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Technical support

for the interoperability Issues Logbook

Methodology for cost benefit analysis of the solutions and pilot projects and impacts estimation

16-03-2022

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Glossary

	DESCRIPTION
ATTI	Agreement On Freight Train Transfer Inspection
CBA	Cost-Benefit Analysis
CBP	Cross-Border Point
CIP	Costumer Information Platform by RNE
DG MOVE	Directorate-General for Mobility and Transport
EC	European Commission
ELETA	Electronic exchange of Estimated Time of Arrival Project
ERA	European Union Agency for Railways
ERTMS	European Railway Traffic Management System
ETA	Estimated Time of Arrival
GPS	Global Positioning System
HGV	Heavy Goods Vehicles
ILB	Rail Technical and Operational Issues affecting Interoperability Logbook
IM	Infrastructure Manager
IT	Information Technology
KPI	Key Performance Indicator
MS	European Union Member State
NSA	National Safety Agency
OD	Origin-Destination
PPP	Purchasing Power Parity
RFC	Rail Freight Corridor
RNE	Rail Net Europe
RU	Railway Undertaking
SCM	Standard Cost Model
SMS	Safety Management System
TAP TSI	Telematics Applications for Passenger Service TSI
TAF TSI	Telematics Applications for Freight Service TSI
TCM	Train Composition Message
TCR	Temporary Capacity Restriction
TID	Train Identifier
TIS	Train Information System by RNE
TKM	Tonne-Kilometre
TSI	Technical Specification for Interoperability
VOT	Value of Time
VSL	Value of Statistical Life

0 Executive summary

The “Rail Technical Operational Issues Logbook” initiative was launched in 2017 by the European Commission with the main objective to identify barriers to interoperability hampering international rail freight traffic, notably along Rail Freight Corridors (RFC). Since then, stakeholders have been reporting issues and potential solutions, largely focused on operational aspects such as braking, train composition, border checks, among others.

In the end of 2019, DG MOVE awarded a study to the Panteia consortium to provide technical support to the ILB, which includes also the support towards the estimation of the economic impacts of solving the rail breakthrough issues.

This report presents the results of the economic impacts of the rail breakthrough issues proposed in the Rail Technical and Operational Issues affecting Interoperability – Logbook (ILB). The analysis performed highlights the positive outcome of the ILB measures. The results are categorised as resource cost savings including two items identified as crucial:

- Rail freight time savings – associated with savings in drivers and other personal wage costs, locomotive energy per stop costs savings;
- Operational savings – namely administrative and overhead expenses reductions.

The ILB identifies 15 issues divided into five large themes containing three priorities (Table 1).

Table 1: Resume of Issues Logbook priorities and issues

Issue category/Priority[1]	Issue Number	Issue Title
1 (Braking)	1	Braking sheets
1(Braking)	2	Braking performance
Other issues	3	Taillights vs. plates
3 (Real time communication)	4	Train composition - Harmonisation of wagon list
3 (Real time communication)	5	Train composition - Working handbrake last wagon
3 (Real time communication)	6	Train composition - No push 6 axles wagons
3 (Real time communication)	7	Train composition - Buffer wagons
2 (Technical checks at border)	8	Technical checks at border stations
2 (Technical checks at border)	9	Mandatory checks in MSs
Other issues	10	Operational implementation of the traffic in ERTMS
Other issues	11	New train number
Other issues	12	Exception from operational rules

[1] The issues from the ILB are grouped in five larger themes. The ILB is a living document. In the beginning of the project three out of the five large themes were referred as priorities by the European Commission. Those priorities include the issues where international freight activities were lagging behind expectations. The remaining themes do not have a priority number associated.

Issue category/Priority[1]	Issue Number	Issue Title
Other issues	13	Two-people cabin crew
Other issues	14	Equipment of border stations with commutable electric power supply
3 (Real time communication)	15	Real-time communication and harmonisation of train composition message (wagon list)

Source: DG MOVE

Only thirteen issues were studied in the economic evaluation as issues 10 and 12 did not have any project support actions defined. From those estimated, it is worth noting that issue 13 does not generate impacts from the same nature as the remaining. In other words, no time savings are expected from solving it and the nature of the operational costs savings is associated with reducing the number of staff and/or train drivers per train.

The impact estimations include a qualitative and a quantitative analysis. The first comprises the description of each issue along with the identification of expected qualitative impacts from solving them. The quantitative analysis translates the savings that elapse from solving the issues in time and costs.

Results are presented for the locations where they have been reported by stakeholders and extrapolated by the consortium for the all the borders where the issues were identified in Europe.
In order to allow for an effective methodology for economic impact assessment and technical assistance to the projects, a selection of representative case studies was proposed. Such case studies represent cross-sections of the geographical scope of the RFCs, and address issues covering the three ILB priorities agreed as follows:

- **Case Study A - Priority 1:** This case study addresses issues 1 (braking sheets) and 2 (braking performance), based on the Dutch-German cross-border braking performance.
- **Case Study B - Priority 2:** This case study addresses issues 8 (technical checks at border stations) and 9 (mandatory checks in Member States), centred on streamlined border crossing procedures along Orient-East Med RFC (RFC 7) and Rhine-Danube RFC (RFC 9), focusing on the Curtici - Lökösháza border (Hungary – Romania).
- **Case Study C - Priority 3:** This case study addresses issues 4 (train composition - harmonisation of wagon list) and 15 (real-time communication and harmonisation of train composition message (wagon list)) on the basis of the through-going real-time train information, as part of the Rhine-Alpine (RFC 1) and Orient-East Med (RFC 7) Rail Freight Corridors. This may include matching trains between borders, missing information in RNE TIS (link to ELETA), as well as no train composition information.

The remaining issues identified for technical support from the consortium were evaluated. The estimation of impacts was performed in the geographical points where the occurrences were reported as a bottleneck to the rail freight operation. These include:

- Issue 3 – Tailights vs plates in trains crossing Belgian, French, Italian, Spanish and Portuguese borders;

- Issue 5 - Train composition (last wagon working handbrake) at cross-border points in Romania;
- Issue 6 – Train composition (no push 6 axles wagons) in mountainous areas in Romania;
- Issue 7 – Train composition (buffer wagons) at cross-border points in Romania;
- Issue 11 – New train number in all cross-border sections entering Romania and Hungary apart from the sections between Slovakia and Hungary, and;
- Issue 13 – Two-people cabin crew affecting all the cross-border points of Italy, Bulgaria and Romania, and;
- Issue 14 - Equipment of border stations with commutable electric power supply in Essen-Grens (DE)/Roosendaal (NL) and Bad Bentheim (DE)/Oldenzaal (NL) borders.

Additionally, a specific case study for Romania was developed. Such analysis derives from the fact that ten of the twelve issues quantitatively analysed are observed in Romania (issues 1|2, 4|15, 5, 6, 7, 8|9 and 11), thus the impact of solving the issues in this specific country can reveal important benefits for rail freight competitiveness.

The economic analysis has been challenged by the (still) persisting lack of data and/or inconsistent datasets at the EU and MS level. While this situation is improving, notably for the Rail Freight Corridors, with large developments being implemented by RNE, data for 2019 (baseline) still face some fragilities. Nevertheless, the choice of 2019 as representative to the Issues LogBook estimations results from a conservative approach to exclude the biased results of more recent years due to the covid-19 pandemic effects.

One of the main issues identified are different number of annual trains in each side of the borders: in some cases, this is the direct consequence of different infrastructural conditions (i.e. different train length forcing to a different train composition and different numbering), in other cases this results from real inconsistent data. Taking such constraints into account, the approach followed along the study was to present all the analysis in a range (i.e., for the minimum and maximum number of trains in the border). By providing the range, the uncertainty about input data on rail traffic in the economic model applied by the consortium, is minimised.

Notwithstanding, when presenting main conclusions, a conservative approach is again adopted, and the main outputs are presented considering the minimum number of trains in the borders. This reduces the risk of overestimation of impacts.

Overall, the analysis undertaken depicts a positive outcome if the ILB problem solving is implemented along the EU borders.

The subset of analysed border points classified in ILB spreadsheet as the most critical and urgent to act upon for solving the issues, shows a direct benefit in the first year of 253,9M€ for all the issues present at the locations reported by stakeholders. These locations are labelled as 'dedicated'. Extrapolating these results to all the other border points where the different issues have been identified would result in a total benefit for the EU of 504,9M€ on the first year after the issue is solved.

Table 2 presents the monetary impacts from solving each issue and case study in the dedicated sites where they have been assessed, for the remaining locations where the issues were identified and overall, for the EU level (i.e. the sum of the previous two).

Additionally, Table 2 also presents the relative weights of impacts in the dedicated sites when compared to the total at EU level.

The results exclude the direct costs associated with the elimination of the issues. Only the savings from solving those issues were quantified.

Table 2: Expected impacts from solving the issues for most urgent locations (dedicated sites), other locations and at EU level (total), in million euros.

Issues	Dedicated sites	Other locations where the issue occurs	EU level	Weight of impacts in dedicated sites at EU level
1|2 (Case study A)	6,6	32,5	39,1	17%
8|9 (Case study B)	7,0	16,1	23,1	30%
4|15 (Case study C)	81,3	79,2	160,5	51%
3	13,5	0,0	13,5	100%
5	1,9	0,4	2,4	81%
6	12,2	3,2	15,3	79%
7	1,9	15,1	17,1	11%
11	14,5	29,6	44,1	33%
13	135,6	0,0	139,6	100%
14	4,2	74,8	78,9	5%
Total	**278,6**	**251,0**	**529,6**	**50%**
Romania	55,8	0,0	55,8	100%

Freight time savings are the main driver of costs in issues 8|9, 11, 4|15 and case specific of Romania, on the other hand, the operational cost savings (due mostly to administrative and overhead expenses reductions) are the main driver of costs for issues 1|2, 3, 5, 6, 7 and also for issue 13. The results do not change if the impacts are considering either the minimum or the maximum number of trains affected by each issue. Issue 14 presents freight time savings as main driver of costs in the scenario of minimum trains and RUs and operational costs as main driver of total costs in the case of maximum trains and RUs.

Figure 1 shows in detail the impacts of solving the issues per category of impact (freight time savings and administrative and overhead cost savings) per issue and case study in the minimum scenario of number of affected trains and railway undertakings, in million euros.

Figure 2 depicts the results in number of trains affected by each issue.

Figure 1: Main drivers of impacts per issue (freight time savings and operational and overhead costs) at EU level, in M€

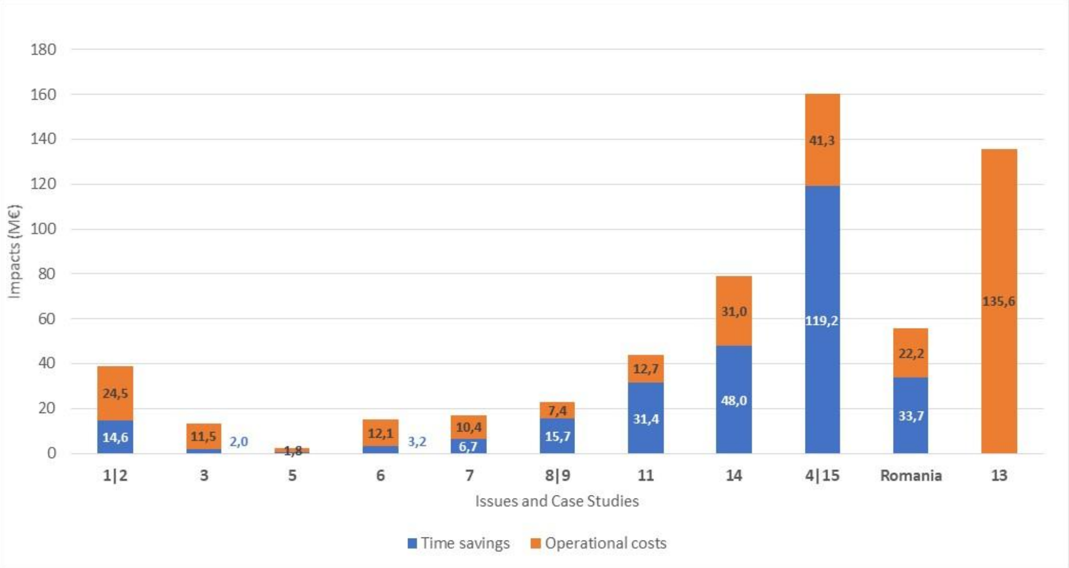
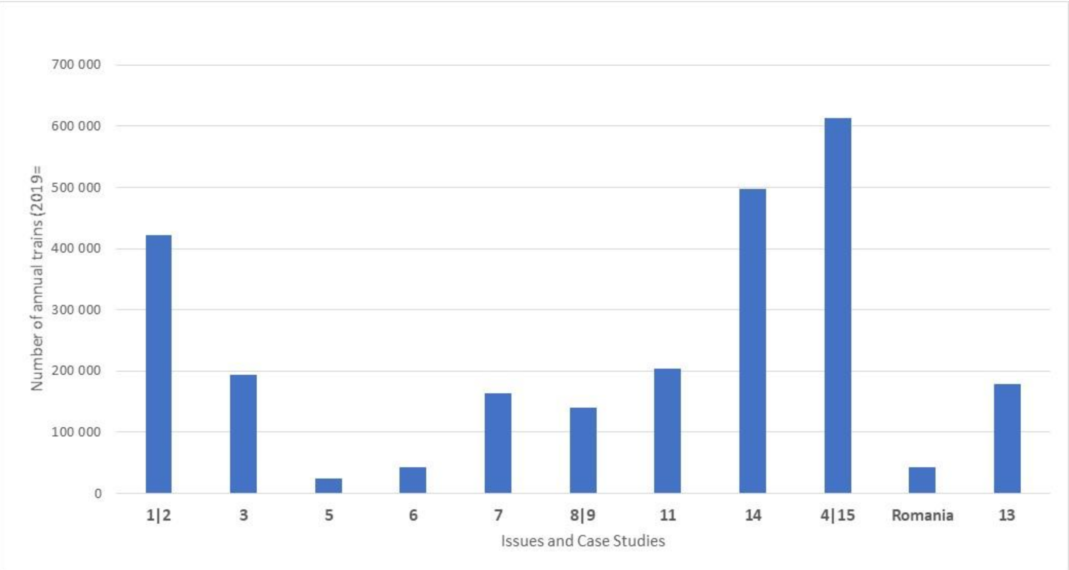


Figure 2: Total number of trains affected annually (2019) per issue and case study



Sources: RNE database, stakeholders' survey results and interviews

In terms of saved hours,

Table 3 shows an overall magnitude of 3,7 million hours lost at the EU level due to the presence of existing issues. Nearly 1,5 million hours are estimated to be lost per year with issue 14, due to different traction and voltage[2] . This is followed by issue 4 and 15,

[2] Taking into account the diversity of traction voltages in the EU network, this value might be underestimated, once it only includes the border sections for which the number of trains is measured by the different RFC. However, we consider Issue 14 sort of an outlier given that, although current practices of loco change at borders due to differences in traction voltage entail certain time loss and costs, this Issue is not entirely an interoperability barrier.

with 1,3 million hours lost along an entire corridor and issue 11 - New train number – responsible for 400 thousand hours lost. Issues 8 and 9 (Case Study B) technical checks at borders stations and mandatory checks in Member States generates time losses of 209 hours in 2019 while issues 1 and 2 (Case study A) counts for 140 thousand hours lost. Overall, all the issues occurring in Romania imply almost 656 thousand hours.

Table 3: Total lost hours per issue and case study annually (2019)

Issues and Case Studies	Hours lost	Weight of lost hours per issue in the total of hours lost
1|2	140 388	5,05%
3	16 196	0,58%
5	18 808	0,68%
6	54 081	1,95%
7	122 077	4,39%
8|9	209 079	7,53%
11	400 744	14,43%
13	n.a.	n.a.
14	1 483 302	38,96%
4|15	1 280 877	46,11%
Total	**3 725 551**	**100,00%**
Romania	655 612	23,60%

The total impacts at EU level from solving the issues analysed in the study has an overall magnitude of 529,6M€ which shows that such type of soft and less cost intensive measures can have a large economic impact for the rail freight stakeholders and notably for the RUs.

Moreover, solving the issues not only contributes to increase the efficiency and the competitiveness of the rail sector in order to expand the rail modal shift, but could enhance and accelerate the expected benefits resulting from the major ongoing rail infrastructure investment at the EU level. Inversely, not acting towards the harmonisation of procedures would contribute to hinder the full potential of those investments given that the infrastructure will be upgraded but the rail operations will be still hindered by the Issues.

In fact, it is highly unlikely that investments will be done to harmonise traction current across the Union. Multi-tension locomotives are a technical solution already available allowing RUs to cross borders without loco change due to voltage differences on the network.

1 Introduction

The Technical Operational Issues LogBook (ILB) is a Commission initiative to accelerate progress on interoperability by focussing on a limited number of priorities and by streamlining the work done at European, corridor and national level by public authorities (European Union Agency for Railways, European Commission, national authorities), infrastructure managers including Rail Freight Corridors, railway undertakings and rail sector associations. Through the Issues LogBook, major hindrances to cross-border rail traffic have been identified "bottom-up" by the sector. These hindrances are related to safety rules or are of a technical and operational nature.

The Rail Breakthrough initiative has highlighted the importance of solving such issues on a relatively short time horizon in view of realising the benefits of long-term investments in the TEN-T core network. In order to accelerate and achieve this, the European Commission has assigned the consortium of Panteia (lead), Railistics, Hacon and TIS a contract to provide technical assistance in addressing the matters defined by the Issues LogBook. It also includes assistance in relation to the quantification of impacts of the issues identified in the current Issues LogBook and the estimation of the economic benefits of removing these interoperability barriers on the TEN-T comprehensive network.

The economic assistance comprises: i) Identification of the current technical barriers of the Issues LogBook and ii) economic assessment of their impact both qualitative and quantitative.

The present report constitutes the final release of the economic analysis including a qualitative economic appraisal of barriers that the measures proposed in the Issue Logbook may face and a quantitative assessment of the economic impact of potential solutions. Such assessment, largely supported in the technical discussions held with stakeholders, allowed for performing a scan of different issues and its expected impacts (such as costs and time savings, quality increase, etc.) as well as for the implementation aspects that might influence the magnitude of the impacts (e.g., easy & quick implementation, border crossing issues, …).

Overall, 15 issues were identified by stakeholders and included in the DG MOVE excel registry of the Issues Logbook, grouped under 5 main themes. The selection of issues and priorities to be studied under the current project was based in the tender specifications where the rail stakeholders, supported by the client, DG MOVE, together with ERA, identified a subset of issues as the most urgent operational, technical and administrative barriers to interoperability within the cross-border rail freight service in the EU. During the first phase of the project an update of the ILB structure and its information (available on the DG MOVE website) and a prioritization of issues that qualify for technical assistance (support activities) was identified.

At an initial phase, three reference case studies were developed. Each case study represents a single ILB priority and containing two issues. The geographic regions represented by the case studies can be cross-border points (CBPs) or Rail Freight Corridors (RFCs), depending on the case study.

The three reference case studies measured the impacts of solving the following issues:

- issues 1 (Braking Sheets) and 2 (Braking performances) in Case Study A,
- issues 8 (Technical checks at border stations) and 9 (Mandatory checks in Member States) in Case Study B, and,
- issues 4 (Train composition (Harmonisation of wagon list)) and 15 (Real-time communication and harmonisation of train composition message (wagon list)) in Case Study C.

The second and third stage of analysis entailed other issues assigned as of "high priority", as showed in the table below:

Table 4: List of issues studied individually

Project	Related Issue(s)
1	5 (Train Composition - Working handbrake last wagon)
	6 (Train Composition - No push 6 axles wagons)
	7 (Train Composition – Buffer wagons)
	11 (New train number)
2	13 (2 people cabin crew)
3	3 (Tail lights vs. plates)
4	14 (Equipment of border stations with commutable electric power supply)

Additionally, two other identified issues (issues 10 and 12) were not included in the analysis as there are no targeted support actions planned within the time of the current study. Those issues are briefly described below.

Issue 10 - Operational implementation of the traffic in ERTMS

There are many non-harmonised rules which are similar in content between Belgium, France and Luxemburg, such as the European Railway Traffic Management System (ERTMS) written orders, shunting, and text messaging in case of beacon failures. According to stakeholder's survey results, this particularly affects North-Sea Mediterranean RFC (RFC 2), which considers that more coordinated rules at the European level are required. According to the answers collected at the stakeholder's survey, RFC 2 on its own has limited power and this issue affects all cross-border points. Issue 10 is currently unsolved. Nonetheless there are no project support actions defined to address it. Therefore, the basis to support the economic analysis cannot be carried

Issue 12 - Exception from operational rules

Non-harmonised operational rules are still a considerable obstacle particularly when trains need to be re-routed via another country in case of planned or unplanned deviations. This issue potentially affects all border crossings.

Notwithstanding its classification as a barrier, Issue 12 is not yet clearly defined, and no support action is planned withing the time of the current study. Consequently, the economic analysis will not be performed.

1.1 Structure of the report

The report is structured in six main chapters, as follows:

Chapter 1 contains the introduction.

Chapter 2 presents the adopted methodology, assumptions, the impact model and the limitations of the analysis.

Chapter 3 presents a qualitative and a quantitative analysis of all the rail breakthrough issues proposed in the ILB in the most critical geographic points. Additionally, an extrapolation exercise is developed for the issues impacts in all locations.

Chapter 4 contains the main conclusions of the economic analysis.

Chapter 5 comprises the references used for the study.

Finally, Chapter 6 presents the annexes.

2 Methodological approach

2.1 Overview

The Cost Benefit Analysis (CBA) is an analytical tool used to evaluate an investment decision and support a decision considering the monetisation of all (or the most important) costs and benefits related to a public intervention or all viable alternatives at hand. It allows quantifying the variation of well-being of the overall society due to the occurrence of an investment. The main goal of the CBA is to support a more efficient allocation of resources while demonstrating the relevance of a certain intervention over its alternatives. The CBA can help to determine the overall impact of an intervention and whether it is worth undertaking it. These fits in the analysis of the impacts of the interventions for the different issues identified in the ILB.

The CBA of a project consists of two main core components: the financial analysis and the economic analysis. While the financial analysis is focused on the costs and benefits ascribed to the stakeholders directly impacted by a project, such as the Railway Undertaking (RU) or Infrastructure Manager (IM), the economic analysis is focused on the costs and benefits for the overall society. Under the ILB initiative, benefits are above all generated by non-intensive capital changes and focused on the operational aspects of cross-border freight trains around Europe. Solving the issues translates particularly on time and cost savings for the border operations which do not require heavy infrastructure investments. Inversely, to a large extent, issues reflect legacy regulations and elimination of national rules which have an economic impact.

Analysis is supported on the information collected through initial desk research, interviews and stakeholder survey and further completed with the review of additional documents and information resulting from the interviews. The economic analysis is done on the top of the technical support to ILB, i.e., it takes into consideration a range of impacts (such as time and costs for performing activities) identified and discussed with stakeholders, notably in terms of metrics. Additionally, survey and interviews allowed to identify the different locations where issues occur which are relevant to provide an overall magnitude of the impacts. All the input data and consequent results take 2019 as a base year. The choice of this year as representative to the Issues LogBook estimations results from a conservative approach to exclude the biased results of more recent years due to the covid-19 pandemic effects.

In this report a brief overview of each issue and its underlying causes and impacts is provided, allowing the reader to have a context for the results interpretation. However for a complete overview of each issue and its technicalities, the reading of the ILB Implementation Deployment Plan is recommended.

Overall, impacts refer to resource cost savings as resulting from the issues solving comprising two main categories that are described in the next chapters. Those are:

- Freight time savings, and;
- Administrative costs and overhead cost savings.

Even though the focus of the quantitative impacts is on the operational savings estimated based on time and administrative costs there are other impacts that can be expected from solving the issues. The resolution of the issues on the Issues LogBook are expected to increase the competitiveness of rail which, as a consequence, can generate the potential for modal shift from road to rail and savings in terms of externalities costs.

The approach followed by ERA in the Impact Assessment for the TSI OPE was based on a cross price elasticity that was also foreseen to be replicated in this analysis. However, taking into account important data gaps at this level, it was jointly agreed with the Commission that the core of the quantitative assessments should remain costs and time, in order to produce robust estimations at local and EU level for all relevant issues, leaving modal shift potential and externalities to future analysis.

All the values are presented as constant prices with reference to January 1st, 2019

All the values are presented net of taxes.

2.2 Freight time savings

The freight time savings were estimated as presented below[3]:

$Freight\ Time\ Saving\ (€/year)\ =\ Nº\ of\ Trains\ Affected\ \times\ ((\text{Cost of Energy} + \text{VOT hour})\times$ % Hour Lost)

Where,

Nº of trains affected correspond to the product of the % of trains affected by a given issue (proxy) and the number of annual trains at the CBPs where the issue was identified;

Cost of energy corresponds to a proxy for the cost of stopping and restarting a train at a CBP;

VOT $_{hour}$ corresponds to the Value of Time per hour at each border where the issue exists;

% hour lost to solve the issue corresponds to the share of one hour that is lost for a given issue to be solved

The Value of Time (VOT) is estimated based on two components:

- The driver costs per hour, and;
- The cost of having a locomotive stopped for one hour

Table 5 details the different variables used in the current analysis as well as the assumptions adopted to define proxies, when no specific data was possible to collect, the corresponding sources of information and identified limitations of the data.

[3] According to the recommendations of the Guide to Cost-Benefit Analysis of Investment Projects, travel time savings generate benefits in freight traffic by: reducing vehicle operating costs per trip; improving service reliability (i.e., timely delivery of transported goods), and; reducing driver wage cost per trip (and other required personal to travel with the load).
The estimation of the benefits related to operating costs of RUs and to improved reliability do not have a generally accepted approach. According to the same source, freight time savings should be estimated separately for the existing traffic of goods, the goods diverted from other transport modes or routes and the generated/induced traffic. Such detailed data is not available, thus, taking as basis the approach adopted by ERA for the Impact Assessment on the TSI OPE, an alternative methodology has been defined.

Table 5: Freight time savings variables, assumptions and sources of information

Variables	Definition	Adjustments to the data	Sources	Limitations of the data
Cross Border Points (CBPs)	Localisation between **stations and countries** - Link with the country where the station is located based on the correspondence between stations names in CIP RNE and RNE database.	This adjustment is necessary because the RNE database used as source of the border stations data does not provide information on the country where the station is located. This information is necessary for this estimation model in order to cross the impacts with the socio-economic variables of the relevant Member States.	CIP RNE and RNE database	Not applicable.
	Localisation between **stations and RFCs** - Link with the Rail Freight Corridor(s) running in each station based on the correspondence between stations names in CIP RNE and RNE database.	This adjustment is necessary because the RNE database used as source of the border stations data does not provide information on the RFCs running in each station. This information is necessary to select inputs on avoided time differentiated per RFC.	CIP RNE and RNE database	Not applicable.
Annual trains	Number of trains reported in the cross-border points in 2019	The number of trains in each side of a border is not always consistent. The estimation of impacts considers a minimum (MIN) and a maximum (MAX) number of annual trains corresponding respectively to the smaller and higher number of trains for the same border point.	RNE database	The database used considers both national and international freight trains at border stations. From 2020, the RNE TIS has a new release improving the way of collecting and reporting the number of trains by the RFCs minimising the gaps identified during this process. In the stations where the number of trains per border were unavailable the numbers from the database, they were substituted based on the joint publication of RFC KPIs from 2019.

Variables	Definition	Adjustments to the data	Sources	Limitations of the data
% hour lost to solve the issue	Share of one hour that is lost for a given issue to be solved. The list of assumption per issue can be found in annex 6.2.		Stakeholder's survey and interviews performed by the technical team	Not applicable.
Percentage (%) of affected trains	Proxy of the percentage of annual trains affected by a given issue. The list of assumption per issue can be found in annex 6.2.		Stakeholder's survey and interviews performed by the technical team	Not applicable.
Locomotive costs	Proxy for the cost of having a locomotive stopped for an hour in a border station. Assumed as 80 € per hour, based on the DBCargo Scandinavia analysed during the TSI OPE impact assessment (page 35).	Weighted by the Purchasing Power Parity in 2019 in order to adapt the assumed hourly cost to each MS.	Impact Assessment Commission Regulation (EU) 2015_995 TSI OPE and Eurostat	The TSI OPE takes the train braking rules on RFC3, more specifically the freight railway operation between Germany, Denmark and Sweden borders as reference for the locomotive costs. In the present study that value is assumed as an average value for all the European borders. There is a risk of it not being representative of each site. The aspects below are excluded from the analysis: -The possibility of a train composition with multiple locomotives; - An indicator of cost per wagon;

Variables	Definition	Adjustments to the data	Sources	Limitations of the data
				-The commercial cost of transported goods.
Energy costs	Proxy for the cost of stopping and restarting a train. Assumed as 20 € per hour, based on the DB case during the TSI OPE impact assessment (page 35).	Weighted by the Purchasing Power Parity in 2019 in order to adapt the assumed hourly cost to each MS.	Impact Assessment Commission Regulation (EU) 2015_995 TSI OPE and Eurostat	The TSI OPE takes the train braking rules on RFC3, more specifically the freight railway operation between Germany, Denmark and Sweden borders as reference for the energy costs. In the present study that value is assumed as an average value for all the European borders. There is a risk of it not being representative of each site.
Driver costs	Wages and salaries (total) per employee in full-time equivalent, per hour (land transport and transport via pipelines - 10 employees or more) per Member State for 2011 and 2016 (most recent year available by the time of the extraction).	Projection was made to 2019 based on 2016 data. The driver costs per hour values are based in the most recent Eurostat data (2016). The driver costs are then updated to constant prices of 1st January 2019 based on the Growth rate GDP per capita market prices (INDEX 2010=100) euros compound interest rate between 2016 and 2019. As follows: For a given country the driver costs in 2019 are equal to: Driver cost (2016)* compound interest rate of Growth	Eurostat LC_NCOST_R2	This simplification assumes that the driver costs correspond to the country that is being crossed which might be different from the rate paid by the RU. As an example, if a train is crossing a border between Romania and Hungary the value of time in the model considers that the driver is either being paid at a Romanian or Hungarian hourly wage. However, there is no guarantee that the train driver is being

Variables	Definition	Adjustments to the data	Sources	Limitations of the data
		rate GDP *per capita* at constant prices (INDEX 2010=100) euros (2016-2019)		paid in any other country average wage.
Growth rate GDP per capita constant prices (INDEX 2010=100) euros	Percentual change of the GDP per capita at constant prices of 2010 over a specific time period (2016-2019). Compound interest rate between 2016 and 2019. $Compound\ interest\ rate_{2016-2019} = [(1 + i_{2016}) * (1 + i_{2017}) * (1 + i_{2018}) * (1 + i_{2019})]^{1/4} 1$		Eurostat, SDG_08_10	Not applicable.
Purchasing Power Parity (PPP)	PPPs are currency conversion rates that convert economic indicators such as inflation expressed in national currencies to a common currency.	Not applicable	Eurostat: DatasetN/A Comparative price levels [TEC00120]. Data extracted on 10/08/2021 12N/A24N/A01 from [ESTAT]	Not applicable.

2.3 Administrative costs and overheads

As for the administrative costs and overhead costs savings the following methodology was used:

The estimation of administrative costs follows the Standard Cost Model (SCM) as presented in the Better Regulation Package. For each administrative activity, several cost parameters are considered such as price, time, quantity and frequency described as:

- **Price**: Price consists of a tariff, wage costs plus overhead for administrative activities done internally or hourly cost for external service providers;
- **Time**: The amount of time required to complete the administrative activity;
- **Quantity**: Quantity comprises the size of the population of businesses affected, and;
- **Frequency**: The frequency that the activity must be completed each year.

The considered basic formula of the SCM, per administrative activity, is:

$$Administrative\ Costs = Price\ \times\ Time\ \times Quantity\ (population\ \times\ frequency)$$

Given the data available for the estimation, the formula of the SCM was adapted as follows:

$$Operational\ Cost\ Savings = \sum_{i\,=\,N^{o}\,CBPs} N^{o}\ of\ RUs\ per\ CBP \times [(Adminstrative\ burden + Overhead\ cost) \times PPP\ Adjusment\ ]$$

Where,

Nº of RUs per CBPs as obtained from RNE database

Administrative burden and **Overhead cost** are constant values resulting from interviews

PPP Adjustment for a given year between the country where the administrative costs per RU were defined and the country dealing with a given interoperability issue.

Table 6 shows the definition of variables and assumptions adopted in the operational cost savings estimations.

The data collected for the definition of the price of the administrative and overhead cost per RU was obtained from the Netherlands Water and Infrastructure Ministry based on their internal estimations of efficiency gains generated by a legal act published in March 2020 on the removing of Dutch mandatory braking tables for incoming freight trains. Due to the lack of more information, it was assumed that costs per RU would be in the same order of magnitude as for the Netherlands and further adjusted in function of the country Purchasing Power Parity (PPP). The base values adopted are 85 000€ in administrative burden and 2 000€ in overhead costs yearly for each Railway Undertaking operating in a border.

Table 6: operational cost savings variables, assumptions and sources of information

Variables	Definition	Assumptions and adjustments to the data	Sources	Limitations of the data
Administrative costs	Stem from the administrative activities (including collection, processing and reporting) necessary to demonstrate compliance with a regulatory requirement.	Based on the costs provided by Netherlands: 85 000€ yearly per RU and further adjusted in function of the Purchasing Power Parity of each country in 2019	TOOL #60 The Standard Cost Model for estimating administrative costs (europa.eu) Netherlands Water and Infrastructure Ministry based on their internal estimations of efficiency gains generated by a legal act published in March 2020 on the removing of Dutch mandatory braking tables for incoming freight trains	Takes administrative costs with braking tables and braking performance from Dutch borders as reference. There is a risk of it not being representative of each site.
Overhead cost	Overhead is any expense incurred to support the business while not being directly related to a specific product or service. In this specific case it refers to the estimated indirect costs of reporting to the National Safety Agencies (NSA) per RUs reported.	It was assumed as 2 000€ per RU per year and weighted by the Purchasing Power Parity of each country in 2019	Netherlands Water and Infrastructure Ministry based on their internal estimations of efficiency gains generated by a legal act published in March 2020 on the removing of Dutch mandatory braking tables for incoming freight	Takes administrative costs with braking tables and braking performance from Dutch borders as reference. There is a risk of it not being representative of each site.
Railway Undertakings (RUs)	Number of Railway Undertakings operating in the cross-border points in 2019	The number of RUs in each side of a border is not always consistent. The estimation of impacts considers a minimum	RNE database	According to RNE, the difference between the number of RUs operating in the two sides of the

Variables	Definition	Assumptions and adjustments to the data	Sources	Limitations of the data
		(MIN) and a maximum (MAX) number of RUs corresponding respectively to the smaller and higher number of RUs for the same border point.		same border concern either the format in which that data is entering the RNE system or/and to different legislative requirements on the border countries. The differences can be justified by multiple reasons that need to checked point by point. For example, it can happen that one RU in one county is being represented by multiple other RUs in the country on the other side. Another example that one RU can, from the TIS point of view, need to be registered in each country in which it operates. Also note that in majority of cases trains are running in cooperation between RUs.
Purchasing Power Parity (PPP)	PPPs are currency conversion rates that convert economic indicators	Not applicable	Eurostat: DatasetN/A Comparative price levels	Not applicable.

Variables	Definition	Assumptions and adjustments to the data	Sources	Limitations of the data
	such as inflation expressed in national currencies to a common currency.		[TEC00120]. Data extracted on 10/08/2021 12N/A24N/A01 from [ESTAT]	

2.4 Specific approach for Issue 13

Issue 13 deals with number of cabin crew members and the number of cabin crews/drivers required in each train with the countries mostly affected by the issue being Italy, Romania and Bulgaria. Unlike the other issues, the issue on two-people cabin crew can be considered indirectly an interoperability issue. This is related with the nature of the solution implying more with labour policies rather than operational aspects, requiring the adoption of a different approach to estimate the impacts of solving this issue.

Supported in interviews and desk research, an average wage cost for a train driver has been calculated, upon which the annual savings to adopt a single driver (product of such cost by the number of annual trains) is estimated. Table 7 below presents the main variables considered for this analysis.

Table 7: variables, assumptions and sources of information for issue 13

Variables	Definition	Assumptions and adjustments to the data	Sources	Limitations of the data
Operational costs per train	The calculation of train operating costs depends on many factors. These factors vary by country and even route. The compounded value takes into consideration Track access charges, energy costs labour costs, wagon costs, locomotives, terminal costs. For the relation Małaszewicze to Nuremberg the cost of per kilometer on this relation have been calculated be approximately 13.75 per kilometer with a total cost of 15-17.000 euros for transport across the entire relation		Analysis conducted by Railistics for Małaszewicze to Nuremberg	An overview of the breakdown of costs using the Małaszewicze - Nuremberg relation has been used as example. This breakdown was based on the costs for a specific route, some differences in costs in other countries and on other routes can occur. Operational costs for a freight train varying in the range of 12 to 24 000 euros can represent a variety of cases. Therefore, an average cost of 18 000 euros has been adopted
Average RU wage cost savings for	Product of the share of staff costs in the operational costs of a rail undertaking, the share of train driver costs in staff costs and		AMT, rail market monitoring	This simplification was required for the estimation of impacts of issues 13

Variables	Definition	Assumptions and adjustments to the data	Sources	Limitations of the data
one cabin driver	the average operational cost of a freight train Collected values (interviews and reports) indicate shares of staff costs in operational costs of 20 to 25% and of 40-41% for train drivers in staff costs Costs are further adjusted in function of the countries PPP		report for Portugal Interviews with DB Cargo Romania and Bulgaria	(from two cabin crew to one). Interviews with DB Cargo Romania and Bulgaria confirmed costs per driver similar to those estimated. Both values (i.e., estimated by the consultants and reported by DB were in the same order as the costs in the Salary Explorer online tool, which give the confidence that PPP adjustment for Italian costs (for which no data was obtained) were reliable

2.5 Other sources

Other references were also reverted in the analysis:

- The Full Impact Assessment on the TSI OPE Revision[4]
- RFCs historical information on the issues under analysis
- Rail Net Europe (RNE) database: The most accurate data that was possible to collect was from a RNE database that identifies the majority of the border stations where RFCs run. From this database was possible to extract the number of RUs and trains in each station in 2018 and 2019. Only 2019 data were used in the model.
- RNE CIP – CBP correspondence: The sections considered in the estimations include the stations in both sides of the same border. It has been necessary to resort to the RNE Customer Information Platform (RNE CIP) in order to create the links between the stations from the RNE database.
- "Guide to Cost-Benefit Analysis of Investment Projects"[5]

[4] European Union Agency for Railways (2018)
[5] European Commission (2014)

2.6 Stakeholders' surveys and interviews

In 2020, a survey targeted to infrastructure managers (IMs), railway undertakings (RUs), public authorities (Ministries of Transport and National Safety Authorities) and Rail Freight Corridors (RFCs) was performed in view of obtaining further details on the locations where the issues occur, and the qualitative impacts generated.

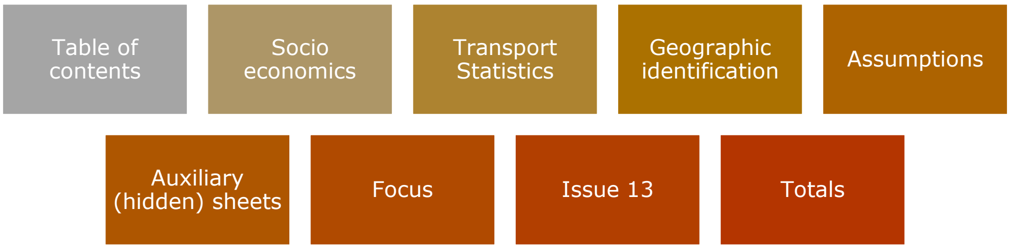
The responses were collected between 14th and 26th of May 2020 for a total of 18 respondents. Following the stakeholder's survey, a set of interviews have been performed. In total, 13 interviews were successfully conducted.

Results from the survey and interviews complemented the consortium knowledge and allowed to define a set of proxies as time loss (shunting times, waiting times and others). Moreover, they served to validate data related with the percentage of annual affected trains at the borders in study and identification of the borders where the issues occur.

2.7 Impact model

For the estimation of impacts resulting from solving the issues an excel database model has been developed (Annex 6.1).

The file is composed by several pages including:



- An introductory page explaining the structure of the file and the information it contains,
- A socioeconomic variables inputs sheet,
- A transport statistics sheet containing all the border points as identified from RNE database. There can also be find the correlation to the country where the border station is located, the RFCs to which correspond, the IMs managing the network in that point, the number of RUs operating in those points annually (base year 2019), the number of annual trains that have crossed those borders in 2019, the power traction and the list of issues occurring in each border,
- A geographic identification sheet presenting the borders where the issues are applicable,
- The assumptions adopted and corresponding sources of information as presented in Table 5 and Table 6,
- A sheet with indexes (hidden) necessary for the calculations.
- A focus sheet that enables the user to select the issue to be evaluated, the specific geographic point and the country, as well as the possibility for the user to change the input parameters values used in the estimations (i.e., if own data is available) and add new geographic points.
    - the total impact per issue on a specific geographic point,
    - the total impacts per zone pair (which means the total impacts of all issues identified in the selected geographic point);
    - the total per issue (total impact of the issue in all the locations where they have been identified.

    - Total per country (the total impact of the all the issues presents in a selected country border stations)
- Issue 13 sheet which presents the estimated impacts from solving issue 13. Issue 13 represents a standalone issue, with different underlying assumptions, not measured as the other issues in terms of time savings, requiring as such a different calculation method.
- The synthesis table highlights the totals per issue, thus proving an overall view of the impact at the EU level.

The tool is delivered to DG MOVE and to ERA as an output of the analysis.

2.8 Consistency checks

Some additional checks have been implemented in order to evaluate if the range of impacts was consistent across the different issues and borders.

For each issue in all borders, the minimum, the maximum, the medium cost values per train and the median variance of the costs among all borders has been calculated, considering that cases with a variance higher than 5 should be verified.

The identified outlier results (affecting four border sections[6]) are originated by inconsistent data:

- diversionary lines with very low number of trains per year (i.e. 10, 20 trains /year) and low number of RUs operating (1 or 2 RU operating in those lines);
- significant differences in number of trains or RU for each side of the border

The selected cases have been removed from the analysis.

2.9 Challenges and limitations

Four main challenges and limitations of the analysis have been identified during the study.

The first one derives from the number of variables impacting on each of the issues identified in the ILB, and the selection of the most relevant ones for the economic analysis. The analysis should remain relatively simple for wide acceptance and replicability of other issues. Nevertheless, it also needs to be consistent, ensuring applicability in all cross-borders points, across different Rail Freight Corridors and Member States where the Rail Freight Corridors cross.

The second main difficulty concerns the fact that the CBA methodology is mainly required as a basis of decision between investment projects when "co-financing of major projects included in operational programs (OPs) of the European Regional Development Fund (ERDF) and the Cohesion Fund"[7].

In the ILB, we are dealing with projects that aim to improve the efficiency of the rail sector in the transport of goods without structural changes in the infrastructure that already exists, aiming to show the competitive attractiveness of the rail mode for freight transport. The ILB consists of a list of projects that identify a set of soft measures and procedures that can be changed in a common trend of harmonisation of procedures across Europe. As predicted, it was not possible to collect estimations of investments. The competitiveness of rail transport currently hindered by the ILB affects primarily the operating costs and travel time of RUs.

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[6] Namely, Golenti (RO)/ BG, BE/ Kleinbettingen (LU); Zwardoń (Gr) (PL)/ Skalité št. hr. (SK), Pougny-Chancy - Frontière Fr-Su (FR)/ La Plaine (CH).

[7] In "Guide for Cost-Benefit Analysis of investment projects -economic appraisal tool for Cohesion Policy 2014-2020", p.15

Being a methodological tool mostly oriented for the analysis of major projects, the CBA will have to be adapted to non-intensive investment projects and to small operational efficiency gains, as well as for the attractiveness of the rail freight transport. In this regard, those operational gains were identified within the consortium and estimated through the use of benchmarks without necessarily relying on the CBA Guide for investments Guidelines.

The third main limitation concerns the availability of operational data regarding the costs and benefits of the issues and the cases studies. While data availability is always a challenge in the different studies, the study required a close articulation with the stakeholders in view of being able to quantify some cost drivers complemented with the consortium know-how.

The fourth aspect is related with the non-quantification of the modal shift potential that could be enabled by the higher competitiveness of rail after the elimination of the issues. While an attempt to quantify those was made in the interim phases of the project, following the same methodology as for the TSI OPE Impact Assessment, it was commonly considered that the cost price elasticity model for road and rail highlight some fragilities, not capturing for instance the role of inland waterways to which it is added the few market data (i.e., net tons transported) per border section as several market studies are still being developed. The decision was to focus the analysis in the quantitative assessments regarding costs and time of rail transport only using the 2019 rail traffic volumes allowing to produce robust estimations at local and EU level for all relevant issues and case studies.

3 Impacts estimation

In the next section, the case studies and issues are described together with their expected qualitative and quantitative impacts resulting from the targeted analysis in specific points and its extrapolation for the remaining points. The lists of border points where the issues occurs and where they were extrapolated can be found in annexes 6.2 to 6.10.

3.1 Introduction

The Issues LogBook is a living document grouped in five larger themes: Braking, Tail plates vs. Tail lights, Train composition, Checks at borders and within MSs and Other issues. In the beginning of the project three out of the five large themes were referred as priorities by the European Commission. Those priorities include the issues where international freight activities were lagging behind expectations. The remaining themes do not have a priority number associated.

During the project development three case studies were defined including two issues each and considered representative of each priority. The remaining issues were analysed separately.

The analysis performed refers to the following issues grouped by priority.

Priority 1 – Train braking rules and documents	Issue 1 – Braking sheets	Case study A
	Issue 2 – Braking performance	Case study A
Priority 2 – Train composition and technical checks	Issue 5 - Train Composition (Working handbrake last wagon)	
	Issue 6 - Train Composition (No push 6 axles wagons)	
	Issue 7 - Train Composition (Buffer wagons)	
	Issue 8 - Technical checks at border stations	Case study B
	Issue 9 - Mandatory checks in Member States	Case study B
Priority 3 – Real time communication	Issue 4 - Train composition (Harmonisation of wagon list)	Case study C
	Issue 15 Real time communication and harmonisation of train composition message (wagon list)	Case study C
Other issues not included in Priorities	Issue 3 - Tail lights vs plates	
	Issue 10 - Operational implementation of the traffic in ERTMS	
	Issue 11 - New train number	
	Issue 12 - Exception from operational rules	
	Issue 13 - 2 people cabin crew	
	Issue 14 - Equipment of border stations with commutable electric power	

Figure 3: Issues within each priority of the ILB

The results of the analysis performed are presented for each priority and issue along the next pages.

3.2 Priority 1 – Train braking rules and documents

According to the current ILB, the issue on braking sheets emerges as every Member State and almost every RU use braking sheets with different layouts and contents. In turn, the braking performance issue stems from Member States setting different requirements for braking performance (namely the braking percentages) and braking calculations. Therefore, RUs are required to switch braking regimes at border crossings, even if the train composition does not change.

Priority 1 cover two issues that have been grouped under case study A as below presented.

- Issue 1 – Braking sheets

Every country and nearly every RU uses a different braking sheet with different layouts and contents. UIC Leaflet 472 provides an overview of the mandatory and optional data and an example for the layout. Thus, the impact of this issue will be reduced after full implementation of the Leaflet.

- Issue 2 – Braking performance

The requirements for braking performance (in particular the braking percentages), as well as the braking calculations are different in the Member States.

3.2.1.1 Case Study A – Priority 1 (issues 1 and 2)

Case study description

The present case study includes issues 1 (Braking sheets) and 2 (Braking performance) based on the cross-border braking performance between the Netherlands and Germany.

This selection was based on:

- The existence of information, as DB Cargo has been developing and running a pilot project in these border points, and;
- The relatively easy access to information from the Dutch Ministry of Infrastructure and Water Management.

Qualitative expected impacts

To estimate the impacts of the issues, a distinction of issue impacts and solution impacts is defined as highlighted below:

Case Study A Impacts

Issue impacts

- Rail traffic volume
- Time lost at the border

Solution impacts (expected results of solving the issues in this case study)

- The elimination of unnecessary red tape after being proved to be an efficiency burden
- Reduced times at the border
- Improvement of the KPIs related with punctuality for both the arrival and departure of freight trains
- Implementation costs (e.g., changes to IT tools and staff training)
-

Quantitative impacts

In 2019, there were three operational Cross Border Points (CBPs) with freight services between the Netherlands and Germany[8]. The Table 8 provides an overview of these CBPs.

Table 8: Cross-border points considered within Case Study A

Cross Border Points	**No of Trains (2019)**		**No of incidences with RUs (2019)**		**Connected RFC***
	Min	**MAX**	**Min**	**MAX**	
Kaldenkirchen (DE)/Venlo (NL)	22 413	22 997	19	43	8
Emmerich (DE)/Zevenar (NL)	26 105	28 265	18	48	1 and 8
Bad Bentheim Border (DE)/Oldenzaal (NL)	7 314	9 949	16	44	1 and 8
Total	**55 832**	**61 211**	**53**	**135**	

Source: RNE database

*RFC 1: Rhine-Alpine Rail Freight Corridor; RFC 8: North Sea-Baltic Rail Freight Corridor

Interviews confirmed that 100% of the trains running in the defined sections are affected by the issues and that every train loses a total of 20 minutes[9]. Solving the issue means that each train running in those borders could save 20 minutes which is equivalent to a total of saved hours varying between 18,6k and 20,4k hours annually.

The economic impact of solving issues 1 and 2 in the Dutch-German border is thus estimated to vary between 6,6M€ and 14,6M€ depending on whether it is considered the minimum, or the maximum number of annual trains.

[8] European Commission (2018)

[9] Issue 1: 5 min for handover braking sheet; Issue 2: 15 min for 600m train length= 10 minutes for walking (1 second per meter train length) + 5 min switching brake regime - estimated by the consortium based on the stakeholders' survey results and interviews.

Table 9: Main cost drivers for issues 1 and 2 in the dedicated sections

Issue 1|2 (dedicated sections)	**Impact (M€)**	
	Min	**MAX**
Operational cost savings	4,2	11,7
Freight time savings	2,3	2,8
Total	**6,6**	**14,6**

Extrapolation and total results

As from the ILB registry and survey results, issues 1 and 2 affect sixteen EU Member States: Romania, Hungary, Slovakia, France, Spain, Netherlands, Luxembourg, Germany, Italy, Austria, Slovenia, Poland, Czech Republic, Croatia, Bulgaria and Greece (the detailed list of the borders included in the estimations is presented in Annex 6.2).

Assuming that similarly to NL-DE borders, all the trains crossing the border points of the above mentioned Member States affected by the issues and similar times could be saved, it is estimated expected savings in the order of 32,5M€ to 82,2M€.

The total impacts of issues 1 and 2 considering both the dedicated estimation of impacts and the extrapolation exercise are presented in Table 10.

Table 10: Total results of issues 1 and 2 at EU level

	Min	**MAX**
Avoided process per CBP (minutes)	20	
% of trains affected by the issue in a CBP	100%	
Sum of incidences with RUs in all CBPs affected	400	800
Sum of annual trains in all CBPs affected	421 163	634 968
Freight time savings (in M€)	14,5	28,9
Administrative and overhead cost savings (in M€)	24,5	67,8
Total sum of impacts (in M€)	**39,1**	**96,7**

A range of 140k to 212k hours can be saved per year if these two issues are solved. The total savings can thus vary between 39,1M€ and 96,7M€.

3.3 Priority 2 – Train composition and technical checks

3.3.1 Issue 5 - Train composition (working handbrake in the last wagon)

The ILB spreadsheet states that the last wagon should have a working brake as a normal requirement. Nevertheless, a working handbrake for the last wagon is not required in any TSI Regulation (nor in the UIC leaflet or as part of other standards). Moreover, requirements are not harmonised across Member States, with some countries even requiring a minimum of 2 wagons with a working handbrake. Therefore, the ILB spreadsheet highlights that this rule should be removed, as it appears to refer to national requirements at a Member State level, rather than at an EU level[10].

Figure 4: Example of a wagon handbrake

This specific issue concerns the equipment of wagons and particularly the requirement that the last wagon of a train is equipped with a handbrake. In case that the last wagon of an international train – entering a country or network with such Regulation – is not equipped with a handbrake, this requirement might lead to unnecessary shunting at border stations.

Qualitative expected impacts

The impacts are assessed by distinguishing between issue impacts and solution impacts. Based on this exercise, the following impacts were identified:

Impacts of Issue 5

Issue impacts

- Traffic volume
- Shunting operations
- Waiting times for an available shunting locomotive
- Planning efforts (time and cost)

Solution impacts

- Potential solution: using brake shoes instead of handbrakes
- Reduction time at CBPs: time lost both on shunting operations and on the waiting for the shunting operations
- Time and cost savings related with the additional planning operations (efficiency gains)

[10] *In* ILB – issues20200805-V4 excel file issue 5 analysis. Acceptable Means of Compliance (AMOC) on "Checks and tests before departure, including brakes and checks during operation" (issued by ERA in December 2021); National Regulations:- Portugal: General Safety Regulations, Basic Principles (PT: Regulamento Geral de Segurança, Principios fundamentais); - Romania: Regulation of traction and braking No 006/2005 of national law, MoT Order no. 1815/2005 on traction and braking rules; International Rules and Standards: UIC IRS 40454 under revision

Quantitative impacts
According to the stakeholder's survey this issue has had greater impact in Italy, Romania and Portugal. Further interviews with stakeholders from RFC 7, DB Cargo (Romania and Bulgaria), Rail Cargo (Hungary and Romania) and TX Italy have also been carried out[11]. Interviewees argued that national regulations in Romania establish that all trains in the country must have an active handbrake in the last wagon, while in Italy it is not mandatory to have a working handbrake at the last wagon. Therefore, this issue was analysed only for Romania.

The cross-border points between Lőkösháza (RO)/ Curtici (HU) and Ruse (BG)/Giurgiu Nord (RO) were highlighted as being the most problematic. In Curtici, the effects are related with the requirement for additional shunting (as trains coming from Hungary are not required to have an active handbrake). In Ruse, the problem is related with the subsequent delays and reduced capacity at the border station. The remaining cross-border points in Romania included in the Orient East Med Rail Freight Corridor (Table 11) were also considered in the analysis, namely Biharkeresztes (HU)/Episcopia Bihor (RO) and Vidin (BG)/Golenti (RO).

The removal of the requirement that the last wagon of a train is equipped with a handbrake is estimated for the four CBPs in Romania.

Table 11: Cross-border points considered within issue 5 impacts estimation

Cross Border Points	No of Trains (2019)		No of incidences with RUs (2019)		Connected RFC*
	MIN	MAX	MIN	MAX	
Lőkösháza (HU)/Curticci (RO)	16 577	17 121	18	23	7 and 9
Biharkeresztes (HU)/Episcopia Bihor (RO)	1 760	2 025	11	13	7 and 9
Ruse Razpredel (BG)/Giurgiu Nord (RO)	5 232	5 908	6	14	7
Total	**23 569**	**25 054**	**35**	**50**	

Source: RNE database

*RFC 7: Orient East Med and RFC 9: Rhine Danube.

Supported in the interviews, it is estimated that 50% of the trains are affected by the issues and that every train loses a total of 45 minutes[12]. The impacts expected from solving issue 5 vary between 1,9M€ and 3 M€ as below.

Table 12: Main cost drivers for issue 5 in the dedicated sections

Issue 5 (dedicated sections)	Impact (M€)	
	Min	MAX
Operational cost savings	1,4	2,4
Freight time savings	0,5	0,7
Total	**1,9**	**3,1**

[11] No answer from Portugal was obtained.

[12] 45 minutes as a result of 30 minutes for the wagon be reordered (assuming a 600m train, wagon from middle to end, the shunting loco approach and coupling) and another 15 minutes of waiting for the shunting service to occur - estimated by the consortium based on the stakeholders' survey results and interviews.

Extrapolation and total results

Besides the Romanian borders, issue 5 affects also the border points between Portugal and Spain.

Assuming the same hypothesis of affected trains and time savings as above, the expected impacts in the Portuguese – Spanish borders due to issue 5 are expected within a range of one to two thousand saved hours, affecting between 1 508 and 2 588 trains. This corresponds to an expected saving between 0,4M€ to 0,8M€.

The aggregated results are now presented for all the borders where issue 5 has been referred as occurring. A list of the geographic occurrence of this issue can be found in Annex 6.4.

Table 13: Total impacts of issue 5 at the EU level

	MIN	MAX
Avoided process per CBP (minutes)	45	
% of trains affected by the issue in a CBP	50%	
Sum of incidences with RUs in all CBPs affected	41	59
Sum of annual trains in all CBPs affected	25 077	27 642
Freight time savings (in M€)	0,6	0,8
Administrative and overhead cost savings (in M€)	1,8	3,0
Total sum of impacts (in M€)	**2,4**	**3,8**

Table 13 shows that annually, taking 2019 as a reference, between 25 077 and 27 642 trains are affected by this issue and that between 19k to 21k hours could be saved annually. The number of affected RUs vary between 41 and 59 which results on a total range of expected impact from solving issue 5 between 2,4 M€ and 3,8 M€.

3.3.2 Issue 6 - Train composition (No push 6 axles wagons)

This issue is a result of legislative or internal company rules which forbid 6-axle wagons, even if the manufacturer's specifications state otherwise. In this case, unnecessary shunting at border stations is required.

Figure 5: Example of a no push 6 axles wagon

The issue affects a small group of railway undertakings which run very long-distance trains.

Temporary solutions to this issue as identified by the technical assistance team "include changing the train composition, splitting the train in two parts, or adding a second traction locomotive, instead of a pushing locomotive or adding buffer wagons at the end of the train to adhere to the rules”.[13]

Qualitative expected impacts

The following impacts were identified:

Impacts of Issue 6

Issue impacts

- Time losses
- Additional shunting operations
- Additional energy costs
- Planning efforts of shunting operations or re-routing trains (time and cost)

Potential solution: Splitting the train into two parts, second traction locomotive instead of pushing locomotive, re-position 6-axle wagons in trains or adding buffer wagons.

Solution impacts

- Reduction of time lost on shunting operations
- Time and cost savings related with the additional shunting, locomotive rent or parking, energy costs and planning operations (re-routing trains)

Quantitative impacts

Different rules for 6-axle wagons occur particularly in the high mountain areas. The rule is complex as it affects train length, train weight and the distribution of weight within the train, implying that for each train, the re-positioning of the wagons must be calculated individually.

The results of the stakeholder’s survey indicate that this issue is most severely observed in the mountainous areas of Romania, affecting the following line sections (Table 14).

Table 14: Cross-border points considered within issue 6 impacts estimation

Cross Border Points	**No of Trains (2019)**		**No of incidences with RUs (2019)**		**Connected RFC***
	MIN	**MAX**	**MIN**	**MAX**	
Predeal (RO)/Brasov (RO)	3 572	3 735	65	65	N/A
Fetesti (RO)/Cernadova (RO)	10 388	10 443	65	65	N/A
Drobeta - Turnu Severin (RO)/Balota (RO)	3 809	4 461	65	65	N/A
Vintu de Jos (RO)/Coslariu (RO)	1 927	2 055	65	65	N/A
Total	**19 696**	**20 694**	**260**	**260**	

Source: RNE database

* N/A: Not applicable.

[13] ILB Implementation Deployment Plan p.11

The number of trains were collected by direct request from RFC 7 (through MÁV) to CRF, the Romanian IM, while the number of RUs reflect the RFC 7 figures considering the alignment Lőkösháza (HU)/Curticci (RO) and Biharkeresztes (HU)/Episcopia Bihor (RO) under RFC 7.

As from the assumptions, a total of 75 minutes per train[14] is required to solve issue 6 with 100% of the trains being affected in these points. Based on this, a total saving of 24,6 up to 25,9k hours per year are expected. In monetary terms, the impacts from issue 6 totals 12,2 M€ where 1,5 M€ result from freight time savings and the 10,7 M€ from operational costs savings.

Extrapolation and total results

Besides the CBP referred in Table 14, issue 6 also occurs in other Romanian border stations. Therefore, the expected impacts from solving it were estimated as resulting in 3,2 M€ up to 4,5M€ of additional savings and avoided lost hours within a range of 34k up to 36k hours annually.

In Annex 6.5 can be found the list of Romanian stations affected by issue 6. The issue is especially relevant for transit traffic from/to Turkey, as this traffic predominantly consists of intermodal trains.

Table 15: Total impacts of issue 6 at the EU level

	MIN	MAX
Avoided process per CBP (minutes)	75	
% of trains affected by the issue in a CBP	100%	
Sum of incidences with RUs in all CBPs affected	295	310
Sum of annual trains in all CBPs affected	43 265	45 748
Freight time savings (in M€)	3,2	3,7
Administrative and overhead cost savings (in M€)	12,1	13,1
Total sum of impacts (in M€)	**15,3**	**16,8**

As for the total results of solving issue 6, an annual saving of 54k up to 57k hours per year could be expected with a total impact within a range of 15,3M€ to 16,8M€. Of this, freight time savings represent 3,2M€ to 3,7M€ depending on the number of annual trains considered and operational costs savings 12,1M€ to 13,1M€.

3.3.3 Issue 7 - Train composition (Buffer wagons)

The number of buffer wagons required between the locomotive and wagons carrying dangerous goods is different among the different Member States. Additionally, different rules are applicable to the type of goods allowed in the buffer wagons. The requirement for buffer wagons can lead to unnecessary shunting and dead weight. Moreover, unnecessary buffer wagons that are not needed must be parked. Nevertheless, the regulation for International Carriage of Dangerous Goods by Rail (RID) does not foresee any buffer wagon in this configuration.

The stakeholder’s survey showed that the countries mostly affected by this issue are Bulgaria, Hungary, Romania, the Netherlands, Germany and the borders between Austria and Italy. However, interviewees from these countries argued that the most severe effects of this issue can

[14] 60 minutes for the train to be split and 15 minutes for the shunting service - estimated by the consortium based on the stakeholders’ survey results and interviews.

be once again found in Romania, with the relatively poor state of the infrastructure largely impacting on this result. In this regard, the cross-border points in Romania which are part of the Rail Freight Corridors represent the geographical points selected for the estimation of solving issue 7.

Qualitative expected impacts

The following impacts were identified:

Impacts of Issue 7

Issue impacts

- Time losses
- Unnecessary shunting operations

Solution impact

- Reduction of time lost on the waiting and operating time of shunting processes
- Cost savings related with additional shunting

Quantitative impacts

The harmonisation of the number of buffer wagons required between the locomotive and wagons carrying dangerous goods between different Member States affects three CBPs in Romania, the same as issue 5 (Table 13).

Based on the interviews it is assumed that:

- it takes 45 minutes per train to have issue 7 solved[15], and;
- 50% of the trains are affected by the issue.

Overall, 17,7k up to 18,8k hours could be avoided with a total impact per year varying between 1,9M€ and 3,0M€.

Table 16: Main cost drivers for issue 7 in the dedicated sections

Issue 7 (dedicated sections)	**Impact (M€)**	
	Min	**MAX**
Operational cost savings	1,4	2,4
Freight time savings	0,5	0,7
Total	**1,9**	**3,0**

[15] 45 minutes as a result of 30 minutes for the buffer wagon to be integrated into the train (between locomotive and wagon train) and another 15 minutes for shunting by the line locomotive - estimated by the consortium based on the stakeholders' survey results and interviews.

Extrapolation and total results

As mentioned above the survey has highlighted that this issue occurs in other borders of Bulgaria, Hungary, Romania, the Netherlands, Germany, the borders between Austria and Italy.

Assuming the same assumptions of % of affected trains and time losses, the remaining locations where the issue was declared to be occurring generate expected results varying between 15,1M€ and 32,8M€. Those are driven by annually saved hours between 104k and 132k from 139 200 and 176 568 affected trains.

As for the total results from having the issues solved, considering the impacts both in the dedicated estimations and from the extrapolation exercise is presented in Table 17.

Table 17: Total impacts of issue 7 at the EU level

	Min	**Max**
Avoided process per CBP (minutes)	45	
% of trains affected by the issue in a CBP	50%	
Sum of incidences with RUs in all CBPs affected	156	334
Sum of annual trains in all CBPs affected	162 769	201 622
Freight time savings (in M€)	6,7	9,4
Administrative and overhead cost savings (in M€)	10,4	26,4
Total sum of impacts (in M€)	**17,1**	**35,8**

The list of geographic occurrences of issue 7 can be found in Annex6.6. Overall, issue 7 can save resources in the order of 17,1M€ up to 35,8 M€ driven by freight time savings in the order of 6,7 M€ up to 9,4 M€ and operational cost saving between 10,4 M€ and 26,4 M€.

3.3.4 Issue 8 - Technical checks at border stations

This issue deals with the requirement imposed at some border points for safety performance checks in each of the border sides, which implies a duplication of procedures and checks for the same border. Some Member States require a technical inspection even in case of a valid Agreement on Freight Train Transfer Inspection (ATTI-agreement).

The countries mostly affected are Romania and Hungary, with Curtici (RO)/Lőkösháza (HU) as the most critical border.

3.3.5 Issue 9 - Mandatory checks in Member States

Mandatory wagon checks vary among Member States. The obligation for wagon checks can be at the border stations, at regular distances and/or time intervals, and before steep gradients (brake check) in one or both cases. However, RUs will themselves sometimes like to have border checks.

The most affected countries include Romania and Italy, with all Italian border crossings being affected.

Issues 8 and 9 from Priority 2 are studied in Case Study B, which is described in detail in the next section.

3.4 Case Study B – Priority 2 (issues 8 and 9)

Case study description

Case study B includes issues 8 (Technical checks at border stations) and 9 (Mandatory checks in

Member States) of the Issues Logbook (ILB). According to the current ILB, RUs need to perform safety checks on CBPs. This can happen in one side of the border or in both sides of the same border. The Lőkösháza (HU)/Curticci (RO) is one example of the first while the French-Spanish CBPs are examples of the latter. In addition, some Member States require different mandatory wagon checks that might have to be performed at border stations, at regular distances and/or time intervals, and sometimes before steep gradients (brake check). These issues lead to inefficiency and stem from Member States' national rules.

The Lőkösháza (HU)/Curtici (RO) is an extreme case where both issues coexist.

In Romania, Regulation No. 250 imposes technical checks both after arrival and prior to departure at border stations whenever trains experience a waiting time of 6 to 8 hours at the station. This happens to most trains in this border station. In addition, there is another regulation in Romania requiring wagon technical checks every 350km. Given this, the case study was focused on the Curtici CBP and after its results further extended to the other border cases where the issue occurs, notably Romania, Hungary, Italy, Austria, Switzerland, Slovenia and France. The extrapolation results are presented in the subsection Extrapolation and total results below.

Qualitative expected impacts

The foreseen qualitative impacts were divided in issue impacts and impacts from the solution, as shown in the text box below.

Case Study B Impacts

Issues impacts

- Delays at border
- Excess of national rules and red tape

Solution impacts (expected results of solving the issues in this case study)

- Reduced operating costs for service providers
- Reduced times at border
- Improvement of operations' KPIs (punctuality at origin and at destination)
- Investment costs in TSI implementation (IMs and RUs)
- Improvements in the coordination with the border police

Quantitative impacts

The removal of the requirement of technical checks at border stations and mandatory checks in Member States is estimated for Lőkösháza (HU)/Curtici (RO) assuming the data presented in Table 18.

Table 18: Cross-border points considered within issues 8 and 9 impacts estimation

Cross Border Point	**No of Trains (2019)**		**No of incidences with RUs (2019)**		**Connected RFC***
	MIN	**MAX**	**MIN**	**MAX**	
Lőkösháza (HU)/Curtici (RO)	16 577	17 121	18	23	7 and 9

Source: RNE database

*RFC 7: Orient East Med and RFC 9: Rhine Danube.

All the trains passing this CBP are affected by the issues and every train loses a total of 6,4 hours (384 minutes)[16], as collected from interviews. The total impacts expected from solving issues 8 and 9 can thus vary between 7M€ and 9,1M€ for a total of saved hours varying between 106k and 110k.

Table 19: Main cost drivers for issues 8|9 in the dedicated sections

Issue 8|9 (RO-HU border)	**Impact (M€)**	
	Min	**MAX**
Operational cost savings	6,3	8
Freight time savings	0,7	1,1
Total	**7**	**9,1**

Extrapolation and total results

Besides Romanian and Hungarian borders, issues 8 and 9 were also reported as affecting Italian borders. Taking as hypothesis that all the trains crossing Italian borders with Austria, Switzerland, Slovenia and France are affected by the given issue and that it takes one hour to have it solved, it is expected that between 122 139 and 170 723 trains are affected. Solving this issue would generate time savings of about 782k up to 966k hours per year, with a total impact in the order of 22,2M€ to 43,20M€.

Romania and Italy are the Member States that reported to be affected by issues 8 and 9. The list of the borders included in the estimations of total impacts from issues 8 and 9 are presented in Annex 6.6.

Supported by the interviews it is assumed that:

- 100% of the trains are affected by the issue;
- The time lost in Romania is 384 minutes, while in Italy it can take between 30 and 60 minutes of additional waiting time at border. In face of more targeted elements, for the estimations of time savings in Italy it is assumed a conservative approach, thus 30 minutes of additional waiting time.

[16] Based on the survey results was assumed that issues 8|9 imply, in the Curticci border, a time loss of 8,4 hours. Those are justified by a technical check of 7 hours and additional 1,4 hours waiting for the border police. Given the fact that Orient East-Med RFC is implementing a minimum required time for technical checks of 2 hours those two are then excluded from the analysis. This means that by the time issues 8|9 are to be solved a time loss of 6,4 hours should be associated with them instead of the 8,4 hours. Was assumed that the time losses with issues 8|9 in all Romanian borders is equal to 6,4h (384 minutes).

Table 20: Total impacts of issues 8 and 9 at the EU level

	MIN	MAX
Avoided process per CBP (minutes)	384 for RO and HU[17], 30 for IT	
% of trains affected by the issue in a CBP	100%	
Sum of incidences with RUs in all CBPs affected	115	189
Sum of annual trains in all CBPs affected	140 043	210 897
Freight time savings (in M€)	15,6	26,3
Administrative and overhead cost savings (in M€)	7,4	16,9
Total sum of impacts (in M€)	**23,1**	**43,2**

The overall magnitude of impacts from solving issues 8 and 9 can vary between 23,1M€ and 43,2M€.

[17] The Hungarian borders affected are those with Romania, therefore the time lost is the one measured for Romania

3.5 Priority 3 – Real time communication

3.5.1 Issue 4 - Train composition (Harmonisation of wagon list)

In accordance with the national network statements, RUs must compile a wagon list/train composition information to run a train. Additionally, the TAF-TSI Regulation requires RUs to inform the IM and the following RU about the parameters of the running train. In this respect, different national requirements force the RU to develop a separate wagon list for each country. Overall, this issue affects all border crossings.

Furthermore, the wagon list / TCM generation and information exchange via a train composition message may require different processes and interfaces. The latter is described in more detail under issue 15.

3.5.2 Issue 15 – Real-time communication and harmonisation of train composition message (wagon list)

Issue 15 is split in two sub-issues: Issue 15a related with real-time train running information and Issue 15b related with the train composition message.

Issue 15a – Real-time communication and harmonisation of train composition message (wagon list) a.) Real-time train running information

The availability of (train running + train composition) status information is an important requirement for a smooth coordination and processing of transport, as well as for the ex-post performance documentation and analyses. The transport chain actors currently generate such real-time tracking information from different sources, involving information systems from national IMs and GPS. Train composition data is mostly exchanged via HERMES (H30) message, with smaller RU companies also exchanging such data via email.

To harmonise the information across borders and support international train management, Rail Net Europe (RNE) has developed the Train Information System (TIS). TIS is a web-based application delivering real-time data concerning international passenger and freight trains. The relevant data is obtained directly from the Infrastructure Managers' systems. However, the matching of train running information from different national IM systems is still a challenging topic resulting that approximately 20-25% of the train numbers not yet being matched.

The mismatching of train numbers can be due to, for instance, from missing parity of train numbers. This is the case in the ES-FR border, since even/odd train numbers are assigned to trains running in opposite directions.

Member State-specific numbering of trains coordination in the yearly timetable planning are connected via related translation tables. However, in case of delay, trains may receive a different new number and the matching is therefore lost. This is the case, for instance, in Denmark for delays over 30 minutes and in Switzerland for delays over 2 hours ("Lastentausch"). In the short-term planning (equal to 10-15% of the total number of trains), there are no translation tables agreed at all and consequently no matching between national train running data and international trains.

Solutions concern the development of a train identifier (TID) in the long-term and the use of train composition data in the mid-term to increase the matching rate. The TID is already defined in the TAF TSI framework and shall be assigned by the RU after the ordering of train paths.

Issue 15b – Real-time communication and harmonisation of train composition message (wagon list) b.) Train composition message

Different national requirements for the TCM or wagon list force the RU to develop a separate message or even a different process or a different Information Technology IT-interface for each country. Non-unified standards imply costs for the provision of diverse IT tools, interfaces and additional efforts connected with the compilation of additional information compared to EU standards. The RNE ILB pilot involves the introduction of HERMES 30 V 2 message, considering TAF TSI Train Composition and aiming at harmonising nationally required train composition parameters. Moreover, there may be additional national requirements not covered by any international rule for the data elements in the wagon list, as well as for the HERMES Message and the (TAF-TSI) Train Composition Message. For instance, in Poland, authorities require specifications of dangerous goods to be included in the wagon list. This causes additional manual work and the generation of a specific TCM or other system only for Poland, which needs to be further investigated.

Issues 4 and 15 from priority 3 are studied in Case Study C, which is described in detail in the next chapter 3.5.3.

3.5.3 Case Study C – Priority 3 (Issues 4 and 15)

Case study description

Case study C includes issues 4 (Train composition – Harmonisation of wagon list) and 15 (Real time communication and harmonisation of train composition message (wagon list)) of the ILB.

This case study focuses on the impacts generated from improved train running information with the analysis being centred in two Rail Freight Corridors: RFC 1 – Rhine Alpine and RFC 7 – Orient-East-Med,

Qualitative expected impacts

The foreseen qualitative impacts were divided in issue impacts and impacts from the solution, as shown in the text box below.

Case Study C Impacts

Issues impacts

- Time lost at the border
  - Additional waiting time at the CBPs
- Efficiency loss
  - The "receiving" IM cannot anticipate the delay due to missing information
  - Required staff resources might not be available on time in case of delay due to missing information
- Service quality
  - Lack of reliable RFC performance data, jeopardising quality management and quality improvement of the rail service
  - Delayed and non-automated information to the customer in case of delays
- Additional bureaucracy leading to inefficient extra work both for RUs and IMs
- The train location in TIS is lost in case of unforeseen deviations leading to the loss of connection to personal, locomotives and wagons

Solution impacts (expected results of solving the issues in this case study)

- Improve the efficiency of communication reducing the waiting time at CBPs (train number)
- Induce time savings due to better and harmonised communication systems
- Improvement in the cross-border check process due to elimination of red tape.

Quantitative impacts

The time saved proxy in each RFC is estimated based on the following[18]. The delays could be reduced by 22% if a smooth transmission of estimated time of arrival (ETA) and an active traffic management of the second IM exists. This occurs because:

- the notification of the ETA, by the first IM to the subsequent IM, could allow the latter to manage one third of the delayed trains without having to subject it to further delays due to Temporary Capacity Restriction (TCR), and;
- the reduction of the delays if the traffic manager enables the train to avoid TCRs is on the order of two thirds.

As result 53 minutes per train could be saved in RFC 1[19] and 222 minutes in RCF7[20], taking into account that all the trains crossing the identified borders are affected by the issues 4 and 15. It should be noted that the effects of implementation of TIS systems where pre-existing legacy systems exist are not included in the analysis.

Regarding RFC 1, the studied borders are presented in Table 21.

[18] Suggested by Société Nationale des Chemins de fer Français (SNCF Réseau).

[19] According to the 2019 Rhine Alpine Annual Report 11,7 million of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 2,6 million minutes saved which is equivalent to 43,5 thousand hours saved annually in this RFC.

[20] According to the RFC 7 Train performance report - Management summary 12/2019, 30,9 million of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 6,9 million minutes saved which is equivalent to 114,6 thousand hours saved annually in this RFC.

Table 21: Cross-border points considered within issues 4 and 15 in RFC 1 impacts estimation

Cross Border Points	No of Trains (2019)		No of incidences with RUs (2019)		Connected RFC*
	MIN	MAX	MIN	MAX	
Montzen-Frontiere(BE)/Aachen-Gemmenich (DE)	23 876	27 857	7	29	1
Venlo (NL)/Kaldenkirchen (DE)	22 413	22 997	19	43	1 and 8
Emmerich (DE)/Zevenaar Oost (NL)	26 105	28 265	18	48	1 and 8
Basel Bad Bf (CH)/ Gellert (DE)	73 189	74 665	14	71	1
Domo II (IT)/Brig Tunnel (CH)	25 841	32 896	9	17	1
Domodossola (IT)/Brig Tunnel (CH)	7 440	32 896	9	17	1
Luino (IT)/Pino-Tronzano (CH)	11 537	12 559	5	12	1
Chiasso Est (CH)/Bivio/Pc Rosales (IT)	16 634	23 053	14	15	1
Total	**207 035**	**255 188**	**95**	**252**	

Source: RNE database

*RFC 1: Rhine Alpine, RFC 8: North-Sea Baltic.

The total impacts per year for the dedicated borders in RFC1 may vary between 28,8M€ and 65,9M€, for a range of hours saved of 167k to 223,6k.

Table 22: Main cost drivers for issues 4|15 in the dedicated sections for RFC1

Issue 4|15 (RFC1 dedicated borders)	Impact (M€)	
	Min	MAX
Operational cost savings	8,1	28,5
Freight time savings	20,7	37,4
Total	**28,8**	**65,9**

In RFC 7 the affected borders are presented in Table 23.

Table 23: Cross-border points considered within issues 4 and 15 in RFC 7 impacts estimation

Cross Border Points	No of Trains (2019)		No of incidences with RUs (2019)		Connected RFC*
	MIN	MAX	MIN	MAX	
Břeclav os.n. (CZ)/Bernhardsthal Fbf (in Bel) (AT)	15 723	40 452	26	43	5 and 7
Marchegg (AT)/Devínska Nová Ves (SK)	880	17 677	5	25	5 and 7
Kittsee (AT)/Bratislava-Petržalka (SK)	10 474	18 163	21	29	5, 7 and 9
Schöna (DE)/Děčín hl.n. (CZ)	17 988	46 505	25	79	7 and 8
Lanžhot (CZ)/Kúty (SK)	25 946	26 288	30	39	7
Rusovce (SK)/Rajka (HU)	7 171	7 745	20	28	7, 9 and 11
Nickelsdorf (AT)/Hegyeshalom (HU)	18 340	23 259	29	29	7 and 9
AT/ Sopron (HU)**	5 835	5 835	14	14	7
Komárno (SK)/ Komárom (HU)	6 177	25 847	12	30	8

Cross Border Points	No of Trains (2019)		No of incidences with RUs (2019)		Connected RFC*
	MIN	MAX	MIN	MAX	
Štúrovo (SK)/Szob (HU)	10 822	12 281	23	28	9
Biharkeresztes (HU)/Episcopia Bihor (RO)	1 760	2 025	11	13	7 and 11
Lőkösháza (HU)/Curtici (RO)	16 577	17 121	18	23	7 and 11
Giurgiu Nord (RO)/ Ruse Razpredel.(BG)	5 232	5 908	6	14	7 and 9
Total	**142 925**	**249 106**	**240**	**394**	

Source: RNE database

*RFC 5: Baltic Adriatic, RFC 7: Orient East Med, RFC 8: North-Sea Baltic, RFC 9: Rhine- Danube and RFC 11: Amber.

** The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points as a consequence the number of annual trains and RUs is considered equal in both sides of the border

The total impacts per year for the dedicated sections under RFC7 may vary between 52,2M€ and 133,1M€, representing a saving of of 529k and 923k hours

Table 24: Main cost drivers for issues 4|15 in the dedicated sections for RFC7

Issue 4|15 (RFC7 dedicated borders)	Impact (M€)	
	Min	MAX
Operational cost savings	12,5	28,6
Freight time savings	40	104,5
Total	**52,5**	**133,1**

Total combined impacts (RFC 1 + RFC 7):

The estimated impacts from\resolving the issues concerning train composition message and real-time communication at Rhine Alpine (RFC1) and Orient East/Med (RFC7) Rail Freight Corridors are presented in Table 25.

Table 25: Case Study C (issues 4 and 15) impacts in dedicated sections

	RFC1		RFC 7	
	MIN	MAX	MIN	MAX
Avoided process per CBP (minutes)	45			
Total saved hours (thousand) in all CBPs	156	192	529	923
% of trains affected by the issue in a CBP	100%			
Sum of incidences with RUs in all CBPs affected	103	267	240	394
Sum of annual trains in all CBPs affected	208362	278241	142 925	249 106
Freight time savings (in M€)	20 695 599	37 448 126	39 970 935	104 504 097
Administrative and overhead cost savings (in M€)	8 058 244	28 450 343	12 532 551	28 641 579
Total sum of impacts (in M€)	28 753 843	65 898 469	**52 503 487**	**133 145 676**

Is expected that between 697k and 1 146k annual hours can be saved in the two corridors with an overall magnitude of impacts between 81,3 M€ and 199M€.

Extrapolation and total results

Issues 4 and 15 were identified as occurring in all European borders. As it was not possible to collect data for all the EU borders, the complete set of RNE database, covering all the RFC network and the most relevant international freight flows, is used as basis (corresponding to the most relevant international rail freight flows). The list of the geographic points considered for the total results is presented in Annex 6.8.

For the extrapolation exercise to the other borders, it was adopted a proxy for the time lost in the border points equal to the average times identified for the RFC 1 (53 minutes), RFC 4 (20 minutes), RFC 5 (176 minutes) and RFC7 (222 minutes), thus corresponding to 116 minutes per border point in average. All trains crossing those borders are considered as affected.

Impacts between 79,2M€ and 132,7M€ are expected as deriving from 262 448 up to 346 906 annual trains affected with 506k to 669k annual hours saved.

The total impacts from solving issues 4 and 15 are presented in Table 26.

Table 26: Total results of issues 4 and 15

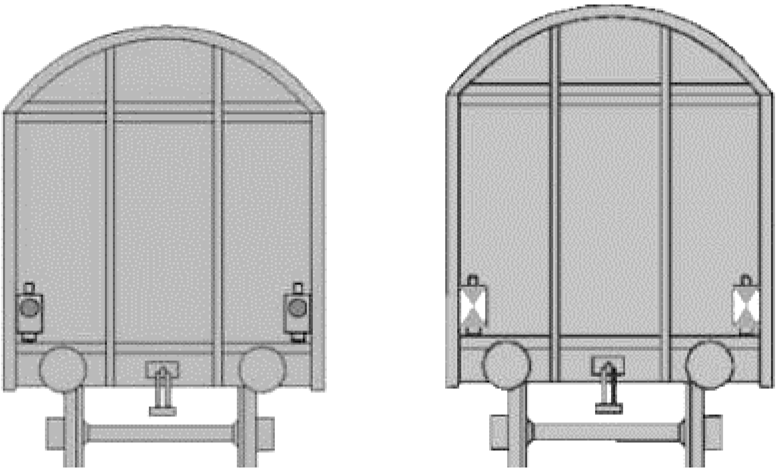
	MIN	MAX
Avoided process per CBP (minutes)	45 for RCF 1 borders; 222 for RFC 7 borders, and; 116 for the remaining	
% of trains affected by the issue in a CBP	100%	
Sum of incidences with RUs in all CBPs affected	686	1 229
Sum of annual trains in all CBPs affected	613 735	874 253
Freight time savings (in M€)	119,2	231,7
Administrative and overhead cost savings (in M€)	41,3	100,3
Total sum of impacts (in M€)	**160,4**	**331,9**

The overall impact for solving issues 4 and 15 along the rail freight network operated by the RFCs can reach a range of 160M€ up to 332M€. Overall, 614k to 874ktrains are affected by issues 4 and 15, for which between 1 281 to 1 915hours could be saved annually.

3.6 Other issues estimated

3.6.1 Issue 3 - Tail lights vs plates

Different types of rear end signals are present in national requirements. This means that a train originally equipped with plates travelling to a country where taillights are compulsory require double equipment and is required to stop and change the equipment at the border, even if the locomotive is equipped with ERTMS.



Lights are allowed in countries with plates. Therefore, in case lights are available and compliance have been checked in the origin, there is no need to stop at the border.

Figure 6: Example of taillights and tail plates

The issue affects most severally the small RUs who do not dispose of additional staff to perform the change of plates. Large RUs often carry out this service for the small ones, despite being a costly service as staff of the former must be paid 24h/day. The analysis showed that both the NSAs and IMs consider that this activity is under the responsibility of the other and not on its own responsibility.

Qualitative expected impacts

The following impacts were identified:

Impacts of Issue 3
Issues impacts • Unnecessary planning efforts (time and costs) • Additional operational costs caused by the additional resources • Time lost at the border (additional waiting time at the CBPs) Solution impacts • Reduction in the times and costs of planning operations

Quantitative impacts

The estimated impacts from the removal of different rear end signals in national requirements that lead to interruptions in border crossings of Belgium, France, Italy, Spain and Portugal is presented in Table 31.

The line sections considered in the analysis totalize 28 cross border points as follows:

Table 27: Cross-border points considered within issue 3 impacts estimation

Cross Border Points	No of Trains (2019)		No of incidences with RUs (2019)		Connected RFC*
	MIN	**MAX**	**MIN**	**MAX**	
Montzen-Frontiere (BE)/Aachen-Gemmenich (DE)	23 876	27 857	7	29	1 and 8
Domo II (IT)/Brig Tunnel (CH)	25 841	32 896	9	17	1
Domodossola (IT)/Brig Tunnel (CH)	7 440	32 896	9	17	1
Luino (IT)/Pino-Tronzano (CH)	11 537	12 559	5	12	1
Chiasso Est (CH)/Bivio/Pc Rosales (IT)	16 634	23 053	14	15	1
Chiasso Est (CH) / Como S.Giovanni (IT)	1327	23 053	8	15	1
Essen-Grens (DE)/Roosendaal (NL)	10 971	13 071	8	14	2 and 8
Mouscron-Frontiere (BE)/ Tourcoing - Bât Voyageurs (FR)	5 081	6 381	7	9	2
Blandain-Frontiere (BE)/Baisieux (FR)	1 220	1 324	4	6	2
Erquelinnes-Frontiere (BE)/Jeumont - Bât Voyageurs (FR)	2 875	3 632	4	6	2
BE / Aubange-Frontiere-France (FR)**	4 034	4 034	2	2	2
Basel St. Johann (FR)/St-Louis (Haut-Rhin) - Bât Voyageurs (CH)	10 433	11 205	7	10	2
Zoufftgen Frontière (FR)/Bettembourg-Marchandises (LU)	3 725	13 966	5	7	2
Mont-St-Martin - Bif (FR)/ Aubange-Frontiere-France (LU)	4 034	4 942	2	3	2
Brennero (IT)/ Staatsgrenze nächst Steinach in Tirol (AT)	19 960	19 960	7	13	3
Stiring-Wendel - Frontière Fr-Al (FR)/ Saarbrücken Hbf (DE)	4 575	7 800	9	23	4
Hendaye - Bât Voyageurs (FR)/ IRUN (ES)	2 117	3 046	2	4	4
Fuentes De Oñoro (ES)/Vilar Formoso (PT)	796	1 876	3	6	4
ES/Elvas (PT)**	712	712	3	3	4
Villa Opicina (IT)/ Sežana (SI)	8 556	11 206	5	14	5 and 6
Thörl-Maglern(AT)/Tarvisio Boscoverde (IT)	19 417	22 889	16	19	5
Joncherey - (FR) / Portbou (ES)	2 652	4 285	3	4	6
Perpignan ES(FR)/Limite Adif - Tp Ferro (ES)	771	1 972	2	2	6
Modane - Bât Voyageurs (FR)/IT**	5 762	7 331	7	17	6
Total	**194 346**	**291 946**	**148**	**267**	

Source: RNE database

*RFC 1: Rhine Alpine, RFC 2: North-Sea Mediterranean, RFC 4: Atlantic RFC 5: Baltic Adriatic, RFC 6: Mediterranean, RFC 8: North-Sea Baltic.

** The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points as a consequence the number of annual trains and RUs is considered equal in both sides of the border.

Table 28 shows that, if a total of 5 minutes per train[21] is required to solve issue 3 and that 100% of the trains are affected by it a range between 16,1k and 24,3k hours would be saved per year. The impacts from solving issue 3 are estimated as varying between 13,5 M€ and 29,7 M€ mostly derived from operational costs savings.

Table 28: Total impacts of issue 3 in dedicated sections

	MIN	MAX
Avoided process per CBP (minutes)	5	
% of trains affected by the issue in a CBP	100%	
Sum of incidences with RUs in all CBPs affected	148	267
Sum of annual trains in all CBPs affected	194 346	291 946
Freight time savings (in M€)	2,0	3,8
Administrative and overhead cost savings (in M€)	11,5	25,8
Total sum of impacts (in M€)	**13,5**	**29,7**

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Extrapolation and total results

Issue 3 was not identified in other borders besides the ones identified. Member States which only allow fixed red lights as rear end signals in their notified national rules are Belgium, France, Italy, Portugal, Spain. The UK is also concerned but not anymore legally bound to OPE TSI.

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3.6.2 Issue 11 - New train number

The issue on new train numbers occurs when no changes are performed in the train composition. Nevertheless, the Infrastructure Manager assigns a new number to the train. When this occurs, the train is considered as a new one and all train preparation procedures (such as full technical wagon check and brake test) must be performed again.

The procedure is considered an issue in Hungary, Romania, Slovakia, Italy and Spanish borders (both with France and Portugal).

Qualitative expected impacts

The following impacts were identified:

[21] 5 minutes estimated by the consortium as general assumption that the plate replacement is performed by local staff available at the station (2 minutes approach to the train + 1 minute plate replacement + 2 minutes going back to starting position). Source: "Rhine – Danube Rail Freight Corridor - capacity improvement and operational bottleneck study". Final report March 2021.

Impacts of Issue 11

Issues impacts

- Time lost at the border (additional waiting time at the CBPs)
- Efficiency loss due to the impossibility of the Infrastructure Manager to anticipate the delay due to missing information
- Additional time loss and costs for the operational staff with the performance of the technical train checks
- Additional bureaucracy leading to inefficient extra work both for RUs and IMs

Solution impacts

- Reduction in the times and costs of planning operations
- Improve the efficiency of communications, reducing the waiting time at CBPs (train number)
- Improvement in the cross-border check process due to elimination of red tape

Quantitative impacts

From the set of interviews performed by the consortium, the effects were identified as most severe for trains entering Hungary and Romania. Given the granularity of the data available is not possible to distinguish the directions of the trains, and consequently the analysis is performed considering the trains crossing those borders in both directions.

The line sections considered in the analysis are presented below:

Table 29: Cross-border points considered within issue 11 impacts estimation

Cross Border Points	**No of Trains (2019)**		**No of incidences with RUs (2019)**		**Connected RFC***
	MIN	**MAX**	**MIN**	**MAX**	
Koprivnica/Gyékényes (HU)	8 955	18 666	6	19	6
Hodoš (SI)/Őriszentpéter (HU)	6 548	7 285	4	15	6
Nickelsdorf (AT)/Hegyeshalom (HU)	18 340	23 259	29	29	7 and 9
AT/ Sopron (HU)**	5 835	5 835	14	14	7
Komárno (SK)/Komárom (HU)	6 177	25 847	12	30	7 and 11
Štúrovo (SK)/Szob (HU)	10 822	12 281	23	28	7 and 11
Biharkeresztes (HU)/ Episcopia Bihor (RO)	1 760	2 025	11	13	7 and 9
Lőkösháza (HU)/ Curtici (RO)	16 577	17 121	18	23	7 and 9
Giurgiu Nord (RO)/Ruse Razpredel. (BG)	5 232	5 908	6	14	7
Total	**80 246**	**118 227**	**123**	**185**	

Source: RNE database

* RFC 6: Mediterranean, RFC 7: Orient East Med, RFC 9: Rhine- Danube and RFC 11: Amber.

** The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points as a consequence the number of annual trains and RUs is considered equal in both sides of the border.

As from the analysis, a total of 118 minutes[22] per train is required to solve issue 11 affecting about 80% of the trains running. Overall, and having in mind that some overestimation could occur as the analysis considers trains running in both directions while the issue affects particularly the entrances, between 14,5M€ and 29,5M€ savings can be foreseen from solving issue 11.

Table 30: Main cost drivers for issue 11 in the dedicated sections

Issue 11 (dedicated sections)	**Impact (M€)**	
	Min	**MAX**
Operational cost savings	5,8	11,7
Freight time savings	8,6	17,8
Total	**14,5**	**29,5**

Extrapolation and total results

Besides being present in the Hungarian and Romanian borders issue 11 was also stated to be occurring in Slovakia, Italy and Spanish borders.

The level of detail obtained for Slovakia was very vague, not allowing to properly identify the impacts. Given this, the extrapolation exercise is provided for the borders between Hungary and Slovakia together with the Italian borders and for Spanish borders with France and Portugal.

It is estimated that between 244k and 349k hours are saved in the remaining locations, affecting between 122 195 and 174 681 trains annually which corresponds to expected savings in the order of 29,2M€ to 58,5M€.

The total impacts of issue 11 considering both the dedicated estimation of impacts and the extrapolation exercise are presented in Table 31.

[22] Based on the stakeholders' survey results and interviews:

1. If the PaP is changed from "corridor" to "operational train" level, this means waiting time until the train receives a new train path for the national rail network. Moreover, the train will lose priorities assigned to corridor trains, which might lead to additional time loss in case of conflicts with other trains.

2. An additional technical examination of the train including brake test is required:

Process: wagon inspector walks along the entire train (both sides), performs wagon check and checks correct tightening and release of each wagon brake.

Assumptions: Time need (if process is performed by 1 wagon inspector): 0.9 min/axle + 10min (approaching/walking back + paperwork), based on Guideline DS 936 (Deutsche Bahn), verified and checked in numerous applications/studies.

- 600 m train length (see above)/20 m = 30 wagons per train * 4 axles/wagon = 120 axles/train
- Time need = 0.9 * 120 + 10 = 118 min (equivalent to 2 h)

Table 31: Total results of issue 11 at the EU level

	MIN	MAX
Avoided process per CBP (minutes)	120	
% of trains affected by the issue in a CBP	80%	
Sum of incidences with RUs in all CBPs affected	216	343
Sum of annual trains in all CBPs affected	203 768	315 961
Freight time savings (in M€)	31,4	67,8
Administrative and overhead cost savings (in M€)	12,7	27,8
Total sum of impacts (in M€)	**44,1**	**95,6**

Overall, the estimated impact of issue 11 at EU level driven by 401k up to 621k saved hours per year, results in a cost range between 44,1 to 95,6 M€.

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3.6.3 Issue 13 – two-people cabin crew

There is no harmonised rule on the number of cabin crew members and the number of cabin crews/drivers required in each train varies for the different Member States. In some cases, two drivers are required, while in other cases one driver and one additional staff member are required.

The Implementation Deployment Plan ILB further highlights the specific problems presented in each of the countries mostly affected by the issue – Italy, Romania and Bulgaria, which are herewith briefly described.

Bulgaria

In Bulgaria, it is required to operate locomotives on railway lines with two qualified drivers. This is the case for some lines on the network but not all. These lines are specified in national regulations. Exceptions are made for trains with two locomotives, including either pushing locomotives at the end of a train or a second locomotive in double traction. The additional locomotive can be operated by only one driver. In these cases, 3 drivers are required in total: two drivers for the leading locomotive and one driver for the second locomotive (either in double traction or pushing at the end of the train). The operation of a single locomotive can also be done with only one driver in certain lines. Up until now, only railway operators have been interviewed on this issue. Thus, the specific lines and the reason for the requirement of two drivers could not yet be identified.

Romania

For Romania, the issue is very similar to the issue in Bulgaria. A two-people cabin crew is required in some specific cases. Unlike in Bulgaria, the second person in the cabin does not necessarily need to be a driver but must be able to stop the train. Nevertheless, a second driver is often preferred by the Rus, in order to utilise the second person for shunting and other tasks. The regulations requiring a second person in the cabin are given in Regulation no. 005, issued by the Ministry of Transport, Construction and Tourism. This regulation was amended in 2019 when some of the conditions for the trains which must be serviced by at least two agents (driver and e.g. assistant driver) were eliminated if certain requirements regarding the type of train and the safety and vigilance equipment can be met. In those cases, trains can also be operated by only one driver without additional staff.

Italy

The case of Italy differs slightly from Bulgaria and Romania. All three countries have in common that two people on one locomotive are only required on certain lines or line sections. The reason for this, however, is not part of the railway regulations but rather part of the health & safety regulations. The second person should assist the driver in his tasks and must be able to intervene in case of unexpected events, including health issues of the driver. In practice, the second person is not necessary in most cases.

Qualitative expected impacts

The following impacts were identified:

Impacts of Issue 13

Issue impacts

- Unnecessary planning efforts and additional operational costs caused by the additional resources (train drivers and operational staff members):
  - Cost of transporting the driver
  - Lost hours
  - Driving time
  - Resting time.

Solution impact

- Cost savings related with planning efforts and unnecessary human resources

Unlike the other issues, the issue on two-people cabin crew can be considered indirectly an interoperability issue. This is related with the nature of the solution implying more with labour policies rather than operational aspects. From the analysis carried out, this issue affects in particular the borders in Italy, Bulgaria and Romania (Table 32). In the cases of Bulgaria and Romania, it is caused by the train control and signalling systems, while in the case of Italy it is mainly caused by the worker's health and safety regulations.

As such, the methodology adopted for the estimation of issue 13 impacts differs from the previous issues, as previously described.

Table 32:Cross-border points considered within issue

Cross Border Points	Country Code	Annual trains (2019)	Cross Border Points	Country Code	Annual trains (2019)	Connected RFC*
Domo II	IT	25 841	Brig Tunnel	CH	32 896	1
Domodossola	IT	7 440	Brig Tunnel	CH	32 896	1
Luino	IT	12 559	Pino-Tronzano	CH	11 537	1
Chiasso Est	CH	23 053	Bivio/Pc Rosales	IT	16 634	1
Brennero	IT	19 960	Staatsgrenze nächst Steinach in Tirol	AT	19 960	1
Villa Opicina	IT	8 556	Sežana	SI	11 206	3

Cross Border Points	Country Code	Annual trains (2019)	Cross Border Points	Country Code	Annual trains (2019)	Connected RFC*
Thörl-Maglern	AT	22 889	Tarvisio Boscoverde	IT	19 417	5 and 6
Modane - Bât Voyageurs	FR	5 762	PC Terres Froides	IT	7 331	5
Biharkeresztes	HU	1 760	Episcopia Bihor	RO	2 025	6
Lőkösháza	HU	17 121	Curtici	RO	16 577	7 and 9
Giurgiu Nord	RO	5 908	Ruse Razpredel	BG	5 232	7 and 9
Kapikule	TR	n.a.	Slivengrad (BG)	BG	150**	7

Source: RNE database

*RFC 1:Rhine Alpine, RFC 5: Baltic- Adriatic, RFC 6: Mediterranean, RFC 7: Orient East Med, RFC 9: Rhine Danube.

** Number of trains from DB Cargo Bulgaria only.

As acknowledged during surveys and interviews, the two cabin drivers is understood as a burden imposed on RU but which impact is not only difficult to be measured (with the current elements it is not possible to anticipate how the second driver would be (re)affected to other activities nor, for the same driver, the number of trains he/she operates per year) and above all, the indication of an economic benefit on top of labour issues is perceived as being highly sensitive for the related industrial relations.

Quantitative impacts

In Romania the 2 people cabin crew is no longer a problem in passenger traffic but remains for freight traffic. The national trains within Romania are also affected. In Bulgaria 2 or 3 drivers (in the case of trains with one or two locos, respectively) are required in both passenger and freight traffic.

The train driver usually is transported to the border via public transport. The costs with the transport, the hotel to rest (10 hours), transport back home and resting time (at home until next shift) are supported by the RU. These costs are being duplicated and sometimes tripled by issue 13 occurrence.

An Extra allowance is paid to the train driver when away from home for more than 24 hours (50 €/day). For example, in Bulgaria for a train going from Turkey to Serbia the train driver would have to be away from home between 24 and 36 hours.

According to the literature[23], on average, the staff costs represent about 25% of the total operational costs for a railway undertaking. Within staff costs, train drivers represent about 40% of the total. These ranges were thus confirmed via interview with contacts from DB Cargo Romania and DB Cargo Bulgaria..

Supported in the analysis of the operational costs for Małaszewicze -Nuremberg, developed by the partner Railistics, an operating cost of 15-17.000 euros for a 650 m combined transport train with e-traction has been defined. The calculation of train operating costs depends on many factors which vary by country and routes. A cost variation from 12 to 24 k€, with an average cost around

[23] Authority for Transport and Mobility (2019). Portuguese Railway Ecosystem – June 2019.

18 000 euros could capture such diversity and the margin for certain extra costs not included. In annex the cost breakdown for the Małaszewicze -Nuremberg is provided.

Bulgarian Borders

On average, staff costs represent about 20% of the total operational costs in DB Cargo BG. Within staff costs, train drivers represent about 40% of the total. As from interviews an average cost of 743€ or a locomotive driver was indicated, whereas the calculation method results in a cost of 768€.

Romania Borders

On average, staff costs represent about 20% of the total operational costs in DB Cargo RO. Within staff costs, train drivers represent about 41% of the total. As from interviews, the cost for 2 locomotive drivers in Romania is in the order of 1780€, thus around 890€ per driver. The calculation method returns a cost of 815€.

Italian Borders

As for Italian borders no specific values were possible to be collected during the course of the project. For this reason, the average values from Romania, Bulgaria and Portugal were used as reference and adjusted to the country PPP.

Overall, for the 148 thousand trains in the borders of Italy, Bulgaria and Romania affected by the two-cabin crew requirement, an annual saving of 110,9 million euro could be expected if issue is solved. This is particularly high for Italy with nearly 120 thousand trains in 2019 being affected by issue 13.

Table 33: Resources cost savings from solving issue 13

	% staff costs in freight Rus	% of train drivers wages in staff costs	Average RUs wage cost per driver (with PPP) [24]	Min Annual trains (2019)	Max Annual trains (2019)	Min Yearly cost savings per country (in euros)	Max Yearly cost savings per country (in euros)
Romania	20%	41%	815 €	23 834	24 789	9 709 400 €	10 098 444 €
Bulgaria	24%	40%	768 €	5 382	5 908	2 065 396 €	2 267 254 €
Italy	23%	40%	1 661 €	149 113	153 204	123 858 439 €	127 256 566 €
			Total	178 329	183 901	135 633 235 €	**139 622 264 €**

The results presented above show that solving issue 13 in Bulgaria, Romania and Italy represent an overall cost varying between 135,6 and 139,6 M€.

Extrapolation

Issue 13 was not identified in other borders besides the ones identified. It has been identified in other countries for passenger traffic only namely Romania, Poland, France, and Spain.

[24] considering an average operation cost of 18 000 euros

3.6.4 Issue 14 - Equipment of border stations with commutable electric power supply

In Europe there are currently four electricity systems on the main railway lines: direct current 1.5kV or 3 kV and single phase alternating current 15kV or 25kV. Different electrification standards imply that in border stations between networks where different kind of electrical current is supplied and where trains travel with single system locomotives one of two things can be foreseen to solve the problem:

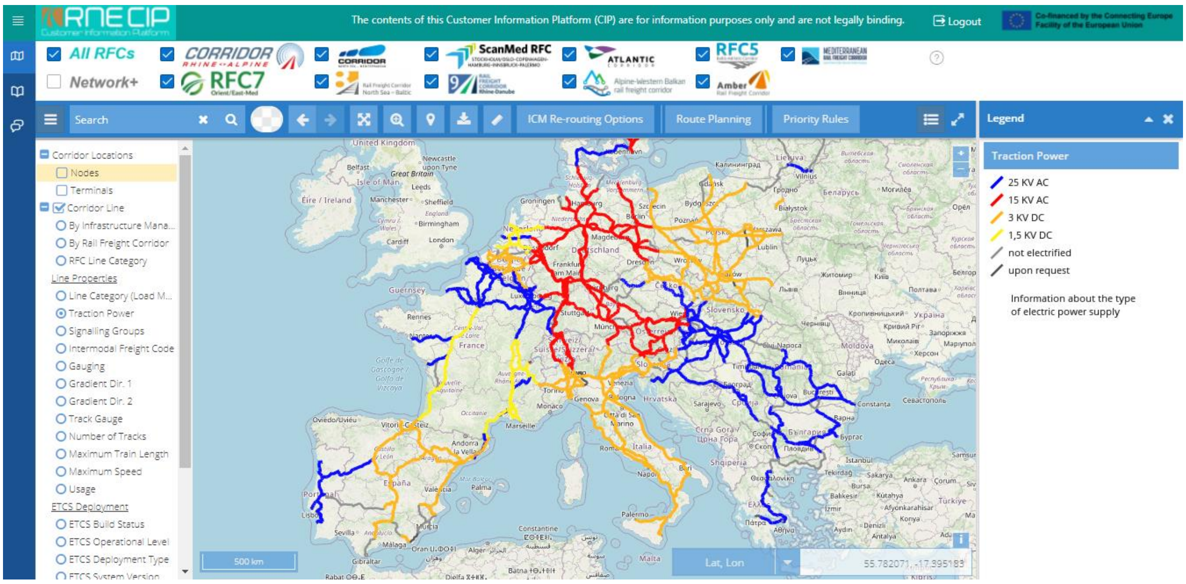
- Shunting manoeuvres, or;
- The purchase of multisystem locomotives

Different power systems imply that trains traveling between countries face additional difficulties. Whenever there are different electric systems at a border two main solutions are considered to change the power supply of trains:

1. The separation point can be located on open track;
2. The separation point can be performed in the station. If so, two variants of the solution are possible:
    a. to have tracks with switchable power supply, or;
    b. to have tracks with non-switchable power supply.

The stakeholder's survey showed that border crossings most affected are the Dutch-German cross-border points of Roosendaal-Essen and Oldenzaal – Bad Bentheim in both directions. Additionally, this issue is also reported as relevant on the cross-border points between Hungary and Slovakia on the Orient East-Med RFC, among others. Overall, this issue impacts barely all the network sections with different traction and voltages schemes (see Figure 7). Nonetheless, as the number of RU and number of annual trains is only available for the border sections, only those sections are analysed[25].

Figure 7 - Traction power across the RFC network



Source: RNECIP

[25] The possibility to extrapolate border figures to the remaining sections with different traction power has been discussed, but the risk of overestimation of impacts was evaluated higher than the resulting benefits of the exercise.

Qualitative expected impacts

The following impacts were identified:

Impacts of Issue 14

Issues impacts

- Unnecessary planning efforts
- Additional operational costs caused by the additional resources (in the case of change in the border station more staff, time and shunting locomotives are needed to change from one power supply to the other)
- Time lost at the border

Solution impacts

- Reduction in the times lost at border
- Reduction of operational costs associated with staff and shunting locomotive manoeuvres.

Quantitative impacts

The locations where issue 14 was measured are presented in Table 34. The Roosendaal/ Essen is an example of a separation point on open track while Oldenzaal /Bad Bentheim is an example of a separation point at a station.

Table 34: Cross-border points considered within issue 14 impacts estimation

Cross Border Points	**No of Trains (2019)**		**No of incidences with RUs (2019)**		**Connected RFC***
	MIN	**MAX**	**MIN**	**MAX**	
Essen-Grens (DE)/Roosendaal (NL)	10 971	13 071	8	14	1 and 8
Bad Bentheim (DE)/Oldenzaal (NL)	7 314	9 949	16	44	8
Total	**18 285**	**23 020**	**24**	**58**	

Source: RNE database

For the estimation of the freight time savings, it was assumed that:

- if the separation point is on open track it takes an average of **240 minutes** lost for each train crossing the borders.
  This value is an assumption supported in the interviews conducted considering that the trains arrive with one single system locomotive. In this scenario a multi-system locomotive must wait for the 30 minutes for the train to arrive, then the single system locomotive attached to the train takes on average 30 minutes to be detached and leave. The multi-system locomotive will take another 30 minutes to be attached to the train and take it to the new single system locomotive. The time of operation of the multi-system locomotive taking the train from one point of the track to the other is not considered in the analysis. Then the multi-system locomotive takes 30 minutes to be detached and leave and the new locomotive has to wait 30 minutes for the train to arrive and another 30 minutes to be attached to the train. This process results in 180 minutes loss in the shunting process. Additionally, 60 minutes should be considered as waiting times of the

locomotives related with an average of 30 minutes for the brake test of the multi-system locomotive and the second single system locomotive.

- If the separation point is on a station with tracks with switchable power supply, then it takes an average of **120 minutes** lost for each train crossing the borders. If a train arrives with one single system locomotive, the locomotive that will be changed takes 30 minutes to detached from the train and the new one will have to wait 30 minutes for the train to arrive to the station and another 30 minutes to be attached to the train resulting in 90 minutes for the shunting process. Additionally, 30 minutes should be considered for the brake test of the train before leaving the station.

Based on the surveys and interviews, it is estimated[26] that about 30% of the trains are still affected by the issue 14[27]. The impact from solving issue 14 in the selected borders is thus estimated to vary between 4,2M€ and 7,9M€ Overall between 54,8 and 69k hours could be saved if issue 14 is solved in the dedicated borders

Table 35: Main cost drivers for issue 14 in dedicated sections

Issue 14 (dedicated sections)	Impact (M€)	
	Min	MAX
Operational cost savings	2	5
Freight time savings	2,2	2,9
Total	**4,2**	**7,9**

Extrapolation and total results

The list of the geographic points considered in the extrapolation of results is presented in Annex 6.10. The list combines the border points indicated by stakeholders as well as the other border points included in a rail freight corridor with different traction power in each side of the border even if this was not highlighted by the stakeholders. The number of trains/RUs calculated at border point is the same as where voltage swap is actually taking place, at the border or some km before/after. This allows for a more complete view on the magnitude of this issue. Nonetheless, as highlighted before, this result still doesn't capture the full magnitude, once the national sections with different traction powers are not captured.

Table 36: Total results of issue 14 at the EU level

	MIN	MAX
Avoided process per CBP (minutes)	240 if separation point in open track 120 if separation point separation point is on a station with tracks with switchable power supply	
% of trains affected by the issue in a CBP	30%	
Sum of incidences with RUs in all CBPs affected	481	1019
Sum of annual trains in all CBPs affected	496 872	739 797
Freight time savings (in M€)	47,9	94,4
Administrative and overhead cost savings (in M€)	30,9	87,9
Total sum of impacts (in M€)	**78,9**	**182,3**

[26] Estimated by the consortium based on the stakeholders' survey results and interviews.

[27] Nevertheless, it is worth noting that through CEF large efforts are being place on the electrification of the network and harmonisation of traction power which will contribute to minimise this impact in the core network until 2030. This might justify why RU are not heavily investing in multi power locomotives for long distance rather than backing on a system that imply in last case the use of three different equipment.

When extrapolating the results is assumed that 30% of the trains are affected in the considered borders and that it takes on average 180 minutes[28] for the issue to be solved. Overall, 496 to 739 thousand trains could be annually affected by this issue, representing between 1,4 to 2,2 million hours lost. The overall magnitude of impacts from solving issue 14 can vary between 78,9M€ and 182,3M€.

3.7 Specific case of Romania

Given that 11 of the 12 issues whose impacts have been studied have registered its occurrence in Romania, a specific case study was designed to assess the overall impact of solving all the rail freight interoperability issues in this country.

Table 37 summarizes the issues and the locations where they have been declared to be occurring and up in which the estimations of impacts are based on.

Table 37: Issues and geographic occurrence in Romania

Issue	Description	Geographical occurrence
1 2	Braking sheets Braking performance	Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Giurgiu Nord (RO)/ Ruse Razpredel (BG)
4 15	Train composition (Harmonisation of wagon list) Real time communication and harmonisation of train composition message (wagon list)	Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Giurgiu Nord (RO)/ Ruse Razpredel (BG)
5	Train Composition (Working handbrake last wagon)	Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Giurgiu Nord (RO)/ Ruse Razpredel (BG)
6	Train Composition (No push 6 axles wagons)	Predeal (RO)/ Brasov (RO) Fetesti (RO)/Cernavoda (RO) Drobeta- Turnu Severin (RO)/Balota (RO) Vintu de Jos (RO)/Coslariu (RO) Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Giurgiu Nord (RO)/ Ruse Razpredel (BG)
7	Train Composition (Buffer wagons)	Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Ruse (BG)/Giurgiu Nord (RO)
8 9	Technical checks at border stations Mandatory checks in Member States	Lőkösháza (HU)/Curtici (RO)
11	New train number	Lőkösháza (HU)/Curtici (RO) Biharkeresztes (HU)/Oradea (RO) Giurgiu Nord (RO)/ Ruse Razpredel (BG)
13	Two cabin crew	Giurgiu Nord (RO) Episcopia Bihor (RO) Curtici (RO)

From the full list of issues being studied only three issues (issues 1-Braking sheets, 2-Braking performance, 3- Taillights vs lights and 14 - Equipment of border stations with commutable electric power supply) do not occur in Romanian stations while the remaining are present in the border stations

[28] Arithmetic mean between the time loss if the separation point is on a station with tracks with switchable power supply (120 minutes) and if the separation point is on open track (240 minutes).

with Bulgaria and Hungary. An exception is present for issue 6 - Train Composition (No push 6 axles wagons), only occurring in the mountainous line sections in Romania.

To perform the analysis for Romania, border sections were isolated from the overall estimation of the impacts. The following assumptions were considered:

- the time savings per train are considered equal to the sum of the impacts from each issue occurring in Romania resulting in 15,2 hours per train (911 minutes[29]);
- the percentage of affected trains is equal to 88%[30].
- For issue 13, all the trains crossing the three indicated borders

Table 38: Impacts specific case of Romania

	Min	Max
Avoided process per CBP (minutes)	911	
% of trains affected by the issue in a given point	88%	
Sum of RUs in all points affected	295	310
Sum of annual trains in all points affected	43 265	45 748
Freight time savings (in M€)	33,8	39,4
Administrative and overhead cost savings (in M€)	12,1	13,1
Issue 13 (two cabin crew)	10,0	
Total sum of impacts (in M€)	**55,8**	**62,4**

Table 38 shows that overall impact of the different issues in Romania range from 55,8 to 62,4 M€ From those between 33,8M€ and 39,4M€ would derive from freight time savings and the remaining from 12,1M€ up to 13,1M€ from resource cost savings. Issue 13, referring to the second train driver counts for a cost of nearly 10 million euro.

[29] From issues 4 and 15 is considered a time saving correspondent to the RFC 7 equal to 222 minutes, 45 minutes from issue 5, 75 minutes from issue 6, 45 minutes from issue 7, 384 minutes from issues 8 and 9, 120 minutes from issue 11 and zero from issue 13.

[30] This results from the weight between the sum of trains affected by issues in Romanian stations divided by the sum of total trains in those stations. the sum of the percentages of affected trains multiplied by the relative weight of the time savings from each issue affecting Romanian borders.

4 Conclusions

This report presented the results of the economic assistance under the technical support for the interoperability of the ILB. Two main outputs were provided to the European Commission:

- First, an economic evaluation of the impacts from solving the issues, and;
- Second, an adapted Cost-Benefit Analysis template for future impact estimations by the European Commission (EC) and the European Railway Agency (ERA).

Overall, 15 issues included in the issues LogBook have been studied and their impacts estimated. From those the quantitative impacts of 12 have been accessed either in the format of cases studies or individually.

The results of the estimations are presented for the locations where the issues were identified by stakeholders as most urgent to be solved and further extrapolated for the remaining sites where they are reported as occurring. The sum of both represents the overall magnitude of impacts at EU level.

Three case studies were considered representative of the three ILB priorities and constitute the first set of issues supported by the study team (technical and economic):

- Case Study A (issues 1 and 2) – Priority 1: Braking;
- Case Study B (issues 8 and 9) – Priority 2: Technical checks at borders;
- Case Study C (issues 4 and 15) – Priority 3: Real time communication.

Other issues were progressively added to the analysis, including:

- issue 3 – taillights versus plates;
- issue 5 - Train composition (working handbrake in the last wagon);
- Issue 6 - Train composition (No push 6 axles wagons);
- Issue 7 - Train composition (Buffer wagons);
- Issue 11 – New train number;
- Issue 13 – 2 cabin crew
- Issue 14 - Equipment of border stations with commutable electric power supply.

Other three issues covered by the ILB but for which no support action was previewed within the scope of this project, include issues 10 - Operational implementation of the traffic in ERTMS – and 12 - Exception from operational rules)

The approach followed distinguish between the description of the issues, the identification of the qualitative impacts of having the issues solved and the measurement of the quantitative impacts. The main quantitative impact drivers are given, on one hand, from freight time savings and, on the other hand, from administrative and overhead costs.

A set of assumptions had to be defined taking as basis the surveys and interviews promoted with the various stakeholders. Those assumptions refer to: i) identification of the geographical occurrence of the issues, ii) proxies for avoided process (minutes) from solving the issues; iii) percentage of trains affected by the issue in a given border point; iv) overhead cost and administrative burden per Railway Undertaking (RU); v) locomotive and energy costs resulting from having a train stopped while dealing with a given issue. All these values are adjusted based on the Parity Purchasing Power of each country considering 2019 as the base year. The selection of 2019 as reference year for the estimation of impacts takes into consideration the availability of one year data from RNE database (number of trains and number of RU) and not using 2020 data which represents an atypical year due to the Covid 19 pandemic.

For issue 13, with a different nature that doesn't fit exactly under an interoperability issue and rather more labour policy oriented, a different approach had to be followed, considering the cost difference of reducing the second driver in the train. The analysis was supported on the interviews and desk research allowing to define an average cost of a driver upon which it was estimated the cost saving for the operation of trains affected by the issue if a single driver is on board.

An impact excel tool for the estimation of impacts per issue has been developed to be used as the template for Cost Benefit Analysis and is an integral part of this study report. The tool enables the user to select the issue to be evaluated, the specific geographic point and the country to be analysed, returning the impacts based on the project input data. It allows also for the possibility to add new geographic point and / or for changing input parameters values if own data is available). For each issue, the tool returns: 1) the total impact per issue on a specific geographic point, 2) the total impacts per zone pair (which means the total impacts of all issues identified in the selected geographic point);3) the total per issue (total impact of the issue in all the locations where they have been identified; 4) Total per country (the total impact of the all the issues for the selected country border stations).

The (still) persisting lack of data and/or inconsistent datasets at the EU and MS level, together with the almost absence information on costs and benefits of the issues and the cases studies revealed as a challenge requiring a close articulation with the stakeholders in view of quantifying the cost drivers. Al the work under the Deployment Implementation study was critical for the establishment of relevant variables and its quantification and / or definition of proxies to be adopted.

In the ILB study, the focus is placed on projects that aim to improve the efficiency of the rail sector without requiring heavy investments on the infrastructure, meaning above all a set of soft measures and harmonisation of procedures across Europe. Through its adoption and implementation, the competitiveness of rail freight transport currently hindered by the presence of issues can increase significantly once those issues affect primarily the operating costs and travel time of Rus.

This analysis reveals only a partial economic impact as it doesn't quantify the modal shift potential associated to the elimination of the issues. The decision was to focus the analysis on the quantitative assessments regarding costs and time of rail transport allowing to produce robust estimations at local and EU level for all relevant issues and case studies. This takes into account that several RFC are concluding the market studies as well as that several infrastructure investments are in conclusion stage even contributing for large difficulties in obtaining market data.

One of the main difficulties across the analysis was associated to different number of annual trains in each side of the borders[31]: in some cases, this is the direct consequence of different infrastructural conditions (i.e. different train length forcing to a different train composition and different numbering), in other cases this results from real inconsistent data. Taking such constraints into account, the approach followed along the study was to present all the analysis in a range (i.e., for the minimum and maximum number of trains in the border). By providing the range, the uncertainty about input data on rail traffic in the economic model applied by the consortium, is minimised. However, in what concerns the main conclusions of the analysis, a conservative approach is followed and results for the minimum number of trains are used.

[31] This situation is currently minimized for the period after 2020, as improvements have been introduced by RNE in the data reporting

The total impacts at EU level from solving the issues analysed in the study has an overall magnitude of 529,6M€ , which shows that such type of soft and less cost intensive measures can have a large economic impact for the rail freight stakeholders and notably for the RUs. Moreover, solving the issues not only contributes to increase the efficiency of the sector, but above all could enhance and accelerate the expected benefits resulting from the major ongoing infrastructure investment at the EU level. Inversely, not acting towards the harmonisation of procedures would contribute to hinder the full potential of those investments.

From those between 278,6M€ correspond to the issues occurring in the geographic points identified as most urgent (dedicated sections) to have the issues solved whereas the remaining 251,0M€ concern the remaining locations where the issues have also been identified and calculations were performed as extrapolations.

A targeted analysis for Romania, where eleven of the issues are occurring is estimated as having an overall magnitude of 55,5M€.

Table 39: Issues impacts at EU level, values in million euros

Issues and Case Studies	Description	EU level	Extrapolation	Dedicated sections
1|2	Braking sheets &Braking performance	39,1	32,5	6,6
8|9	Technical checks at border stations & Mandatory checks in MSs	23,1	16,1	7,0
4|15	Train composition - Harmonisation of wagon list & Real-time communication and harmonisation of train composition message (wagon list)	160,5	79,2	81,3
3	Taillights vs. plates	13,5	0,0	13,5
5	Train composition - Working handbrake last wagon	2,4	0,4	1,9
6	Train composition - No push 6 axles wagons	15,3	3,2	12,2
7	Train composition - Buffer wagons	17,1	15,1	1,9
11	New train number	44,1	29,6	14,5
13	Two people cabin crew	135,6	0,0	135,6
14	Equipment of border stations with commutable electric power supply	78,9	74,8	4,2
	Total	**529,6**	**251,0**	**278,6**
Romania	Specific case of Romania (issues 1|2, 4|15, 5, 6, 7, 8|9 11 and 13)	55,5		62,5

The total impacts include all the border points where the issues have been identified during the course of this project and for which there is information regarding the number of annual trains and Railway Undertakings operating in those points. The list of all the points included in the analysis can be found in Table 27 and from annexes 6.3 to 6.10.

Freight time savings are the main driver of the impacts in issues 8|9, 11, 4|15 and case specific of Romania and the operational cost savings are the drivers of overall impacts in the analysis of issues 1|2, 3, 5, 6, 7 and 14.

Table 40: Main drivers for impacts per issue, in million euro

Issues and Case Studies	Description	Freight time savings	Operational costs
1|2	Braking sheets &Braking performance	14,6	24,5
8|9	Technical checks at border stations & Mandatory checks in MSs	15,7	7,4
4|15	Train composition - Harmonisation of wagon list & Real-time communication and harmonisation of train composition message (wagon list)	119,2	41,3
3	Taillights vs. plates	2,0	11,5
5	Train composition - Working handbrake last wagon	0,6	1,8
6	Train composition - No push 6 axles wagons	3,2	12,1
7	Train composition - Buffer wagons	6,7	10,4
11	New train number	31,4	12,7
13	Two people cabin crew		135,6
14	Equipment of border stations with commutable electric power supply	47,9	30,9
	Total	**241,1**	**288,5**
Romania	Specific case of Romania (issues 1|2, 4|15, 5, 6, 7, 8|9 and 11)	33,7	22,2

It is estimated that about 2,5 million trains are affected annually by the current issues of the ILB table.

Table 41: Number of trains affected annually (2019) per issue and case study

Issues and Case Studies	Description	Nr of trains
1|2	Braking sheets &Braking performance	421 163
8|9	Technical checks at border stations & Mandatory checks in MSs	140 043
4|15	Train composition – Harmonisation of wagon list & Real-time communication and harmonisation of train composition message (wagon list)	613 735
3	Taillights vs. plates	194 346
5	Train composition – Working handbrake last wagon	25 077
6	Train composition – No push 6 axles wagons	43 265
7	Train composition – Buffer wagons	162 769
11	New train number	203 768
13	Two people cabin crew	178,3
14	Equipment of border stations with commutable electric power supply	496 872
	Total	**2 479 377**
Romania	Specific case of Romania (issues 1|2, 4|15, 5, 6, 7, 8|9 and 11)	43 265

Table 42 shows the overall magnitude of hours lost with each issue.

Table 42: Total lost hours per issue and case study annually (2019)

Issues and Case Studies	Description	Hours	Weight of lost hours per issue in the total of hours lost
1|2	Braking sheets &Braking performance	140 388	3,77%
8|9	Technical checks at border stations & Mandatory checks in MSs	209 079	4,64%
4|15	Train composition - Harmonisation of wagon list & Real-time communication and harmonisation of train composition message (wagon list)	1 280 877	35,04%
3	Taillights vs. plates	16 196	0,45%
5	Train composition - Working handbrake last wagon	18 808	0,38%
6	Train composition - No push 6 axles wagons	54 081	1,05%
7	Train composition - Buffer wagons	122 077	2,77%
11	New train number	400 744	11,37%
13	Two people cabin crew	n/a	n/a
14	Equipment of border stations with commutable electric power supply	1 483 302	40,44%
	Total	**3 725 551**	**100%**
Romania	Specific case of Romania (issues 1|2, 4|15, 5, 6, 7, 8|9 and 11)	655 612	17,60%

If all the measures proposed by the consortium to solve the issues are adopted, the impacts are expected as package impacts, for which no synergies between effects are expected. Since the considered rail breakthroughs need to be in place by 2023, a maximum period of 3 years is assumed as reference to have all the issues solved at least in border stations that are part of Rail Freight Corridors.

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6 Annexes

6.1 The model

In separate attachment.

6.2 Assumptions: Avoided process (minutes) and % of trains affected by the issue in a given point

Issue No	Issue Description	Avoided time (in minutes)	Description of tasks	Trains affected by the issue (%)
1|2	Braking sheets Braking performance	20	Issues 1|2: O Hand over braking sheet: Total time need = 5 minutes Process: local shunting staff walks to the locomotive (not along the train), hands over paper to loco driver and walks to next process. Assumptions: 2 min approaching time (to locomotive) + 1 min handover + 2 min walking back to starting position or to next process (all experience values) O Checking/adjusting brake positions: Total time need = 15 minutes Process: local shunting staff walks along the entire train and checks/adjusts the brake positions of each wagon. Assumptions: train length = 600m, average wagon length = 20m, walking speed = 1 m/s (experience value for walking along the track), time need for checking/adjusting brake position = 10s/wagon (experience value) ▪ Time need for walking = 600/1 = 600s = 10 min. ▪ Time need for checking/adjusting brake positions: 600/20 = 30 wagons per train * 10 s/wagon = 300 s = 5 min	100%
3	Tail lights vs plates	5	5 minutes estimated by the consortium as general assumption that the plate replacement is performed by local staff available at the station. Assumption: 2 minutes approach to the train + 1 minutes plate replacement + 2 minutes going back to starting position. Note: the local shunting staff walks to the end of the train (again along the train). Source: "Rhine – Danube Rail Freight Corridor - capacity improvement and operational bottleneck study". Final report March 2021.	100%

Issue No	Issue Description	Avoided time (in minutes)	Description of tasks	Trains affected by the issue (%)
4|15	Train composition (Harmonisation of wagon list) Real time communication and harmonisation of train composition message (wagon list)		The delays could be reduced by 22% if a smooth transmission of ETA and an active traffic management of the second IM exists. This occurs because: ○ the notification of the estimated time of arrival (ETA), by the first IM to the subsequent IM, could allow the latter to manage one third of the delayed trains without having to subject it to further delays due to Temporary Capacity Restriction (TCR), and; ○ the reduction of the delays if the traffic manager enables the train to avoid TCRs is on the order of two thirds.	
4|15	RFC1	45	According to the 2019 Rhine Alpine Annual Report 11,7 million of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 2,6 million minutes saved which is equivalent to 43,5 thousand hours saved annually in this RFC which divided by the average number of annual trains reported in the borders where RFC 1 run (approximately 57,8 thousand trains in 2019) results in 45 minute savings per train.	100%
4|15	RFC 4	20	According to the RFC 4 Train performance report - Management summary 12/2019, 553 thousand of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 122,9 thousand minutes saved which is equivalent to 2,05 thousand hours saved annually in this RFC. If divided by the average number of annual trains reported in the borders where RFC 4 run (approximately 6,6 thousand trains in 2019) results in 19 minutes savings per train.	100%
4|15	RFC 5	176	According to the RFC 5 Train performance report - Management summary 12/2019, 22,3 million of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 4,95 million minutes saved which is equivalent to 82,5 thousand hours saved annually in this RFC. If divided by the average number of annual trains reported in the borders where RFC 5 run (approximately 29,1thousand trains in 2019) results in 170 minutes savings per train.	100%

Issue No	Issue Description	Avoided time (in minutes)	Description of tasks	Trains affected by the issue (%)
4|15	RFC7	222	According to the RFC 7 Train performance report - Management summary 12/2019, 30,9 million of delay minutes were reported to TIS in 2019 (both directions). 22% of avoided delays equals to 6,9 million minutes saved which is equivalent to 114,6 thousand hours saved annually in this RFC. If divided by the average number of annual trains reported in the borders where RFC 7 run (approximately 31 thousand trains in 2019) results in 222-minute savings per train.	100%
4|15	Average (RFCs 2, 3, 6, 8, 9, 10 and 11)	116	The Train performance report - Management summary 12/2019 was not available and for this reason was considered the average delay minutes of RFCs 1, 4, 5 and 7 for which concrete data was available. Additionally, all trains crossing those borders are considered as affected.	100%
5	Train Composition (Working handbrake last wagon)	45	45 minutes as a result of 30 minutes for the wagon be reordered (assuming a 600m train, wagon from middle to end, the shunting loco approach and coupling) and another 15 minutes of waiting for the shunting service to occur - estimated by the consortium based on the stakeholders' survey results and interviews.	50%
6	Train Composition - No push 6 axles wagons	75	60 minutes for the train to be split and 15 minutes for the shunting service - estimated by the consortium based on the stakeholders' survey results and interviews.	100%
7	Train Composition - Buffer wagons	45	45 minutes as a result of 30 minutes for the buffer wagon to be integrated into the train (between locomotive and wagon train) and another 15 minutes for shunting by the line locomotive - estimated by the consortium based on the stakeholders' survey results and interviews.	50%
8|9	Technical checks at border stations Mandatory checks in Member States	:	Based on the survey results was assumed that issues 8|9 imply, in the Curticci border, a time loss of 8,4 hours. Those are justified by a technical check of 7 hours and additional 1,4 hours waiting for the border police. Given the fact that Orient East-Med RFC is implementing a minimum required time for technical checks of 2 hours those two are then excluded from the analysis. This means that by the time issues 8|9 are to be solved a time loss of 6,4 hours should be associated with them instead of the 8,4 hours. Was assumed that the time losses with issues 8|9 in all Romanian borders is equal to 6,4h (384 minutes).	100%
8|9	Romania and Hungary	384	The time lost in Romania is 384 minutes. Based on the survey results was assumed that issue 8 and 9 together imply in the Curticci border a technical check of 7 hours and additional 1,4 hours waiting for the border police.	100%

Issue No	Issue Description	Avoided time (in minutes)	Description of tasks	Trains affected by the issue (%)
			Given the fact that Orient East Med is implementing a minimum required time for technical checks of 2 hours those 2 are then excluded from the analysis.	
8|9	Italy	30	In Italy it can take between 30 and 60 minutes of additional waiting time at border. For the estimations of time savings in Italy it is assumed the most conservative approach.	100%
10	Operational implementation of the traffic in ERTMS	:	:	:
11	New train number	118	1. If the PaP is changed from "corridor" to "operational train" level, this means waiting time until the train receives a new train path for the national rail network. Moreover, the train will lose priorities assigned to corridor trains, which might lead to additional time loss in case of conflicts with other trains. 2. An additional technical examination of the train including brake test is required: Process: wagon inspector walks along the entire train (both sides), performs wagon check and checks correct tightening and release of each wagon brake. Assumptions: Time need (if process is performed by 1 wagon inspector): 0.9 min/axle + 10min (approaching/walking back + paperwork), based on Guideline DS 936 (Deutsche Bahn), verified and checked in numerous applications/studies. ▪ 600 m train length (see above)/20 m = 30 wagons per train * 4 axles/wagon = 120 axles/train ▪ Time need = 0.9 * 120 + 10 = 118 min (equivalent to 2 h)	80%
12	Exception from operational rules	:	:	:
14	Commutable power supply in border stations	:	:	30%
14	Commutable power supply in border stations <u>if the separation point is on open track</u>	240	This value is an assumption supported in the interviews conducted considering that the trains arrive with one single system locomotive. In this scenario a multi-system locomotive must wait for the 30 minutes for the train to arrive, then the single system locomotive attached to the train takes on average 30 minutes to be detached and leave. The multi-system locomotive will take another 30 minutes to be attached to the train and take it to the new single system locomotive. The time of operation of the multi-system locomotive taking the train from one point of the track to the other is not considered in the analysis. Then the multi-system locomotive takes 30 minutes to be detached and live and the new locomotive as to wait 30 minutes for the train to arrive and another 30 minutes to be attached to	30%

Issue No	Issue Description	Avoided time (in minutes)	Description of tasks	Trains affected by the issue (%)
			the train. This process results in 180 minutes loss in the shunting process. Additionally, 60 minutes should be considered as waiting times of the locomotives related with an average of 30 minutes for the brake test of the multi-system locomotive and the second single system locomotive.	
14	Commutable power supply in border stations if the separation point is in the station with tracks with switchable power supply	120	If a train arrives with one single system locomotive, the locomotive that will be changed takes 30 minutes to detached from the train and the new one will have to wait 30 minutes for the train to arrive to the station and another 30 minutes to be attached to the train resulting in 90 minutes for the shunting process. Additionally, 30 minutes should be considered for the brake test of the train before leaving the station.	30%
Romania	Specific case of Romania (issues 4|15, 5, 6, 7, 8|9, 11 and 13)	911	The sum of the impacts from each issues occurring in Romania resulting in 15,2 hours per train (909 minutes). From issues 4 and 15 is considered a time saving correspondent to the RFC 7 equal to 222 minutes, 45 minutes from issue 5, 75 minutes from issue 6, 45 minutes from issue 7, 384 minutes from issues 8 and 9, 120 minutes from issue 11 and zero from issue 13.	88%*

* This results from the sum of the percentages of affected trains multiplied by the relative weight of the time savings from each issue affecting Romanian borders. For example, for issue 6 is 75/911*100%.

6.3 List of geographic occurrences of issues 1 and 2

Table 43: List of geographic occurrences of issues 1 and 2

Point Name*	Country	Point Name*	Country
Hendaye - Bât Voyageurs	FR	Irun	ES
Joncherey -	FR	Portbou	ES
Perpignan ES	FR	Limite Adif - TP Ferro	ES
Břeclav os.n.	CZ	Bernhardsthal Fbf (in Bel)	AT
Marchegg	AT	Devínska Nová Ves	SK
Kittsee	AT	Bratislava-Petržalka	SK
Montzen-Frontiere	BE	Aachen-Gemmenich	DE
Kaldenkirchen	DE	Venlo	NL
Emmerich	DE	Zevenaar Oost	NL
Basel Bad Bf	CH	Gellert	DE
Domo II	IT	Brig Tunnel	CH
Domodossola	IT	Brig Tunnel	CH
Luino	IT	Pino-Tronzano	CH
Chiasso Est	CH	Bivio/PC Rosales	IT
Modane - Bât Voyageurs	FR	PC Terres Froides	IT
Villa Opicina	IT	Sežana	SI
Savski Marof gr.	SI	Dobova	HR
Koprivnica	HR	Gyékényes	HU
Hodoš	SI	Őriszentpéter	HU
Schöna	DE	Děčín hl.n.	CZ
Lanžhot	CZ	Kúty	SK
Rusovce	SK	Rajka	HU
Nickelsdorf	AT	Hegyeshalom	HU
AT	AT	Sopron	HU
Komárno	SK	Komárom	HU
Štúrovo	SK	Szob	HU
Biharkeresztes	HU	Episcopia Bihor	RO
Lőkösháza	HU	Curtici	RO
Giurgiu Nord	RO	Ruse Razpredel	BG
Bad Bentheim	DE	Oldenzaal	NL
Kiefersfelden	DE	Kufstein	AT
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.

6.4 List of geographic occurrences of issue 5

Table 44: List of geographic occurrences of issue 5

Point Name*	Country	Point Name*	Country
Giurgiu Nord	RO	Ruse Razpredel	BG
Biharkeresztes	HU	Episcopia Bihor	RO
Lőkösháza	HU	Curtici	RO
Fuentes de Onõro	ES	Vilar Formoso	PT
ES	ES	Elvas	PT

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.

6.5 List of geographic occurrences of issue 6

Table 45: List of geographic occurrences of issue 6

Point Name*	Country	Point Name*	Country
Biharkeresztes	HU	Episcopia Bihor	RO
Lőkösháza	HU	Curtici	RO
Giurgiu Nord	RO	Ruse Razpredel.	BG
Predeal	RO	Brasov	RO
Fetesti	RO	Cernavoda	RO
Drobeta- Turnu Severin	RO	Balota	RO
Vintu de Jos	RO	Coslariu	RO

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.

6.6 List of geographic occurrences of issue 7

Table 46: List of geographic occurrences of issue 7

Point Name*	Country	Point Name*	Country
Giurgiu Nord	RO	Ruse Razpredel	BG
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT
Thörl-Maglern	AT	Tarvisio Boscoverde	IT
Kaldenkirchen	DE	Venlo	NL
Emmerich	DE	Zevenaar Oost	NL
Kiefersfelden	DE	Kufstein	AT
Schöna	DE	Děčín hl.n.	CZ
Bad Bentheim	DE	Oldenzaal	NL
Biharkeresztes	HU	Episcopia Bihor	RO
Lőkösháza	HU	Curtici	RO

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points

6.7 List of geographic occurrences of issues 8 and 9

Table 47: List of geographic occurrences of issues 8 and 9

Point Name*	Country	Point Name*	Country
Lőkösháza	HU	Curtici	RO
Domo II	IT	Brig Tunnel	CH
Domodossola	IT	Brig Tunnel	CH
LUINO	IT	Pino-Tronzano	CH
Chiasso Est	CH	Bivio/PC Rosales	IT
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT
Villa Opicina	IT	Sežana	SI
Thörl-Maglern	AT	Tarvisio Boscoverde	IT
Modane - Bât Voyageurs	FR	PC Terres Froides	IT
Biharkeresztes	HU	Episcopia Bihor	RO
Giurgiu Nord	RO	Ruse Razpredel	BG

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.

6.8 List of geographic occurrences of issues 4 and 15

Table 48: List of geographic occurrences of issue 8 and 9

Point Name*	Country	Point Name*	Country
Montzen-Frontiere	BE	Aachen-Gemmenich	DE
Kaldenkirchen	DE	Venlo	NL
Emmerich	DE	Zevenaar Oost	NL
Basel Bad Bf	CH	Gellert	DE
Domo II	IT	Brig Tunnel	CH
Domodossola	IT	Brig Tunnel	CH
Luino	IT	Pino-Tronzano	CH
Chiasso Est	CH	Bivio/PC Rosales	IT
Chiasso Est	CH	Como S.Giovanni	IT
Essen-Grens	BE	Roosendaal	NL
Mouscron-Frontiere	BE	Tourcoing - Bât Voyageurs	FR
Blandain-Frontiere	BE	Baisieux	FR
Erquelinnes-Frontiere	BE	Jeumont - Bât Voyageurs	FR
BE	BE	Aubange-Frontiere-France	FR
Basel St. Johann	FR	St-Louis (Haut-Rhin) - Bât Voyageurs	CH
Zoufftgen Frontière	FR	Bettembourg-Marchandises	LU
Mont-St-Martin - Bif	FR	Aubange-Frontiere-France	FR
Kornsjø	NO	Kornsjö-gränsen	SE
Peberholm (BDK)	SE	Peberholm	DK
Padborg	DK	Flensburg Friedensweg	DE
Kiefersfelden	DE	Kufstein	AT
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT
Stiring-Wendel - Frontière Fr-Al	FR	Saarbrücken Hbf	DE
Hendaye - Bât Voyageurs	FR	Irun	ES
Fuentes de Onõro	ES	Vilar Formoso	PT
ES	ES	Elvas	PT
Lichkov	CZ	Międzylesie (Gr)	PL
Bohumín os.n.	CZ	Chałupki (Gr)	PL
Bohumín-Vrbice	CZ	Chałupki (Gr)	PL
Zebrzydowice (Gr)	CZ	Petrovice u Karviné	PL
Mosty u Jablunkova	CZ	Čadca št. hr.	SK
Břeclav os.n.	CZ	Bernhardsthal Fbf (in Bel)	AT
Marchegg	AT	Devínska Nová Ves	SK
Kittsee	AT	Bratislava-Petržalka	SK
Spielfeld-Straß	AT	Maribor	SI
Villa Opicina	IT	Sežana	SI
Thörl-Maglern	AT	Tarvisio Boscoverde	IT
Joncherey -	FR	Portbou	ES
Perpignan ES	FR	Limite Adif - TP Ferro	ES
Modane - Bât Voyageurs	FR	PC Terres Froides	IT
Savski Marof gr.	SI	Dobova	HR
Koprivnica	HR	Gyékényes	HU

Point Name*	Country	Point Name*	Country
Hodoš	SI	Őriszentpéter	HU
Schöna	DE	Děčín hl.n.	CZ
Lanžhot	CZ	Kúty	SK
Rusovce	SK	Rajka	HU
Nickelsdorf	AT	Hegyeshalom	HU
AT	AT	Sopron	HU
Komárno	SK	Komárom	HU
Štúrovo	SK	Szob	HU
Biharkeresztes	HU	Episcopia Bihor	RO
Lőkösháza	HU	Curtici	RO
Giurgiu Nord	RO	Ruse Razpredel	BG
Mockava	LT	Trakiszki (Gr)	PL
Kunowice (Gr)	PL	Frankfurt (Oder) Pbf	DE
Bielawa Dolna (Gr)	PL	Horka Gbf	DE
Horní Lideč	CZ	Lúky pod Makytou št. hr.	SK
Kunowice (Gr)	PL	Frankfurt (Oder) Pbf	DE

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points

6.9 List of geographic occurrences of issue 11

Table 49: List of geographic occurrences of issue 11

Point Name*	Country	Point Name*	Country
Lőkösháza	HU	Curtici	RO
Biharkeresztes	HU	Episcopia Bihor	RO
Giurgiu Nord	RO	Ruse Razpredel	BG
Koprivnica	HR	Gyékényes	HU
Hodoš	SI	Őriszentpéter	HU
Nickelsdorf	AT	Hegyeshalom	HU
AT	AT	Sopron	HU
Komárno	SK	Komárom	HU
Štúrovo	SK	Szob	HU
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT
Thörl-Maglern	AT	Tarvisio Boscoverde	IT
Domo II	IT	Brig Tunnel	CH
Domodossola	IT	Brig Tunnel	CH
Luino	IT	Pino-Tronzano	CH
Chiasso Est	CH	Bivio/PC Rosales	IT
Villa Opicina	IT	Sežana	SI
Modane - Bât Voyageurs	FR	PC Terres Froides	IT
Fuentes de Onõro	ES	Vilar Formoso	PT
ES	ES	Elvas	PT
Hendaye - Bât Voyageurs	FR	Irun	ES
Joncherey -	FR	Portbou	ES
Perpignan ES	FR	Limite Adif - TP Ferro	ES

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.

6.10 List of geographic occurrences of issue 14

Table 50: List of geographic occurrences of issue 14

Point Name*	Country	Point Name*	Country
Emmerich	DE	Zevenaar Oost	NL
Chiasso Est	CH	Como S.Giovanni	IT
Essen-Grens	BE	Roosendaal	NL
Erquelinnes-Frontiere	BE	Jeumont - Bât Voyageurs	FR
Stiring-Wendel - Frontière Fr-Al	FR	Saarbrücken Hbf	DE
Hendaye - Bât Voyageurs	FR	Irun	ES
Fuentes de Onõro	ES	Vilar Formoso	PT
Břeclav os.n.	CZ	Bernhardsthal Fbf (in Bel)	AT
Spielfeld-Straß	AT	Maribor	SI
Schöna	DE	Děčín hl.n.	CZ
Chiasso Est	CH	BIVIO/PC ROSALES	IT
Y. Autelbas	BE	Autelbas/Kleinbettingen	LU
Pougny	FR	Bellegarde	CH
Ram. Golenți	RO	Vidin/Golenți	BG
Kulata	BG	Promachon	GR
Svilengrad	BG	Kapikule	TR
Lugaži	EE	Valga	LV
Strasbourg	FR	Kehl	DE
Čaňa	SK	Hidasnémeti	HU
Giurgiu Nord	RO	Ruse Razpredel	BG
Kunowice (Gr)	PL	Frankfurt (Oder) Pbf	DE
Bielawa Dolna (Gr)	PL	Horka Gbf	DE
Bad Bentheim	DE	Oldenzaal	NL
Rusovce	SK	Rajka	HU
Montzen-Frontiere	BE	Aachen-Gemmenich	DE
Kittsee	AT	Bratislava-Petržalka	SK
Nickelsdorf	AT	Hegyeshalom	HU
Savski Marof gr.	HR	Dobova	SI
Dimitrovgrad	RS	Kalotina Zapad	BG
Rosenbach	AT	Jesenice	SI
Hodoš	SI	Őriszentpéter	HU
Modane - Bât Voyageurs	FR	Bardonecchia - Bardonecchia	IT
Perpignan	FR	Limite Adif - TP Ferro	ES
Portbou	ES	Cérbere	FR
Thörl-Maglern	AT	Tarvisio Boscoverde	IT
CZ | Lichkov	CZ	Międzylesie	GR
Brennero	IT	Staatsgrenze nächst Steinach in Tirol	AT
Padborg	DK	Flensburg Friedensweg	DE

Point Name*	Country	Point Name*	Country
Peberholm (BDK)	DK	Peberholm	SE
Basel St. Johann	CH	St-Louis (Haut-Rhin) - Bât Voyageurs	FR
Aubange	BE	Rodange	LU
BE	BE	Aubange-Frontiere-France	FR
Blandain-Frontiere	BE	Baisieux	FR
Mouscron-Frontiere	BE	Tourcoing - Bât Voyageurs	FR
LUINO	IT	Pino-Tronzano	CH
Domodossola	IT	Brig Tunnel	CH
Venlo	NL	Kaldenkirchen	DE

Source: Stakeholder's survey and interviews

* The point name is considered equal to the country when there is no possible correspondence between the CIP RNE and the RNE database points.