport	Electric traction	4,919	6,221	6,018	5,944	4,326	4,418	4,836	4,321
	Diesel traction	3,436	2,223	2,126	1,938	1,113	1,310	1,077	899
Total Energy consumption (TJ)	Electric traction	2,794	3,489	3,261	3,382	2,472	2,092	2,248	1,922
	Diesel traction	2,268	1,450	1,339	1,282	739	721	582	465
Specific Energy consumption (KJ/tkm)	Electric traction	567.948	560.880	541.819	568.951	571.368	473.465	464.892	444.828
	Diesel traction	660.115	651.900	629.746	661.281	664.090	550.299	540.335	517.015

SOURCES: OWN CALCULATIONS BASED ON SNCB (2009), SNCB (2013) AND SNCB (2015)

Using these freight share values between electric and diesel traction and the data provided by SNCB concerning CO_2 emissions from rail freight in Belgium for the period 2006 to 2012, shown in table 15, the specific CO_2 direct emission for electric and diesel traction can be estimated for Belgium.

To obtain the specific CO_2 emission factor for electric and diesel traction for the observed period in Belgium, the following equation can be used:

$$Specific\ CO_2\ emission\ factor\ \left(\frac{g}{tkm}\right) = \frac{Direct\ CO_2\ emission\ (t)}{Freight\ transport\ (millions\ tkm)} \quad (7)$$

Therefore:

$$Specific\ electric\ CO_2\ emission\ factor\ \left(\frac{g}{tkm}\right) = \frac{Direct\ electric\ CO_2\ emission\ (t)}{Freight\ transport\ by\ electric\ traction\ (millions\ tkm)} \quad (8)$$

$$Specific\ diesel\ CO_2\ emission\ factor\ \left(\frac{g}{tkm}\right) = \frac{Direct\ diesel\ CO_2\ emission\ (t)}{Freight\ transport\ by\ diesel\ traction\ (millions\ tkm)} \quad (9)$$

To explain the procedure, the data from 2012 can be used as an example:

$$Specific\ electric\ CO_2\ emission\ factor\ \left(\frac{g}{tkm}\right) = \frac{26{,}681\ t\ CO_2}{4{,}321\ millions\ tkm} = 6.175\frac{g}{tkm}$$

$$Specific\ diesel\ CO_2\ emission\ factor\ \left(\frac{g}{tkm}\right) = \frac{37{,}151\ t\ CO_2}{899\ millions\ tkm} = 41.31\frac{g}{tkm}$$

A specific electric CO_2 emission factor of 6.175 g/tkm and a specific diesel CO_2 emission factor of 41.325 g/tkm can be calculated for Belgium for the period 2012. Table 15 shows the values for several years.

TABLE 15: DIRECT CO2 EMISSIONS OF RAIL FREIGHT IN BELGIUM

Rail Freight - Belgium		1990[3]	2006[1]	2007[1]	2008[1]	2009[2]	2010[3]	2011[3]	2012[3]
Freight transport (millions tkm)		8,354	8,442	8,148	7,882	5,439	5,729	5,913	5,220
Freight Transport (million tkm)	Electric traction	4,919	6,221	6,018	5,944	4,326	4,418	4,836	4,321
	Diesel traction	3,436	2,223	2,126	1,938	1,113	1,310	1,077	899
Total Direct emissions ($t\ CO_2$)	Electric traction	92,373	89,962	76,374	72,505	48,797	40,198	38,214	26,681
	Diesel traction	166,397	106,356	98,257	94,035	54,194	52,895	42,708	37,151
Specific Direct emissions (g/tkm)	Electric traction	18.779	14.461	12.691	12.198	11.280	9.099	7.902	6.175
	Diesel traction	48.428	47.843	46.217	48.522	48.692	40.378	39.655	41.325

SOURCES: SNCB (2009)[1], SNCB (2013)[2] AND SNCB (2015)[3]