# Guidance on appraising the economic impacts of rail freight measures

June 2017

# JASPERS Appraisal Guidance (Transport)

## Guidance on Appraising the Economic Impacts of Rail Freight Measures

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*supported by:*

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*Guidance on Appraising the Economic Impacts of Rail Freight Measures*

JASPERS (Joint Assistance in Supporting Projects in European Regions) is a partnership between the European Commission (EC) and the European Investment Bank (EIB).

JASPERS aims are to improve the preparation of major projects to be co-financed by the Cohesion Fund and the European Regional Development Fund (ERDF) across all Member States, providing support to project preparation, capacity building and strengthening of public administration. JASPERS is also involved in some of the IPA Countries under the regulations of the EU IPA Fund, supporting the candidate countries through gradual improvements in the practice and processes required for absorptions of the EU Funds.

In order to support these activities, JASPERS has produced a series of Guidance Notes which set out generic advice and recommendations with regard to specific areas of strategy or project preparation. This advice is intended to provide an early understanding of the requirements and expectations of JASPERS key experts.



JASPERS would like to acknowledge the important and valuable input of IMC Worldwide, **Panteia** and **Significance** into the preparation of this Guidance Document.

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# Glossary of Terms

*It is recognised that the terminology used in this report may differ between different jurisdictions. As such, a glossary of technical terms is provided here.*

| | |
|---|---|
| **Assignment Model** | The method of allocating trips between transport zones to the most appropriate routes (i.e. those with the lowest Generalised Cost) |
| **Block Train** | A train in which all cars (wagons) carry the same commodity and are shipped from the same origin to the same destination, without being split up or stored en-route |
| **Calibration** | The process of adjusting the various elements of a base year transport model such that it will fit sufficiently with observed data |
| **Cargo Cost Component of Travel Time** | The costs associated with goods being in transit, to include capital lock-up, impacts on the logistics chain, and loss in end-value. |
| **Generalised Cost** | For freight, a means of representing the full "cost" of travel between two points, which incorporates the economic value of travel time , distanced related costs, fixed costs and any other perceived costs (such as the cost of poor reliability) . Used as the basis for assignment of trips to destinations, routes and modes. |
| **Mode Shift** | The activity where transport demand (freight or passengers) will change to a different travel mode as a result of a change in the Generalised Cost of competing modes. |
| **Mode Choice Model** | The splitting of trips between modes for each OD relation based on probability models reflecting the generalised cost of relation per mode |
| **Operational Costs** | In this study, defined as those costs that are only directly relatable to the train transportation distance, such as energy (traction) costs, and infrastructure access charges. Access charges are relevant for mode choice modelling and financial analysis, however for economic analysis, O&M costs for the infrastructure (maintenance, traffic management) are the relevant costs.<br><br>All other operational costs are treated in the Transport Cost Component of Travel Time |
| **Origin Destination (O-D) Matrix** | A means of representing individual trips between origin and destination zones in a transport model. The total of all cells in an Origin Destination Matrix will be equal to the number of trips undertaken in a transport system. |
| **Reliability Costs** | The costs associated with expected or unexpected delays in the logistics chain |
| **Transport Cost Component of Travel Time** | That element of cost representing Crew Time, Vehicle Time and other Company Overheads that are related to the time that train assets are utilised. |
| **User Classes** | Categories of journey purpose, normally including commuting, business, leisure and freight as a minimum |
| **Validation** | The process of comparing a calibrated base year transport model with independent observed data to understand if it sufficiently reflects reality |
| **Wagonload Train** | Trains made of single wagon consignments of freight |

# Contents

# 1. Introduction to this Guidance

## *1.1. Overview*

For many rail infrastructure development projects, a significant part of the economic benefit is derived from savings in travel times and operating costs and by the switching of demand from road to rail as a result of the project (the mode shift leading to significant reductions in external costs).

Whilst methods for estimating and valuing such effects are fairly consistent and standard in *passenger* transport, the method and parameters of appraisal of railway corridor enhancements which provide for enhanced *freight* operations continues to be the subject of research and discussion in the wider appraisal community with a wide range of approaches and parameters applied.

JASPERS has therefore developed this guidance, with the support of IMC Worldwide as leading experts in the field, to offer a logical and consistent framework for the appraisal of impacts of *rail infrastructure projects with reference to rail freight*. The guidance has been developed based on a review of available research across the EU, a comparison of alternative best-practice methodologies, and an EU-wide market consultation with Shippers, Freight Forwarders and Rail Operators to understand the key issues driving operational decisions.

This guidance is intended to support the type of CBA analysis that may be used for options assessment and appraisal in a feasibility study or a stand-alone CBA required for project approval at a national or EU level. It does not replace the need for a proper process of strategic transport planning, which should guide the choices of main corridors and appropriate design solutions for freight at National and European level.

## *1.2. Improving the Performance of Rail Freight in Europe*

Increasing the effectiveness, efficiency and offer of freight transport on rail and thereby substantially increasing rail volumes at the expense of road is a key objective of European transport policy.

Significant mode-shift and efficiency gains can only be made however with coherent European, national and corridor transport strategies that employ a balanced combination of organizational, operational and infrastructure measures to fully support rail freight. Such measures might include:

- Increasing the cost of road transport through tolls and other fees to reflect to greater extent the internal and external costs of transport;
- Removing unnecessary red-tape/delay in rail customs procedures, crew hand over, locomotive switching etc.;
- Improving the efficiency of freight service operators and infrastructure managers (in particular public owned major national operators). This might include improved dispatching or traffic management.
- Increasing the operational priority of freight and adjusting overall timetable plans to accommodate freight fluency and reduce delay;
- Implementation and modernization of container terminals for rail/road and water/rail at perspective locations;
- Implementation and reconstruction of sidings;
- ITC measures to improve tracking and management of freight flows; and

- Modernising/upgrading infrastructure to achieve (as appropriate):
  - The elimination of capacity bottlenecks for freight on the TEN-T network (commonly found on mixed lines in highly populated areas with a strong inter-city and regional train offer);
  - The implementation of an efficient cross-European TSI standard on the TEN-T network, allowing more weight per axle (22.5 t standard) , longer freight trains (740 m standard) and standard loading gauge (cross-sectional profile – mainly sufficient tunnel and bridge clearance);
  - The removal of gradient bottlenecks (causing high operational costs e.g. need for extra locomotive, often found in hilly terrain);
  - A reduction in operational breakdowns and planned and unplanned maintenance/repair thus reducing delay and the need for re-routing of freight;
  - An increase in track speed through modernization and selected realignments; and
  - An increase in speed and energy efficiency through electrification.

### *1.3. Factors that Influence Rail Freight Transport Performance and Effectiveness*

In essence, the main driver of performance and modal competitiveness in rail and combined rail freight is the door-to-door cost in comparison to competing modes (which is impacted by travel distance, trip time and other logistics costs). As such, understanding the improvement in cost efficiency is the key to realistically assessing potential benefits.

Typically, rail freight has a much higher starting overhead cost per train than road transport, but considerably lower marginal unit costs make rail much more efficient with longer distance and larger train loads.

The cost equation can be complex and interrelated, and over-simplification of appraisal can sometimes lead to erroneous conclusions. For this reason, we have defined the most relevant variables that influence cost for defining the right investment options in any given case and for making proper appraisal[1]. These are:

- **Travel Distance**, which impacts energy/fuel costs, infrastructure access charges and travel time. Shortening or straightening railway alignments, or indeed improving capacity to reduce long detours can reduce travel distance;

- **Loading per Train,** which impacts unit distance and time costs, with higher loads leading to more efficient services. Improvements to standards that enable passing of longer freight trains at stations, improved maximum loading per axle, improved cross-sectional profile (loading gauge) length can all help to increase loading per train. Nevertheless, these all need to be ensured for the whole train route before benefits can be gained, which might well be over 1000 km long through several countries. Any assessment should provide some kind of risk analysis of how and when benefits might be achieved given the dependence on achieving standards along the whole train route;

- **Door-to-Door Travel Time and Reliability** which impacts crew costs, vehicle costs and in the longer term operator overheads, and which is impacted by time spent moving (speed

[1] For example, it is certainly wrong to say that travel time is not important for rail freight transport as it is a major contributor to freight cost (impacting crew cost, vehicle cost and overheads) which also drives mode shift. However, freight travel time might not necessarily be greatly improved by increasing the maximum speed on the infrastructure (often at high cost). A number of factors are involved in determining door-to-door travel times and a maximum speed gain does not necessarily bring time benefits. “Excessive” speed will often not be utilised by most types of freight as it would unreasonably increase locomotive and fuel costs.

related) and time spent waiting. A number of considerations are relevant with regard to travel time:

- Higher speed can improve travel time and reduce time related costs but increases operational costs (higher fuel costs, locomotive costs and higher infrastructure maintenance costs[2]). Maximum operational line speed for freight is impacted mainly by line quality, alignment, cost-efficiency and gradient but also by noise limitation requirements in built up areas;

- Waiting is an important issue at borders for customs reasons or in loading and marshalling activities and on busy lines when other types of transport have higher priority in stations and on open-track or there are frequent emergency or planned works due to poor infrastructure quality;

- Poor travel time reliability will often lead to travel time increases due to increased headroom (buffer) being built into planned travel times (either in the timetable already or planned by carriers/shippers) in order to arrive on time at the destination. Some market segments have stricter demands for arriving on time (especially for JIT delivery) and will need larger headroom if the service is unreliable. Also the risk of catastrophic (unexpected) delay is a significant factor in mode choice; and

- Travel time value expressing the depreciation of goods value (reflected in interest on the capital tied up in transit, actual deterioration, possible loss of shelf life and disruption of production/logistics processes) is in most cases of more limited importance for rail and only for certain segments (mainly higher value density and quickly deteriorating goods) but can also be evaluated.

- **Gradient,** which can impact travel time and operational costs (higher possible speed, lower fuel costs and lower locomotive costs result from reductions in gradient). This is a key issue in hilly terrain;

- **Traction**, which might typically involve electrification, and may facilitate a change in locomotive if there are different types of traction; and

- **Access costs to the railway network,** which are driven by any road access to the rail, the availability and characteristics of a suitable rail head/terminal and/or rail sidings. In many cases where access to rail is poor, costs are prohibitive already without even considering the quality of the rail service. Treatment of cost savings related to railway access improvement for freight are not covered in detail in this document and require a tailored treatment, however the general principles of evaluation outlined in this document apply. However, average terminal handling costs are included in the railway access charges found in Annex A.

Typically a rail improvement scheme will involve changes to one or more of these variables, which in turn generate the economic benefits, described below.

[2] This report does not deal in detail with increases in infrastructure maintenance costs, but it is a valid area for consideration of benefits

### *1.4. The Benefits of Rail Freight Improvements*

When appraising the impact of rail improvements, it is necessary to define those key benefits that will accrue as a direct result of changes to travel distances, train loading, travel times, gradient reductions and other sources of costs. Below we have defined four types of economic benefit that can arise from freight measures for rail:

**Type A: Operational Cost Savings**

Operational Cost Savings are an important economic benefit in their own right (and also are a significant driver of mode shift – see Type D below).

Operational Cost Savings usually relate to overall **distance**, **gradient or train make-up** changes which impact on costs by either reducing the total required km to be hauled, or by reducing unit costs per km. In principal, such costs include reductions in traction energy costs and for economic analysis the marginal costs of wear and tear which are related to the distance travelled or effort required to cover a defined transport distance.

Access charges are relevant operational cost savings for mode choice modelling and financial modelling, however for economic analysis, O&M costs for the infrastructure (maintenance, traffic management) are relevant rather than access charges, O&M costs should be set per country based on real/planned costs and will usually involve a fixed cost per track km and a variable cost per train-km or tonne-km.

Operational Cost Savings can also result from reductions in the unit costs of travel time or traction due to a decrease in the length of time that equipment such as rolling stock is in an 'Operational State'. These time-related reductions are, however, treated separately as Travel Time Savings (see Type B below) and double-counting of benefits is thus eliminated.

This document provides guidance on how to calculate changes in Operating Costs for the purposes of assessing direct financial and economic savings and modelling mode shift for different types of projects.

**Type B: Travel Time Savings**

Assessing the benefit of freight Travel Time Savings is a complex issue. There are many studies from across Member States with different conceptual valuation approaches behind them, many of which lead to different outcomes. In practice this ranges from ignoring Travel Time Savings completely; just evaluating capital tied up in goods and the depreciation of perishable goods; including just crew time costs; also including the cost of freight vehicles; and finally also operational overheads.

When making any appraisal, it is also necessary to assess whether Travel Time Savings that result from any freight measure can really lead to cost reductions in the whole logistics chain. Sometimes this can only be understood through specific market consultation.

In this Guidance, Travel Time costs not only include the cost of train crew, but also the cost associated with the rolling stock/locomotives being made available, as well as operational overhead cost. We also include an additional component that reflects the cost of the cargo being transported (mainly due to capital lock-up and loss of/risk to cargo value during transport).

Based on targeted market consultation with the industry, and informed by available research, this document provides definitive guidance on how to assess real Travel Time Savings without double counting with operations cost savings based on the best available evidence.

**Type C: Travel Time Reliability Improvements**

In most qualitative surveys of shippers and rail freight operators, travel time and overall reliability is frequently quoted as an important issue of mode choice. Reliability is generally related to the available capacity and quality of the infrastructure and the quality of the operations management (especially where there are frequent planned and unplanned works) particularly where freight has low priority compared to passenger transport and as a result can experience large waiting times.

Poor reliability of travel time imposes costs through its impacts on the logistics chain (which depends on the type of goods being delivered). In many cases where rail reliability is poor, headroom (buffer) is built into travel timetables or travel planning in order to ensure on-time arrival. This therefore translates into longer effective travel times, with resulting increases in travel time cost (as outlined in Type B above) and resulting impacts on mode share. On the other hand, unexpected variation in travel time may not be already built into the planning and hence can disrupt production schedules or lead to additional costs for onward transport, thereby leading to additional unforeseen costs. In some cases, a shipper may perceive a risk of unacceptable (catastrophic) delay, which may dissuade that shipper from using the rail mode.

For major investments, it is often necessary to examine how and to what extent infrastructure improvements can have a significant impact on travel time reliability and how this can be practically and consistently measured and evaluated in economic terms. The measurement of reliability is however a complex issue. Although various approaches have been adopted for individual studies, there is as yet no commonly accepted approach. This document provides guidance on a methodology for assessing reliability benefits based on the best available evidence.

**Type D: External Cost Savings resulting from Mode Shift from Road to Rail**

It is clear that Mode Shift of freight to rail is usually a main goal in line with European and national policy and a main source of potential economic benefits for major interventions in rail freight infrastructure and operations/organisation due to reductions in emissions, noise and traffic accidents. For any major investment in rail freight corridors, it is therefore desirable to be able to reasonably assess the potential for mode shift.

Many rail freight movements are international (in particular but not only container shipments) and thus any assessment of mode shift potential needs to consider the international context of origin-destination movements and transport service/infrastructure per market segment. It is clear that for shipments over very long distances, the reduction in external costs due to mode shift can become substantial.

Whilst there are a number of approaches available for estimating Mode Shift, this document provides guidance on how to assess Mode Shift in order to produce a reasonably robust analysis.

It is noted that external cost savings can also be achieved without mode shift through efficiency improvements in rail and changes in technology such as electrification.

Conversion of mode shift into externality savings and their subsequent monetisation are not covered in this document but are covered for example in the EU 2014-2020 CBA guide and by a number of international studies.

**Loss or Damage**

Understanding the probability of loss or damage is often quite subjective, and in any case is likely to be a small element of the Economic Analysis. The market analysis (See Annex B) concluded that loss/damage is rarely a decisive factor for (not) using rail, and that the issues of operating costs, time and reliability are far more important. It is therefore not proposed to develop a methodology here for assessing the benefit of changes to the probability of loss/damage, although this is not to say that a case for damage/loss reduction benefits cannot be made. In a case where loss/damage is seen as an important feature of a project, this needs to be based on solid market consultation and a robust methodology for determining the value of such gains.

### *1.5. Scope/Context of Appraisal and Defining 'Significance' of Rail Freight Measures*

When undertaking an appraisal, it is important that the benefits that are evaluated should reflect the significance of those possible freight related benefits and investments. For example, major data collection and wider network modelling work to calculate Mode Shift effects need not be undertaken unless Mode Shift is likely to be a significant response to a project, or where the expected benefit for mode shift needs to be captured in order to justify a project or a project option. Likewise, a project that might lead to Travel Time Savings but will have little or no impact on Travel Time Reliability need not undertake any analysis of reliability as it would not be expected to yield any significant project benefit.

In order to assist in defining the types of benefits that might need to be measured as part of any evaluation, we have therefore defined 3 broad levels of rail project below, each of which has increasing complexity of responses, and hence increasing requirements for appraisal of freight impacts.

These definitions can therefore help describe the range of benefit types that are likely to be worth calculating in an evaluation. They are based on the nature/complexity of a project and not necessarily related to the volumes of freight impacted (although it is somewhat related). In some cases, a practical market consultation, combined with the skill and judgement of an expert, in addition to an initial benefits scoping will be required to fully understand the range and significance of impacts arising from any one project.

**Low Freight Significance**

Projects defined as 'Low Significance' are those that are likely to generate only limited benefits for rail freight. This may arise in the case of works on the network where there are low volumes of freight with limited potential for growth and/or where the measures of the project might lead to relatively small Travel Time or Operational Cost Savings for that freight traffic.

As such, the assessment might be either left out altogether (if considered negligible) or restricted to assessing direct cost savings, mainly related to Travel Time or Operational Cost Savings. No mode shift modelling would need to be undertaken. Likewise, an assessment of reliability impacts will very probably not be relevant.

The scope of analysis for these projects might be restricted to the geographical boundary of the project in question with only a simple section-based demand analysis required, without the need to consider network effects or origin-destination movements.

**Medium Freight Significance**

Projects defined as 'Medium Freight Significance' represent those projects where current or future potential freight demand is significant. The measures of such projects are also expected to lead to more notable Travel Time Savings, Operational Cost Savings and possibly even Reliability Improvements (some market consultation may be required to understand potential reliability impacts). Mode Shift however is not expected to be a significant response in these cases. This normally means that:

- the projects generally do not address either significant bottlenecks such as capacity constraints (common in rail junctions or poor access to the railmode; and/or
- the dominant existing and potential freight market segments are not very mode-sensitive to the sort of measures being put in place (e.g. maximum train length improvements on lines dominated by heavy commodities or where rail already has nearly 100 % market share for these segments).

Assessment should generally be restricted to assessing direct cost reductions related primarily to Travel Time Savings or Operational Cost Savings. In cases where Travel Time Reliability is a major issue which will be addressed by the project, then it may also be advisable to assess this. Mode Shift modelling will not normally be undertaken unless easily tested with an existing model. If small levels of Mode Shift are expected, and in cases where they do not contribute significantly to the economic benefits, it might be calculated using a simplified conservative approach.

The scope of analysis for these projects might be restricted to the geographical boundary of the project in question with only a simple section-based freight demand analysis required, without the need to consider network effects or origin destination movements.

In cases where demand is high (e.g. for major bulk lines), market consultation may be advisable to better understand the future demand and potential impacts of the project on travel time efficiency (e.g. is there a stable demand for the goods flow into the future, does the project lead to real door-to-door travel time savings and will there be a full impact on the efficiency of use of the rolling stock?).

**High Freight Significance**

Projects defined as 'High Freight Significance' mainly represent those where current or future potential freight demand is significant and the measures of the project would be expected to lead to substantial changes in the level of service (e.g. Capacity Increase, Travel Time Savings, Operational Cost Savings or Reliability Improvements) usually leading to Mode Shift responses, and also possibly Reassignment (rerouting) of rail freight from „competing" railway corridors over significant distances. A substantial portion of the freight market relevant to the project is normally expected to be mode-sensitive to the measures being put in place.

Such projects might typically include:

- longer corridor sections including stations or major junctions resolving significant freight capacity or performance bottleneck(s) including upgrades to TSI standards;
- significant freight facility upgrades, expansion or new build (such as an intermodal terminal);
- new lines serving areas/regions previously served only by other modes;
- other key organisational or operational measures to improve freight transport (such as improved priority or reduction of operational incompatibilities across borders)

These types of projects will normally involve assessing the full scope of freight benefits considered in this report, with an assessment of Travel Time Reliability if it is considered to be an important issue which the project will address.

Initial market consultation and policy mapping is certainly advisable to understand the wider (often international) project demand and network context including realistic impact potential/constraints for different segments of the market. For example it is important to understand network bottlenecks along whole door-to-door routes and the plans for their removal.

The physical/market scope of appraisal should cover all significant origin-destination relations and distinguish between commodity/train types. This will typically require a multi-modal demand model and forecast with this kind of scope both for the demand part (origin-destination relations) and the supply part (network), often following an international corridor or a wider network, including alternative routes.

The table below presents a simple summary of the different categories of project outlined above.

*Table 1.1: Defining the Significance of Rail Freight Measures within a Project*

<table>
<tr><th></th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Profile of Demand and expected demand impact</td><td>• Low existing and potential demand freight demand with limited expected demand impact of project</td><td>• Significant existing or potential demand but with limited expected demand impact of project</td><td>• Significant existing and/or potential demand with significant expected demand or re-routing impact of project</td></tr>
<tr><td>Typical Examples of Measures</td><td>• Line speed improvement<br>• Local realignment</td><td>• Localised line speed improvement relevant for freight<br>• Local realignments<br>• Localised replacement of infrastructure at end of its lifetime<br>• Signalling or capacity enhancement to improve reliability<br>• Modernisation of significant bulk lines with a captured rail market and without capacity issues</td><td>• Elimination of major capacity or standards bottlenecks<br>• Major replacement of infrastructure at end of its lifetime<br>• Corridor line speed improvements relevant for freight<br>• New railway line or new/upgraded freight terminals</td></tr>
<tr><td rowspan="4">Typical Significant Benefits</td><td>Travel Time Savings for trains and goods (if not negligible)</td><td>Travel Time Savings for trains and goods</td><td>Travel Time Savings for trains and goods</td></tr>
<tr><td>Operational Cost Savings (if not negligible)</td><td>Operational Cost Savings</td><td>Operational Cost Savings</td></tr>
<tr><td></td><td>Reliability (if relevant)</td><td>Reliability Improvements (if relevant)</td></tr>
<tr><td></td><td></td><td>Mode Shift</td></tr>
</table>

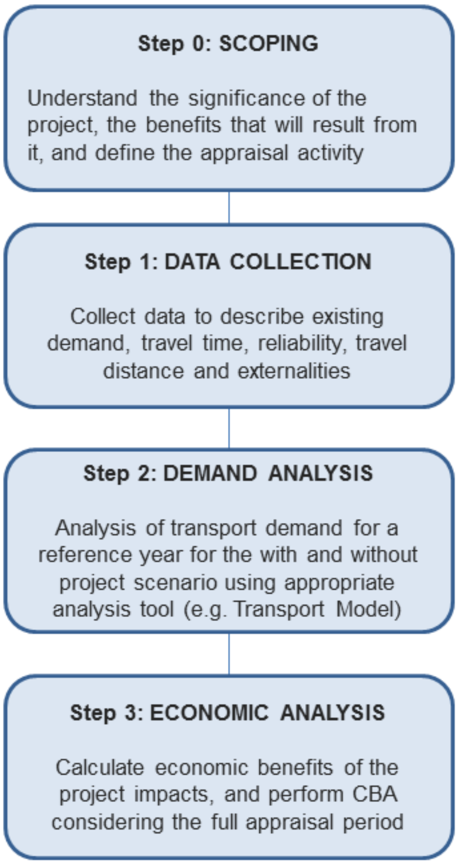
### *1.6. Procedure for Appraising Rail Freight Improvements*

First we note that in most cases, appraisal of projects is best carried out as part of a wider Feasibility Study considering options and the whole range of risks for achieving benefits and implementation, including (where it makes sense) different options aimed at freight transport.

The appraisal of rail freight projects can be described by three basic Steps, in addition to an initial scoping activity (Step 0). The approach to undertaking each of these Steps is presented here,

**Step 0: Context and Problem Analysis, Market Consultation and Scoping**

The initial scoping exercise is fundamental to fully understanding the anticipated impacts and significance of a project, and hence informing the specification of activities in Steps 1 to 3. Activities associated with the Scoping might include:




- A review of previous analyses from, for example, European policy, EU corridor studies, existing regional or national Transport Plans or previous Feasibility Studies to understand the likely impact and the overall context of the project;
- A Market Consultation with industry representatives (shippers, freight forwarders, transport operators, infrastructure manager) to understand market needs, possible project impacts and potential areas of new demand if relevant;
- Preliminary investigation of data to understand the basic level of demand potential and areas of non-performance relevant for freight (e.g. highlighting poor reliability) and hence those areas upon which the project appraisal should focus; and
- Preliminary analysis of the potential project impact (Pre-Feasibility) using strategic models or elasticities where necessary

**Step 1: Data Collection**

Collect data to describe the following for the Base Scenario:

- transport flows per train type in net tonnes;
- parameters of the existing infrastructure, including any relevant infrastructure outside the scope of the project which might dictate the effective project capacity or the type/weight/size of trains that can run on the project section (e.g. an upstream or downstream bottleneck determining);
- origin-destination movements per commodity group in tonnes for each transport mode (if required for mode shift modelling)
- transport distances;

- transport time;
- transport time reliability (if required);
- transport unit costs, (if default values are not used); and
- other costs such as goods handling costs as appropriate.

This should be done segmented by commodity group and train type as necessary (see Section 4 of this report and Annex B)

This data collection has a dual purpose. Firstly, it assists in describing the existing situation and demonstrating the 'need for investment' through analysis of current problems/potentials. Secondly, it provides the necessary data for the development of the Future Year Without-Project Scenario in the transport model (i.e. the scenario without the project against which the With-Project scenario is compared) and the related future problems/potentials. The necessary data collection should be defined before data collection begins.

**Step 2: Demand and Operational Analysis**

*[See Chapter 3 for more detailed discussion on Demand Analysis]*

This next Step requires the use of an appropriate analysis tool (e.g. Transport Model and/or Operational Model) to generate transport conditions for the future year scenarios (the Without-Project and the With-Project scenarios). Analysis tools might comprise:

- Section or junction demand forecasts for Low and Medium Freight Significance projects either taken from existing (e.g. national) models or starting from existing flows and simplified assumptions about the main drivers of expected demand (e.g. assumed elasticities to GDP derived from literature).
- Modal Split models with commodity segmentation for High Freight Significance projects which allow an assessment of the attraction of new demand to rail from other modes between various origins and destinations. These may be newly constructed or adapted existing models for a specific project or they may be existing national/regional models that are available for use; and
- Operational Models which allow specimen timetables to be defined within a network that incorporate capacity limitations, and which therefore allow capacity, reliability and travel time impacts to be defined in congested networks;

If proper mode shift models are not available, and it is not possible to improve existing models or build new ones, then as a last resort one might use more generic approaches, such as the simplified transport models HIGHTOOL and an elasticity-based model such as EXPEDITE, for a quick scan analysis. In the case of reliability, the best alternative to using Operational Models will probably be manual adjustment of existing data on the transport time distribution.

**Step 3: Economic Appraisal**

*[See Chapter 4 for more detailed discussion on Economic Appraisal]*

In this Step, the benefits are calculated and the Economic Appraisal is elaborated. As discussed earlier, the benefits might include:

- Type A: Operational Cost Savings

- Type B: Travel Time Savings
- Type C: Travel Time Reliability Improvements
- Type D: External Cost Savings resulting from Mode Shift from Road to Rail

The general approach to Economic Appraisal requires the conversion of all benefits into monetary units. In the benefit types above, only Type A (Operational Cost Savings) will be already in monetary units, whereas all other benefit Types will be expressed in other physical units and hence will require conversion using unit monetary values.

The estimation of Operational Cost and Travel Time Savings are relatively straightforward, using the approaches and parameter values that are presented in Chapter 4 of this report. Reliability Improvements will typically be expressed as an equivalent travel time, and hence can be converted to monetary units using Value of Time parameter values. For Mode Shift, benefits will not only relate to the change in Operational Cost, Travel Time and Reliability but should also consider reductions in External Costs (reduction in emissions, accidents and potentially decongestion associated with the previous mode of transport).

For all benefits mentioned here, except the Operational Costs Savings, unit conversion values are therefore needed. These should ideally be as a result of specific country, corridor or project specific valuation studies, notably stated preference investigations. However, it is recognised that such will often not be available/ possible and default values are therefore provided in Chapter 4 of this report.

When preparing the Economic Analysis, the appraisal period is typically over an extended period (e.g. 30 years). As such, time escalation factors are required to reflect increases in demand and increases in parameter values through the period. This is also discussed in Chapter 4.6 of this guidance.

# 2. Data Collection

### *2.1. Relevant Data for Rail Freight Projects*

Data is an inherent part of the assessment of the impacts that proposed measures will have on rail freight. The data to be collected should, in essence, reflect the scope of impacts that are expected – for example a project with Low Freight Significance is likely to require a lower level of data collection than a project with High Freight Significance.

Common to all projects is the need to establish a robust understanding of the reference scenario (Without-Project Scenario) such that a forecast of the impacts of the project can be undertaken (With-Project Scenario). It is the difference between these two scenarios that defines the impact of the project.

The Without-Project Scenario is developed by first constructing the Base Year Scenario (i.e. a representation of current conditions) which is then carried forward to the future years Without-Project Scenario using assumptions based on economic growth, changes to the spatial distribution and types/volume of business activity creating freight transport and other committed network investments/changes to the operational model.

This guidance is not focused on base case freight volume forecasting, however this is an important part of any freight assessment. For freight rail projects in particular, there are often just a few industrial sources for the majority of the traffic volume and therefore for a base future forecast a micro-level understanding of the market is often necessary (with the help of market consultation) as well as a macro-economic perspective.

In this regard, the datasets presented below should typically be collected to support in the development of the Base Year scenario:

*Table 2.1: Data Collection to Assess the Impact of Rail Freight Measures*

| **Project Significance** | **Low** | **Medium** | **High** |
|---|---|---|---|
| **Freight Demand** | • Existing corridor flows for each type of train (e.g. block trains / wagonloads / container trains). Demand needs to describe rail mode only. | • Existing corridor flows for each type of train (e.g. block trains / wagonloads / container trains). Demand needs to describe rail mode only. | • Matrix of demand by origin-destination for each type of train (e.g. block trains / wagonloads / container trains), and for road transport. The data should be segregated by goods type (for example, NST2007 categories or aggregations of this[3]). The data should cover the **full area that will potentially be affected** by the project.<br>• Matrix should be prepared to describe all competing modes.<br>• If as a last resort an elasticity method is used, |

[3] Solid Bulk, Liquid Bulk, Containerised Cargo and General (non-containerised) Cargo should be defined as a minimum.

| | | | |
|---|---|---|---|
| | | | only the railway matrix is needed.<br>• Parameters of the infrastructure including important upstream and downstream bottlenecks or constraints. |
| **Travel Time** | • Existing travel time along the corridor, with timing points at key nodes including the start/end of the actual improvement works. | • Existing travel time along the corridor, with timing points at key nodes including the start/end of the actual improvement works. | • Travel time between each Origin-Destination pair, with measurements obtained for each travel mode. Data might be collated from observations or through the interrogation of timetables.<br>• Travel time may be required for competing railway routes where re-routing of rail freight is expected. |
| **Operational Cost** | • Distance along the corridor, with chainage points at key nodes including the start/end of the actual improvement works.<br>• Average loading per train.<br>• Number of wagons per train (if default values not used).<br>• Gradient of the line (if applicable).<br>• Type of traction being used. | • Distance along the corridor, with chainage points at key nodes including the start/end of the actual improvement works.<br>• Average loading per train.<br>• Number of wagons per train (if default values not used).<br>• Gradient of the line (if applicable).<br>• Type of traction being used. | • Existing distance between each Origin-Destination pair, with measurements obtained for each travel mode.<br>• Average loading per train.<br>• Number of wagons per train (if default values not used).<br>• Gradient of the line (if applicable).<br>• Type of traction being used.<br>• Costs of alternative modes |
| **Reliability** | Not Applicable. | • Measurements of travel time distribution along the corridor..<br>• Estimates of buffer times in timetable if reserve is built into timetables. | • Measurements of travel time distribution between each Origin-Destination. Measurements are required for the rail mode only.<br>• Estimates of buffer times in timetable if reserve is built into timetables. |

In some cases, there may be already a transport model that has been developed that has generated the relevant datasets above (see Chapter 3 for more detailed discussion on Transport Models). In such cases, the information outlined above may be drawn from the existing transport model, although care is needed to ensure that the transport model is fit for purpose for the relevant project.

In the measurement of demand, note that the assessment requires consideration of the *Full Area that will be Significantly Affected* by the project. For freight projects of High Significance, this may be a large area, particularly where there is a significant attraction of demand from other modes or existing routes over long distances. For example, an improvement on a strategic corridor that attracts long-distance road haulage to rail can lead to goods transfer from parts of the network that are quite distant from the location of the proposed works. For this reason, projects defined as High

Significance may need to consider the impact of a project on networks that stretch far beyond the immediate corridor being examined.

The measurement of Travel Time Distribution can be achieved through measurements of the observed Standard Deviation of Travel Time. This is only required for the rail mode – measurements of other modes are not relevant unless a change in travel time distribution for those modes is also expected as a direct result of the project.

*2.2. Project Data on the With-Project Scenario:*

The data to be measured for the With-Project Scenario is as follows:

- Total Travel Time changes and changes to Unit Travel Time costs for the project (e.g. related to train speed, waiting times, train length, axle loading) calculated based on the line design parameters and operational reactions to these; and
- Operational Cost changes (relating to travel distance, fixed costs and changes to Unit Operational Costs affected for example by gradient, axle loading or traction type) for the new project, calculated based on the alignment and design standards;

It is noted that the impact of a project may vary according to train type. For example, an electrification project will only have an impact on those trains that will change to electric traction. Likewise, a measure to increase line speed may only impact those trains that have the ability to travel at the new increased speed (e.g. Bulk trains may be limited to lower operational speeds)

It is through using these measurements derived from the project concept and expected operational reactions to it that the other impacts (Mode Shift and Reliability Improvements) can be assessed. This is discussed briefly below:

**Estimating Mode Shift**

Mode Share in a transport system is estimated based on a comparison of Generalised Costs for different transport modes. Generalised Cost, in turn, is a combination of Travel Time, Operational Cost and Reliability Indices for a defined movement. As such, modifying the operating cost/time/reliability inputs will change Generalised Cost for one mode and will therefore lead to a different Mode Share for that mode. This is how the revised rail demand is calculated for High Significance Projects.

The use of Transport Models to calculate Mode Shift for High Significance Projects is discussed in Chapter 3 of this document.

**Estimating Reliability Changes**

As with demand, these impacts cannot be estimated directly from a project concept. There are two broad approaches to developing estimations for reliability changes as follows:

- For projects where reliability impacts are not the major effect of the project, the Travel Time Distribution (expressed as either Standard Deviation of travel time, or as absolute headroom in the timetable) may be modified manually by taking an assumption that previous poor levels of reliability will improve to more nominal levels of reliability. Such an approach would require clear justification for the expected improvement in reliability (e.g.

upgrading from single to double track) and the benchmarking of assumptions for the new reliability against other comparable parts of the network; or

- For complex projects where reliability improvements are a major source of scheme benefit, the analysis may use an operational model (microsimulation of train traffic, e.g. RAILSYS) to demonstrate how perturbations in the operating schedule can be reduced with the removal of a capacity bottleneck. The output from that analysis can then be expressed as a Standard Deviation in travel times. This impact can also be converted to a reduction in reserve times due to reduced delay risk, which can be added to travel time savings.

Using Operational Models to estimate the benefits of reliability is discussed in Chapter 3 of this document.

### *2.3. Guidance on Collecting Data*

The collection of transport data requires the use of an unbiased, representative collection of information from a transport system. The guidance here outlines some basic requirements for the collection of different elements of data.

**Measuring Travel Times**

Travel Times for rail can be measured from timetables (Scheduled Time), through site observations (Observed Time) or through an engineering assessment of the transport network (Theoretical Time).

In reality, theoretical travel time is unlikely to be achievable, as constant perturbations and conflicts within a system will always lead to some form of delay/underperformance. Scheduled Time is generally a good representation of travel times in a system, on the basis that it includes headroom for expected delays and is therefore (supposed to be) representative of the Observed Times that are achieved. Such timetables for freight and passenger traffic are generally available from infrastructure managers.

For other modes, travel times may be measured through fieldwork, using manual observers, moving observers, or vehicle matching (through number plate matching or Bluetooth systems). As with all surveys, a sufficiently statistically significant representative sample is necessary that cover all periods of a typical day and week.

**Measuring Travel Time Reliability**

In the case of unexpected delay (i.e. delay not already included as headroom in the timetable), the difference between Theoretical Time and Observed Time relates to delay, and the distribution of this delay is an input to the reliability calculation. In calculating the Observed Travel Time and the standard deviation of travel time, a sample of at least 50 observations should be sought, with as good as possible a spread throughout the year (transport may experience different levels of reliability during different times of the year).

**Measuring Demand**

For projects of Low to Medium Significance, the demand for rail/waterways freight per train type can generally be established through a request of data from the Infrastructure Manager on the number of vehicles and goods tonnage. Such data may also be available from rail operators, ranging from detailed origin-destination data to basic representations of trip-ends, or sometimes in the form of total tonnage across borders. Where information is not made available or is insufficient, more detailed analysis using field observations of vehicles, estimated tonnage and train type (wagon load/block/container trains) will be necessary.

In the case of High Significance Projects, data for road demand might require fieldwork to determine tonnage on the corridor, calculated as a factor of the number of vehicles and an assumed average load.  Again, separation by haulage type (container/bulk/general cargo) will be important.

In the case of High Significance Projects, the development of an Origin Destination Matrix (for all relevant modes) may require a detailed schedule of data possibly including a combination of Freight Travel Surveys, Roadside Interviews, National/Regional Economic Data, Freight Operator Data, National/International Statistics or O-D data from an existing model.  The development of a network-based Mode Share model therefore requires the input of relevant experts and is not fully described here.

# 3. Transport Modelling of Freight Movements

## *3.1. Introduction*

Transport Models represent different forms of Analysis Tools that are used to support in the estimation of scheme impacts. The development of Transport Models is generally based on the use of available data to describe an existing situation, with a forecast model developed for one or several future years (at least years of scheme start and end) and with the model then used to quantify how that situation changes under different inputs (e.g. changes in the transport network or changes in transport costs in the with and without project scenarios).

This chapter of the document will describe the use Transport Modelling tools for freight assessment, as follows:

| | |
|---|---|
| Mode Share Models | These models are used to estimate how freight demand switches between modes when the relative competitiveness of each mode changes. In the current context, changes in costs of rail may lead to capture of demand from other modes – the Mode Share Models estimate the allocation of demand between competing modes based on a comparative analysis of costs for those different modes; and |
| Assignment Models | The models are used to determine the routing of freight through railway networks. Typically, assignment models are only relevant in complex or congested networks where multiple competing freight routes exist. In simple networks, this assignment can often be undertaken by manually allocating freight to an alternative route following an upgrade – although note that forcing freight trains to follow longer routes can lead to an increase in operational costs and hence generate a disbenefit for a project. |
| Operational Models | Operational Models replicate the complex routing of railway services through complex rail networks. They use information on signalling, track layout and speed limitations to allow working timetables to be developed, and allow the robustness/reliability of those timetables to be assessed based on perturbations in the system that are defined by the user. They are also used to better understand bottlenecks in the network which may significantly suppress the demand potential for rail freight. |

Guidance on **Mode Share Models (potentially combined with Assignment Models)** and their application in assessing the impacts of rail freight improvements is presented here, and refers almost exclusively to projects of **High Significance**.

## *3.2. Recommendations on Types of Mode Share Model*

When many of the project benefits in rail projects are expected to come from modal shift, multimodality is important. A unimodal model is generally not sufficient here (unless elasticity approaches are used although these are not recommended), what is required is a multimodal model that includes the competition between rail and other modes (certainly including road transport; in some situations also inland waterway transport and short sea shipping).

The module within transport models that is most relevant is the modal split (or mode choice) model. This is the module that is sensitive to changes in transport cost by mode, which can be changed for the rail mode by the projects investigated. Production, attraction and distribution of freight transport are usually not sensitive to changes in rail time and cost and therefore not discussed here. Route choice models (network assignment) are needed to determine the rail routes used and therefore also the distance and time by rail in the reference and project situation. So, route choice in the rail network is important for CBA, but for rail freight the networks are not generally very dense and the optimal routes can often be determined quite easily using manual methods.

Within the models for modal split, the three types that are used most in Europe are the following.

- Disaggregate models for freight transport are used in Scandinavia and Germany;
- Aggregate logit models for freight transport are used in The Netherlands, France and in the European models (NEAC and TRANSTOOLS); and
- Multimodal assignment models for freight were used in Scandinavia and The Netherlands, but have been replaced by other types of models. The model for the Walloon Region in Belgium uses multimodal assignment and so does the Great Britain Freight Model.

**Disaggregate Choice Models** (models at the level of the individual decision-maker: the firm, or the shipment) require the collection of disaggregate data. In JASPERS countries under the current circumstances these are unlikely to be available. It is possible to collect project-specific disaggregate data, especially Stated Preference (SP) data (which is a form of disaggregate data), but a forecasting model for modal split should not be based on SP data alone (monetary values on the other hand, such as VTT and VTTR, can be based on SP data).

**Aggregate Logit Models**, on the other hand, use data aggregated across all shippers for each origin-destination movement between the zones. To construct these models, aggregate data on flows are therefore required by commodity type in tonnes by mode between the zones. The aggregate logit models can be estimated statistically based on this data along with a unimodal network model of appropriate geographical scope and an appropriate generalised cost model underpinning this (segmented at least by block, wagon-load and container trains) for each mode in the model.

**Multimodal Assignment Models** are those models that deal only with route choice, based on a comparison of generalised cost for each possible route between an origin and destination. If not correctly applied, these models may assign all demand along the cheapest path between zones which is not always a reflection of the complexity of transport decisions. To address this weakness however, stochastic assignment can be used to obtain realistic flows for several alternatives per flow in the network. This is essential especially in cases where there are only a few origin-destination movements are being considered.

**Elasticity Models** are a more simple form of Mode Share Model. The transfer of demand between modes is based on a % sensitivity (elasticity) to a % change in costs for one mode on a particular origin-destination relation (in this case we would look at the change in costs of rail). Such an approach ignores the relative cost and proportion of the other modes and is therefore relatively crude in application. Elasticity models do have the advantage however of taking into account the total trip cost when calculating the sensitivity of mode shift to changes in that cost (logit models generally do not), which can be useful when there are large differences in distance between the different origin – destination movements considered. They also require no knowledge of the demand for other modes.

*Table 3-1 Advantages and Disadvantages of the Mode Share Models*

| Type | Advantages | Disadvantages |
|---|---|---|
| **Disaggregate Choice Models** | • Theoretical basis<br>• Potential to include many causal variables and policy measures<br>• Can be statistically estimated on data<br>• Can handle choice between transport chains (and shipment sizes) | • Need disaggregate data (shipper or commodity survey and/or SP) |
| **Aggregate Logit Models** | • Lower data requirements<br>• Can be statistically estimated on standard statistical data on freight movements per commodity | • Weak theoretical basis<br>• Little insight into causality |
| **Multimodal Assignment Models** | • Can be statistically estimated based on data<br>• Also deals with routing in complex networks | • Higher data requirements<br>• Potentially higher model complexity<br>• Little insight into causality |
| **Elasticity Models** | • Very limited data requirements<br>• Fast in application | • Elasticities may not be transferable over space and time<br>• Only impact of single measures, no synergies<br>• Do not explain impact on mode share |

Our recommendation is generally to use **Aggregate Logit Models** (multinomial or nested) for mode choice in freight transport. The aggregate data (flows by commodity type in tonnes by mode between zones) that are required here are more often available than disaggregate data or can be modelled synthetically based on statistics on production and attraction factors per model zone. These can be either network models also considering routing within a mode or pure O-D models which consider choices between road and rail.

The use of Elasticity Models applying elasticities derived from literature is generally supported as a scoping tool to understand *approximate* impacts of a project on demand. In the case of High Significance projects, there is still therefore a need for a more sophisticated model providing a more definitive mode shift estimation tool.

### *3.3. Scoping of an Aggregate Logit Mode Share Model*

General guidance on the development of Transport Models is set out in **Jaspers Modelling Guidance**[4], which sets out the steps to be taken in the development of such models. That Guidance highlights the necessity of a Scoping Stage as an important first step in the model development exercise. That stage applies not only to the development of new models, but also to the review of existing transport models before they are applied on the appraisal of any project.

With regards to the development or application of freight models in particular, the following questions are most relevant to the scoping stage:

- Does the likely range of possible impacts warrant the development of such a model (a range of possible mode shift to cost change elasticities from the literature and a high level

[4] JASPERS Appraisal Guidance (Transport): The Use of Models in Transport Planning and Project Appraisal (2014)

simulation of the economic impacts of such mode shift relative to the relevant part of the project cost can be made to do this scoping).

- Can the model include all the relevant networks and modes (certainly road and rail, also inland waterways and short and long sea shipping if these compete with rail in the study area)?
- Can the model distinguish between different types of train in terms of the calculation of transport costs (preferably distinguishing at least block train, wagonload train and container train; also diesel versus electric traction)?
- Can the model include the required policy variables (transport cost, time and preferably also reliability)?
- Will the model use different segments for different commodity groups (at least bulk versus general cargo) in terms of different behaviour between segments (different model coefficients per segment) and in terms of outputs that the model can provide?
- What type of data is to be used? Stated Preference data is suited for deriving monetary valuations for weighting the various elements of the generalised cost function, but not for the mode shift scaling factors or mode constants of forecasting models - this requires data that are fully or partly revealed preference (RP). Other types of data are time series and panel data (both of which are best suited for short to medium term forecasting); and
- Can the model be estimated on the relevant data using statistical methods, so that measures of model fit and significance of estimated coefficients are available and statistical test can be performed?

The above questions are equally applicable when reviewing an existing transport model to understand its appropriateness for the assessment of a specific project. When reviewing such existing models, a number of additional questions are relevant:

- For models that are statistically estimated, does the model achieve a fit in terms of $r^2$ or Log likelihood value relative to benchmark models, and what are the standard deviations or t-ratios of the estimated coefficients (t-ratios should be below -1.96 or above 1.96)?
- Do the estimated coefficients have the right sign? and
- Are the relative sizes of the effects of costs and time (etc.), expressed as elasticities, plausible within their segment?

If the above list highlights any issues in relation to the quality of a model, refurbishment of that model may be necessary prior to it being used in a project appraisal.

### *3.4. Updating an Existing Aggregate Logit Model*

In the cases where a model lacks relevant modes or transport costs, has implausible elasticities, or is simply outdated it can be a significant task to repair such a model. In those cases, it may be more cost effective to develop a new model. When updating a model (one should consider the following:

- Ensure that each transport mode includes a representational model of relevant transport costs which can reflect likely changes caused to the cost base by the project (including time-dependent costs such as crew/overhead/vehicle costs, and distance-dependent costs such as traction power and infrastructure access charges;

- Some models might additionally include the influence of time on modal split through the cargo itself (e.g. interest cost on the cargo in transit). But if these would not be part of the model, the transport model can be improved/extended by adding an extra influencing variable to the modal split model, whose influence relative to transport cost depends on the cargo component value of time.;
- In a similar way, the Mode Share Model can be improved/extended by adding a reliability variable to it, with a coefficient that is derived from the value of reliability. We measure reliability as the standard deviation of transport time.

Whenever a significant change is made to a Transport Model, the model needs to be re-calibrated, so that for the base year it will predict the observed shares of the available modes. This re-calibration is not only needed when new variables have been added to the model, but also when the study area of the model and the project are different. An example of this would be a national model that has to be applied for a specific corridor within a country. This requires that in the corridor zones at a fine geographic level are kept, but outside the corridor zones will be aggregated. The market shares of the modes at the national level and the corridor-level will differ and the model first needs to be recalibrated so that for the base situation it predicts the observed mode shares for the project corridor.

### *3.5. Developing a New Aggregate Mode Share Model*

Should there not be an transport model available that is appropriate or can be improved to become appropriate, the next best option is to construct a new model, specifically for the study area (the model building can sometimes take at least half a year and the need in the context of project justification or options comparison should be well demonstrated).

These models are generally built by revealed preference approach using existing aggregated mode share market segmented origin destination data, but can also be supplemented with data from stated preference surveys with shippers and forwarders.

The key activity in the model construction is to estimate an aggregate logit model for modal split that best explains the available data. First one needs to decide which modes will be used in the model (rail, road, inland waterways and/or short/long sea shipping). The availability of modes can differ by origin-destination pair. Within rail transport, a further distinction between container, wagonload and block trains is highly recommended and if possible also between diesel and electric trains. The data needed for estimation should all refer to the same base year. This should include:

- As variable to be explained, the observed shares of the modes in the transport flows (in tonnes) between the zones, with some distinction by commodity class (at least between bulk and general cargo but the more classes, the better the chance of a good statistical fit per class); and
- As explanatory variables, the transport cost by mode (and vehicle type such as train type, if these distinctions can be made) between the zones, the transport time between the zones and if possible also the transport time reliability (standard deviation).

The number of observations then is the number of origin-destination combinations. Each alternative (minus one for normalisation) should also include an alternative-specific constant (mode-specific constant) as explanatory factor, to account for other differences between the modes (on average) than in cost, time and reliability (or other factors that are explicitly included in the model).

After the logit model has been estimated, it needs to be implemented (programmed) into a computer programme that can be used to predict the mode shares for a reference and a and a project situation. This can be done in a scientific programming language (e.g. C# or Delphi), a spreadsheet (if the model remains relatively simple) or specific transport modelling software (such as CUBE, VISUM, OMNITRANS, EMME). These transport modelling software packages can also handle the choice of route and the calculation of transport distance and time on a network if needed. The data used in the model predictions refers to the same explanatory variables as used in estimation, but now the values that these variables take should reflect the reference and the project situation in the future

### *3.6. Using Elasticity Models*

If no transport models are available or can be constructed for use in a specific project case, one may apply a simple Elasticity Model to gain an indicative understanding of project impacts.

Note however, that transferring a single elasticity (e.g. for the impact of rail cost on rail demand in tonne-km) from one country to another to reflect all freight transport is not recommended. To make the elasticity approach work as a reasonable approximation of a full local transport model, it is required to distinguish elasticities by segment (e.g. commodity and distance class).

One might for instance re-use the EXPEDITE elasticities (dating back to 2002). These are elasticities by mode, segmented by commodity type and distance class for the impact of time and cost changes, by mode, on tonnes and tonne-km by mode, derived from runs with various national and European transport models (taking averages over models for the same segment).

When one uses elasticities from the literature, the transport cost function to use can be chosen freely (since there is no transport model with its own transport cost functions). So it would be possible to use detailed cost functions (with distinctions in unit values between countries), then calculate percentage changes on costs that would result from the project and evaluate the impact of these on transport demand using a set of elasticities.

Based on the large differences in elasticities presented in the literature, we recommend distinguishing elasticities by mode, commodity type (especially bulk versus general cargo) and by distance class, by input variable (e.g. time or cost) and by output variable (e.g. tonnes or tonne-km). Distinguishing also by the current market share (e.g. segments defined as different mode share bands) is more problematic - if the market share is high there should be an explanation as to why it is high (based on the size of the transport flow, the distance, the prices, the quality offered, etc.) instead of taking this high share as a given.

However, there can be specific situations where the market share of rail is so close to either 0 or 100% that the use of elasticities from the literature, that are probably based on more competitive situations closer to the middle part of the logit curve) are not representative. Coal movements for instance with a 100% market share for rail should have an elasticity of 0 or very close to 0. When using elasticities as a substitute for a transport model, conservative values should be taken from the literature and plausibility check should be made on market share.

We also recommend that when using an elasticity-approach, only the own price and time elasticities are based on the literature. The cross elasticities then can be derived by splitting the amount that is transferred proportional to the available market shares of the available competing modes. This gives cross elasticities that are in line with one of the basic assumptions of the standard logit model (uniform cross elasticities) but that match with the observed market shares in the study area. Application of the elasticities then should take place on the basis of a full OD matrix of transport flows, not only on a relative change in transport costs on a small section of the network.

Since the elasticities that are available in the literature constitute a considerable range (this is partly due to the difference in the starting mode shares between the studies), and there is additional uncertainty that results from transferring the elasticities (that practically all were derived for OECD countries) to JASPERS countries, we recommend not to use a single elasticity value (not even per segment), but if possible perform a range of estimations. To estimate the Mode Shift effect (i.e. the increase in rail demand) of a change in rail transport costs per tonne we have the following typical ranges:

- For the impact on total tonnes: -0.7, -1.1 and -1.5 for lower bound, central and upper bound respectively (based on the literature, using the 80-20 rule for the bounds); and
- For the impact on tonne-km: -0.8, -1.2 and -1.6 for lower bound, central and upper bound respectively.

The impact of a change in transport time depends on the share of the time-dependent costs in the total rail freight costs (often 70-80%) and on whether there also is an impact through the cargo value of time, but on average can be taken to be very similar to the transport cost elasticities or just below (in absolute values).

### *3.7. Developing the Cost Model for Mode Choice and/or Assignment Models*

When using transport models to determine Mode Choice or Route Assignment, the modelling is generally based on a comparative Generalised Cost of each mode. When calculating the Generalised Cost for each mode, it is important to note that all relevant costs that are perceived by the users should be included in the models. For rail freight this also includes rail access charges which will be included in the cost model. In such cases, however, unperceived "external" costs from the perspective of the user are not included (damage/wear and tear to the railway or the costs of congestion/pollution on other users).

The cost model might therefore typically include for a defined Origin-Destination pair:

- Purely distance based costs, such as rail track access charges and energy costs;
- Time Costs both moving and waiting, including crew costs, vehicle time and overhead costs, degradation of the goods in transit; - for all modes of transport used on the trip;
- Other more fixed costs such as handling costs at interchange points.

It is not always the case that the quickest or shortest freight route is the best one. Where there are significant differences in unit distance or time costs on different routes within the same mode on sections which may be relevant to project impacts, this should ideally be taken into account explicitly in the cost model (e.g. unit vehicle and/or energy costs can vary greatly based on maximum axle loading, train length, route gradients, and traction type).

The above are converted into a Generalised Cost value (non-monetary costs are converted using unit values of time) and this forms the input to the assignment, mode shift or elasticity models. In the case of combined transport, combinations of road, rail and IWW costs may be considered together in one cost model.

### *3.8. Conclusions on Transport Models*

In practice, given the data situation in JASPERS countries, we recommend using **Aggregate Logit Models** for Mode Share. These models can provide predictions of modal shift as a result of a rail project, which are needed to calculate the new users for the internal benefits in CBA, but also for the external benefits of the project.

When national or regional freight transport models are available as inputs to project appraisal, these models should be judged first, to see whether they include the right modes, explanatory variables and segments and whether their sensitivity to changes in cost is in line with what we know about elasticities in the literature.

Existing freight transport models can be extended to include the cargo component of the value of time and to include reliability and cost models modified to allow modelling of the key cost changes brought by the project. National and regional models can be customized for application to a specific corridor by aggregating zones outside the study area and by re-calibrating the mode-specific constants.

If transport models are not available and cannot be constructed as part of the project, elasticity-based models can be used as a last resort, but these will only be very approximate. We generally recommend only to use elasticity-based models for a first analysis (‘quick scan’) of a project, to see whether it deserves further investigation. This further investigation then should use a proper network-based transport model, so that funding decisions will not be directly be based on elasticity calculations.

# 4. Economic Appraisal

## *4.1. General Recommendations on the Appraisal Method*

After having completed the collection of data on transport cost, time and reliability and having applied the transport models to predict the flows of goods between zones in the reference and the project situation, the actual project appraisal can be carried out. In this report we take as given that there is the requirement to evaluate proposed projects and that this evaluation includes financial and economic analysis of the impacts of the project, as described in the European Commission's 'Guide to Cost-Benefit Analysis of Investment Projects, Economic appraisal tool for Cohesion Policy 2014-2020' of 2014.

The CBA deals with various benefit types in different ways, as follows:

Travel Time Savings — Travel Time Savings are originally expressed in number of hours or minutes that are saved as a result of the project. In CBA of rail transport projects these benefits are usually calculated separately for the existing freight and new rail demand. These time benefits in hours or minutes are multiplied by a unit (per hour or minute) value of time (the VTT) to give the monetary time benefits. The VTT preferably comes from a specific study carried out in the project area. In annex A however we provide unit VTT for JASPERS countries that can be used in the absence of project specific VTT. These are values for the year 2010 expressed in market prices. In chapter 4.6, we discuss how unit values for future years can be calculated.

Operational Cost Savings — Reductions in the transport costs are by nature already in money units but a fiscal correction should be applied to calculate economic costs. Just as for the Travel Time Savings, the Operational Cost Savings are provided by comparing operating costs for the reference and the project situation.

Project impacts on unit costs of infrastructure maintenance are not considered in this document or in the following examples, but would in practice be likely and potentially significant if infrastructure is significantly improved. They are generally calculated on a case to case basis.

Reliability Improvements — Unlike for the Value of Travel Time, many countries do not have an official Value of Travel Time Reliability (VTTR) that is used for project evaluation. This topic has only recently gained attention of policy makers, and in several countries researchers are working on the VTTR now. The Reliability Improvements before monetisation (measured for instance as a reduction in the standard deviation of transport time) are usually not included in transport models and therefore need to be calculated from a project-specific reliability forecasting model or in an ad-hoc fashion (e.g. using scenario assumptions). A simpler alternative would be to assume that the reliability benefits are a fixed percentage surcharge on the time benefits. However in that case one cannot cope with projects that have a different impact on time and reliability.

| | |
|---|---|
| External Cost Savings | The reduction in external costs (e.g. in harmful emissions) can result from modal shift from road to rail when the project makes rail more attractive (lower transport costs, shorter transport time, more reliable) or can provide more capacity (given that there was a suppressed demand for rail). But it can also be the result of increased efficiency in the rail operations or electrification (the same amount of tonnes between zones is transported with fewer train km). This report will not discuss unit values for external effects, but modelling and predicting modal shift has already been discussed in chapter 3. |
| Different Train Types | The market research activity has highlighted that unit transport cost, often does not differ significantly between commodity types, but does differ between the selected types of haulage (i.e. solid/liquid bulk in block trains, non-containerised wagonloads, containerised cargo). Different types of measure have different impacts on these 3 types (e.g. maximum train length and travel time is more important for container trains, while maximum loading and gradient is more significant for block trains). Therefore a distinction should if possible be made between these types of train in economic analysis. |
| Project Scale | In line with almost all national guidance and the current academic position on this issue, we recommend using the same unit values for small and large savings (e.g. time reductions) instead of using a zero or smaller unit value for small savings. |
| Rule of Half | In the case of freight traffic shifted from road-rail, the use of the rule of half applied to rail costs is generally recommended to estimate travel time, reliability and operational cost savings (traction only) - unless the cost model has a sufficiently comprehensive definition of the full relative costs of travel of all relevant modes from door-to-door, in which case, the difference between road costs and rail costs of the transferred traffic might also be used. |

Preferably, one would use good local cost data for rail from the study area of the project that is investigated. These can come from railway operators and infrastructure managers in the specific corridor. If these are not available, the parameter values presented in Annex A of this report may be used as a base with the appropriate care.

There is one major difference between CBA and mode share / assignment modelling in the treatment of infrastructure operations and maintenance costs. For economic CBA, the relevant costs are the actual infrastructure operations and maintenance costs, while for mode share/assignment modelling, the relevant costs are rather those experienced by the operator, i.e. the infrastructure access charges For financial CBA, the cash flows will differ for different entities (e.g. (these will differ for example between the infrastructure manager and a combined transport operator). It is therefore necessary to clearly define the relevant entity being considered.

In the simplified examples developed below, no consideration is made for the demand growth trends in the without project case (for simplicity, no growth is assumed). This is of course in practice an important consideration.

## *4.2. Calculating the Benefits of Transport Time Savings*

### 4.2.1. Classification of Transport Time Costs

Transport Time Costs represent those costs that accrue as a result of the time taken for a transport activity. The costs consist of two categories, as follows:

- The **Transport Cost Component of Travel Time** (Crew Time, Vehicle Time and other Company Overheads) which varies per train type
- The **Cargo Cost Component of Travel Time**, being those costs associated with goods being in transit which varies per commodity type.

If no project-specific values of travel time are available or can be established as part of the project (due to time and costs constraints or missing expertise on VTT studies), standard unit values or rules can be used. Another reason to work with standard values can be that it is seen as desirable that all projects (in a given area) should be evaluated using the same unit values. Such rules and unit values are presented below in this section and annex A.

Unit values for the Transport Time Benefits are presented in Annex A.

### 4.2.2. Determining the **Transport** **Cost Component of Transport Time**

For the Transport Cost Component we recommend an approach adopted from The Netherlands (Kennisinstituut voor Mobiliteitsbeleid, 2013) that uses staff and vehicle time costs. For these time-based transport costs we have generated default values per JASPERS country based on EU-15 rail transport costs, and using data on wage levels for the crew costs in these countries.

### 4.2.3. Determining the **Cargo** **Cost Component of Transport Time**

There is a common view among CBA researchers that the cargo component should be included in the VOT in some form. Based on research undertaken in France (CGSP, 2013) we recommend a unit value for the cargo component in euro per tonne of cargo per hour that differs between three types of commodities. Values are presented below in Table 4-1.

*Table 4-1: Unit Values for the Cargo Component (€/tonne/hour in 2010 values)*

| Commodity | Value (€/tonne/hour) |
|---|---|
| Freight with low added value: < 6000 euro/tonne, e.g. bulk/aggregates | 0* |
| Ordinary freight: 6000-35000 euro/tonne, e.g. other rail, sea and river transport | 0.2 |
| Freight with high added value: > 35000 euro/tonne, e.g. combined, parcels, refrigerated, roro | 0.6 |

** The value was set based on a review of the literature at an average of €0.01 tonne/hour, but this has been concluded to be relatively insignificant in the context of an appraisal, and hence is rounded to zero.*

It is noted that the above values are based on unit values developed and used in France, which represent median values found in the literature, and are therefore considered to be the most transferable. Given the small or non-existent differences in market value between countries for typical rail freight goods, it is practical to provide this as a single default value for all Member States. However, if the local/national circumstances are considered unusual (e.g. a high degree of low shelf life goods or sensitive logistics conditions), tailored values might be set with a specific stated preference survey aimed at measuring cargo time value (differentiating between different cargo types).

Where demand on a line is a combination of freight types, one needs to know the average value of the goods transported, or a distribution of the transported tonnes over the three categories can be used to apply all three values. The threshold values then are €6,000 and €35,000 per tonne. If this information is not available, one can use zero for goods with low value, and 0.2 for all other goods transported by rail.

Nevertheless, in applying the above, it is noted that the highest value of 0.6 is unlikely to be applied. In fairly representative surveys in freight transport in Germany, France and Sweden no single commodity category had an average value per tonne above €35,000/tonne.

### 4.2.4. Ramp-Up in Transport Time Benefits

It is generally accepted that the impact of changes in the Transport Time may not always be felt immediately, and in fact it may take a number of years for operators, and indeed the full logistics chain, to adapt to the full advantage of savings that are accrued. In this regard, a ramp-up period of benefit accrual is warranted. Through our research we have concluded that the ramp-up period should be no less than 5 years.

For year 1, we use a fraction of this full 100%, taken from Stated Preference surveys carried out in the Netherlands (the responses of the firms in these surveys are regarded as inherently short-term in nature). In Table 4-2 are the ratios for year 1 recommended as defaults for the CBA of rail freight projects in JASPERS countries. The values represent the proportion of the calculated annual project benefits that are accrued in each year of the appraisal.

*Table 4-2: Ramp up Rates for Travel Time Benefits (Year 6 and later = 1.0)*

| | **Ratio of Travel Time Benefits Achieved** | | | | |
|---|---|---|---|---|---|
| **Type** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
| All goods | 0.44 | 0.55 | 0.66 | 0.77 | 0.89 |
| Containers | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 |
| Bulk | 0.44 | 0.55 | 0.66 | 0.77 | 0.89 |
| Wagonload | 0.42 | 0.53 | 0.64 | 0.76 | 0.88 |

The above ramp-up applies to the Transport Time Benefits only, and only the Transport Cost Component of Transport Time. No Ramp-Up is applied to the Cargo Time Cost Component or the Transport Operational Costs as it is assumed that reductions in such costs will, by their nature, accrue immediately.

### 4.2.5. Worked Examples of Transport Time Benefits

An example showing the calculation of a simple project that generates only Travel Time Benefits is presented below.

| | |
|---|---|
| **Example 1:** | **Travel Time Improvement** |
| **Description**: | An existing electrified line carrying container traffic suffers from a number of speed restrictions due to poor quality and design speed of the infrastructure. The line is upgraded, leading to a reduction in transit time from 10 hours to 8 hours. Total flow is 100,000 tonnes per year. |
| **Project Significance**: | Low (Time Savings only and Low existing demand) |
| **Country**: | Greece |

**Summary of Impacts**

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Transport Distance (km) | d | d | 0 |
| Transport Volume (net tonnes) | 100,000 | 100,000 | 0 |
| Transport Time (hours) | 10 | 8 | -2.0 |
| Transport Reliability | r | r | 0 |

**Parameter Values for Cost Benefit Analysis**

| Parameter | Value | Source |
|---|---|---|
| *Transport Time* (€/train-hr) | 351.89<br>(excluding Taxes) | Table A.1:<br>Value for Greece, Container Trains, Electric |
| Cargo Time Cost (€/tonne-hr) | 0.2 | Table A.2<br>Value for Ordinary Freight |
| Ramp Up Factor | 0.5<br>(year 1) | Table A.3:<br>Value for Container Trains |
| Train Loading (tonnes/train) | 750 | Table A.4<br>Value for Container Trains |

**Calculation of Transport Time Benefits**

| | | | | |
|---|---|---|---|---|
| (a) | Demand | (tonnes/year) | 100,000 | |
| (b) | Time Change | (hours) | -2.0 | |
| (c) | Transport Time Cost | (€/train-hr) | 351.89 | |
| (d) | Estimate Trains | (a)/750 | 133.33 | trains/year |
| | **Annual Benefit** | **-(b)*(c)*(d)** | **€ 93,837** | |
| | Calculate Ramp-Up | | *€ 46,919* | *Year 1* |
| | | | *€ 56,302* | *Year 2* |
| | | | *€ 65,686* | *Year 3* |
| | | | *€ 75,070* | *Year 4* |
| | | | *€ 84,454* | *Year 5* |
| | | | *€ 93,837* | *Year 6+* |

**Calculation of Cargo Time Benefits**

| | | | |
|---|---|---|---|
| (a) | Demand | (tonnes/year) | 100,000 |
| (b) | Time Change | (hours) | -2.0 |
| (e) | Cargo Value of Time | (€/tonne-hr) | 0.2 |
| | **Annual Benefit** | **-(a)*(b)*(e)** | **€40,000** |
| | *No Ramp-Up applied* | | |

**Calculation of Total Benefits**

| | **Year 1** | **Year 2** | **Year 3** | … |
|---|---|---|---|---|
| **Transport Time** | *€ 46,919* | *€ 56,302* | *€ 56,302* | … |
| **Cargo Time** | € 40,000 | € 40,000 | € 40,000 | … |
| **Total** | **€ 86,919** | **€ 96,302** | **€ 96,302** | **…** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

## 4.3. Calculating Operational Cost Savings

### 4.3.1. Classification of Operational Costs

Operational Costs represent those costs that are directly related to the transportation effort, such as energy (traction) costs, and infrastructure access charges. These costs are regarded as purely distance-dependent, not time-dependent.

Access charges (presented in table A.6) are relevant operational cost savings for mode choice modelling and financial modelling. Nevertheless, for economic analysis, O&M costs for the infrastructure (maintenance, traffic management) are relevant rather than access charges. O&M costs are set per country based on real/planned costs and will often involve a fixed cost per track km and a variable cost per train-km or tonne-km.

Project impacts on infrastructure maintenance unit costs of are not considered in this document or in the following examples, but would in practice be likely and potentially significant if infrastructure is significantly improved.

Unit maintenance costs - regular and periodic - are generally calculated on a case to case basis depending on the current technical state of the track and assumptions of how to further maintain track quality in the with and without project case.

Example 2 below uses a working assumption for O&M costs that have been calculated based on average maintenance expenditure for maintenance of steady-state infrastructure in 2005[5]. The values incorporate the variable cost element of train activity, and are adjusted for different member states based on the assumption that 40% of the costs are wage-linked. In addition, the values assume that the maintenance cost of double track is 1.67 times that of single track, due to cost efficiencies.

### 4.3.2. Determining the Parameter Values for Transport Operational Cost

Default values per JASPERS country for operational costs are given in Annex A. The variable traction costs are based on rail transport costs in EU-15 countries, but corrected for the diesel taxes in JASPERS countries. The rail access charges are based on data for each JASPERS country (van Essen et al., 2010).

### 4.3.3. Worked Example of Transport Operational Cost Benefits

Two examples showing the calculation of Operational Cost Benefits are provided below, representing a shortening of an existing line (which also leads to travel time savings) and the rehabilitation and electrification of a major bulk (coal) line.

[5] Lasting Infrastructure Cost Benchmarking, International Union of Railways, 2007

| | |
|---|---|
| **Example 2:** | **Track Shortening leading to Operational Cost and Travel Time Savings** |
| **Description**: | An existing single-track line serving container trains is improved, leading to a reduction in transit distance from 200km to 175km, and a time saving of 30 minutes. Total flow is 5,000,000 tonnes per year with no additional demand expected. The line is non-electrified. Following the realignment, the existing line is removed from use. |
| **Project Significance**: | Medium (Operational Cost Savings plus Time Savings with Significant existing demand) |
| **Country**: | Bulgaria |

**Summary of Impacts**

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Transport Distance (km) | 200 | 175 | -25 |
| Transport Volume (tonnes) | 5,000,000 | 5,000,000 | 0 |
| Transport Time (hours) | t | t-0.5 | -0.5 |
| Transport Reliability | r | r | 0 |

**Parameter Values for Cost Benefit Analysis**

| Parameter | Value | Source |
|---|---|---|
| Transport Cost Component of Travel Time (€/train hr) | 342.06 (excluding Taxes) | Table A.1: Value for Bulgaria, Container Trains, Non-Electric |
| Cargo Time Cost (€/tonne hr) | 0.2 | Table A.2 Value for Ordinary Freight |
| Train Tonnage (Tonnes/train) | 750 | Table A.4: Value for Container Trains, Non-Electric |
| Ramp Up Factor | 0.5 (year 1) | Table A.3: Value for Container Trains |
| Operating Cost - *Traction* (€/train-km) | 4.47 (excluding Taxes) | Table A.5: Value for Bulgaria, Container Trains, Non-Electric |
| Operating Cost - *Infrastructure* (€/line-km/year) | 25,710 | Table A.9: Value for Single-Track, Bulgaria |

**Calculation of Transport Time Benefits**

| | | | | |
|---|---|---|---|---|
| (a) | Demand | (tonnes/year) | 5,000,000 | |
| (b) | Time Change | (hours) | -0.5 | |
| (c) | Transport Time Cost | (€/hr) | 342.06 | |
| (d) | Estimate Trains | (a)/750 | 6,667 | trains/year |
| | **Annual Benefit** | **-(b)*(c)*(d)** | **€1,140,002** | |

| | | |
|---|---|---|
| Calculate Ramp-Up | *€507,100* | *Year 1* |
| | *€684,120* | *Year 2* |
| | *€798,140* | *Year 3* |
| | *€912,160* | *Year 4* |
| | *€1,026,180* | *Year 5* |
| | *€1,140,200* | *Year 6+* |

**Calculation of Cargo Time Benefits**

| | | | |
|---|---|---|---|
| (a) | Demand | (tonnes/year) | 5,000,000 |
| (b) | Time Change | (hours) | -0.5 |
| (e) | Cargo Value of Time | (€/tonne-hr) | 0.2 |
| | **Annual Benefit** | **(a)*(b)*(e)** | **€500,000** |
| | *No Ramp-Up applied* | | |

**Calculation of Operating Costs Benefits**

| | | | | |
|---|---|---|---|---|
| (d) | Trains | (trains/year) | 6,667 | |
| (f) | Distance Change | (km) | -25 | |
| (g) | Operating Cost | (€/train-km) | 4.47 | *Traction* |
| (j) | Operating Cost | (€/line-km) | 25,710 | *O&M fixed* |
| | **Annual Benefit** | **[(d)*(f)*(g)]+[(j)*(f)]** | **€1,387,787** | |
| | *No Ramp-Up applied* | | | |

**Calculation of Total Benefits**

| | **Year 1** | **Year 2** | **Year 3** | |
|---|---|---|---|---|
| **Transport Time** | *€ 507,100* | *€ 684,120* | *€ 798,140* | … |
| **Cargo Time** | *€ 500,000* | *€ 500,000* | *€ 500,000* | … |
| **Operating Costs** | *€ 1,387,787* | *€ 1,387,787* | *€ 1,387,787* | … |
| **Total** | **€ 2,394,887** | **€ 2,571,907** | **€ 2,685,927** | **…** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

## Example 3: Rehabilitation and Electrification of a Bulk Freight Line

**Description**: An existing 300 km line serving mainly coal trains directly connecting a coal mine to a power station is to be rehabilitated and electrified. The line continues to deteriorate due to poor levels of maintenance spending, and this is likely to continue leading to ongoing line degradation if no investment is made.

Total flow is high at 15 million tonnes per year, and trains return empty from the power station to the coal mine. The forecast (consulted with the coal shipper and considering energy policy) confirms that coal stock will still be available/used for at least another 30 years at the current mining rates.

At present, the poor quality of the line leads to a restriction of 18 tonnes axle loading. Following the rehabilitation, this will be increased to accommodate 22.5 tonne axle loads. Consultation with the operator has confirmed that there is good potential for turnover of locomotive and wagon use to increase, and thus reduce overall time related vehicle costs.

No mode shift is expected despite the major improvement because no other mode option is anywhere near being cost-competitive with rail.

**Project Significance**: Medium (Time plus Operational Cost Savings with Significant existing demand)

**Country**: Bulgaria

**Summary of Impacts**

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Track length (km) | 300 | 300 | 0 |
| Transport Volume (tonnes) | 15,000,000 | 15,000,000 | 0 |
| Round Trip Transport Time (hours) | 15* | 11 | 4 |
| Transport Reliability | r | r | 0 |

*Simplified weighted lifetime average here. In practice this will increase in time.

**Parameter Values for Cost Benefit Analysis**

| Parameter | Without Project | With Project | Source |
|---|---|---|---|
| Transport Cost Component of Travel Time (€/train hr) | 367.36* (excluding Taxes) | 339.37 (excluding Taxes) | Table A.1: Value for Bulgaria, Block Trains, Diesel/Electric |
| Cargo Time Cost (€/tonne hr) | 0.0 | | Table A.2 Low Value Freight |
| Train Tonnage (tonnes/train) | 1143 | | Table A.4: Value for Block Trains, Non-Electric |
| Ramp Up Factor | 0.44 | | Table A.3: Value for Bulk |
| Operating Cost – *Traction* (€/train-km) | 4.47* (excluding Taxes) | 3.12 (excluding Taxes) | Table A.5: Value for Bulgaria, Block Trains, Diesel/Electric |
| Wagon Weight (tonnes) | 26.5 | | Table A.10: Value for Block Trains, Diesel |
| Cargo Weight per Wagon (tonnes/wagon) | 63.5 | | Table A.10: Value for Block Trains, Diesel |
| Average Train Length (number of wagons) | 18 | | Table A.10: Value for Block Trains, Diesel |
| Average Train Weight (Gross weight, including Loco) | 1733 (1620 wagons, plus 113 loco) | | Table A.10: Value for Block Trains, Diesel/Electric |
| Cost of wagons (€/hr) | 1.5 | | Table A.11 Value for Mixed Wagons (rounded from 1.47) |

* Note that these parameter values are based on train loadings without the effect of the axle weight restriction, which is addressed below.

**Calculation of Effect of the Axle Restriction in Addition to Electrification**

The axle restriction that is imposed on this line leads to the use of wagons that are partially full. As such, the train length is increased to compensate for the individual axle restriction – this increases the operating cost of rolling stock in addition to the impacts of electrification. The adjusted train operating cost is therefore calculated as se out below.

| | | | | |
|---|---|---|---|---|
| | **<u>Transport Time</u>** | | | |
| (a) | Maximum Axle Weight | (tonnes) | 18 | |
| (b) | Maximum Wagon Weight | (tonnes) | 72 | |
| (c) | Allowable Goods Weight | (b)-26.5 | 45.5 | tonnes/wagon |
| (d) | Number of Wagons Required | 1145/(c) | 26 | wagons |
| (e) | Additional wagons per train | (d)-18 | 8 | wagons |
| (f) | Additional Operating Cost per hour | (e)*1.5 | 12 | €/ hour |
| | **Adjusted Operating Cost** | **(f)+367.36** | **379.36** | **(€/train hr)** |
| | **<u>Operating Cost – Traction</u>** | | | |
| (g) | Additional weight per train | (e)*26.5 | 212 | tonnes |
| (h) | New weight per train | (g)+1733 | 1945 | tonnes |
| (j) | Weight factor | (h)/1733 | 1.12 | |
| | **Adjusted Traction Cost** | **(j)*4.47** | **5.01** | **(€/train hr)** |

**Calculation of Transport Time Benefits**

| | | | | |
|---|---|---|---|---|
| (a) | Demand | (tonnes/year) | 15,000,000 | |
| (b) | Existing Travel Time | (hours) | 15 | *without project* |
| (c) | Transport Time Cost | (€/ train hr) | 379.36 | *without project* |
| (d) | New Travel Time | (hours) | 11 | *with project* |
| (e) | Transport Time Cost | (€/train hr) | 333 | *with project* |
| (f) | Estimate Trains | (a)/1143 | 13,123 | |
| | **Annual Benefit** | **(f)*[(b)*(c)-(d)*(e)]** | **€26,605,570** | |
| | Calculate Ramp-Up | | €11,706,451 | *Year 1* |
| | | | €14,633,064 | *Year 2* |
| | | | €17,559,676 | *Year 3* |
| | | | €20,486,289 | *Year 4* |
| | | | €23,412,902 | *Year 5* |
| | | | €26,605,570 | *Year 6+* |

**Calculation of Cargo Time Benefits**

The Cargo time value is set at €0.0, and hence no Cargo Time Benefits apply.

**Calculation of Operating Costs Benefits (Traction)**

| | | | |
|---|---|---|---|
| (a) | Round Trip length | (km) | 600 |
| (b) | Trains | (trains/year) | 13,123 |
| (c) | Existing Operating Cost | (€/train-km) | 5.01 |
| (d) | New Operating Cost | (€/train-km) | 3.12 |
| | **Annual Benefit** | **(a)*(b)*([(d)-(c)]** | **€14,881,482** |
| | *No Ramp-Up applied* | | |

**Calculation of Total Benefits**

| | **Year 1** | **Year 2** | **Year 3** | |
|---|---|---|---|---|
| **Transport Time** | €11,706,451 | €14,633,064 | €17,559,676 | … |
| **Cargo Time** | €0 | €0 | €0 | … |
| **Operating Costs** | €14,881,482 | €14,881,482 | €14,881,482 | |
| **Total** | **€ 26,587,933** | **€ 29,514,546** | **€ 32,441,158** | **…** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

Additional expected externality impacts of electrification are not calculated in this example.

## *4.4. Calculating Reliability Benefits*

When estimating the effect of Travel Time Savings, time reductions should be measured using *expected* transport times - this will include time compensation in travel planning due to *expected* delays because of poor reliability and also *unexpected* delays. Both types of delay are considered within the assessment of Reliability Benefits.

### 4.4.1. Time Loss Due to Expected Reliability Issues

If „expected" delays e.g., if headroom (buffer) are included in a timetable or an allowance is made within the logistics chain planning to account for reliability issues, then the reduction of such expected delays due to the project is valued as a normal transport time reduction using the VTT (or VOT) unit costs.

### 4.4.2. The Reliability Cost Component for Unexpected Intrinsic Reliability Improvement (VTTR)

When reliability is improved however, there is also generally a decrease in the risk of unexpected (often catastrophic) delay and this change can be valued as a further separate intrinsic reliability improvement. This is known as Value of Travel Time Reliability or VTTR.

For the VTTR we do not explicitly distinguish a transport cost and a cargo component because there is not sufficient empirical literature that makes this distinction.

As in the Dutch CBA, the reliability for all modes is defined as the standard deviation of transport time. The importance of the standard deviation relative to transport time itself is given by the *Reliability Ratio*.

$$Reliability\ Ratio = \frac{Value\ of\ a\ Change\ in\ Standard\ Deviation\ of\ Travel\ Time}{Value\ of\ Change\ in\ Equivalent\ Travel\ Time}$$

Reliability Ratios have been calculated for the same commodity categories as used for the cargo component. For products with a low added value ('bulk') a reliability ratio of 0.4 was found, which implies that a change in the standard deviation by 1 hour is equivalent to a change in transport time by 24 minutes. For the remainder of products, a Reliability Ratio of 0.65 is recommended. This can be applied in addition to any change in the scheduled travel time resulting from the project (if such a change is expected). In other words, an improvement which leads to a reduction in the deviation generates both a reliability benefit *and* a travel time benefit – which will be greater than the value of the travel time benefit alone.

It has been decided not to recommend a higher value for goods with high added value (>35000 €/tonne), because for these products the value of time is already very high and through the reliability ratio the value of reliability is proportional to the value of time.

*Table 4-3: Recommended unit values for the Reliability Ratio*

| **Commodity** | **Reliability ratio (=VTTV/VTT)** |
|---|---|
| Freight with low added value: < 6000 euro/tonne, e.g. bulk/aggregates | 0.40 |
| Ordinary freight: 6000-35000 euro/tonne, e.g. other rail, sea and river transport | 0.65 |
| Freight with high added value: > 35000 euro/tonne, e.g. combined, parcels, refrigerated, roro | 0.65 |

The above values are used to convert changes in Standard Deviation into an Equivalent Travel Time Reduction, and this Equivalent Travel Time Reduction is then assessed in the same way as an actual travel time reduction (i.e. it is added to any net reduction in average travel time that also occurs).

#### 4.4.3. Worked Examples of Reliability Cost Benefits

An example showing the calculation of a simple Reliability Benefit is provided below.

| | |
|---|---|
| **Example 4:** | **Improvement in Reliability** |
| **Description**: | An existing electrified mixed freight and passenger line carrying containerised goods suffers from poor reliability due to a long section of single track, poor condition of the track and limited train passing opportunities. Whilst the timetable indicates a travel time of 5 hours, delays often occur due to limited redundancy and poor reliability of the system. Targeted investments are made to improve the reliability.<br><br>The measured average travel time is 5:30 with a standard deviation of 60 minutes. Following investment, this will be reduced to an average travel time of 5:00 with a standard deviation of 15 minutes. Total flow is 2,000,000 tonnes per year. |
| **Project Significance**: | Medium (Time plus Reliability Cost Savings and with a significant level of existing demand) |
| **Country**: | Poland |

**Summary of Impacts**

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Transport Distance (km) | d | d | 0 |
| Transport Volume (tonnes) | 2,000,000 | 2,000,000 | 0 |
| Transport Time (hours) | 5.5 | 5.0 | -0.5 |
| Transport Reliability (Standard Deviation) | 1.0 | 0.25 | -0.75 |

**Parameter Values for Cost Benefit Analysis**

| Parameter | Value | Source |
|---|---|---|
| Transport Cost Component of Travel Time (€/train hr) | 327.53 (excluding Taxes) | Table A.1 Value for Poland, Container Trains, Electric |
| Cargo Time Cost (€/tonne hr) | 0.2 | Table A.2 Value for Ordinary Freight |
| Train Tonnage (tonnes/train) | 750 | Table A.4 Value for Container, Electric |
| Ramp Up Factor | 0.50 (year 1) | Table A.3 Value for Container |
| Reliability Ratio | 0.65 | Table A.7 Value for Ordinary Freight |

**Calculation of Transport Time Benefits for Equivalent Time (Reliability) Benefit**

| | | | | |
|---|---|---|---|---|
| (a) | Change in Standard Deviation | (hours) | 0.75 | |
| (b) | Reliability Ratio | | 0.65 | |
| (c) | Demand | (tonnes/year) | 2,000,000 | |
| (d) | Cargo Value of Time | (€/tonne-hr) | 0.2 | |
| (e) | Transport Time Cost | (€/train hr) | 327.53 | |
| (f) | Equivalent Time | (a)*(b) | 0.49 | hours |
| (g) | Estimate Trains | (c)/750 | 2,667 | trains/year |
| | **Reliability Benefit (Cargo Time)** | **(c)*(d)*(f)** | **€196,000** | **€/year** |
| | **Reliability Benefit (Transport Time)** | **(e)*(g)*(f)** | **€425,842** | **€/year** |
| | Calculate Ramp-Up (Transport Time) | | € 212,921 | *Year 1* |
| | | | € 255,505 | *Year 2* |
| | | | € 298,089 | *Year 3* |
| | | | € 340,674 | *Year 4* |
| | | | € 383,258 | *Year 5* |
| | | | € 425,842 | *Year 6+* |

**Calculation of Transport Time Benefits related to reduction in Average Time**

| | | | | |
|---|---|---|---|---|
| (f) | Average Time Change | (hours) | -0.5 | |
| (e) | Transport Time Cost | (€/train hr) | 327.53 | |
| (g) | Estimate Trains | (c)/750 | 2,667 | trains/year |
| | **Annual Benefit** | **-(f)*(e)*(g)** | **€436,707** | |
| | Calculate Ramp-Up | | €218,353 | *Year 1* |
| | | | €262,024 | *Year 2* |
| | | | €305,695 | *Year 3* |
| | | | €349,365 | *Year 4* |
| | | | €393,036 | *Year 5* |
| | | | €436,707 | *Year 6+* |

**Calculation of Cargo Time Benefits related to reduction in Average Time**

| | | | |
|---|---|---|---|
| (c) | Demand | (tonnes/year) | 2,000,000 |
| (f) | Time Change | (hours) | -0.5 |
| (d) | Cargo Value of Time | (€/tonne-hr) | 0.2 |
| | **Annual Benefit** | **-(c)*(e)*(d)** | **€200,000** |
| | *No Ramp-Up applied* | | |

### Calculation of Total Benefits

| | Year 1 | Year 2 | Year 3 | |
|---|---|---|---|---|
| **Reliability (Cargo)** | €196,000 | €196,000 | €196,000 | … |
| **Reliability (Transport)** | €213,986 | €256,784 | €299,581 | |
| **Transport Time** | €218,353 | €262,024 | €305,695 | |
| **Cargo Time** | €200,000 | €200,000 | €200,000 | … |
| **Total** | **€828,339** | **€914,808** | **€1,001,276** | **…** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

## 4.5. Calculating External Cost Changes due to Mode Shift

### 4.5.1. Including Mode Shift in the Appraisal

The calculation of the Mode Shift response is most relevant for High Significance projects where the transfer of goods to rail is an important element of the project benefits. This requires recourse to the transport model, using preferably an Aggregate Logit model (with the ability to use elasticity models in limited cases where the mode shift benefits are not a dominant part of the project benefits).

The inclusion of mode shift introduces a number of extra requirements to the calculation, as follows:

- The requirement to develop a validated transport model that can estimate the transfer of demand to rail as a result of the project, and which takes into account the resulting cost changes across the full logistics chain;
- The use of market prices (includes taxes) to model the mode shift response, as these are the prices that are perceived by users and hence drive the decision making;
- Where appropriate, the 'Rule of a Half' can be used for new demand attracted to the railway. In other words, the savings that accrue to existing demand on the rail network as a result of the project will accrue to new demand at a rate of 50% of savings accruing to the existing demand; and
- The calculation of the change in external costs as a result of the transfer of freight to the railway network (i.e. reduction in emissions and pollutants) – this can be a significant element of the project benefits particularly where long distance freight transfers from the road network to the railway network.

### 4.5.2. Determining the Costs for Competing Modes

For the modal shift model, costs of competing modes are an important piece of input information. Preferably these should be based on local data, but in the absence of these we also provide below some averages that could be used as defaults. These costs for road, inland waterway and sea transport are based on costs for The Netherlands, modified for the lower crew costs in JASPERS countries (based on Eurostat labour statistics).

*Table 4-4: Costs for Competing Modes in JASPERS Countries (€/vessel, with taxes)*

| Variable | Calculations | Truck | Inland waterways | Short sea shipping |
|---|---|---|---|---|
| **Capacity (tonnes)** | | 27 | 2500 | 30000 |
| **crew cost per hour** | (a) | 20 | 60 | 90 |
| **crew cost per year** | (b) | 52000 | 122220 | 589680 |
| **fuel cost per km** | (c) | 0.4 | 6 | 10 |
| **fuel cost per year** | (d) | 52000 | 190662 | 2950000 |
| **other cost** | (e) | 49000 | 288000 | 2390000 |
| **total cost** | (b)+(d)+(e) | 153000 | 600882 | 5929680 |
| **Cost per km** | | 1.18 | 18.91 | 20.10 |

### 4.5.3. Worked Example of External Cost Benefits due to Mode Shift

An example showing the calculation of benefits for a Mode Shift response is provided below.

Note that there are no changes in travel distance for rail trips for this example and therefore there is no calculation of the operating cost benefits of existing traffic. For new traffic attracted from road, the rule of half is applied in this case to transport time benefits. It would also apply to the operating cost benefits for rail traction but again in this case there is no change in rail travel distance per trip, so no benefits accrue in this specific example.

Whilst it is sometimes suggested to use Access Charges as a proxy for the marginal maintenance costs, it is noted that there is no clear relationship between access charges and infrastructure, and hence this approach is probably not appropriate. Instead, O&M cost savings resulting from Mode Shift are best treated by comparing the incremental reduction in road maintenance costs (reduced truck traffic) with the incremental increase in rail maintenance costs (increased rail traffic). The latter is not considered in this calculation but is a valid consideration in a full CBA.

| | |
|---|---|
| **Example 5:** | **Mode Shift through Electrification due to Travel Time Improvement and Operating Cost Reduction** |
| **Description**: | Part of an existing line serving mainly international container trains is electrified. The 200 km section is a missing electrification link, thus the project will allow electric traction along more door-to-door routes without changing locomotives. The project leads to a reduction in overall average travel time on this section of the railway from 4 hours to 2.5 hours (including elimination of the need to change between a diesel and electric locomotives).<br><br>Total average flow on the section is 8,000,000 tonnes per year before the project. |
| **Project Significance**: | High (Time Savings with Significant existing demand and with the potential for new demand) |
| **Country**: | Hungary |

**Summary of Impacts**

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Transport Distance – average trip (km) | 200 | 200 | 0 |
| Transport Time (hours) | 4 | 2.5 | -1.5 |
| Transport Reliability | r | r | 0 |

**Parameter Values for Mode Shift Modelling**

| Parameter | Without project | With project | Source |
|---|---|---|---|
| Transport Cost Component of Travel Time (€/train-hr) | 371.86 (including taxes) | 333.44 (including taxes) | Table A.1: Value for Hungary, Container Trains, Diesel/Electric |
| Cargo Time (€/tonne-hr) | 0.2 | | Table A.2 Value for Ordinary Freight |
| Train Tonnage (tonnes/train) | 750 | | Table A.4: Value for Container Trains, Non-Electric |
| Operating Cost - *Traction* (€/train-km) | 4.08 (including taxes) | 3.12 (including taxes) | Table A.5: Value for Hungary, Container Trains, Diesel/Electric |
| Operating Cost - *Access charge* (€/train-km) | 2.12 (including taxes) | | Table 6 (container trains, non-electric) |

**Mode Shift Modelling**

An Aggregate Logit Mode Choice Model is used to calculate the change in demand by rail, and also the network-wide impact on demand by different modes. For the purpose of this exercise it is assumed that the Mode Choice Model provides the following output:

| Indicator | Without Project | With Project | Project Impact |
|---|---|---|---|
| Rail Transport tonne-km | x1 | y1 | +400,000,000 |
| Road Transport tonne-km (HGV) | x2 | y2 | -425,000,000 |
| Transport Volume by Rail (tonnes) | x3 | y3 | +500,000 |

We note that the modelling exercise considered a range of freight origin destination movements with total trip length mainly between 600 and 1500 km. The 200 km section subject to investment forms just a part of these door-to-door trips.

When considering Mode Shift, note that the mode shift effect may not always occur immediately following the improvements. The response may instead take a number of years to realise (ramp-up), and in such cases this should be taken into account in the analysis. For simplicity, in this example we assume that the full Mode Shift response occurs in year 1.

**Parameter Values for Cost Benefit Analysis**

| Parameter | Without project | With project | Source |
|---|---|---|---|
| Transport Cost Component of Travel Time (€/hr) | 348.69 | 329.00 | Table A.1: Value for Hungary, Container Trains, Diesel/Electric |
| Cargo Time Cost (€/hr) | 0.2 | | Table A.2 Value for Ordinary Freight |
| Operating Cost *Traction Cost* (€/train-km) | 4.08 | 3.12 | Table A.5: Value for Hungary, Container Trains, Diesel/Electric |
| Train Tonnage (Tonnes/train) | 750 | | Table A.4: Value for Container Trains, Non-Electric |
| Ramp Up Factor | 0.50 (year 1) | | Table A.3 Value for Container |
| External cost of rail (EUR/ton-km) | 0.0057 | | Indicative, based on CE Delft study, 2011 |
| External cost of road HGV (EUR/ton-km) | 0.0266 | | |

### Calculation of Transport Time Benefits

| | | | | |
|---|---|---|---|---|
| | **<u>Existing Demand</u>** | | | |
| (a) | Demand | (tonnes/year) | 8,000,000 | |
| (c) | Existing Travel Time | (hours) | 4.0 | *without project* |
| (d) | Transport Time Cost | (€/train hour) | 348.69 | *without project* |
| (e) | New Travel Time | (hours) | 1.5 | *with project* |
| (f) | Transport Time Cost | (€/train hour) | 329 | *with project* |
| (b) | Estimate Trains | (a)/750 | 10,667 | |
| | **Annual Benefit** | **(b)*[(c)*(d)-(e)*(f)]** | **€ 9,613,440** | |
| | *Calculate Ramp-Up* | | *€ 4,806,720* | *Year 1* |
| | | | *€ 5,768,064* | *Year 2* |
| | | | *€ 6,729,408* | *Year 3* |
| | | | *€ 7,690,752* | *Year 4* |
| | | | *€ 8,652,096* | *Year 5* |
| | | | *€ 9,613,440* | *Year 6+* |
| | **<u>New Demand</u>** | | | |
| (g) | New Demand | (tonnes/year) | 500,000 | |
| (h) | Estimate Trains | (f)/750 | 667 | trains/year |
| | **Annual Benefit** | **0.5*(h)*[(c)*(d)-(e)*(f)]** | **€ 300,570** | |
| | *Calculate Ramp-Up* | | *€ 150,285* | *Year 1* |
| | | | *€ 180,342* | *Year 2* |
| | | | *€ 210,399* | *Year 3* |
| | | | *€ 240,456* | *Year 4* |
| | | | *€ 270,513* | *Year 5* |
| | | | *€ 300,570* | *Year 6+* |

### Calculation of Cargo Time Benefits

| | | | |
|---|---|---|---|
| | **<u>Existing Demand</u>** | | |
| (a) | Existing Demand | (tonnes/year) | 8,000,000 |
| (b) | Time Change | (hours) | -1.5 |
| (c) | Cargo Value of Time | (€/tonne-hr) | 0.2 |
| | **Annual Benefit** | **(a)*(b)*(c)** | **€2,400,000** |
| | *No Ramp-Up applied* | | |
| | **<u>New Demand</u>** | | |
| (e) | New Demand | (tonnes/year) | 500,000 |
| | **Annual Benefit** | **(b)*(c)*(e)*(0.5)** | **€75,000** |
| | *No Ramp-Up applied* | | |

**Calculation of Operating Costs Benefits**

| | | | |
|---|---|---|---|
| | **<u>Existing Demand</u>** | | |
| (a) | Existing Demand | (trains/year) | 10,667 |
| (b) | Operating Cost Change | (€/train km) | -0.96 |
| (c) | Distance | (km) | 200 |
| | **Annual Benefit** | **(a)*(b)*(c)** | **€2,048,064** |
| | **<u>New Demand</u>** | | |
| (d) | New Demand | (trains/year) | 667 |
| | **Annual Benefit**<br>*No Ramp-Up applied* | **(b)*(c)*(d)*(0.5)** | **€64,032** |

**Calculation of Time and Operations Costs Benefits**

| | **Year 1** | **Year 2** | **Year 3** |
|---|---|---|---|
| **<u>Existing Demand</u>** | | | |
| **Transport Time** | €4,806,720 | €5,768,064 | €6,729,408 |
| **Cargo Time** | €2,400,000 | €2,400,000 | €2,400,000 |
| **Operating Costs** | €2,048,064 | €2,048,064 | €2,048,064 |
| **<u>New Demand</u>** | | | |
| **Transport Time** | €150,285 | €180,342 | €210,399 |
| **Cargo Time** | €75,000 | €75,000 | €75,000 |
| **Operating Costs** | €64,032 | €64,032 | €64,032 |
| **Total** | **€9,544,101** | **€10,535,502** | **€11,526,903** |

*Note that the above calculation excludes normal demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

**Calculation of External Cost Savings**

It is noted that the transfer of road traffic to the railway in this case will also lead to a significant reduction in external costs (e.g. noise, pollution, CO2, safety etc). These should be calculated on the basis of a final reduction of 425 million road tonne-km and an increase of 400 million rail tonne-km - monetised using justified/standard unit externality values.

Unit monetary externality values are not a subject of this study, however there is extensive European literature and studies on this and it is an ongoing topic of active research - including proposed approaches to time based escalation. Ideally, care should be taken to ensure that unit external benefits are reasonable in the given context as they can vary significantly based on the terrain – e.g. air pollution and noise is generally more damaging in inhabited areas. An example calculation is given below using indicative values from the Parameter Values for Cost Benefit Analysis table above.

The additional expected externality impacts of electrification for existing traffic are not calculated in this example.

| | Year 1 | Year 3 |
|---|---|---|
| **Rail costs change** | *+€2,280,000* | *+€2,280,000* |
| **Road costs change** | *-€11,305,000* | *-€11,305,000* |
| **Total** | ***+€9,025,000*** | ***+€9,025,000*** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

**Calculation of Total Benefits**

| | Year 1 | Year 3 |
|---|---|---|
| **Time and Operations** | *€9,544,101* | *€ 11,526,903* |
| **External Cost Savings** | *€9,025,000* | *€9,025,000* |
| **Total** | ***€ 18,569,101*** | ***€ 20,551,903*** |

*Note that the above calculation excludes base demand growth, escalation and discounting – discounting of the benefit stream to a Price Base Year is necessary to calculate the Net Present Value of Benefits (NPVB) of the project.*

### *4.6. Multi-year calculation in CBA and Escalation of Unit Values*

In a CBA, costs and benefits usually refer to different years (most commonly investment costs refer to years before the project starts operation and once the new facility is opened, the benefits accrue year by year). This implies that costs and benefits need to be calculated for every year within a period that may last until 20-50 years after the opening of the facility including discounting of these values.

The forecast transport models used as an input to the CBA are often static models based on cross-sectional data. These models are used to predict transport volumes (and changes in transport times, costs and distances) for a single forecast year (e.g. 2030) or just a few future years covering the evaluation period (e.g. 2020, 2030 and 2040). For all other years, the relevant volumes are assumed to be the same as in one of these forecasting years or an interpolation between these year values.

This will get overall costs and benefits for all relevant years in the CBA. However, after conversion into monetised units, the unit values need to be corrected for price and real value changes

All unit values, such as the VOT presented in this report, are in 2010 price level euros. If the base price level year for the CBA is later than this, these unit prices should be first inflated to these base prices using the nominal EURO inflation rate.

For later evaluation years, the unit values need to be corrected for real (excluding predicted inflation) changes in the wages and prices that are relevant for the production of transport services over time.

We recommend to base the time escalation factor for transport time and operating costs on the real changes over time in the transport costs (instead of GDP/capita)[6], since the transport costs are the key driver of the changes of the values over time. This method for escalation is also use for freight transport value of time and reliability in The Netherlands for example.

The amount of change in the transport costs depends on the changes in the various components of transport costs (notably the rail transport cost here):

- Crew cost
- Cost of wagons and locomotives
- Energy costs (electric, diesel)
- Infrastructure access cost (or marginal maintenance cost)
- Overhead costs.

The preferred method for escalation is to make bottom-up assumptions on the evaluation over time of these costs items. This then needs to be combined with the share of total transport costs of these cost items. Together this will yield the growth nominal terms of transport costs, but also of value of time and value of reliability for the cases that were given in absolute euros of 2010.

The above nominal growth in the transport costs can be compared to the general price increase to reflect how much the transport costs increase more (or less) than the expected general price level

[6] Some countries use a correction based on real GDP per capita growth here (on top of the general price increase). For instance in the values of time and safety that RAND Europe and CE Delft recommended for EIB (in 2004), a GDP per capita elasticity of the VOT of 1 was used. HEATCO in 2006 recommended an elasticity of 0.7 here.

(inflation). Real % increases can then be applied to the benefits in the CBA for each of the relevant years.

If it is not possible to provide proper assumptions on the future increase of specific cost items, one could use an elasticity of 0.15 between real cost increase to real GDP growth for the transport cost component of VoT, which corresponds approximately to the average proportion of crew cost in the overall freight VoT cost across Europe, which it is assumed will grow linearly with GDP.

For the cargo element of VoT and for km based traction and access costs, we would recommend no real increase of unit costs as there is no evidence to suggest that such prices will increase systematically with GDP. This assumption can also be applied for km based O&M costs in the absence of a comparative date set between countries at different economic levels as unit labour cost increases may well be fully offset by efficiency increases (e.g. with more use of machines for maintenance).

In various European projects, scenarios have been constructed for the expected increase in transports cost by mode and the general price level, which if needed could also be used as a default.

# 5. Modelling other complex changes to freight cost in CBA for typical rail freight improvement measures

### *5.1. General*

When scoping the transport model and the CBA, it is necessary to gain an understanding of the type of impacts that can accrue from a project, and how they might be modelled.

Below we list how some other types of rail improvement measures (aside from the ones of travel time improvements, reliability improvements, route shortening, electrification and reduction in maximum axle loading elaborated in sections 4.2.5 to 4.6.3) which might impact the freight cost model and the corresponding components of the CBA including the Mode Choice model and its outcome. The list of examples is not meant to be exhaustive, but rather illustrative.

### *5.2. Increase in Train Length*

| Train Length<br>INCREASE | Transport Cost per Tonne<br>DECREASE | Staff and Vehicle Time<br>DECREASE |
|---|---|---|

If maximum allowable train length is increased by 10% through introducing longer passing sidings for freight trains, then the cost of hiring wagons will go up more or less proportionally. For non-container trains, the default for these costs is 1.5 euro per hour per wagon. For these trains we assume 18 wagons per train as default, giving a base cost of wagons of 26 euro per hour per train. A 10% longer train will therefore lead to 2.6 euro per hour extra wagon cost. For container trains, the average default cost is 1.12 euro per hour per wagon. For the default train length for container trains of 20 wagons this gives 22.35 euro per train per hour and a 10% increase then is 2.24 euro per hour per train.

Furthermore we assume that in this case the energy cost also go up proportionately (this is a conservative assumption). There might also be an increase in the rail infrastructure access charges, depending on whether the current category of trains in the charging system leaves room for an increase in train weight or not. Here we assume that all distance-based costs go up by 10%. The defaults vary between 5.39 and 7.85 euro per kilometre per train, so the costs per km would increase by 0.54 to 0.79 euro per train per km. There will be no other cost increases than for wagon cost and distance cost.

Because of the longer trains, the shippers need fewer trains for the same amount of transport. We assume proportionality, so this reduces the total transport costs in the above example by 10%. This therefore applies to all cost components.

So all in all there will be a reduction in transport cost per tonne, which consists of a proportional reduction of the crew costs, the costs of hiring locomotives and overhead costs (assuming the longer trains do not require extra staff and locomotives).

In the transport model, one can simulate this by reducing these transport costs components for rail, which will lead to substitution towards rail. The reduction in staff time costs and for hiring locomotives in the CBA is handled by reducing these costs and thus calculating time benefits.

### 5.3. Change in Maintenance Regime

| Maintenance Expenditure<br>INCREASE | Transport Cost per Tonne<br>DECREASE | Transport Time<br>DECREASE |
|---|---|---|

This will probably not change the unit costs per hour nor the overhead or rail access cost, but can reduce the traction cost per km. However it's difficult to give general guidelines to determine by how much, and this also goes for the reduction in transport time and unreliability as a result of a higher quality of rail infrastructure and maintenance. The best thing to do is to take these impacts from similar projects that have been carried out elsewhere.

### 5.4. Change in Prioritisation

| Prioritisation of Rail Freight<br>INCREASE | Transport Time<br>DECREASE | Transport Reliability<br>INCREASE |
|---|---|---|

If practical policy is changed to give freight higher priority on international freight corridors where there is limited passenger transport, then this might be reflected in time and reliability gains for freight. Gains might be derived from considerations of the lower reliability impacts of planned or unplanned works on timetables (if for example freight trains are left undisturbed). Any expected reductions in operator buffer times or changes to timetables should be counted here and valued using the same VTT. For the change in reliability (standard deviation), the basis might be observations on actual travel time over a longer period (e.g. a year). For the impact of policy measures/projects on reliability, specific assumptions then need to be made how these might influence the base distribution of transport time.

### 5.5. Intermodality

| Availability of InterModal Terminals<br>INCREASE | Access and Waiting Time<br>DECREASE |
|---|---|

This will reduce the terminal costs, which are incorporated in the rail access charges in the Excel sheet on transport costs. But they can also lead to time gains, which are as relevant to the transport models and the CBA as the time gains between terminals, since what matters are the door-to-door transport times (therefore see speed changes above). It can also lead to reductions in unreliability and damage.

### 5.6. Change in Gradient of Railway

| Line Gradient<br>DECREASE | Line Capacity<br>INCREASE | Transport Cost per Tonne<br>DECREASE | Transport Time<br>DECREASE |
|---|---|---|---|

If the railway line in the reference situation has a steep gradient (in a mountainous area) and this gradient is reduced as part of the project (e.g. by more curves or by more tunnels) this will reduce the need for a more than standard number of locomotives. For the reference situation one could for instance calculate the transport costs using two locomotives (by doubling the variable traction cost). And then one could use a single locomotive for the project situation, so that the project will reduce the traction cost. There will also be an impact on travel time (and POSSIBLY reliability), which could be quite large in the case of tunnel projects.

# Annex A - Default Parameter Values

*Table A.1: Transport Cost Component of Travel Time (Including Overhead Cost), EUR per Train-Hour, 2010 PRICES*

| **Train Type** | **block train** | | | | **wagonload train** | | | | **container train** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Traction** | electric | | diesel | | electric | | diesel | | electric | | diesel | |
| **Taxes** | with | without | with | without | with | without | with | without | with | without | with | without |
| | | | | | | | | | | | | |
| **Country** | | | | | | | | | | | | |
| **Bulgaria** | 340.57 | 339.37 | 385.56 | 367.36 | 377.68 | 380.88 | 439.88 | 417.80 | 317.54 | 316.35 | 356.07 | 342.06 |
| **Croatia** | 360.57 | 356.34 | 405.26 | 374.93 | 397.97 | 394.37 | 459.73 | 422.67 | 337.39 | 329.46 | 375.78 | 350.87 |
| **Czech** | 362.97 | 361.61 | 407.63 | 384.56 | 400.41 | 399.72 | 462.11 | 434.69 | 339.77 | 334.66 | 378.14 | 359.51 |
| **Estonia** | 356.05 | 354.31 | 400.82 | 378.47 | 393.39 | 392.32 | 455.25 | 429.07 | 332.91 | 327.46 | 371.33 | 353.17 |
| **Greece** | 397.08 | 379.10 | 441.25 | 399.58 | 435.01 | 417.46 | 495.98 | 448.80 | 373.64 | 351.89 | 411.76 | 375.02 |
| **Hungary** | 356.59 | 355.87 | 401.35 | 372.26 | 393.94 | 393.90 | 455.78 | 418.83 | 333.44 | 329.00 | 371.86 | 348.69 |
| **Latvia** | 349.97 | 348.76 | 394.82 | 371.89 | 387.22 | 386.69 | 449.20 | 421.84 | 326.87 | 321.99 | 365.33 | 346.84 |
| **Lithuania** | 355.27 | 355.02 | 400.04 | 378.06 | 392.59 | 393.04 | 454.47 | 428.10 | 332.13 | 328.16 | 370.55 | 353.01 |
| **Poland** | 355.47 | 354.39 | 400.25 | 375.22 | 392.80 | 392.39 | 454.67 | 424.09 | 332.34 | 327.53 | 370.76 | 350.66 |
| **Romania** | 344.59 | 345.72 | 389.51 | 369.99 | 381.76 | 383.60 | 443.86 | 420.48 | 321.53 | 318.99 | 360.03 | 344.70 |
| **Slovakia** | 359.45 | 363.26 | 404.16 | 387.29 | 396.84 | 401.39 | 458.62 | 438.02 | 336.28 | 336.28 | 374.68 | 361.99 |
| **Slovenia** | 382.67 | 364.33 | 427.05 | 386.12 | 420.40 | 402.47 | 481.67 | 436.46 | 359.34 | 337.33 | 397.56 | 361.70 |
| **FYR Macedonia** | 341.56 | 343.94 | 386.54 | 366.52 | 378.69 | 381.80 | 440.86 | 416.08 | 318.53 | 317.24 | 357.05 | 341.61 |
| **Montenegro** | 341.11 | 342.90 | 386.09 | 365.50 | 378.23 | 380.74 | 440.41 | 415.04 | 318.07 | 316.21 | 356.60 | 340.58 |
| **Serbia** | 345.70 | 347.69 | 390.62 | 370.22 | 382.89 | 385.60 | 444.97 | 419.83 | 322.64 | 320.94 | 361.13 | 345.31 |
| **EU15** | **460.02** | **416.56** | **504.23** | **441.51** | **498.54** | **455.09** | **560.40** | **489.08** | **435.47** | **392.02** | **409.00** | **372.29** |

*Table A.2: Cargo Cost Component of Travel Time, EUR per Tonne-Hour – 2010 PRICES*

| **Taxes** | **Freight with Low Added Value:**<br>< 6000 euro/tonne,<br>e.g. bulk/aggregates | **Ordinary Freight:**<br>6000-35000 euro/tonne,<br>e.g. other rail, sea and river transport | **Freight with High Added Value:**<br>> 35000 euro/tonne,<br>e.g. combined, parcels, refrigerated, roro |
|---|---|---|---|
| | | | |
| **EU28** | **0.0** | **0.2** | **0.6** |

*Table A.3: Ramp-Up in Transport Cost Component of Travel Time Benefits*

| | **Ratio of Travel Time Benefits Achieved** | | | | |
|---|---|---|---|---|---|
| **Type** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
| All goods | 0.44 | 0.55 | 0.66 | 0.77 | 0.89 |
| Containers | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 |
| Bulk | 0.44 | 0.55 | 0.66 | 0.77 | 0.89 |
| Wagonload | 0.42 | 0.53 | 0.64 | 0.76 | 0.88 |

*Table A.4: Assumed Train Loading (tonnes)- basis for table A1 and A5 train values*

| | **Block Train** | | **Wagonload Train** | | **Container Train** | |
|---|---|---|---|---|---|---|
| **Traction** | electric | diesel | electric | diesel | electric | diesel |
| Wagons | 18 | 18 | 18 | 18 | 20 | 20 |
| Gross Tonnage | 1705 | 1733 | 1705 | 1733 | 1385 | 1413 |
| Net Tonnage | 1143 | 1143 | 1143 | 1143 | 750 | 750 |
| Tonnage/Wagon | 63.5 | 63.5 | 63.5 | 63.5 | 37.5 | 37.5 |

*Table A.5: Operating Cost (Traction), EUR per Train-km – 2010 PRICES*

| **Train Type** | **block train** | | | | **wagonload train** | | | | **container train** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Traction** | electric | | diesel | | electric | | diesel | | electric | | diesel | |
| **Taxes** | with | without | with | without | with | without | with | without | with | without | with | without |
| | | | | | | | | | | | | |
| **Country** | | | | | | | | | | | | |
| **Bulgaria** | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 |
| **Croatia** | 3.12 | 3.12 | 5.59 | 4.19 | 3.12 | 3.12 | 5.59 | 4.19 | 3.12 | 3.12 | 5.59 | 4.19 |
| **Czech** | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 |
| **Estonia** | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 |
| **Greece** | 3.12 | 3.12 | 5.59 | 4.30 | 3.12 | 3.12 | 5.59 | 4.30 | 3.12 | 3.12 | 5.59 | 4.30 |
| **Hungary** | 3.12 | 3.12 | 5.59 | 4.08 | 3.12 | 3.12 | 5.59 | 4.08 | 3.12 | 3.12 | 5.59 | 4.08 |
| **Latvia** | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 |
| **Lithuania** | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 | 3.12 | 3.12 | 5.59 | 4.42 |
| **Poland** | 3.12 | 3.12 | 5.59 | 4.30 | 3.12 | 3.12 | 5.59 | 4.30 | 3.12 | 3.12 | 5.59 | 4.30 |
| **Romania** | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 |
| **Slovakia** | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 | 3.12 | 3.12 | 5.59 | 4.47 |
| **Slovenia** | 3.12 | 3.12 | 5.59 | 4.36 | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 |
| **FYR Macedonia** | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 |
| **Montenegro** | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 |
| **Serbia** | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 | 3.12 | 3.12 | 5.59 | 4.39 |
| **EU15** | **3.12** | **3.12** | **5.59** | **4.39** | **3.12** | **3.12** | **5.59** | **4.39** | **3.12** | **3.12** | **5.59** | **4.39** |

*Table A.6: Track access charge, EUR per Train-km – 2010 PRICES*

| **Train Type** | **block train** | | | | **wagonload train** | | | | **container train** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Traction** | electric | | diesel | | electric | | diesel | | electric | | diesel | |
| **Taxes** | with | without | with | without | with | without | with | without | with | without | with | without |
| | | | | | | | | | | | | |
| **Country** | | | | | | | | | | | | |
| **Bulgaria** | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 |
| **Croatia** | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 |
| **Czech** | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 | 3.39 |
| **Estonia** | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 |
| **Greece** | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 |
| **Hungary** | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 | 2.12 |
| **Latvia** | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 | 9.97 |
| **Lithuania** | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 |
| **Poland** | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| **Romania** | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 | 3.32 |
| **Slovakia** | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 |
| **Slovenia** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **FYR Macedonia** | | | | | | | | | | | | |
| **Montenegro** | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| **Serbia** | | | | | | | | | | | | |
| **EU15** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** | **2.27** |

*Table A.7: Recommended Reliability Ratios*

| **Commodity** | **Reliability ratio (=VTTV/VTT)** |
|---|---|
| Freight with low added value:<br>< 6000 euro/tonne,<br>e.g. bulk/aggregates | 0.40 |
| Ordinary freight:<br>6000-35000 euro/tonne,<br>e.g. other rail, sea and river transport | 0.65 |
| Freight with high added value:<br>> 35000 euro/tonne,<br>e.g. combined, parcels, refrigerated, roro | 0.65 |

*Table A.8: Default Costs for Competing Modes (€ per Vessel, Including taxes) – 2010 PRICES*

| **Variable** | **Calculations** | **Truck** | **Inland waterways** | **Short sea shipping** |
|---|---|---|---|---|
| **capacity (tonnes)** | (L) | 27 | 2500 | 30000 |
| **assumed hrs/year** | (h) | 2600 | 2037 | 6552 |
| **assumed km/year** | (k) | 130000 | 31777 | 295000 |
| **crew cost per hour** | (a) | 20 | 60 | 90 |
| **crew cost per year** | (b) | 52000 | 122220 | 589680 |
| **fuel cost per km** | (c) | 0.4 | 6 | 10 |
| **fuel cost per year** | (d) | 52000 | 190662 | 2950000 |
| **other cost** | (e) | 49000 | 288000 | 2390000 |
| **Total vessel cost/year** | **(b)+(d)+(e)** | **153000** | **600882** | **5929680** |
| *Cost per tonne-km* | *(c)/(L)* | *0.015* | *0.002* | *0.000* |
| *Cost per tonne-hour* | *(a)+(e)/(h)* | *38.8* | *201.4* | *454.8* |

*Table A.9: Maintenance Costs for Railway Infrastructure (€ per track km, Including taxes) – 2010 PRICES*

| Country | Single Track | Double Track |
|---|---|---|
| **Bulgaria** | 25,710 | 42,859 |
| **Croatia** | 28,647 | 47,755 |
| **Czech** | 29,000 | 48,343 |
| **Estonia** | 27,984 | 46,650 |
| **Greece** | 34,010 | 56,695 |
| **Hungary** | 28,063 | 46,782 |
| **Latvia** | 27,091 | 45,160 |
| **Lithuania** | 27,869 | 46,457 |
| **Poland** | 27,899 | 46,508 |
| **Romania** | 26,300 | 43,842 |
| **Slovakia** | 28,483 | 47,481 |
| **Slovenia** | 31,894 | 53,167 |
| **FYR Macedonia** | 25,856 | 43,102 |
| **Montenegro** | 25,789 | 42,991 |
| **Serbia** | 26,464 | 44,116 |
| **EU15** | 39,369 | 65,629 |

*Note: These are illustrative values that should be adjusted based on national data if available.*

*Table A.10: Default Parameters for Train Weights*

| Country | | Weight of loco | Weight of single wagon | Number of wagons | Weigh of all wagons |
|---|---|---|---|---|---|
| Block Train - Electric | Gross (tonnes) | 85 | 90 | 18 | 1620 |
| | Wagon (tonnes) | 85 | 26.5 | 18 | 477 |
| | Cargo (tonnes) | 0 | 63.5 | 18 | 1143 |
| Block Train - Diesel | Gross (tonnes) | 113 | 90 | 18 | 1620 |
| | Wagon (tonnes) | 113 | 26.5 | 18 | 477 |
| | Cargo (tonnes) | 0 | 63.5 | 18 | 1143 |
| Wagonload Train - Electric | Gross (tonnes) | 85 | 90 | 18 | 1620 |
| | Wagon (tonnes) | 85 | 26.5 | 18 | 477 |
| | Cargo (tonnes) | 0 | 63.5 | 18 | 1143 |
| Wagonload Train - Diesel | Gross (tonnes) | 113 | 90 | 18 | 1620 |
| | Wagon (tonnes) | 113 | 26.5 | 18 | 477 |
| | Cargo (tonnes) | 0 | 63.5 | 18 | 1143 |
| Container Train – Electric | Gross (tonnes) | 85 | 50;70 | 5 - Sgns;15- Sggmrss* | 1300 |
| | Wagon (tonnes) | 85 | 30;40 | 5 - Sgns;15- Sggmrss | 550 |
| | Cargo (tonnes) | 0 | 20;30 | 5 - Sgns;15- Sggmrss | 750 |
| Container Train - Diesel | Gross (tonnes) | 113 | 50;70 | 5 - Sgns;15- Sggmrss | 1300 |
| | Wagon (tonnes) | 113 | 30;40 | 5 - Sgns;15- Sggmrss | 550 |
| | Cargo (tonnes) | 0 | 20;30 | 5 - Sgns;15- Sggmrss | 750 |

** See Table A.11 for definitions*

*Table A.11: Default Rolling Stock Costs*

**Locomotive costs, diesel**

| | Depreciation (€/year) | Interest (€/year) | Insurance (€/year) | Maintenance (€/year) | Total per loco (€/year) | Costs per turn | Duration of one turn (h) | Costs per hour, based on turnaround time | Costs per hour, based on utilization rate of loco=30% |
|---|---|---|---|---|---|---|---|---|---|
| Loco 1 | 120000 | 90000 | 66000 | 195000 | 471100 | 1811.54 | 6.79 | 266.80 | 179.26 |
| Loco 2 | 100000 | 75000 | 55000 | 162500 | 392500 | 1509.62 | 5.2 | 290.31 | 149.35 |
| Loco 3 | 120000 | 90000 | 66000 | 195000 | 471000 | 1811.54 | 7.3 | 248.16 | 179.22 |
| **Average** | | | | | | | | **268.42** | **169.28** |

**Locomotive costs, electric**

| | Depreciation (€/year) | Interest (€/year) | Insurance (€/year) | Maintenance (€/year) | Total per loco (€/year) | Costs per turn | Duration of one turn (h) | Costs per hour, based on turnaround time | Costs per hour, based on utilization rate of loco=30% |
|---|---|---|---|---|---|---|---|---|---|
| Loco 1 | 128000 | 96000 | 70400 | 138000 | 432400 | 3326.15 | 18.325 | 181.51 | 164.54 |
| Loco 2 | 120000 | 90000 | 66000 | 138000 | 414000 | 3184.62 | 20.725 | 153.66 | 157.53 |
| Loco 3 | 140000 | 105000 | 77000 | 138000 | 460000 | 3538.46 | 17.48 | 202.43 | 175.04 |
| **Average** | | | | | | | | **179.20** | **165.70** |

**Cost of wagons**

| Type | Freight type | Depreciation (€/year) | Interest (€/year) | Insurance (€/year) | Maintenance (€/year) | Total per wagon (€/year) | Costs per turn (€/turn) | Duration of one turn (h) | Costs per hour | Costs per hour, based on utilization rate of wagon=85% |
|---|---|---|---|---|---|---|---|---|---|---|
| Sgns | Container (TEU) | 2400 | 1650 | 720000 | 1800 | 6570 | 25.27 | 48.70 | 0.52 | 0.88 |
| Sggmrss | Container (TEU) | 3680 | 2530 | 1104 | 2760 | 10074 | 38.75 | 48.70 | 0.80 | 1.35 |
| Zans | Liquid fuel | 3000 | 2063 | 900000 | 3750 | 9713 | 37.36 | 48.75 | 0.77 | 1.30 |
| Habbins | Mixed | 4000 | 2750 | 1200 | 3000 | 10950 | 42.12 | 34.96 | 1.20 | 1.47 |

*Source: "Costs and performance of European rail freight transportation" prepared by Panteia*

# Annex B - Technical Reports