Costs of Non-Interoperability

Agency Briefing Note – March 2023

EUROPEAN UNION AGENCY FOR RAILWAYS

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Contents

1. Summary

According to the Interoperability Directive (Directive (EU) 2016/797), 'interoperability' means the ability of a rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance. The Interoperability Directive provides the context for identifying potential costs of non-interoperability by setting the following objectives behind promoting interoperability for the EU rail system (Article 1.1):

- *to make it possible to facilitate, improve and develop rail transport services within the Union and with third countries*
- *to contribute to the completion of the single European railway area and the progressive achievement of the internal market.*

Although interoperability of the Union railway system is improving, the progress has been slow so far and it appears to be unequal/uneven when looking at different areas. Despite some positive developments, rail in Europe is not yet achieving its full potential[1]. The cost of non-interoperability is to be considered from multiple perspectives: the cost of inefficiency generated by non-seamless rail transport across borders, the opportunity cost affecting competitiveness of rail and the investment cost needed to overcome technical and technological barriers present within the EU.

In this note the costs of non-interoperability of the EU rail system are examined drawing on a variety of recent sources. Quantitative figures of these costs are highlighted where available. Therefore, it offers a tentative and partial overview not covering all subsystems due to inherent challenges for any quantification in this field. The present note complements an earlier note (from February 2022) on the benefits of TSI implementation (included as Annex 1 to this note). A summary of the various contributions to the cost (including opportunity cost) of non-interoperability (or absence of optimal technical harmonisation) is provided below in Table 1:

Complementing the summary given in Table 1, concrete examples of the substantial cost of non-interoperability are offered in the Agency's 2022 study on cross-border rail transport potential (ERA, 2022)[2]. In particular, the two freight case studies provide a quantitative assessment of the significant impacts of technical and operational barriers on travel time, which in turn adversely affect rail volumes and the modal split. For one of the considered cross-border sections (Brennero (IT) – Staatsgrenze (AT)) the time losses are estimated to be at least **50 minutes per train that crosses the border**, while for the second case (Giurgiu Nord (RO)-Ruse Razpredel (BG)) the time losses amount to at least **6 hours per train that crosses the border**. These illustrative examples highlight the direct costs incurred by the stakeholders (notably RUs) due to non-interoperability. Additional indirect costs for these two cases would be the reduced competitiveness of the rail-based connections resulting in lost traffic and missed opportunity for modal shift and reduction in external costs not realised.

Another set of illustrative examples of the cost of non-interoperability are given by Kemmeter (2020) in relation to rolling stock procurement and availability for cross-border services. The author found that interoperable trainsets are more costly than non-interoperable trainsets. For example, for a 5-car Stadler Flirt3 EMU the extra costs are € 1 million for dual-voltage and €2 million for triple-voltage. Another example concerns the cost of retrofitting a 3-car German DMU with the Polish automatic safety system SHP. The costs have been estimated at €275 000 – €450 000 per train set for prototypes and €75 000 – €90 000 for

[1] https://www.era.europa.eu/content/report-railway-safety-and-interoperability-eu-2022_en
[2] https://www.era.europa.eu/content/report-cross-border-rail-transport-potential

serial installation. These figures provide concrete indications of the cost of non-interoperability for single trainsets as it could be expected that with optimal technical harmonisation the add-on costs for interoperable rolling stock should disappear. Considering a reasonable replacement rate of 2% per annum of the European EMUs the cost of non-interoperability for this particular aspect alone could well amount to at least **1 bln EUR per annum**[3].

[3] This is assuming an add-on cost of 1 mln EUR per trainset and approx. 1000 EMUs to be replaced per annum.

Table 1. Costs of non-interoperability

Selected cost elements	Comments	Annual estimate (mln EUR)	Present Value (PV) estimate (bln EUR)
1. Higher investment costs for both RUs and IMs			
Higher design costs for rolling stock	The cost figure is from the Cost of non-Europe report on road transport and railways. The PV figure could be higher (up to 9 bln EUR depending on the scope for design cost savings)	+500	+6.5
Higher onboard signalling costs for cross border installations and authorisations	The cost figure is based on the Cost of non-Europe report on road transport and railways. The figure could be higher (up to 1.3 bln EUR depending on the scope for design cost savings)	+50	+0.7
Smaller economies of scale	Due to market fragmentation, access to some markets is economically unattractive. Moreover, more difficult to export non-standardised products outside EU market.	n.a.	n.a.
Cost of multisystem traction/multiple signalling systems	Kemmeter (2020) highlighted cost impacts of purchasing dual and triple-voltage systems. No calculation of impact on European level available.	n.a.	n.a.
2. Higher maintenance cost for both RUs and IMs			
Additional maintenance costs for Class B signalling systems	The estimate is included in the ERTMS 2022 Work Plan. The costs incurred are linked to legacy system maintenance costs incurred by IMs without full on-board deployment of ERTMS	+900	+12
Exposure to obsolescence		n.a	n.a.
Supplier lock-in, meaning supplier can dictate the price	/	n.a.	n.a.
Flat learning curve because of smaller series leading to quality problems	/	n.a.	n.a.

Table 1 (continued)

3. Time losses and higher operational costs for cross-border services			
Waiting times at borders need additional resources	The estimate is put forward in the ILB final economic report. The costs considered covers 2 main elements: additional time and operating costs at cross-border sections for freight train operations	+500	+6.8

Train manipulation at borders needs additional resources	See previous point	n.a.	n.a.
Complicated multisystem vehicles need more training of operational staff	See previous point	n.a.	n.a.
4. Opportunity cost due to loss of business			
Rail too expensive because of 1) to 3) above	Indicative figures for possible lost revenue and higher external costs are given below (using a simple elasticity approach)	n.a.	n.a.
Rail transport times too long in comparison to road	Due to operational inefficiencies following from non-interoperability, the time needed for rail transport is longer, hampering the attractiveness of rail for the transport of time sensitive goods. This limits the modal shift potential of rail.	n.a.	n.a.
5. Far lower residual value for rolling stock			
Lower reselling value, if any, due to lack of interoperability	Reduced scope for alternative use of assets along with the resulting higher cost of financing	n.a.	n.a.
6. Less incentive for innovation			
Fewer patents due to fragmented and small markets, limited research budgets	A study by the Agency on patenting trends showed that since the introduction of the TSIs, European companies have filled more patents. Sector input confirmed that standardisation and higher levels of interoperability are conducive to greater investments in research and innovation.	n.a.	n.a.
Lack of competition reduces the incentive to innovate	/	n.a.	n.a.
Total	**Summation of the individual estimates. It is likely to be a rather conservative estimate.**	**+1950**	**+26**

Source: See details in table re. references

Note 1: Present Values (PVs) are calculated with 4% discount factor and 20-year time period

Note 2: The total estimate of cost of non-interoperability in the table is likely to be a significant underestimation even of the direct costs, e.g. costs associated with time losses / operating costs for passenger traffic, NRs for vehicles and infrastructure are not included nor are the costs for non-harmonisation re. NOI TSI

2. Quantifying key costs of non-interoperability

In the overview section quantitative estimates of cost of non-interoperability are set out drawing on available studies and concrete cases. It should be noted that it has only been possible to provide quantitative cost estimates for a selection of the identified impacts of non-interoperability. In particular, the focus has been on the direct cost of non-interoperability rather than indirect / dynamic costs (e.g. linked to prevented modal shift and more limited progress on reducing external costs). As always, any quantification in this area is challenging and the provided estimates should be considered as indicative / order of magnitude and be used with due care.

The order of magnitude of the overall direct cost of non-interoperability of +26 bln EUR (as PV) correspond well to the estimates included in European Parliament (2014) Cost of Non-Europe's reporting as well as an earlier 4th RTD project MINIMISE (Managing Interoperability by Improvements in Transport System Organisation in Europe) concluded in 1999[4]. MINIMISE covered all main modes of transport, including rail, estimating annual net-benefits for rail freight of 1.4 bln EUR and 1.3 bln EUR for passenger rail by addressing interoperability barriers. These annual figures would imply an NPV for a 20-year time horizon and 4% discount rate of **37 bln EUR**.

Complementing the above estimates for direct cost of non-interoperability a tentative conservative estimate for the opportunity costs would be linked to missed railway traffic (both passenger and freight). Additional annual direct costs for the railway system of 2bln EUR represent roughly 2% of total annual costs for RUs and IMs. If these costs are passed on to the customers an order of magnitude for missed revenue would amount to annually some 650 mln EUR[5] (or a PV of **9 bln EUR**).

Equally, an estimate of the incurred cost of non-interoperability linked to higher external costs[6] could be developed assuming that the suppressed rail demand instead would have used alternative modes. Our preliminary estimation of these costs is based on the alternative mode for both passenger and freight transport would be road based (car and HGV). Additional annual external costs would amount to roughly 600 mln EUR (or a PV of **8bln EUR**)[7]

[4] Managing Interoperability by Improvements in Tranport System Organisation in Europe | MINIMISE Project | Results | FP4 | CORDIS | European Commission (europa.eu)

[5] Main source for these estimates is the New Mobility Patterns in European cities Part C report: 2022 New Mobility Patterns in European Cities Task C Final Report.pdf (europa.eu)

[6] According to the CE Delft (2019) analysis the considered external cost elements include: Accidents, air pollution, climate, noise, congestion, well-to-tank, habitat damage.

[7] CE Delft 2019 study on external costs is the main source for the estimated costs.

3. Perspectives on investment costs requirements

It is expected that the estimated cost of non-interoperability in the form of inefficiencies and opportunity costs would if addressed, provide net-gains over time. Critical issues would then be linked to a) time required for capturing these gains and b) the investment costs required to realise the gains. It should be noted that the required investment costs would vary by category of non-interoperable feature of the rail system with some of these not being capital intensive at all and others relative capital intensive. For context of future investment costs addressing non-interoperability, current annual investment in infrastructure (nearly 40 bln EUR)[8], rolling stock (some 30 bln EUR per annum)[9] and signalling / electrification systems (approx. 1 bln EUR) are recalled. These levels should be contrasted to the overall total railway asset value (indicated in the Cost of non-Europe report from 2014 as an order of magnitude of 3000 bln EUR). EU funding plays already an important role re. railway investment using channels such as CEF, ESIFs, EFSI and Horizon 2020. In particular, it should be noted with reference to CEF funding that for every 1 million euros spent at European level will generate 5 million from Member State governments and 20 million from the private sector[10].

A preliminary perspective on the required **future** investment costs over the coming years is outlined below. Considering the elements of the costs of non-interoperability in Table 1 the following remarks are pertinent regarding expected investment requirements:

- *Issues Logbook related barriers: Overall the investment costs are likely to be limited as the different aspects are mainly linked to operational and administrative provisions. In the Agency's Fast Track B/C analysis some one-off costs were identified under the OPE TSI revision linked to a) Migration cost towards EU harmonised rulebook; b) Migration cost towards EU harmonised language (in total order of magnitude 850 mln EUR one-off)*
- *Maintenance costs for Class B signalling systems: Significant investment costs are likely required to avoid these annual maintenance costs. As indicated in the ERTMS 2022 Work Plan this would involve one-off investment of some 5 bln EUR (fitment and retrofitting related costs) allowing then savings on ageing class-b systems that can be dismantled*
- *Rolling stock design costs: The Cost of Non-Europe report suggests that a reduction in RST design costs between 5-10% could be achieved with a 20-30% replacement over the 20-year time horizon. On the basis of available evidence, it is likely that 30 bln EUR rolling stock per annum (2017 level)[11] would be sufficient to ensure this level of replacement. EU funding may be relevant in order to support faster introduction of new rolling stock that may also facilitate onboard deployment (see previous point).*
- *Onboard signalling costs for cross border installations and authorisation are likely to be addressed as part of future replacement of rolling stock but EU funding could support faster take-up.*
- *Other rolling stock investment priorities would be linked to rail freight with particular attention on Digital Automatic coupling (DAC)*

Overall, the points above would suggest that EU funding priorities could optimally over the coming period concentrate on:

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[8] Rail Market Monitoring (RMMS) (europa.eu)

[9] Study on the competitiveness of the rail supply industry - Publications Office of the EU (europa.eu)

[10] Trans-European Transport Network TENTEC - Funding - European Commission (europa.eu)

[11] Study on the competitiveness of the rail supply industry - Publications Office of the EU (europa.eu)

- *Realisation of short-term gains through addressing comprehensively the technical and operational barriers for cross-border traffic for both rail freight and passenger (see Issues Logbook and follow-up work)*
- *ERTMS trackside and onboard deployment*
- *Accelerated replacement of rolling stock*

4. Conclusions and further perspectives

On the basis of the available evidence, it is highly likely that the costs of non-interoperability for the EU railway system remains significant. Therefore, ongoing actions need to be continued and reinforced. Overall, the direct costs of non-interoperability are estimated to amount to at least 2 bln EUR per annum (or more than 26 bln EUR in PV over a 20-year period). This is, in all likelihood, a very conservative estimate considering that a number of elements have not been possible to quantify. However, the estimate is aligned with earlier indications about the potential gains to be achieved through further progress for interoperability. As such any quantification in this area is complex and challenging and the given estimates should be considered as order of magnitude figures. Further in-depth analysis could permit further precision as well as allowing for quantification of additional elements.

It should be noted that the potential gains achievable through reduced non-interoperability should be contrasted with any costs of interoperability, particularly investment costs required to address the lack of technical harmonisation. However, for some interoperability barriers the costs are mostly administrative and therefore negligible. As a whole, the efficiency gains as well as the reduced opportunity costs are expected to outweigh significantly any costs incurred from addressing the technical barriers. Key issues would relate to optimising the migration path towards a more harmonised railway system.

From a generic perspective (see Annex 2), relevant indications are provided re. the costs incurred from a lack of optimal technical harmonisation drawing on evidence re. economics of standardisation, trade facilitation and mutual recognition.

From a railway specific perspective (see Annex 3), available studies have highlighted the possible areas of gains by addressing non-interoperability. This part of the Briefing Note focused on information from the cost of non-Europe reports as well as Commission and Agency studies.

This topic would definitely deserve more in-depth analysis covering several aspects:

- *The lack of ex-post work concerning assessing the actual gains from technical harmonisation would be valuable to facilitate more precision in the estimation of cost of non-interoperability*

- *A particular area where more insight would be relevant concerns the potential gains from standardisation throughout the life-cycle of railway assets.*

- *Moreover, in-depth analysis would be required concerning the possible migration costs associated with reaching optimal technical harmonisation*

- *It would also be important to promote systematic efficiency analysis within the railway sector and its stakeholders to understand fully what the best-practice is as well as estimating with more precision the scope for efficiency increases (this concerns in particular RUs, IMs, railway manufacturers and the system as a whole)*

- *An additional dimension regarding costs of non-interoperability concerns the area of digital transformation in Europe where further insights are highly pertinent to the railway sector.*
- *As part of the promotion of a more holistic approach to economic analyses linked to interoperability measures it would be relevant to provide regularly an overarching perspective on the advantages / disadvantages associated with the all measures adopted together based on the information from each individual measure*

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Annexes

Annex 1. Overview of quantifiable benefits of TSIs (Note prepared Q1 2022)

1. Introduction

The following note outlines available information concerning quantifiable benefits linked to the TSIs. This note is intended as supporting evidence for MOVE's work on strengthening the implementation of the set of TSIs. The document draws on analyses carried out since 2006, with particular focus on the economic analyses undertaken by the Agency; while other studies are also included.

It should be noted that there are several different perspectives for identifying benefits from TSIs. Firstly, there would be a distinction between forward looking analyses (IA), and retrospective studies (ex-post). Secondly, the benefits could be determined in terms of either the revision of an existing TSI (what are the additional benefits) and the benefits for the TSI as such (benefits from having the TSI compared to having no TSI). Thirdly, analyses could also be done for the complete set of TSIs, i.e. considering all complementary benefits between the TSIs as a package.

The following sources are covered in the note:

- *Section 2: Fast-Track B(enefit)-C(ost) analysis*
- *Section 3: Information from Agency IAs: recent examples*
- *Section 4: Synthesis of Agency IAs: 2014 analysis*
- *Section 5: 2010-2012 Extension of Scope – High level analysis*
- *Section 6: 4th Railway Package Technical Pillar Impact Assessment*

Section 7 provides some concluding remarks and further perspectives.

2. Fast-Track B(enefit)-C(ost) analysis

Description

The Fast-Track B/C analysis covered all main Agency workstreams in terms of estimating key benefits and costs. In particular, it estimated for SPD outputs and/or clustered – e.g. 4th Railway Package, Closure of TSI open points, Cleaning NTRs, OPE, Registers, Noise, PRM etc. It provided estimates for:

- *initial and recurring costs for rail – assumptions on drivers, quantity, unit values*
- *benefits for rail and society – assumptions on drivers, quantity, unit values*

This analysis was initially undertaken in 2017-18 and shared with the Agency's Management Board as well as the Economic Steering Group (ESG). A minor update was done in 2020. It should be noted that the Fast-Track B/C analysis takes a relative high-level perspective with benefits / costs indications reflecting orders of magnitude. All values were expressed in Net Present Value (NPV) terms over a 20-year time-horizon.

Main findings linked to TSIs:

- *Significant net-benefits expected for the revision of the vehicle and infrastructure TSIs (e.g. closure of Open Points)*
- *Also benefits expected from the cleaning-up of national rules and revising and facilitate the implementation of the OPE TSI (as confirmed also by the Issues Log Book with specific reference to cross-border rail freight)*
- *Substantial benefits for society are identified for the NOI TSI as well as the ERMTS game changers*

3. Information from Agency IAs: recent examples

Description

Each Agency Impact Assessment linked to revisions of TSIs provides consideration to the possible benefits and costs associated with the revision (noting that due to lack of data quantification is not always feasible). A couple of recent examples where benefits where quantified are included below:

- *NOI TSI revision from 2018, see this link to the IA: https://www.era.europa.eu/system/files/2022-10/Recommendation%20on%20the%20amendment%20of%20TSI%20NOISE%20-%20Full%20impact%20assessment_0.pdf*
- *OPE TSI revision from 2018, see this link to the IA: https://www.era.europa.eu/system/files/2022-10/Recommendation%20on%20the%20amendment%20of%20Commission%20Regulation%20%28EU%29%202015_995%20-%20Impact%20assessment.docx*

Main findings linked to TSIs

In the case of the NOI TSI revision the quantified net-benefits (NPV and B/C ratios for the different options) are summarised in the table below for a 20-year period. 4% discount factor

Option	*0*	*$I_{a,b}$*	*$II_{a,b}$*	*$III_{a,b}$*	*$IV_{a,b}$*
NPV (mln EUR)	38,985	79,469 71,375	64,995 57,300	62,025 57,151	68,185 68,821
B/C ratio	10.33	12.56 13.35	12.71 13.86	13.64 14.40	14.02 14.81

In the case of the OPE TSI revision the quantified net-benefits (NPV and B/C ratios for the different options) are summarised in the table below for a 20-year period. 4% discount factor

	Option 0 (baseline)	*Option 1*	*Option 2 & 3*
NPV (mln EUR)	/	280	340
B/C ratio	/	15	18

It is under consideration to provide as part of the Agency's Impact Assessment service a table / file which will summarise the main issues across the recommendations, incl. indications of benefits and costs. This will further facilitate cross-cutting analyses.

4. *Synthesis of Agency IAs: 2014 analysis*

Description

An overview analysis was provided in the Spring 2014 of the main IAs undertaken since 2006 covering also TSI related IAs. The analysis listed whether the IAs included qualitative assessment, quantitative assessment as well as indicating the conclusion of each IA. Additional comments per IA were also provided.

Main findings

A couple of highlights from this analysis are included below for IAs linked to TSIs:

- *Revision of WAG TSI (from 2011): Benefits in the range from 75 mln EUR (cost impacts) to 128 mln EUR were expected, depending upon assumptions relating to the evolution of the wagon fleet, wagon costs and assumed discount rate.*
- *Revision of SRT TSI (from 2013): Reduced administrative burden linked to conformity assessment and authorisation for placing in service sub-systems, 4 - 10 mln EUR per annum. Benefits from Extension of scope and economies of scale, 17 - 23 mln EUR per annum.*

5. *2010-2012 Extension of Scope – High level analysis*

Description

The study was undertaken at the time when the possible extension of the scope of all TSIs was under discussion but without knowing completely what would be put into the revised TSIs – neither in Chapters 2 (geographic or technical scope), not in Chapters 4 (basic parameters: possible new values or categorisation), nor in Chapters 7 (added, removed, or changed specific cases). The analysis focused on estimating annual costs of authorisation for locomotives. In particular, the following drivers for reducing costs were considered (obviously predating the 4th Railway Package framework):

- *Common application of 2011/217/EC on the authorisation for the placing in service of structural subsystems and vehicles under Directive 2008/57/EC effective, by 2013*
- *Cross Acceptance fully applied, by 2018*
- *No more open points in TSIs, by 2020*
- *TSI scope extension to the full network, by 2020*
- *All networks conform to TSIs (Full technical harmonisation), by 2050*

Main findings

The analysis provided an insight into the substantial potential benefits of the full implementation of the TSI framework (with a perspective from 2010-12). In particular, it is noted that scope extension of the application of the TSIs to the entire EU rail network could result in approx. 40 mln EUR per annum cost savings for locomotive authorisation. Considering also closing open points and progress with harmonisation of the process for authorisation it was estimated that per annum costs for authorisations of locomotives could be more than halved compared to the 2011 baseline (above 300 mln EUR per annum).

6. *4th Railway Package Technical Pillar Impact Assessment*

Description

The MOVE impact assessment work accompanying the 4th Railway Package (Technical Pillar) that was building on an SDG study is also of relevance. Several options were put forward which all provide quantitative estimates of benefits. For the present exercise on quantifying the benefits of TSI the so-called base scenario provides pertinent information. Several improvements for the railway sector in the base scenario were indeed identified, (see page 19 of the IA document), e.g.:

- *an improved understanding of Railway Directives and Regulations through the publication of Commission recommendations and guidelines, e.g. the Commission Recommendation 2011/217/EU on the authorisation for the placing in service of structural subsystems and vehicles as well as follow-up*
- *Improved coherence of the EU rail market as a result of continuing implementation of the Railway Directives*
- *On-going process of reducing existing national rules should provide limited progress, especially in relation to vehicle* authorisation rules.

Main impacts resulting from TSIs and cleaning up national rules were analysed and reflected in Option 2 (of the SDG study).

TABLE 0.2 DISCOUNTED TOTAL QUANTIFIED BENEFITS 2015-2025 (€M NPV)

Option	Impact assessment calculator			Admin costs calculator	ERA/NSA authorisation fee revenue loss*	Total net benefit	Additional funds necessary from EU budget to cover ERA costs (€ mil.)
	Authorisation	Safety certification	Opportunity costs	Cost savings (increase)			
Option 2: Further ERA "Coordination"	201	2	237	9	(28)	**420**	28
Option 3: ERA as One-Stop-Shop	217	2	255	25	(28)	**471**	29
Option 4: ERA & NSAs share competencies	235	2	265	33	(28)	**508**	a: 0 b: 0 c: 18
Option 5: ERA takes over activities of NSAs regarding authorisation & certification	276	3	295	(69)	(28)	**477**	155
Option 6: Horizontal measures	156	1	174	11	N/A	**331**	N/A

Note: Options 2 to 5 represent the results for the combined options with Option 6 incorporated within each of these options. We have also included (shaded in grey) the impact of Option 6 on its own. The individual values for Options 2 to 5 cannot be obtained simply by subtracting the value for Option 6 due to the overlap of a number of single measures that make up the various Options.

These benefits were estimated with EUR mil. 420 over a 10-years period.

Additional benefits resulting from the new role of the Agency (authorisation entity, safety certification entity) were considered in the other options.

Main findings

It was estimated in the IA report that all the improvements in the base scenario would close the gap between average *authorisation* costs and presumed minimum achievable authorisation costs by over 30%.

7. Synthesis and further perspectives

The present note has provided a summary of relevant information on the quantification of TSI benefits. These are focussed on a forward-looking perspective from impact assessments.

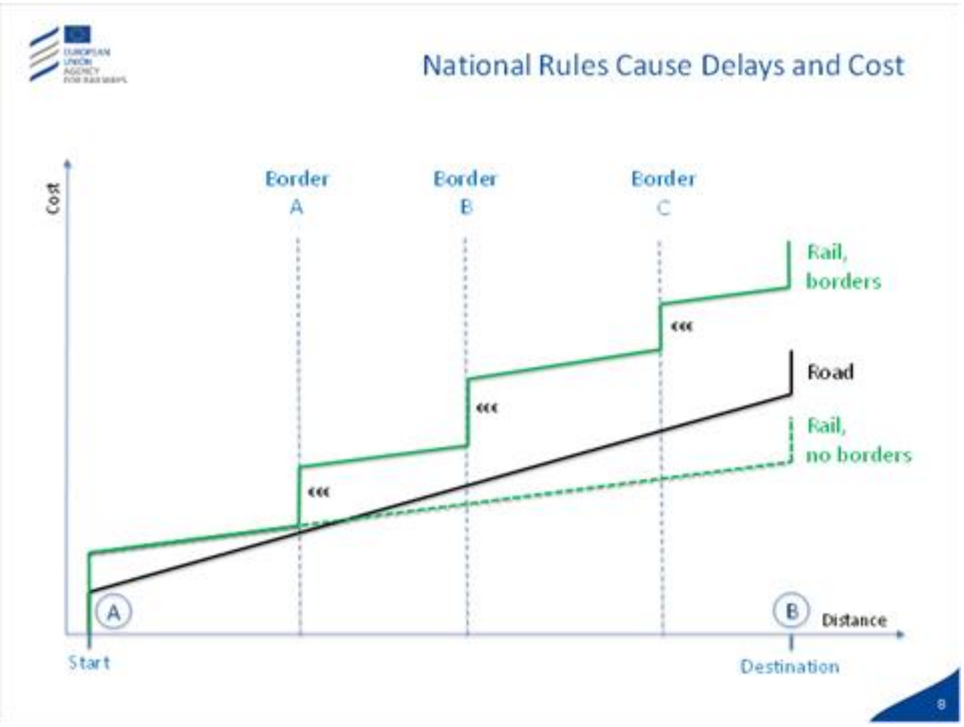
Complementary indications could also be provided through ex-post evaluations (as provided for in the Agency Regulation, Article 8(3)). This is an area that is highly important and could be developed further to facilitate improvements and draw lessons for the future. The recent ex-post on the CSM on CSTs is a case in point, see this link: [report_ex-post_csm_cst_final_public_en.pdf (europa.eu)](report_ex-post_csm_cst_final_public_en.pdf).

Another example linked to TSIs is ex-post work done for the SRT TSI in 2012-13 in preparation of the revision of the legal text. While not providing quantitative figures, it did contain qualitative aspects showing how stakeholders considered the application of this TSI, noting the advantages and disadvantages.

Apart from enhanced emphasis on ex-post, it is also foreseen in the coming period to undertake an update of the Fast-Track B/C (described above) in order to include indications of benefits and costs linked to new / adjusted Agency workstreams.

Moreover, there are important other aspects that should be examined to optimise and strengthen the role of rail transport:

a) *long-distance freight across one or more borders, as shown in the below graph (e.g. by looking at specific corridors). Such analysis could also be of relevance for passenger transport.*



b) *the fitting of vehicles with multiple Class B CCS systems is costly and significantly increases the technical and operational complexity of railways.*

c) *"go-everywhere passenger vehicles" (for which we have already the initial examples in the Agency's authorisation portfolio) – there it could be expected to see benefits in terms of lower price of rolling stock, shorter delivery times, and higher resale value.*

In particular, Item c) will be extremely important for strengthening the cross-border passenger transport in Europe, and for lowering the barriers to entry for new entrants into a liberalised passenger rail market.

Annex 2. Generic complementary evidence

The theoretical evidence regarding the potential advantages that can be gained from technical harmonization and improved interoperability in the European railway sector draws from a variety of strands. From a general perspective, the literature within the field of the economics of standardization is clearly relevant (see, e.g., Swann, 2010, DTI, 2005 or DIN, 2011). Similarly, there are elements of theoretical evidence linked to research on the impacts of technical barriers to trade (see, e.g., Maskus and Wilson, 2001). Another related strand is the theoretical underpinnings for mutual recognition (see, e.g., Productivity Commission, 2009).

Below, a few selected examples for economywide impacts associated with these strands (standardisation, trade facilitation and mutual recognition) are outlined:

- *Standardisation:*
  - *DIN (German Institute for Standardisation) estimated in 2011 the economic benefits of standards in Germany as a follow-up to an earlier (2000) study using an econometric approach. Overall, the estimates indicated more than 16 bln EUR of benefits per annum corresponding to approximately 0.72% of GDP in Germany.*
  - *DTI (2005) examined the role of standards for the UK economy. The analysis highlighted the importance of standards for productivity and economic growth estimating that standards were contributing to about 13% of the growth in labour productivity in the UK over the period 1948-2002*

- *Removing technical barriers to trade and trade facilitation:*
  - *OECD (2013) highlighted that eliminating half of the non-tariff barriers to trade caused by regulatory divergences could increase EU GDP by 0.7 per cent*
  - *Maskus and Wilson (2001) outlined some empirical methods and challenges in quantifying the gains of trade facilitation in the area of harmonized regulations*
  - *Orliac (2012) refers to OECD work from the early 00' involving a series of comprehensive surveys of different costs and benefits estimates about trade facilitation. This work indicated that the total gains from trade facilitation improvements (measured as a 1% reduction of transaction costs) to the world economy of about US$40 billion,*

- *Mutual recognition:*
  - *The Australian Productivity Commission reviewed in 2015 the mutual recognition schemes in place for removing obstacles to trade and labour mobility within Australia and across the Tasman (Productivity Commission, 2015). The final report mentions that quantification of benefits is particularly difficult for goods with the lack of data / several contributing factors being key elements. However, based on the available evidence it is concluded that these schemes 'are generally working well for goods and occupations covered by the schemes'*
  - *OECD (2010) examined the impacts associated with its Environment, Health and Safety Programme covering a range of initiatives to reduce the costs involved in interjurisdictional testing and evaluation of industrial chemicals, pesticides, and biotechnology and nanotechnology products. In this study it was estimated that the net savings from this programme amounted to 153 mln EUR annually.*

From the perspective of railway technical harmonization, insight into the implications is provided by several studies (e.g. BTRE, 2006, NERA, 2000 and Symonds Travers Morgan, 1998).

BTRE (2006) contains a comprehensive analysis of harmonization in the railway sector, covering both theoretical and empirical aspects with particular focus on Australia. The focus of the study is on the conditions for optimal technical and regulatory harmonization in the Australian railway sector. Particular attention is given to the point that optimal harmonization does not require complete standardization. Therefore, there is a need to balance the benefits of harmonization with those of customization. Among the benefits of harmonization, the following are mentioned: lower input costs; improvements in operational efficiency; higher inherent safety; lower training costs and access to a wider market.

National Economic Research Associates (2000) emphasized the cost of diversity regarding railways in Europe due to differences between national railway safety regulation regimes, which result in obstacles to the development of the European railway. The study involved an assessment of the extent to which railway safety regulations in the EU (Member States) have an impact on railway competitiveness. Cost of diversity was linked to: (1) loss of economies of scale in production; (2) redundancy of approval processes; and (3) scope for exploiting diversity as a weapon for protectionism. In addition, there is a risk that diversity may translate into reduced safety. The study was undertaken for the Commission, feeding into the work on the Second Railway Package.

An earlier study by Symonds Travers Morgan (1998) examined the key directions for moving towards an integrated railway system in Europe. In particular, a three-step approach was recommended. Firstly, the focus should be on removing operational barriers (for example, coordinating timetables and harmonizing cross-border procedures), as this is likely to be characterized by low costs and immediate benefits (quick wins). Subsequently, the emphasis should shift towards creating a fleet of multisystem rolling stock (for example, in order to enable the use of rolling stock on different networks) – this strategic element was perceived to involve, in principle, high costs along with quick benefits. Thirdly, the attention should shift towards harmonizing railways technically; in principle, this was foreseen to generate very high costs and late benefits. It should be mentioned that, in general, harmonizing the railways in accordance with the TSI framework is likely not to generate significant costs, given that the TSIs only apply to new vehicles (subsystems), as well as (conditionally) to renewed and upgraded subsystems. In broad terms, the three-step approach to harmonization outlined above reflects the actual path followed.

Annex 3. Specific complementary evidence

A useful starting point would be to highlight the significant technical differences that existed in the 1990s between the EU countries, making any progress towards improved international rail transport difficult, and, importantly, preventing rail from competing effectively with other modes (notably road). In particular, the rail system was characterized by:

- *Five types of electrification system;*
- *19 signalling systems;*
- *Five track gauges;*
- *Five classes of axles load;*
- *Six clearance gauges;*
- *National operational rules.*

Indeed, in recent decades ('70s, '80s and '90s), rail was losing market share to road (both in passenger and freight), with technical impediments for seamless transport being one of the explanatory factors. Technical differences remain today, though the focus for technical harmonization with TSIs implies that not all aspects of the EU rail system have to be harmonized, but rather only those that are linked to interoperability.

Evidence on the cost of non-interoperability is presented below drawing on a range of sources. It is noted that there is a lack of ex-post studies on the realised benefits from technical harmonisation as the process is still ongoing.

A key source of relevance for this analysis is the Cost of Non-Europe report re. road transport and railways from the European Parliament from 2014 prepared by the Directorate-General for Parliamentary Research Service.

On technical harmonisation the report stresses that '*…the heart of the problem for the railways lies in the lack of interoperability between the various national railway systems*' (p. 64). Estimates of the (short-term) benefits by harmonising technical aspects are provided:

- *Rolling stock:*
    - *Potential cost savings linked to standardisation are considered to reach about 10% due to reduced design costs resulting in overall net-benefits in the range from 4-9 bln EUR (this would cover a 20-year period from 2015-2035). The authors take the view that additional benefits could be generated outside the 20-year period*
    - *Additional benefits are linked to cost savings for onboard signalling systems with respect to cross-border installation and authorisation. These benefits are estimated to be in the order of 200 mln EUR up to 1.3 bln EUR over a 20-year period. Similarly, the authors take here the view that additional benefits could be generated outside the 20-year period.*
- *Infrastructure:*
    - *In this domain no quantification of benefits is provided. However, the authors put forward that standardisation of technical parts could amount to a percentage cost saving in the order of 5% to 10% of total materials costs across Europe (although realising these design cost savings may not happen over the short / medium term considering the lifetime of infrastructure)*
- *Operations:*
    - *Potential benefits through reduced training costs from having a single common language for the railways or a single language for regions are assessed to be of relative limited importance with one-off estimates being in the range from 11 mln EUR to 194 mln EUR*

In-depth analysis of the potential migration costs towards a harmonised railway system would be required in order to determine economic feasible options. Some consideration to these aspects is included in the Cost of non-Europe report mentioned above.

Furthermore, it is considered in the Cost of non-Europe report that single vehicle authorization process (and safety certification) could bring additional benefits above those captured through the current provisions in the 4th Railway Package.

Other relevant sources include the ones considered in Annex 1 covering:

- *The Agency's Fast-Track B(enefit)-C(ost) analysis (from 2018 and updated in 2020)*
- *Information from Agency IAs: selected recent examples (WAG and OPE TSIs)*
- *Synthesis of Agency IAs: 2014 analysis*
- *Agency high-level analysis on Extension of Scope: 2010-2012*
- *4th Railway Package Technical Pillar Impact Assessment*

In particular, the Fast-Track B-C analysis indicated that there could be substantial net-benefits from further technical harmonisation. The indicative estimates are aligned with findings from specific Agency IAs along with the 2014 synthesis as well as the impact assessment work undertaken for the 4th Railway Package, technical pillar. In particular, the 4RP IA includes quantification of the potential benefits of the different options that can be used as indicative / conservative figures for the cost of non-interoperability. Further details are provided in Annex 1.

Additional insight is provided in the Agency's high-level analysis on the extension of scope where estimates of cost savings re. rolling stock authorisation (locomotives) until full technical harmonisation in 2050 suggesting a substantial potential, over 50% reduction (although cost savings may be smaller for other rolling stock categories, e.g. freight wagons).

As an additional source, Di Pietrantonio et al. (2004) mentions that industry experts considered '*...that total cost savings due to fully-fledged interoperability and a higher degree of technical harmonisation could be in the order of 30-40 per cent on the total value chain costs (equipment, operations, maintenance)*'.

Furthermore, the Agency's recent cross-border study provides additional insight into the time losses linked to current technical / operational barriers for cross-border rail transportation in Europe (ERA, 2022). The study focussed on four case studies for both passenger and freight involving specific cross-border sections. The cases on cross-border passenger transport built primarily on qualitative inputs, including observations on international high speed rail connections. The two case studies focusing on freight provide a quantitative evaluation of the impacts of technical and operational barriers on travel time, which in turn adversely affect rail volumes and the modal split. In this context, it is relevant to make reference to the Commission's Issues Logbook work (phase 1) where estimates of the benefits of removal of national rules are provided. Benefits are estimated to be of an order of magnitude of +500 mln EUR[12] per annum.

An additional dimension regarding costs of non-interoperability concerns the area of digital transformation in Europe. From a general economic perspective across sectors this issue is examined in a report from the European Parliament, Directorate-General for Parliamentary Research Services (European Parliament, 2022). This report analyses the status quo in digital transformation in the European Union and identifies gaps and barriers hampering the full potential of the digital transformation. Based on this examination, the cost of non-Europe is analysed qualitatively and quantitatively using a computable general equilibrium

[12] The economic impact report is available from this link: ILB_Final_Economic_report.pdf (europa.eu)

model. The report estimates already significant cost for Europe in 2021, at €315billion, and would continue to grow increasingly over time. It would be highly relevant to consider the cost of gaps and barriers with specific focus on the railway sector.