Exploring the feasibility of multimodal KPIs for the 2024 ERA Compelling Vision

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EUROPEAN UNION AGENCY FOR RAILWAYS

Contents

1. Introduction and objectives

From a literature review and the available data, it appears that there are not currently sound KPIs related to multimodality at EU level which are monitored on a regular basis.

For rail to play its role as backbone of EU transport, its integration with other modes is crucial. Therefore, evolution of multimodality needs to be monitored for further actions to be taken forward.

Multimodal transport can be defined as the carriage of goods or passengers by at least two different modes of transport. Intermodal transport is a type of multimodal transport, and it includes also combined transport as a subset[1].

This brief report presents the considerations made and the methodology proposed to define possible multimodal KPIs (distinguishing between passenger and freight).

The proposed definition of these KPIs would be *"the shortest available (door-to-door) transport times between a selected set of 'origin-destinations' involving different transport modes, for both freight and passengers, and with indication also of the associated CO_2 emissions per passenger or tonne of goods"*. The transport time to be considered includes all components, incl. first/last mile, waiting time, access and exit times etc.

From the definition it follows that the metric of the KPIs will be 'hours', together with CO_2 emissions, while the main format will be represented by tables or graphs. A yearly update/monitoring of the KPIs on selected 'origin-destinations' (O/Ds) is foreseen.

The selection of O/Ds will be based mainly on relevance of the analysed routes with available information. Corridors for passenger and freight transport may differ. The analysis will focus on best and worst scenarios. It will be based on data/sources and on a methodology which allow a regular analysis of trends for the various modes of transport, i.e. improvements/deteriorations in door-to-door transport time. Resources needed to evaluate and update the indicators will also be considered in a balanced way with the details/accuracy of the analysis.

It is important to highlight that, while several static studies have already been published on transport times per transport mode along several corridors, they do not allow a time-trend analysis. This is particularly true for the first/last mile and access/exit times.

2. Methodology

This section will follow a two-step approach. Firstly, the methodology for evaluating the transport times between main transport hubs/centres (i.e. stations, airports, intermodal terminals, ports, etc.) will be presented, followed then by considerations on the first/last mile and/or access/exit times. Limitations of the proposed methodology will be duly described.

2.1 Transport time between main transport hubs/centres

Passenger transport

In order to get regularly updated information on travel time, it is proposed to use Google Maps.

In particular, beside ranges of transport times by road, it provides information on travel possibilities and times by rail and air, which can be double-checked through other web-tools like Skyscanner or Rail Undertakings websites.

The calculation will focus mainly on the transport time through the fastest direct connection, or the best combinations of routes, if direct connection is not available. The frequency of the selected services will not enter in the calculation, but could be provided as an additional information. If both High-Speed (HS) and

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[1] Proposal for the revision of the combined transport directive, available here (see pag. 22)

conventional rail services are offered on a route, for easiness the methodology will focus only on the shortest transport time. Other considerations on frequency and costs could be analysed later to further improve the methodology.

Freight transport

Regarding freight transport, while Google Maps could provide for road rather accurate ranges of transport time, for railways the planned timetables are not really of help and the analysis could instead focus on the Pre-arranged Paths (PaPs) along the Rail Freight Corridors (RFCs). RNE and also the RFCs webpages provide regularly updated information such as the average distance, speed and consequently time along specific O/Ds.

2.2 First/last mile and access/exit times

Passenger transport

For passengers, Google Maps can provide information on the travel times by public transport to reach airports and or stations, and by car to exit the city centre. The main difficulty is to establish where to fix the initial and end points of transport, that are the 'origin' and the 'destination'.

By considering the city centre, likely access/exit time by rail would benefit from the location of stations usually inside the city, while airports are usually located outside. Trips by car would suffer the congestion time to cross the city. This would be particularly significant in the case of large metropolitan areas.

A possible quick approach, already proposed in the scientific literature, could be to consider average times to reach the stations/airports or the highways depending on the metropolitan area under consideration.

The main benefit of this approach is to limit the efforts needed to evaluate this part of the trips, allowing a reliable (even if average) comparison of transport times. The main drawback is the use of static values which will not allow to follow changes in performances over time for the last mile and access/exit trips.

Freight transport

For freight, Google Maps can also provide information on transport times for the first and last miles. In general, it is assumed that the transport of goods for the first/last mile, usually within short distance, is carried out by road given the capillarity of reachable origins/destinations. This, except for specific situations with mass transport from A to B and/or when the main transport hub is a port. Like for passengers, the proposed approach for freight transport is to consider average times to travel the first/last mile depending on the transport centres/hubs under consideration.

2.3 CO_2 emissions

For the evaluation of the CO_2 emissions, data[2] from the European Environment Agency (EEA) are considered. These figures are based on a recent study[3] commissioned by the EEA and conducted by Fraunhofer ISI and CE Delft. For each connection, the emission factors per vehicle category disaggregated per transport activity (passenger-km and tonne-km) are multiplied by the travelled distance in km (by road, by rail, or in straight line for flights) to obtain/present the associated CO_2 emissions per passenger or tonne of goods transported. The total distance travelled for each mode of transport is considered as the sum of the travelled distance between the main transport hubs/centres plus a constant/average distance for the first/last mile.

3. Study scope and activities

As described earlier, the scope of this study is to explore the feasibility of multimodal KPIs for the Agency strategic document 'A Compelling vision for a target railway system'[4].

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[2] See here
[3] Available here
[4] See here

A first estimation of the KPIs for 2022 and 2023 on an initial selection of O/Ds is presented. Depending on the resources available, and on the desired level of detail of the analysis, more in-depth and specific analyses could be carried out with an enlarged list of ODs covering additional routes. In addition, the final KPIs could be based on generalised costs, instead of travel time. This would require the use of monetary values for travel time and external costs, e.g. both for emissions and for safety.

3.1 Time planning, study phases and deliverables

A first scoping report was prepared in November 2022, including a first estimation of the KPIs on selected O/Ds. Those KPIs were used as basis for the trend analysis. This report includes the trend analysis between 2022 and 2023.

Depending on the Agency work plan and priorities, the regular monitoring of the indicators is foreseen to be carried out on a yearly basis. This task may be undertaken as part of externally commissioned work / studies or using internal resources.

The recurrent deliverables will be tables/graphs showing the multimodal transport performance evolution per selected O/Ds.

4.   Estimation of the KPIs on an initial selection of ODs.

4.1 Passenger transport

Transport time between main transport centres (A to B)

For the selection of possible routes, the following data/figures could help in identifying interesting case studies. As literature suggests that train is particularly competitive compared to cars and flights for distances between 100 and 800 km, this information will also form the basis for the selection of the O/Ds to study.

Figure 1: Speed (and availability) of rail connection between major urban centres (left) and access to flights by NUTS3 (right), 2019
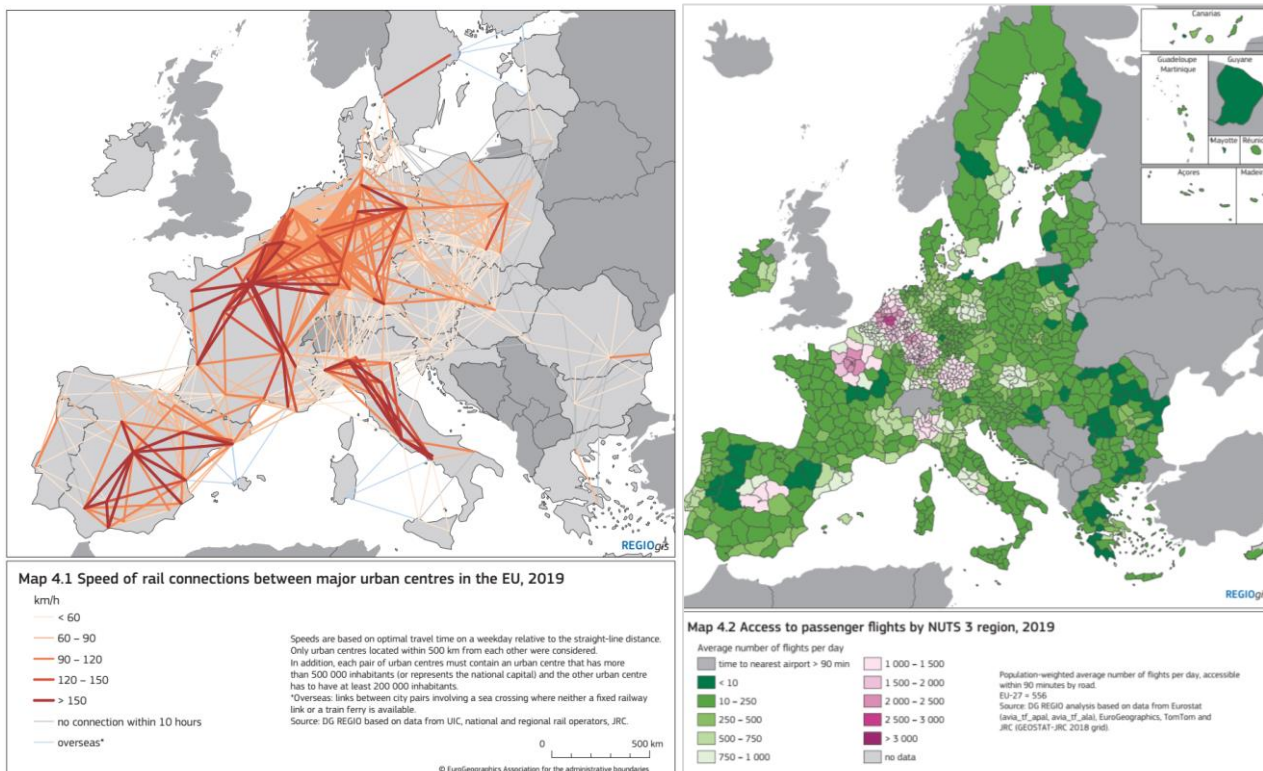
Source: 8th Report 'Cohesion in Europe towards 20250', DG Regio

Possible proposals would be to focus on:

1) An O/D pair with a distance within 100 and 800 km and served by HS with high frequency of rail services and good access to passenger flights. An example could be the connection **Paris-Brussels,** for which Google Maps indicated a travel time by car between 2h40min and 3h50 min (entrance of A3 in Paris, until exit 17 on E19 for Brussel city centre), while the HS train takes around 1h30min (station to station) and the flights take around 1 hour (CDG-BRU). An interesting alternative to be analysed in the future is the O/D pair Paris-London, since after Brexit longer access/egress times are due to documents checks for HS services.

2) An O/D pair with a distance within 100 and 800 km, not served by direct rail service and with relatively poor access to passenger flights (and no direct flight). An example could be the connection **Lille-Strasbourg,** for which Google Maps indicates a travel time by car between 4h40min and 6h40min (entrance of A25 in Lille, until exit 4 on A35 in Strasbourg), while the HS take between 3 and 4 hours and the flights connection currently is over 4h (LIL-SXB) in the best scenarios with 1 connection.

3) An O/D pair with a distance higher than 800 km, not served by direct HS but with relatively good access to passenger flights. An example could be the connection **Paris-Madrid**, for which Google Maps indicates a travel time by car between 10h40min and 14h40min (entrance of A6B in Paris, until exit 51 on M40 for Madrid city centre), while the HS trains (via Barcelona) take more than 10h, and the direct air connection a bit more than 2h (CDG-MAD).

4) An O/D pair with a distance higher than 800 km, served by HS and with relatively good access to passenger flights. An example could be the connection **Paris-Barcelona**, for which Google Maps indicates a travel time by car between 8h30min and 11 (entrance of A6B in Paris, until start of B10 in Barcelona), with HS connection of less than 7h and direct air connection of less than 2h (CDG-BNC).

5) An O/D pair with a distance higher than 800 km, not served by direct rail service and with relatively poor access to passenger flights (and no direct flight). Example could be the connection **Luxembourg-Zagreb** for which travel time by car is between 10h10min and 13h50min (round bound/entrance of A3 in Luxembourg, until exit Ljubljanska avenija on E70 for Zagreb), while the train takes more than 15h (station to station, with several changes) and the air connection take around more than 3 hours (in the best scenario with 1 change).

Access/exit transport time (e.g. to/from stations/airports)

The access/exit time can be constituted by several elements as shown in the below figure.

Figure 2: Example of door-to-door travel time

Source "High Speed Rail. Fast track to sustainable mobility", UIC, 2018

The proposed approach is to consider 2 main elements for both access and egress times:

- Transfer time to/from the main point of departure/arrival (i.e. airport/rail and main/extra-urban road)
- Waiting time in the airport or railway station, i.e. this component is null for road.

For easiness it is proposed to assume a transfer time of 30 minutes for all transport modes in each city. It means that we assume that a passenger will need on average 30 minutes to reach for example the station/airport or to reach extra-urban road from the city centre by car. This is a rough assumption that could be fine-tuned through further analyses, like a collaboration with the Joint Research Centre of the European Commission (EC-JRC) which has data from TomTom and public services in many cities in Europe. From those data, a catchment area could be defined and it could be possible to evaluate the average travel time to reach station/airport or to exit the urban area by car for passengers departing within that catching/interest area. In addition, a differentiation of transfer times based on the dimension of the metropolitan area of departure/arrival could be possible. In any case, unless a quite detailed (and relatively time-consuming) analysis will be carried out each year for all the considered cities, it is considered that it will be quite difficult to catch differences in access/egress time, reducing the added value of intermediate/semi-detailed approaches. For the waiting time, it is proposed 15 minutes for rail and 1.5 hour for air at departure (including baggage drop-off), while 5 minutes for rail and 30 minutes for air (including baggage claim) at final destination. This leads to a total access and egress time for this first study of:

- 1 hour for road
- 1hour and 20 minutes for rail
- 3 hours for air

CO2 emissions

For the evaluation of the CO_2 emissions, data from the EEA[5] are considered and reported below.

Figure 3: Average CO2 emissions per passenger-km by motorised mode of passenger transport, EU-27, 2014-2018
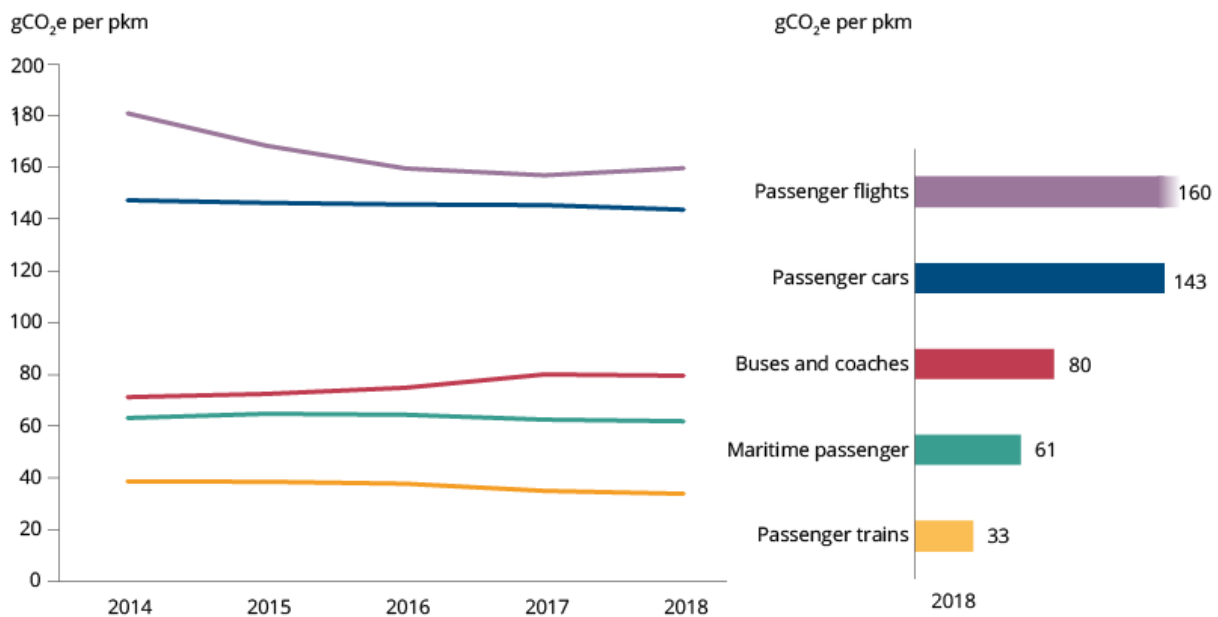
Source: Fraunhofer ISI and CE Delft, 2020

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[5] See here

By multiplying the emission factors per passenger-km with the corresponding distance by each mode of transport, it is possible to obtain an indication of the average CO_2 emissions per passenger for each O/D pair using the selected modes of transport.

The total distance in km for each O/D pair is calculated as the sum of the travelled distance between the main transport hubs/centres, plus a constant/average distance for the first/last mile assumed for all modes equal to 20 km by bus for trains and flights connections. More detailed, but time consuming, analyses would be possible to determine more precise catchment areas for each specific connection.

4.2 Freight transport

Transport time between main transport hubs (A to B)

For freight, it is proposed to analyse connections between main transport hubs (both on a short and on a long distance[6]) along two different corridors. The first one along the so-called 'blue banana' (constituting a natural cluster of regional economic activities[7]), and the second on a corridor characterised by lower flows/demand.

Figure 4: Population density in Europe (left) and freight flows of more than 300 km distance (right)
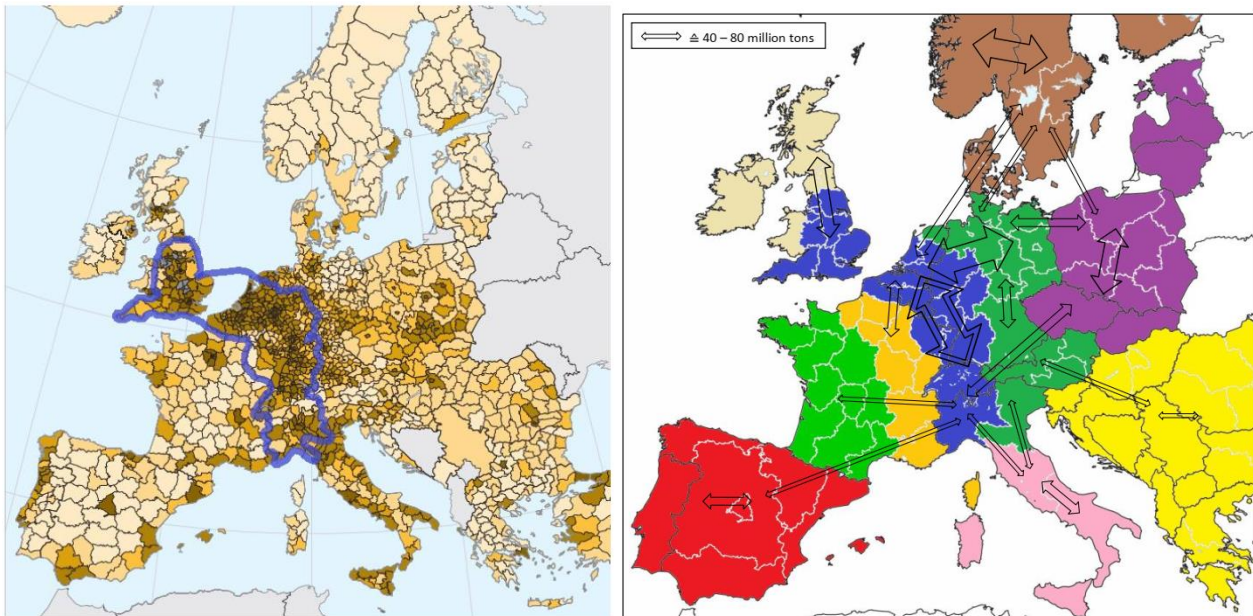
Source: 'The structure of freight flows in Europe and its implications for EU railway freight policy', 2014

Possible proposals would be to focus on:

1) The RFC 1 and in particular on the short connection (228 km) Maasvlakte (Rotterdam) - Oberhausen Sterkrade (Germany) and on the long connection (1148.3 km) Maasvlakte - Milano Sm (Italy), for which average speed and length of the PaPs are available and yearly updated/monitored. Google Maps indicated a transport time by car/truck between 2h40min and 3h30min for Maasvlakte - Oberhausen Sterkrade, and between 10h30min and 13h40min for Maasvlakte - Milano Sm. The Rail Freigh Corridor (RFC) KPIs from RailNetEurope (RNE), instead, indicate in November 2022 (TT2023) an average time of 3h13min (and 3h11min for the TT2024, in Dec 2023) for the PaPs along

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[6] Since railway freight transport tends to become more economically viable on longer transport distances.

[7] The 'Blue Banana' area/region starts in the North with the main industrial cities in central England, includes the London area, then crosses the Channel, contains the major cities of The Netherlands and Belgium as well as the region around Lille in France, then continues in Germany with the metropolitan regions Rhine-Ruhr, Rhine-Main, Rhine-Neckar, and Stuttgart, as well as the French regions of Alsace and Lorraine, then contains Switzerland, and then finally the North-Western industrial region of Italy. Altogether, some 148 Million people live in the Blue Banana. This corresponds to 28 % of the population of all those European regions which are shown as coloured in the figure above. At the same time the Blue Banana produces some 36 % of the BIP of all these regions.

Maasvlakte - Oberhausen Sterkrade, and an average time of 21h18min for the PaPs along Maasvlakte – Milano Sm for the TT2023 (while 20h6min for the TT2024).

Figure 5: Average planned speed of PaPs for O/D pairs along the RFC 1
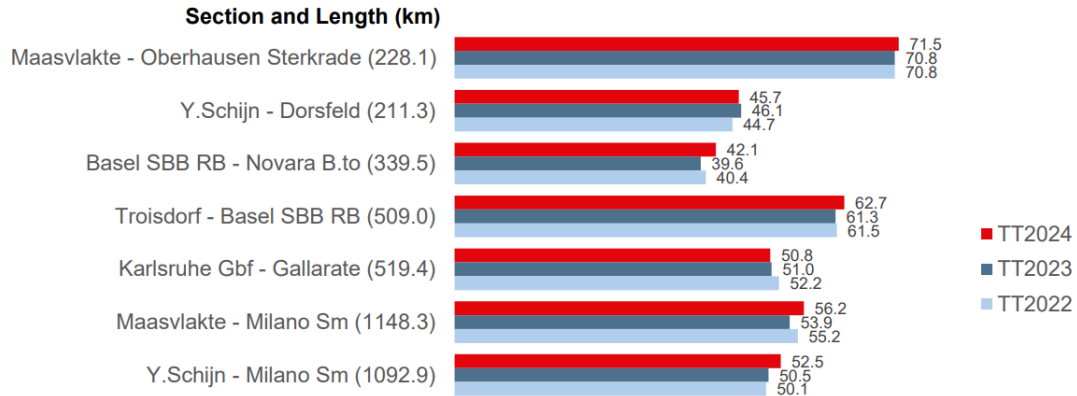
Source: RFC Rhine-Alpine KPIs, Dec 2023

2) The RFC 9 and in particular on the relatively short connection (484.3 km) Wien Zvbf (Austria) - Oradea Est (Romania) and on the long connection (1510 km) Strasbourg Port du Rhin (France) – Curtici (Romania), for which average speed and length of the PaPs are available and yearly updated/monitored. Google Maps indicated a transport time by car/truck between 4h50min and 6h30min for Wien Zvbf - Oradea Est, and between 11h30min and 16h30min for Strasbourg Port du Rhin - Curtici. The RNE/RFC KPIs, instead, indicate for 2022 an average time of 17h10min in the TT2023 (while 21h20min in the TT2024) for the PaPs along Wien Zvbf - Oradea Est, and an average time of 32h04min in the TT2023 (58h59min in the TT2024) for the PaPs along Strasbourg Port du Rhin - Curtici.

Figure 6: Average planned speed of PaPs for O/D pairs along the RFC 9
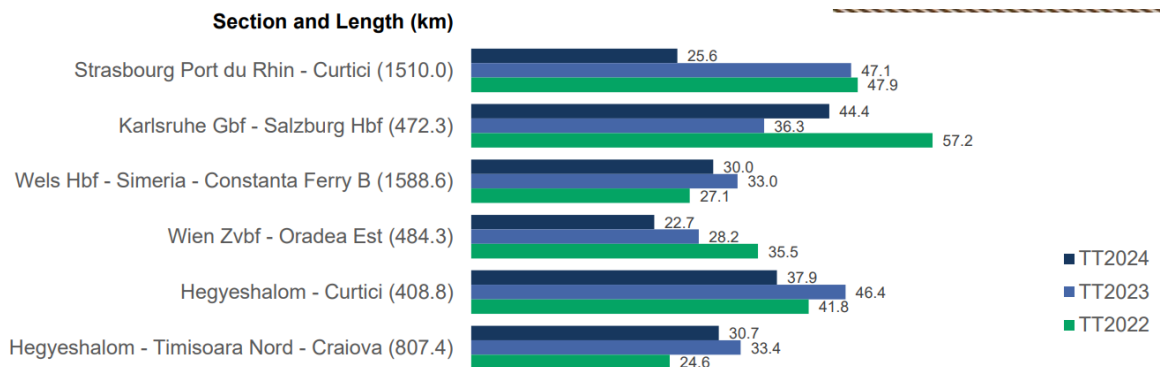
Source: RFC Rhine-Danube KPIs, Dec 2023

Transport time for the first/last mile

Regarding the freight transport time related to the first/last mile, the evaluation is even more complex than for the access/egress time for passengers. The last/first mile can be in general divided in two legs: 1) from/to the main transport hubs to/from warehouses/factories, and 2) from/to warehouses/factories to/from the final delivery point. Our analysis focuses only on the first leg.

The transport time for the first/last mile is very context-dependent; in general freight are transported in last/first mile by road/tracks for the great flexibility, even if there are some cases of railway lines serving dedicated routes. Like for the passenger cases, a more precise evaluation would be possible but would be time and resources intensive, especially as the number of O/D pairs increases. For easiness/feasibility, it is also proposed for freight a simplified approach for a first study, by assuming that all goods are in general

transported by road in the last/first mile, and by assuming an average final and initial transport times of around 1.5 hour both at departure or arrival (unless the initial/final transport hub is a port, since in that case the last/first mile is assumed null). The proposed approach does not take fully in account some specificities/constraints of the two modes, like the importance of the time coordination between road/rail (in case of rail transport) and the need of two drivers or recovery/sleeping time for road transport above 8-9 hours.

CO_2 emissions

For the evaluation of the CO_2 emissions, data[8] from the EEA are considered and reported below:

Figure 7: Average CO_2 emissions per tonne-km by motorised mode of freight transport, EU-27, 2014-2018
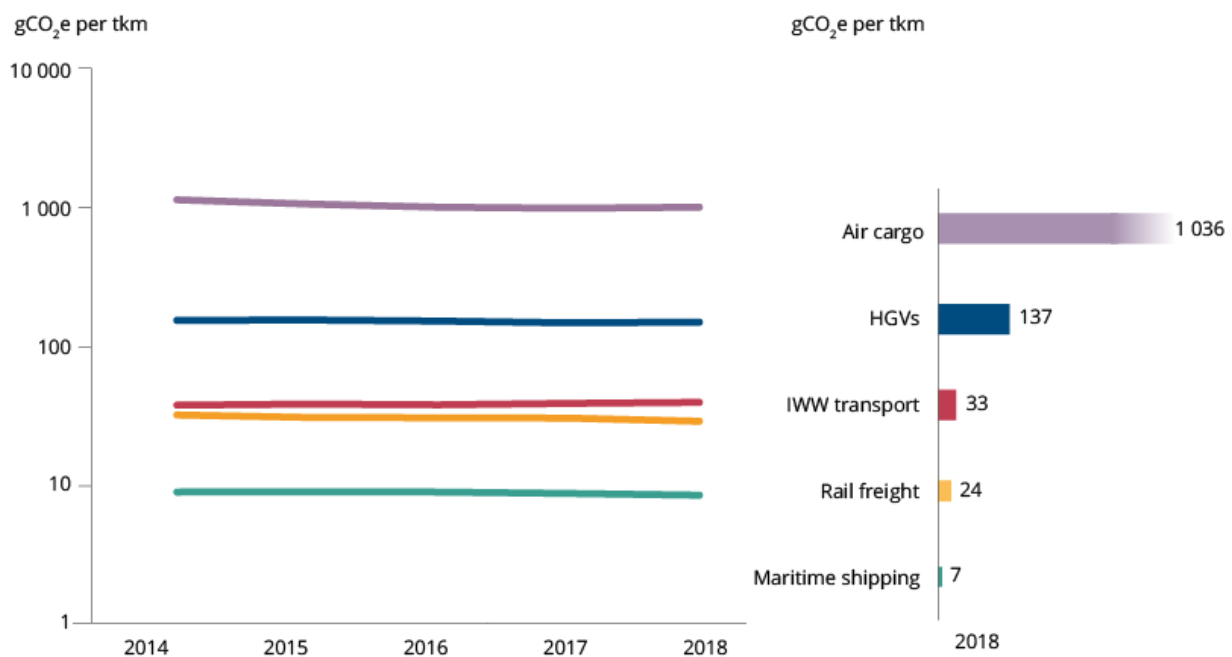
Source: Fraunhofer ISI and CE Delft, 2020

By multiplying the emission factors per tonne-km by the corresponding distance for each mode of transport, it is possible to obtain an indication of the average CO_2 emissions per tonne of carried goods on that O/D pair using the selected modes of transport.

The total distance in km for each O/D pair is calculated as the sum of the travelled distance between the main transport hubs/centres by each mode of transport, plus a constant/average distance for the first/last mile travelled always by road (for all modes) and equal to 70 km (unless the initial/final transport hub is a port, since in that case distance is assumed null). More detailed, but time consuming, analyses would be possible to determine more precise catching areas for each specific connection.

4.3 Summary of the KPIs for the initial selection of ODs

The following tables summarise the evolution of the proposed KPIs for the initial selection of ODs between 2022 and 2023 (although with some limitations reported in the next section).

Some of the observed variations over the two years are very low, while for a few connections they are more significant.

For **passenger transport**, only the variation for one O/D pair (out of the five analysed) appears to be significant:

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[8] See here

- A reduction of 12% of the travel time by HS rail between Lille and Strasbourg (only for 1 connection per day, in the morning around 8 a.m.), accompanied by a quite significant increase of the travel time by air (47%).

For **freight transport**, instead, the variation is significant for two O/D pairs, out of the four analysed:

- A significant increase in the transport time is observed for freight by rail along the RF9 between Vienna and Oradea and between the port of Strasbourg and Curtici.

No changes/variations are evident for travel time by road (possibly also due to the approach/tools used).

Passenger transport	A-to-B travel time			Door-to-Door travel time			Distance	gCO$_2$
Origin-Destination by mode of transport	Nov 2022	Dec 2023	Δ%	Nov 2022	Dec 2022	Δ%	km	per passenger
Paris-Brussels, by rail	1h:22min	1h:30min	10%	2h:42min	2h:50min	6%	320+40	13 760
Paris-Brussels, by air	60-65min	55 min	-8%	4h	3:55h	-2%	265+40	45 600
Paris-Brussels, by road	2h:40min 3h:50 min	2h:40min 3h:50 min	0%	3h:40min 4h:50 min	3h:40min 4h:50 min	0%	295+40	47 905
Lille-Strasbourg, by rail	3h:29min 4h:08min	3h:03min 4h:07min	-12%	4h:49min 5h:28min	4h:23min 5h:27min	-9%	688+40	25 904
Lille-Strasbourg, by air	3h-3h:30min	4h:25min or more	47%	6h-6h:30min	7h:25min	24%	408+40	68 480
Lille-Strasbourg, by road	4h:40min 6h:40min	4h:40min 6h:40 min	0%	5h:40min 7h:40min	5h:40min 7h:40 min	0%	517+40	79 651
Paris-Madrid, by rail	9h:33min 11h:55min	10h:3min 12h:31	5%	10h:53min 13h:15min	11h:23min 13h:51min	5%	1741+40	60 653
Paris-Madrid, by air	2h:15min	2h:05min	-7%	5h:15min	5h:05min	-3%	1053+40	171 680
Paris-Madrid, by road	10h:40min 14h:40min	10h:40min 14h:40min	0%	11h:40min 15h:40min	11h:40min 15h:40min	0%	1257+40	185 471
Paris-Barcelona, by rail	6h:40min	6h:45min	1%	8h	8:05h	1%	1115+40	39 995
Paris-Barcelona, by air	1h:45min 1h:50min	1h:40min 1h:50min	-5%	4h:45min	4h:40min	-2%	832+40	136 320
Paris-Barcelona, by road	8h:30min 11h	8h:30min 11h	0%	9h:30min 12h	9h:30min 12h	0%	1021+40	151 723
Luxembourg-Zagreb, by rail	17h:44min 19h	15h:37min 19:30h	-12%	19h:04min 20h:20min	16h:57min 20h:50min	-11%	1140+40	40 820
Luxembourg-Zagreb, by air	3h:20min 7h:05	3h:15min 7h:05	2%	6h:20min 10h:05min	6h:15min 10h:05min	1%	900+40	147 200
Luxembourg-Zagreb, by road	10h:10min 13h:50min	10h:10min 13h:50min	0%	11h:10min 14h:50min	11h:10min 14h:50min	0%	1066+40	158 158

Freight transport	A-to-B travel time			Door-to-Door travel time			Distance	CO$_2$
Origin-Destination by mode of transport	Nov 2022	Dec 2023	Δ%	Nov 2022	Dec 2023	Δ%	km	per tonne
Maasvlakte-Oberhausen Sterkrade, by rail	3h:13min	3h:11min	-1%	6h:13min	6h:11min	-1%	228+140	24 652
Maasvlakte-Oberhausen Sterkrade, by road	2h:40min 3h:30 min	2h:40min 3h:30 min	0%	5h:40min 6h:30 min	5h:40min 6h:30 min	0%	245+140	52 745
Maasvlakte – Milano Sm, by rail	21h:18min	20h:26min	-4%	24h:18min	23h:26min	-4%	1148+140	46 732
Maasvlakte – Milano Sm, by road	10h:30min 13h:40 min	10h:30min 13h:40 min	0%	13h:30min 16h:40 min	13h:30min 16h:40 min	0%	1089+140	168 373

Wien Zvbf – Oradea Est, by rail	17h:10min	21h:20min	24%	20h:10min	24h:20min	21%	484+140	30 796
Wien Zvbf – Oradea Est, by road	4h:50min 6h:30 min	4h:50min 6h:30 min	0%	7h:50min 9h:30 min	7h:50min 9h:30 min	0%	504+140	88 228
Strasbourg Port du Rhin–Curtici, by rail	32h:04min	58h:59min	84%	33h:34min	60h:29min	80%	1510+70	45 830
Strasbourg Port du Rhin–Curtici, by road	11h:30min 16h:30 min	11h:30min 16h:30 min	0%	13h:00min 18h:00 min	13h:00min 18h:00 min	0%	1287+70	185 909

5. Conclusions

This report explores the feasibility of multimodal KPIs, by using available data sources that are regularly updated. The proposed approach allows to monitor transport times (and CO_2 emissions per passenger or tonne) on selected 'origins-destinations' by mode for both freight and passenger. It appears to be feasible and to be a good starting point to monitor and update those multimodal KPIs on an annual basis.

The provided data is expected to support the European Union Agency for Railways as well as other stakeholders' identification of relevant activities to enhance multimodality.

Findings

The evolution of the proposed KPIs for the initial selection of ODs between 2022 and 2023 shows that:

- Significant variations/changes in travel time by air and rail are registered only for 1 of the selected O/D pairs for passenger transport (out of the five selected).
- The average planned speed for rail freight on two selected O/D pairs along the RF9 corridor registered a significant decrease in the 2024 timetable compared to the timetable in 2023.
- On the other selected O/D pairs, changes appear quite low or not really significant.
- No variations in travel time for road transport were recorded.

Limitations

Linked to the assumptions made and to the findings above, the following limitations have been identified for the proposed methodology:

- Frequency of the transport services, their costs and the related demand are not covered by the KPIs.
- Only an average and simplified estimation of the access/exit time, first/last mile and distances of the related catching areas is used.
- Similarly, only average values of CO_2 emissions for each mode of transport are applied (without any detailed classifications/differentiation among the possible vehicles)
- The methodology will catch main differences in transport times due to major causes (e.g. addition or deletion of direct connections by rail or air), while it could be more difficult to detect (year-by-year) small changes due to minor interventions. This seems to be particularly the case for road transport, for which no changes between 2022 and 2023 were observed.

Way forward and research agenda

The methodology can be further improved, balancing the desired depth of analysis with data availability and resources needed, by:

- Introducing considerations on the standard deviation in addition to the variation in the average travel time.
- Exploring more intuitive easy-reading visuals, based on the analysed data overtime.

The study scope could be further refined/extended by:

- Fine-tuning the list of O/D pairs based on the observed KPIs, e.g. focusing on routes/connections where competition, demand, investments or other factors influence multimodality, positively or negatively.
- Adding considerations on other externalities (e.g. land use, noise, accidents) for each route and mode of transport.
- introducing variations in the first / last mile component as well as transfer times.
- Exploring ways to include routes where combined or intermodal transport are performed.

The specifics of follow-up improvements could be detailed as a proposal for additional studies.