ASSESSMENT IMPACT OF THE INFRASTRUCTURE CONSTRAINTS ON RAILWAY UNDERTAKINGS

SYNTHESIS OF THE STUDY

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■ INGENIOUS SOLUTIONS

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1. Introduction

The objective of the study is to assess the infrastructure constraints on the railway undertakings operations along the **Rail Freight Atlantic Corridor** (RFC 4), taking into account studies which have already been conducted by the Atlantic Corridor EEIG, and in particular the Transport Market Study (TMS) and the Infrastructure and Exploitation Study (IDOARC)[1]. The TMS study has identified major international relations along the corridor for transport demand, along which these infrastructure constraints will be assessed. The IDOARC study has provided information about infrastructure description, links and nodes, for the base year and at the horizon 2030.

However in this study the perimeter of the corridor had to be adapted to new connections in particular towards Germany, Zaragoza, and Atlantic ports, so that the RFC4 corridor becomes better aligned with the Atlantic Core Network Corridor (CNC 7), the multimodal corridor defined to structure the Core Network of the TEN-T network.

The study has been developed by a consortium coordinated by **BG Ingénieurs Conseils** from France, associated to consulting companies chosen in the three other countries of the corridor, **MCRIT** for Spain, **Instituto Técnico** de Lisboa for Portugal, and **PLANCO** for Germany.

From a methodological point of view this study is particularly challenging and relevant

- Challenging because of the necessity to adopt a very analytical approach with a large volume of information to be taken into account concerning different segments of demand, but mainly the conditions of operations per type of train for relations with Spain and Portugal having different rail gauge than the rest of Europe, and often a difficult geographic context with important slopes. Along a given route the operating solution will most of the time depend upon a "sequence" of constraints encountered and a consequence is that all this information had to be "geocoded" and integrated in order to assess performance of a route, taking into account the operating constraints, and possible solutions to face them[2] ;

- Relevant because the performance of rail operations is what comes up at the end as the critical point for competitiveness of rail transport against road, and this is too often neglected or underestimated in infrastructure investments. In the case of the Atlantic corridor, there is a situation where average distances for international exchanges are generally quite long as compared to other corridors. This occurs even within Spain and Portugal, which should play in favor of rail, but with on the other hand more infrastructure constraints for international relations and it is then important to investigate what is the resulting impact for final performances along relations.

However, beyond the detailed analytical approach required to assess operation performances along the main relations of the corridor, a concept of "ideal solution" had to be proposed by EEIG so that impact of different types of infrastructure investments at horizon 2030 could be assed and compared. Indeed, such assessment and comparison could only be done on the base of "optimal" operation solutions as regards existing infrastructure constraints, without infrastructure investments.

[1] Which is referred to as IDOARC study, achieved by IDOM, ARCADIS, GIBB consortium. The TMS study was achieved by SETEC/EPYPSA/VTM/PROGTRANS

[2] For example use of 2 locomotives along a given section or use of a more powerful one along the route

As a derived result of introduction of such concept, the difference between present situation without "optimization", and an "ideal situation" without investment, could be appreciated pointing out how competitiveness of rail can be improved, for main relations of the corridor that characterize the market of international "slots" supply, managed by EEIG.

After these preliminary considerations about methodology, it is then possible to present the sequence of tasks and their main results in order to reach the final goal of comparison of impact of different types of investments along different relations of the corridor, for different type of trains (or products transported) as regards not only increased performance of rail, but also as regards potential modal shift from road in 2030, that somehow defines a future potential international "slot" market.

These are:

- **1** Estimation of the demand in tons for major relations of the corridor for base year 2010 and comparison of rail and road performances along these relations.
- **2** Comparative analysis of logistic practices for rail and road
- **3** Comparison of rail and road costs for major relations
- **4** International transport plans and evaluation of scenarios per type of infrastructure investment
- **5/6** Profit and Loss of competitiveness expected per type of investment, including ERTMS

Note also that in the first three tasks the analysis has concentrated upon main relations of the TMS study (Transport Market Study), but that in the last two tasks all the international relations of the corridor have been considered, in order to have a more accurate appraisal upon the impact of different types of infrastructure investments upon rail performances versus road.

The next figure illustrate how different tasks are related in the study:

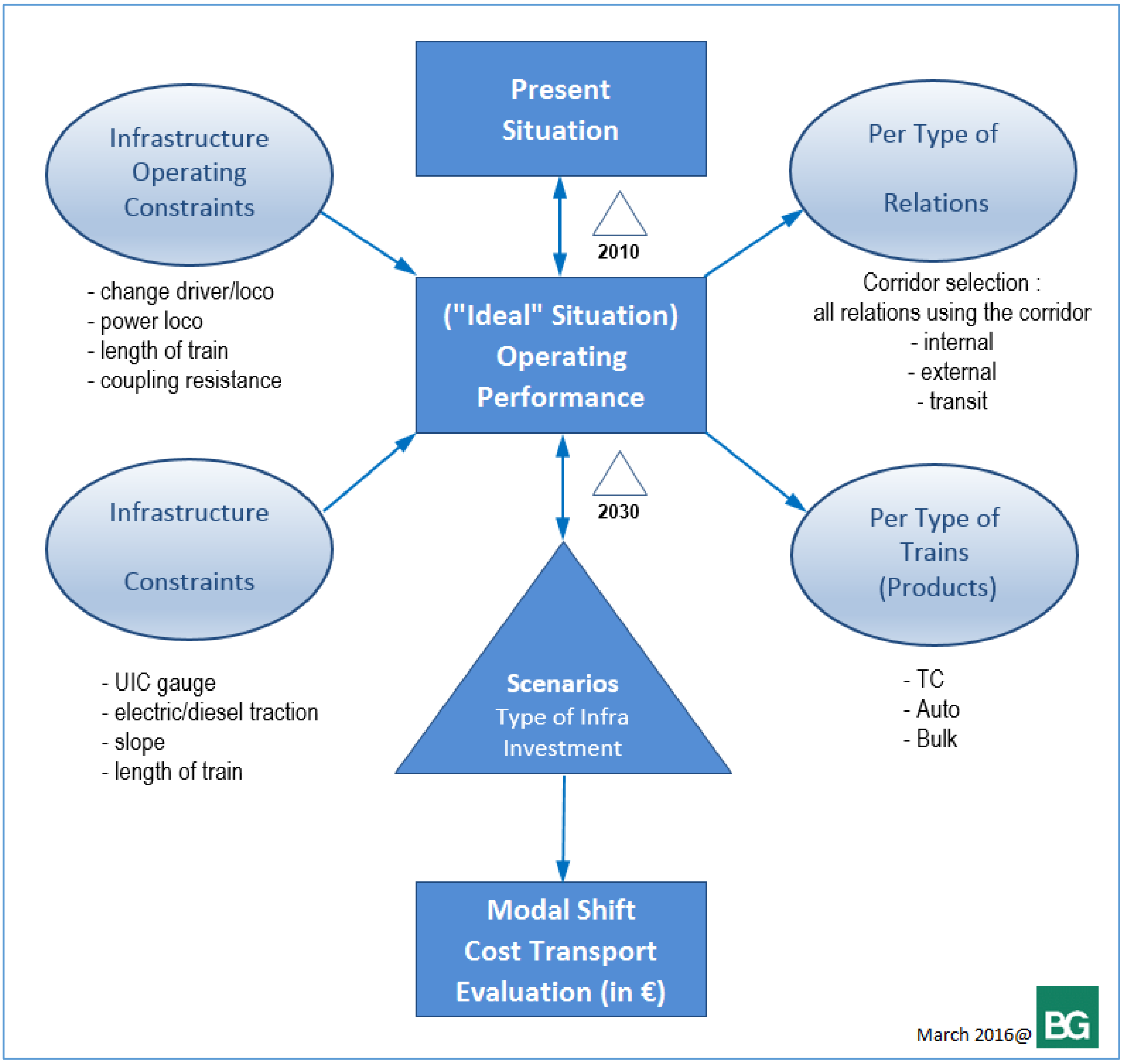

Figure 1 Synthesis scheme

2. Estimation of the demand in tons for major relations of the corridor for base year 2010 and comparison of rail and road performances along these relations

The objective of the first task is to make an estimation of the volume of traffic in tons along major relations of the corridor and to achieve a first comparative analysis of road and rail performance along these relations of the corridor. This analysis is based on border surveys between France and Spain as well as between Spain and Portugal, but also on European data base such as ETIS (for traffic flows between European regions), as well as the **Transport Market Study** (TMS) completed for the EEIG in 2014. This TMS study highlights 13 major relations along the corridor, between most important points, from which rail demand of slots can be estimated along the corridor.

These are in particular,

- The border points between Spain, Portugal, France and Germany
- The extreme of the corridor in Germany
- The major intercontinental ports, which are gateways for Europe in the world trade
- The capitals of France Spain and Portugal served by the corridor

From the demand side the Selected Link Analysis (SLA) has been applied to European O/D matrix flows, region to region, obtained from the databases, and applied to the major relation of the TMS study in order to select European flows passing along these relations, for rail and road.

In order to do so it was necessary to make a first assignment of road and rail flows on the European rail and road network, and to select then those passing through the ends of the corridor TMS relations for road and rail, excluding traffic of possible routes which are not along the Atlantic corridor[3].

The following map illustrates the application of this technique for the Paris-Madrid relation:

[3] For example, traffic passing through the Mediterranean border point

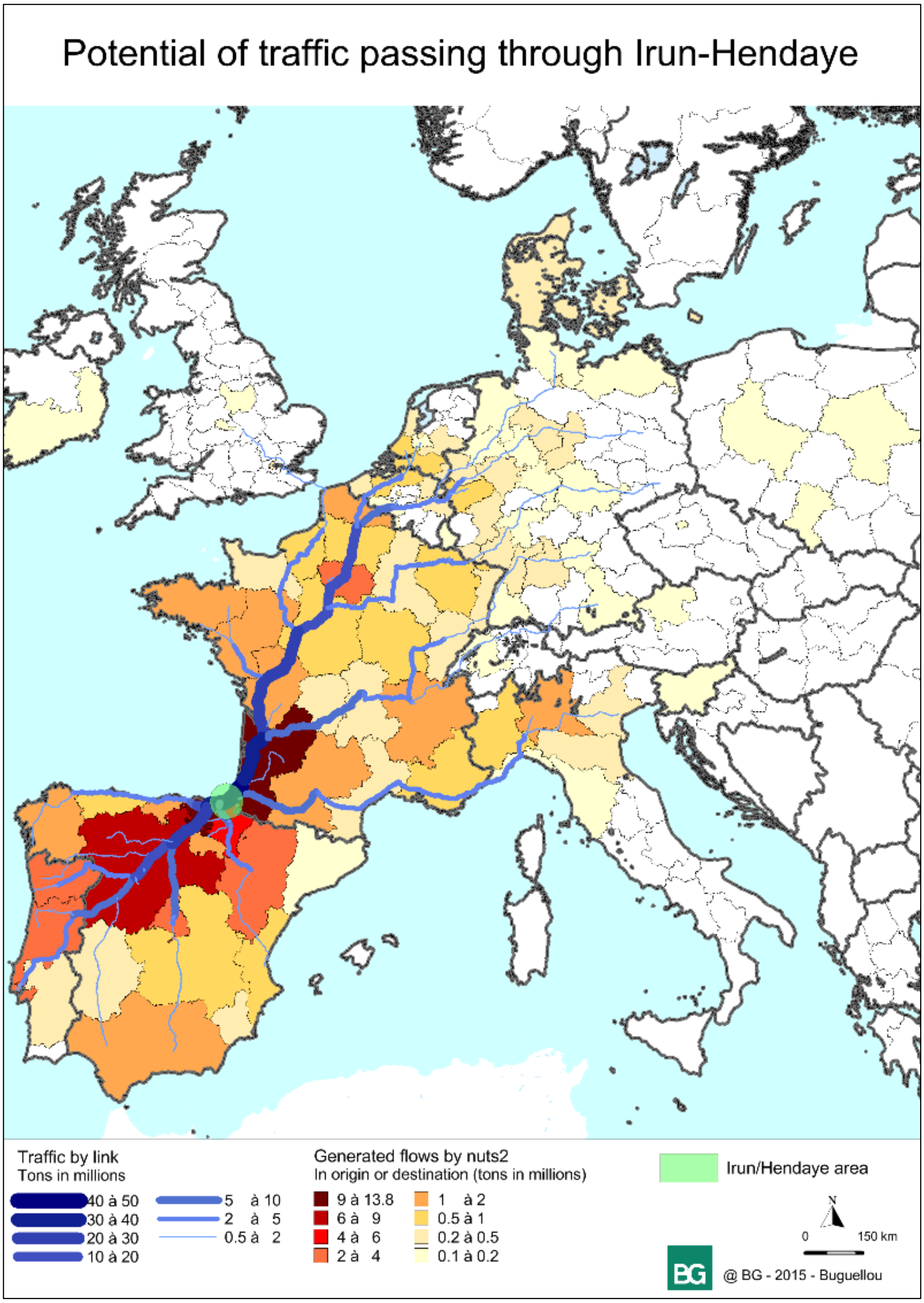

Figure 2 Potential of traffic passing through Irun-Hendaye

Once the selected link analysis has been done, it is then possible to obtain the global volume of demand of the relation, as well as the distance of transport for rail and road, and the time of transport for road using information about average road speed along the sections of the relation.

For rail, travel time has been obtained from two types of sources,

- Travel time based on corridor path 2015-2016
- Travel time taking account of the stopping time recorded in the "Files track-staking" of international path of corridor

The following table summarizes the results obtained in task 1:

	Time station to station without loading & unloading and pre post-routing				Travel time for combined transport with loading and unloading & pre post - routing			
Time in hours	Only road time	Only rail time	Differential	Variation	Road + loading & unloading	Rail time + loading & unloading + pre & post routing	Differential	Variation
Irun - Metz	24.8	16.6	-8.2	-33%	28.0	26.4	-1.7	-6%
Irun - Mannheim	27.3	19.8	-7.5	-27%	30.5	29.6	-0.9	-3%
Vitoria - Metz	26.4	27.1	0.6	2%	29.6	36.9	7.2	24%
Vitoria - Mannheim	37.9	30.3	-7.6	-20%	41.1	40.0	-1.0	-2%
Vitoria - Paris	21.6	21.2	-0.5	-2%	24.8	30.9	6.1	25%
Poceirao - Metz	57.2	46.0	-11.2	-20%	60.4	55.7	-4.6	-8%
Poceirao - Mannheim	59.6	49.1	-10.5	-18%	62.8	58.9	-3.9	-6%
Poceirao - Paris	44.1	40.0	-4.1	-9%	47.3	49.8	2.5	5%
Leixoes - Mannheim	57.1	49.6	-7.5	-13%	60.3	59.4	-0.9	-1%
Madrid - Mannheim	44.2	39.5	-4.7	-11%	47.4	49.2	1.8	4%
Le Havre - Mannheim	18.8	11.6	-7.3	-39%	22.0	21.4	-0.7	-3%
Leixoes - Paris	40.8	40.5	-0.3	-1%	44.0	50.3	6.3	14%
Paris - Mannheim	7.6	6.9	-0.7	-10%	10.8	16.7	5.9	54%
Algeciras - Paris	56.5	48.8	-7.7	-14%	59.7	58.6	-1.1	-2%
Paris - Madrid	28.0	30.4	2.4	9%	31.2	40.1	9.0	29%
Algeciras - Irun	27.5	29.2	1.6	6%	30.7	38.9	8.2	27%
Vitoria - Leixoes	19.2	19.4	0.1	1%	22.4	29.2	6.7	30%
Leixoes - Madrid	8.7	19.8	11.1	127%	11.9	29.6	17.7	148%
Irun - Madrid	7.9	12.4	4.4	56%	11.1	22.1	11.0	99%
Poceirao - Madrid	9.0	19.3	10.3	114%	12.2	29.1	16.9	138%

Table 1 Time and distance for main OD

The analysis of results shows:

- <u>**The important traffic potential of these relations**</u>

This is in particular the case for Vitoria/Paris with more than 11 MT and Irun/Madrid with more than 5.5 MT, with other O/D relations being between 100 and 300 thousand tons. Only relations serving ports such as Le Havre, Leixoes or Algeciras, appear at a low level for such international long distance continental relation, in year 2010.

In this potential the present share of rail is low, between almost 0% up to 7%, taking into consideration rail-road traffic (with transshipment in French terminals close to the border) for relations where France is not included.

- **<u>The importance of the distances of these relations, with sometimes significant longer distances for rail</u>**

The distances are in general well above 500 Kms (except for Irun/Vitoria) and often above 1000Kms, and even 2.000 Kms for Trans Pyrenean relations. For some relations in the south, rail distances can be longer than road distances, by 20 or 30% for crossing mountainous zones between Spain and Portugal or around Madrid. In the North, short distances for road are related to existence of "by-pass" of some dense areas such as Paris region for East/West relation (such as relation between Le Havre and Irun).

- **<u>The variability of rail performances in time as compared to road</u>**

Different sources have been used to estimate rail transport time in 2010, from slots definition to "files track staking" for rail. For road, resting/driving cycles have been introduced.

The detailed analysis of rail transport time, including stopping times along the routes of trains, has been first conducted for relations in the North and relations in the South for which such information is available. Then the Trans-Pyrenean relations have been considered, adding time for border crossing at Hendaye/Irun.

The results of the analysis show important variations in time for different O/D mainly due to the variability of stopping times for the same O/D, with better performances in general for the relations in the north (although not for all relations and all trains) than for relations in the South (although there are examples of good performances for some trains). However, the estimation of waiting time in the relations of the South is incomplete because of lack of data.

It is then also clear that long distances of relations play more in favor of rail, but :

- This occurs only when best performing time of trains are considered for a given relation, with most of the time a large difference with the worst performing time for the same relation. In the analysis, brackets for stopping times along relations have been considered pointing out that rail cannot perform better than road with the high values of stopping time but that it can perform better for relations in the North and sometimes for relations in the South if we consider the low values.

- The addition of stopping time in Hendaye/Irun makes it still difficult to have a better performing rail solution compared to road for relations across the Pyrenees, although distances are very long. We did not include a road time penalization during the week end (interdiction of circulation) for road.

This results point out the need to analyze more in detail the reasons for the long stopping times that cannot be only attributed to infrastructure constraints considering the importance of their variability for a given point of the network. It might also be a question of organization or availability of capacity and this will be explored in the next chapter about rail logistic practices.

This point has contributed to introduce in task 4 the concept of "ideal" situation so that impacts of different types of infrastructure constraints could be better differentiated for freight operations independently of other considerations related to importance of other types of traffic, such as passenger flows creating congestion or commercial policies of freight operators looking for correspondences between services or completion of train load.

3. Comparative analysis of logistic practices for rail and road

This second task is qualitative, and provides a first background analysis of logistic practices for road and rail in an economic and transport evolution context based on information collected in different countries, as well as upon interviews with rail operators.

In a second step, this task goes more in detail of rail logistic practices developed in order to face existing infrastructure constraints, and to provide rail services and in particular intermodal services along the corridor, that have been identified.

When coming down to concrete and detailed analysis of rail operations in order to face infrastructure constraints, it appears then necessary to build up a clear typology of types of constraints. It is based on precise criteria characterizing these constraints, in terms of tonnage, slope, length of train, measure of stopping/waiting time… Such a typology was proposed by EEIG so that corresponding operating solutions could be defined for each of these types of constraints in rail operations, not only for the specific section or node where the constraint is located but for the whole train operation along the corridor relation.

3.1 Concerning the general economic and transport context

Task 2 starts with a comparison of results of the 2004 and 2010 surveys conducted at the Atlantic border between Spain and France. Since the rail data are not available, the figures for rail have been estimated in a context where rail modal share remains at a low level and has not significantly changed between the two dates although some changes in organization are developing with the opening of the international rail market, as well as improvement in slots allocation for international transport.

In fact, this period appears more as a period of transition for the transport market

- in the expectation of more important changes to come with progress in interoperability, for what is supposed to be a promised long distance transport market for rail ;
- but at a time when the economic crisis arrived, in a context of very strong competition with road.

However, between these two dates, the Trans Pyrenean traffic along Atlantic coast kept increasing, at a lower annual growth rate, when traffic along Mediterranean axis has been decreasing significantly. Exports of Spain and Portugal towards the North of Europe stayed at a high level when imports have decreased, pointing out that even during the crisis, trade between these two countries is still competitive. During these two dates road transport remained very competitive, with low prices and increasing third countries road haulers introduction in the market. In parallel, there was a development of road logistics and implementation of new road logistic platforms well connected to infrastructures.

In rail transport some progress has been achieved in terms of organization of services and in particular for intermodal services between Spain and Portugal, especially services to ports. However, such progress across Pyrenees did not really influence the relative situation versus road across the Pyrenees. In fact improvement of intermodal services between France and Germany, for East/West relations in the Northern part of the corridor, across Paris region, was limited.

3.2 The typology of rail operations constraints (EEIG)

This typology is presented in the table below:

ATLANTIC CORRIDOR CONSTRAINTS CLASSIFICATION FOR FREIGHT TRAFFIC				
Track gauge	Iberian			UIC
Electrification	Non electrified			Electrified
Number of tracks	Single track			Double track & +
Tunnel gauge	GA	GB / IBE	GB1 / PTb+	GC
Maximum gradient by direction	> 18 °/°°	18 à 12°/°°	12 à 6°/°°	< 6°/°°
Signalisation available capacity	Manual block < 4 trains/h/dir	Block semi auto 4 to 8 trains/h/dir	Block auto 8 to 12 trains/h/dir	ETCS > 12 trains/h/dir
Maximum length of train	< 400 m	400 to 550 m	550 to 700 m	> 700 m
Maximum loading gauge / axle	18 tons	20 tons	22,5 tons	25 tons
Maximum speed	<60 km/h	60 to 80 km/h	80 to 100 km/h	> 100 km/h
Double direction signalisation	Non équiped			Equiped
Terminal availability	5 days / week 16 hours / day	5 days / week 24 hours / day	7 days / week 16 hours / day	7 days / week 24 hours / day
Terminal length of tracks	< 400 m	400 to 550 m	550 to 700 m	> 700 m

Table 2 Constraints classification for freight traffic

Once this typology formulated, it was possible:

- to produce maps for each types of operating constraints, along sections (slopes, type of gauge, and length of trains…), or upon singular points (border points, points for change of locomotive or drivers…);
- to characterize rail logistics practices, in order to face these constraints: place for change of drivers or locomotive depending upon electrification or not, adaptation of length of trains, power of locomotive (electric or diesel with 4 or 6 axes), and taking also into consideration the "coupling resistance" depending upon the slope, in parallel with the traction power.

Finally, based on the constraints typology a MCA has been conducted, combining estimated weights (expert views) of constraints for the corridor network, pointing out sections where operations constraints are the most important. However, such analysis will not inform about the global impact of the constraints of a section upon the entire train trip along the corridor, as this also depends upon the relation considered, and will appears as a major difficulty of the analysis, preventing simplification of a detailed analytic approach[4].

3.3 Comparison of rail and road costs for major relations

[4] This will appear when importance of differences of impact per corridor of types of investments are presented

The objective of this task is to estimate road and rail cost of international transport along the main O/D relations of the corridor RFC 4 and to compare for a base year, using the most recent information available.

In order to do so a general structure of a cost function will be defined, with a time and distance component, as well as a constant term when relevant (the so called "trinomial function"), which will be applied to each link and node of the corridor, for road and for rail, along international routes.

The information has been collected from different professional and official sources, as well as previous studies developed at national and international level, when available and applicable to international transport.

The deliverable is structured in two parts with estimation of international road and rail costs, which are applied to main O/D relations of the corridor so that results of comparison of these costs of transport can be presented per relation, with differentiations according to the type of product transported.

3.3.1 The road costs for international transport along the corridor

This is done in 3 steps. First homogenization of operating costs coming from different sources; second, minimization of cost; third, application to main O/D relations.

The basic assumptions for the homogenization of operating costs are:

- The kilometric costs like energy, repair and maintenance, pneumatic are proportional to the distance.
- The energy consumption is the same for all carriers, considering that we are looking to define a valid international cost on given routes
- Tolls are directly assigned to infrastructure and do not depend upon the type of relation (regional, national or international).
- Salaries are calculated per year, taking into account differences of working days, and traveling expenses is a function of operating days.
- The indirect charges of Spanish carriers are not reported in the Spanish survey of Fomento. Thus, we assume that the sum of Assurance, Tax and indirect charge are the same for French and Spanish carriers.

Concerning the minimization of road operating costs, in a context of strong international competition that pushes to select the lowest price with lower costs, the assumptions are:

- In a context with carriers of different countries, French, Portuguese, Spanish and others, the cost for an international relation will be below than the average cost of all carriers.

- Therefore, the international road cost function can be obtained from to the minimum elementary cost, per item, of the national surveys[5].

The average cost per truck/kilometer according to the distance is shown in the following graph[6]. This graph also shows the effects of driving/resting cycles upon the operation costs including the detention cost of the vehicle during the rest. The red line represents the average annual cost for international road transport, this average is in 2010, 1.05 € per truck/km.

[5] The most detailed surveys available for the corridor are the French CNR and Spanish Fomento surveys

[6] The graph is constructed with "average" speed and toll.

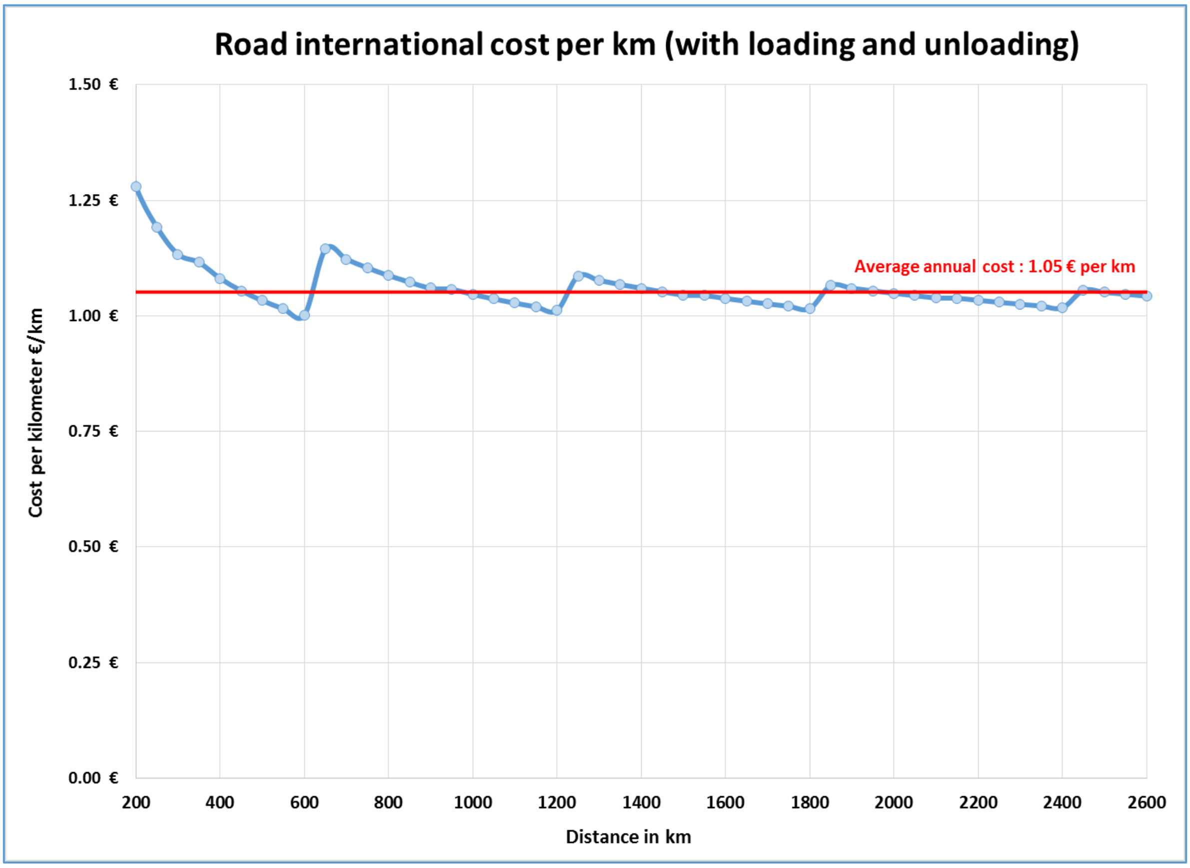

Figure 3 Road international for articulated lorry of 40 ton - cost per km

3.3.2 Rail operating cost for international transport

The definition of a cost function is essential for the study. It has to take into account, besides generic cost of operations for different types of international trains, the specific costs generated by different types of infrastructure constraints mentioned earlier if we want to have a proper assessment of their impact on costs, as well as of the impact of their relief trough infrastructure investments, for international rail operations along an O/D relation of the Atlantic corridor. Only such last estimation of rail operation can be compared to previous road costs, along a relation for different types of products.

Therefore, the estimation of the cost function will include a "generic" part, per type of train, and a specific part more directly related to specific infrastructure constraint, depending upon the type of constraint.

The basic components of the "generic" operating cost are shown in the table below per type of train, and have been estimated using different sources mentioned in the detailed report.

Item of cost	Kilometric cost	Time cost	Constant cost
Driving cost			
Traction cost			
Detention of locomotives			
Maintenance of locomotives			
Energy			
Wagons Cost			
Detention of wagons			
Maintenance			
Structure charge			
Infrastructure charge			

Table 3 Structure per item of rail generic cost

However, these basic components must be further detailed depending upon the length of the train, the type of locomotive (for power traction), the mass of locomotive and wagons (for slope and coupling resistance), the mass of goods transported… Then the generic cost function can be estimated for what has been called a "profile of train", since depending on infrastructure constraint of a section only certain profile of train can be operated. For each type of train (full train, combined transport train and automotive train) such profiles have been differentiated, with quite different impact of infrastructure constraints upon the rail operating costs of these trains, along sections and relations.

The following figure illustrates the definition of such train profiles (case of a combined transport train) to be considered in order to take into account impact of infrastructure constraints, separately along a section or through a node, and then jointly along a corridor relation.

Type of combined train	Profile of train	Number of wagons	Gross tonnage hauled + locomotive 1	Average number of loaded wagons	Mass of goods 2	Tare of conteneurs 3	Hauled net tonnage 1+2+3
300m		**14**	**370**	12.8	**251**	64	**685**
450m		**21**	**510**	19.1	**377**	96	**983**
600m		**29**	**670**	26.4	**521**	132	**1323**
750m		**37**	**830**	33.7	**665**	169	**1663**

Table 4 Profile of combined transport train

The next table provide examples of such estimation for combined transport train with different locomotive types (which is dependent upon electrification of line but also has an impact on traction power, not forgetting the coupling resistance constraint, which might eventually intervene), and also different type of operators ("historical" or "new entrant").

Type of operator	Type of traction	lenght of train	Distance between Origin and Destination - Cost in € ton.km (cents) without infrastructure charge and transhipment		
			500 km	750 km	1000 km
Historic operator	Electric	300m	4.18	3.95	3.83
		450m	3.49	3.26	3.14
		600m	3.11	2.88	2.76
		750m	2.90	2.67	2.55
Historic operator	Diesel	300m	4.71	4.47	4.36
		450m	3.94	3.70	3.59
		600m	3.51	3.28	3.16
		750m	3.27	3.04	2.92
New operator	Electric	300m	3.86	3.65	3.54
		450m	3.25	3.04	2.94
		600m	2.92	2.71	2.61
		750m	2.73	2.52	2.42
New operator	Diesel	300m	4.38	4.17	4.07
		450m	3.70	3.49	3.38
		600m	3.32	3.11	3.01
		750m	3.11	2.90	2.79

Table 5 Exploitation costs for combined transport for different profile – energy – operator and distance

Concerning specific operation cost, different types of constraints are considered.

First border crossing, for which we must differentiate costs related to transshipment, when there is a difference of gauge, and the border crossing itself, since it is assumed that stops will remain by 2030 at border crossing, at least between Spain and France.

Then as a specific cost there is the cost related to reinforcement of traction required because of ramps, depending upon the gradient class of the ramp identified in the infrastructure constraints typology.

Finally we have to take into account changes of drivers and locomotives and possible recomposition/de-composition of trains which might be required.

The results for rail operation costs along the corridor are presented in the table below for different relations of the corridors and type of trains for year 2010. This table also provides comparison between different types of trains and relations at the columns on the right where cost is expressed in cents per ton/kilometers.

		Distance - Time - Average speed			Cost in € per ton			Cost in c€ per ton.km		
Relationship		Distance (km) (1)	Time in line (h) Combined Transport (2)	Average speed in line for combined transport (km/h) (1)/(2)	Combined transport without transshipment	Full train	Automobile transport train	Combined transport without transshipment	Full train	Automobile transport train
Irun	Metz	1 167	16.6	70.3	37.9	26.0	100.1	3.25	2.23	8.57
Irun	Mannheim	1 374	21.9	62.9	46.0	32.0	121.2	3.35	2.33	8.82
Paris	Mannheim	563	6.9	82.0	18.9	12.3	50.5	3.35	2.18	8.97
Le Havre	Mannheim	793	11.6	68.4	26.9	18.1	71.5	3.40	2.29	9.02
Madrid	Mannheim	2 017	41.5	48.6	78.5	57.4	196.6	3.89	2.84	9.75
Vitoria	Mannheim	1 522	32.3	47.1	60.8	46.3	151.8	4.00	3.04	9.97
Vitoria	Metz	1 315	27.1	48.6	52.8	40.4	130.7	4.01	3.07	9.93
Madrid	Paris	1 451	30.4	47.8	59.0	43.2	145.9	4.07	2.98	10.05
Poceirao	Mannheim	2 474	51.2	48.3	104.4	72.9	245.9	4.22	2.95	9.94
Poceirao	Metz	2 267	46.0	49.3	96.3	67.0	224.8	4.25	2.95	9.92
Algeciras	Paris	2 214	48.8	45.3	94.7	65.3	230.4	4.28	2.95	10.41
Vitoria	Paris	956	21.2	45.2	41.4	32.1	101.1	4.33	3.36	10.57
Irun	Madrid	643	12.4	52.0	28.0	16.5	69.8	4.36	2.56	10.85
Algeciras	Irun	1 406	29.2	48.2	62.0	37.5	149.4	4.41	2.66	10.63
Leixoes	Mannheim	2 336	51.7	45.2	103.4	72.2	245.3	4.43	3.09	10.50
Poceirao	Paris	1 908	40.0	47.7	84.9	58.7	195.2	4.45	3.08	10.23
Leixoes	Paris	1 770	40.5	43.7	84.0	58.0	194.6	4.74	3.28	10.99
Poceirao	Madrid	877	19.3	45.4	46.5	27.4	103.9	5.30	3.13	11.85
Leixoes	Vitoria	814	19.4	42.0	46.1	27.1	104.2	5.66	3.33	12.80
Madrid	Leixoes	739	19.8	37.3	45.5	26.7	103.2	6.16	3.62	13.97

Table 6 Rail cost by type of train in 2010

These results point out for these base year three major types of relations:

- **First** relations from Irun to the north of France and north of Europe, and relations between France and Germany with better operating performances related to:

    - The differences of length of trains for combined transport and automobile transport train since trains of 450m have been considered in Portugal and Spain and trains of 600m in France and Germany.
    Such differences are not made for the full trains, whose length is 450m at maximum; consequently railways costs, per ton, for the various OD are more homogeneous between the north and south of the Pyrenees
    - The average speed which is higher north of the Pyrenees, despite sometimes significant wait times especially for the crossing of Ile de France
    - For combined transport, the most efficient rail relationship7 appears to be between Irun and Metz with a cost of 3.25 c€ per ton.km for a distance of 1167 km and a travel time of 16.6 hours8, with an average speed close to 70 km/h.
    - The cost of the relations between Le Havre or Paris and Mannheim are close to 3.40 c€ ton per km although these relations are with relatively short distances.
    - The cost for full train is between 2.20 and 2.30 c€ per km. For the automobile transport train, the cost is less than 9 c€ per ton.km.

- A **second** group is composed of international Trans Pyrenean relations requiring today transshipment operations at the border.

  The cost of this relations is close to or higher than:

    - 4 c€ per ton.km for the combined transport
    - 3 c€ per ton.km for full train
    - 10 c€ per ton.km for automobile transport train.
    - The impact of transshipment is particularly significant for full trains due to the large share of the wagon cost and the immobilization during the transshipment. This effect is reinforced by the fact that we consider similar length of trains, for the full train, on both sides of the Pyrenees.
    - For relationships requiring reduced traction reinforcements or on long-distance routes, rail costs in Spain are similar to those recorded in France like Irun Madrid or Algeciras Madrid.
    - It can be also noted that, the impact of transshipment is relatively lower for automobile transport trains.

- **Finally**, when considering all types of traffic, it seems that the highest rail costs occur for international relations with Portugal in particular from France and Spain. These results can be explained by:

    - The weak performance in terms of speed of train paths; this low speed increases the cost of immobilization of rolling stock and driving costs, and this speed effect is especially important for traffic of automobile transport train.
    - The network constraints between Pampilhosa and Miranda del Campo, which limit the performance of rail services because of traction reinforcements required on fairly long distances and lack of electrification of the line between Vilar Formoso and Miranda del Campo.

[7] Considering only the OD on TMS study.

[8] Without loading and outloading.

3.3.3 Comparison between Road and Rail cost: examples on combined transport

From the former detailed operating cost analysis, it is then possible to compare rail and road cost performances per relation and type of goods, for the base year 2010, taking into account the impact of infrastructure constraints. In this synthesis, an illustration of such results is provided for combined transport, which is in close competition with road, for the most important volumes of traffic along the Atlantic corridor.

The graph below illustrates[9] a comparison between road costs and the cost for combined transport including pre and end haulage, for main OD relations of the TMS study[10]. On the graph an additional margin of 20% for costs has been represented for illustration to better appreciate order of magnitude of the differences, pointing out situations were a difference above 20% exists.

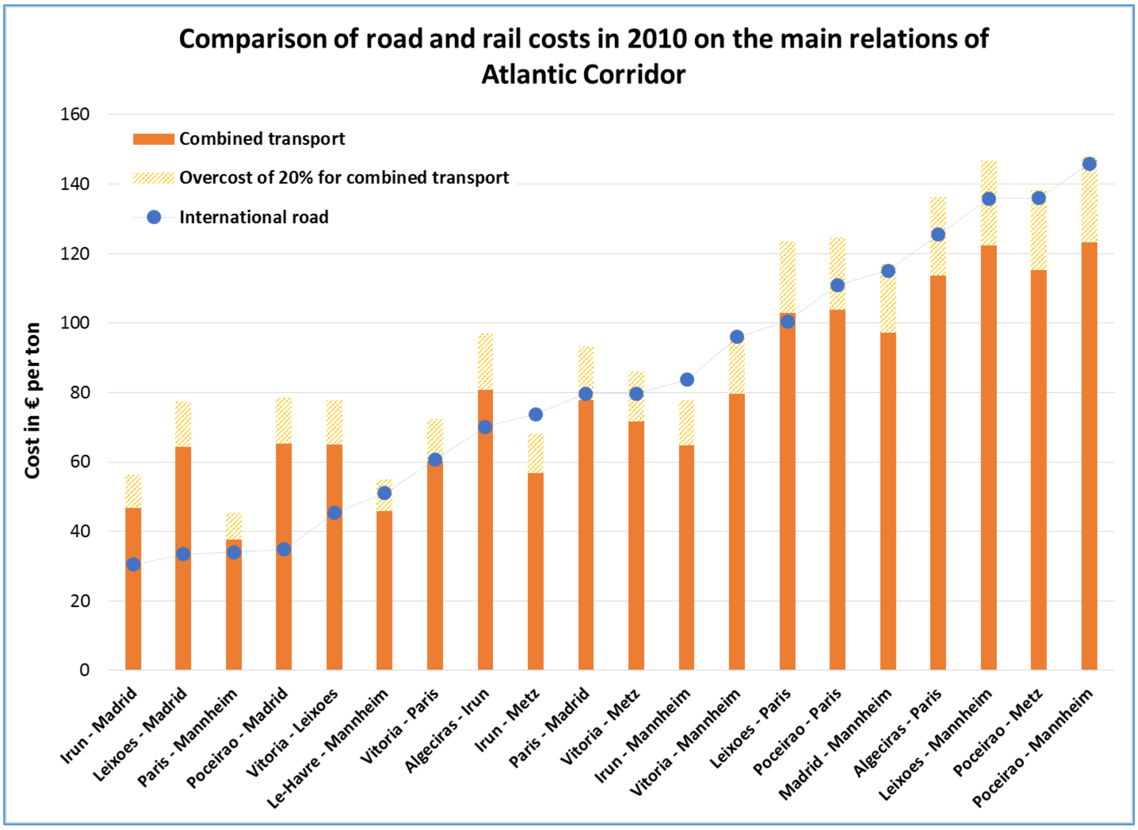

Figure 4 comparison of road and rail cost in 2010 on the main relations on Atlantic Corridor

From these results, several comments can be made:

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[9] Details of costs per relation and costs components are provided in the report

[10] The cost of pre and post routing are here evaluated relatively simply with:

- An average distance of 40 km by extremity, this segment generates a detour of 20 km per extremity
- An average speed of 67 km/, value of CNR
- An average kilometric cost of 1.13 € per lorry.km with an empty return rate of 25% (which means multiplication by 1.25 of running costs).
- A waiting time of 45 minutes of the lorry and driver on the intermodal node.
- Transshipment cost of 30 € per movement.
- The post and pre-shipment, finally, is considered here as a constant equivalent to 107 € for each extremity.
- Finally we have integrated the cost and the time of loading and unloading of road in the end and pre-haulage; on both modes, this cost is identical.

- In a general way, railway relations with Portugal are generally underperforming as regards international road transport especially for relatively short distance relations between Portugal and Spain. Indeed several factors intervene such as:

    - Infrastructure constraints (non-electrification)
    - Operational constraints (traction reinforcement)
    - Morphology of the respective networks, which affect rail distances that are significantly longer than road distances.

  The railway cost per ton is 64.4 € for the relation Leixoes - Madrid while it is just of 33.5 € per ton by the road. The distance by rail is 44% higher than the distance by road, travel time is extremely higher (+150%, considering the immobilization of 6h on the terminal and the low speed in line) and the cost is 92% higher (distance, traction reinforcement on long distance, thermic traction between Vilar Formoso and Medina del campo).

  The case of the relation Madrid-Irun is different. The rail performance is relatively good, but the distance of the road route is short (less than 500 km) and more direct than the rail route.

- Relations between the Iberian Peninsula and France show similar performances between road and railway as it is the case for the relations Vitoria-Paris, Madrid-Paris. However, in terms of distances covered, rail transport appears to be significantly better performing than the road. The main handicap for rail versus road is mainly due to the change of gauge at the border and to rail operations which take place at the border related to train length, traction reinforcement and waiting time.

- For two relations the rail costs are even lower by 20% or more than road costs: these are Irun - Metz and Irun – Mannheim. This is confirmed by the fact that combined transport services do already exist from Germany to the Spanish border, from Koln, Ludwigshafen or Saarbrucken to Irun, as pointed in the analysis of logistic practices in the review of existing services.

4. International transport plans and evaluation of scenarios per type of infrastructure investments

The objective of task 4 is to measure the impact of infrastructure investments upon performance of rail operations along the corridor. Such investments have been identified and updated after a review of International transport plans achieved by the different partners of the consortium in their respective countries, in relation with EEIG national representatives, taking also into account previous documents such as CID documents of RFC4 or IDOARC study, which also report about such investments. Note that such investments are also presently reviewed, for all modes, in the corridor studies conducted by the European Commission (Core Network Corridor studies, including Atlantic Corridor 7).

However, the objective here is not to evaluate the impact of infrastructure of each of these investments, located on specific sections or nodes. It is in fact to estimate the impact of different "types" of investments, implemented along the rail freight Atlantic corridor upon rail operations costs for the chosen horizon of 2030.

Therefore such "types" of investments had to be defined and aggregated along the rail corridor in order to be able to compare their relative impact upon the operating costs along the main relations selected of the corridor, for measures of impacts that will undoubtedly differ from one relation to another. In order to do that, the detailed cost analysis of rail operations of the previous task 3 is applied, using distinction between so called "generic" and "specific" costs which allows to identify precisely costs related to different "types" of infrastructure constraints, which will be used to define "types" of investments.

The necessity to isolate properly impact of different "types" of investments upon operations costs requires a common base reference of operating performance: this base is what has been called an "ideal" situation, without infrastructure investments, resulting from an "optimization" of management of existing infrastructure constraints, and excluding other types of constraints related to capacity or commercial strategies[11]. In fact the results will show that it is certainly more appropriate to talk about "ideal situations" (in plural) since the most relevant solutions to improve rail operations will very much depends upon the transport relation considered between two nodes of the corridor, and obviously, upon the type of train.

The deliverable 4 is structured as follows:

- The definition of the "ideal" situation for base year, which will be used as reference for rail operating performances along main O/D relations of the corridor
- The definition of infrastructure investments scenarios for the rail corridor and their respective impact on rail operation costs.
- The relative improvement of rail operation costs of types of investments against road for corridor relations

[11] See introduction. Since congestion is most of time related to passenger traffic in dense area (these are more depending upon rules of priority or practices which are out of the scope of this study), and commercial strategy might induce supplementary waiting time related to optimization of loading of trains, or coordination of services provided to the client (more relevant to specific business case studies). We note that in the recent years there has been clearly an increasing difficulty for freight trains to obtain performing slots along the corridor, mainly due to increase of rail passenger transport and in particular to increase of regional passenger services, which are most of the time privileged in the assignments of slots at peak periods during the day; this generate supplementary waiting and stopping time along rail routes of the "corridor" as pointed in task 2.

4.1 Definition of "ideal" situation and impact on rail operations performances.

4.1.1 The improvement of rail operations and definition of "ideal" situation

The definition of "ideal" situation, or "ideal transport plan", starts from the observation that there are along the corridor "singular "points for rail operations where the rail operating constraints apply.

These points have been identified and they are mainly:

- Cross-border points with a stop at the border between Spain and France, Spain and Portugal, with a difference of gauge between France and Spain.
- Points for change of locomotive or driver due to electrification or driving/resting cycles for the driver
- Points of reinforcement of traction due to slope
- Points of decomposition/ decomposition of trains due to train length constraints

In some of these points different types of operating constraints are taken into account, at the same time, as for example changing of locomotive and drivers, reinforcement of traction and change of locomotive. Even transshipment of goods with change of locomotive and driver, as it is the case between at the cross border point between France and Spain. Therefore, there are solutions of combination of such operations in order to improve rail operation along an O/D relation of the corridor.

The definition of an "ideal" situation or "ideal" transport plan will then concern the localization of relays for driver and locomotive, as well as the composition/profile of the train, the type of locomotive/power of traction (which might require use of two locomotives), and waiting time associated to operation taking place in "singular points" of the corridor. Such transport plan will depend on type of train (combined transport, full train for bulk transport, automotive train), leaving options open as far as traction is concerned, as regards type of locomotive (with possible diesel traction even when sections are electrified), power of traction (single or double locomotive) as regards the weight and length of train….

The analysis is first conducted at country level, with more infrastructure constraints existing in Spain and Portugal mainly because of profile of the line having more sections with of important ramps along a given route. Then a synthesis is done per type of train[12] at the level of the entire corridor, as illustrated on the map below for combined transport, where singular points are represented[13].

The basis hypothesis of such transport plan are:

- The average speeds are evaluated considering 90% of this maximum freight speed, per section with for Spain and Portugal 70% of maximum speed for passenger.
- The maximum average speed is limited at 100km/h,
- The maximum driving time is 8 hours per day and 4h for operations in round trip. However, to ensure more robustness to the system, we have also considered travel time of around 6h
- Round trips limit situations of "sleeping out"
- With a time for change of locomotive of 30 minutes, and only 5 minutes for optimized waiting time.

[12] With details for diesel option mentioned earlier, as well as options between single/double traction with shorter/longer trains affecting differently operating costs of different relations

[13] Same types of maps are provided for other type of trains as well as for diesel option in the reports.

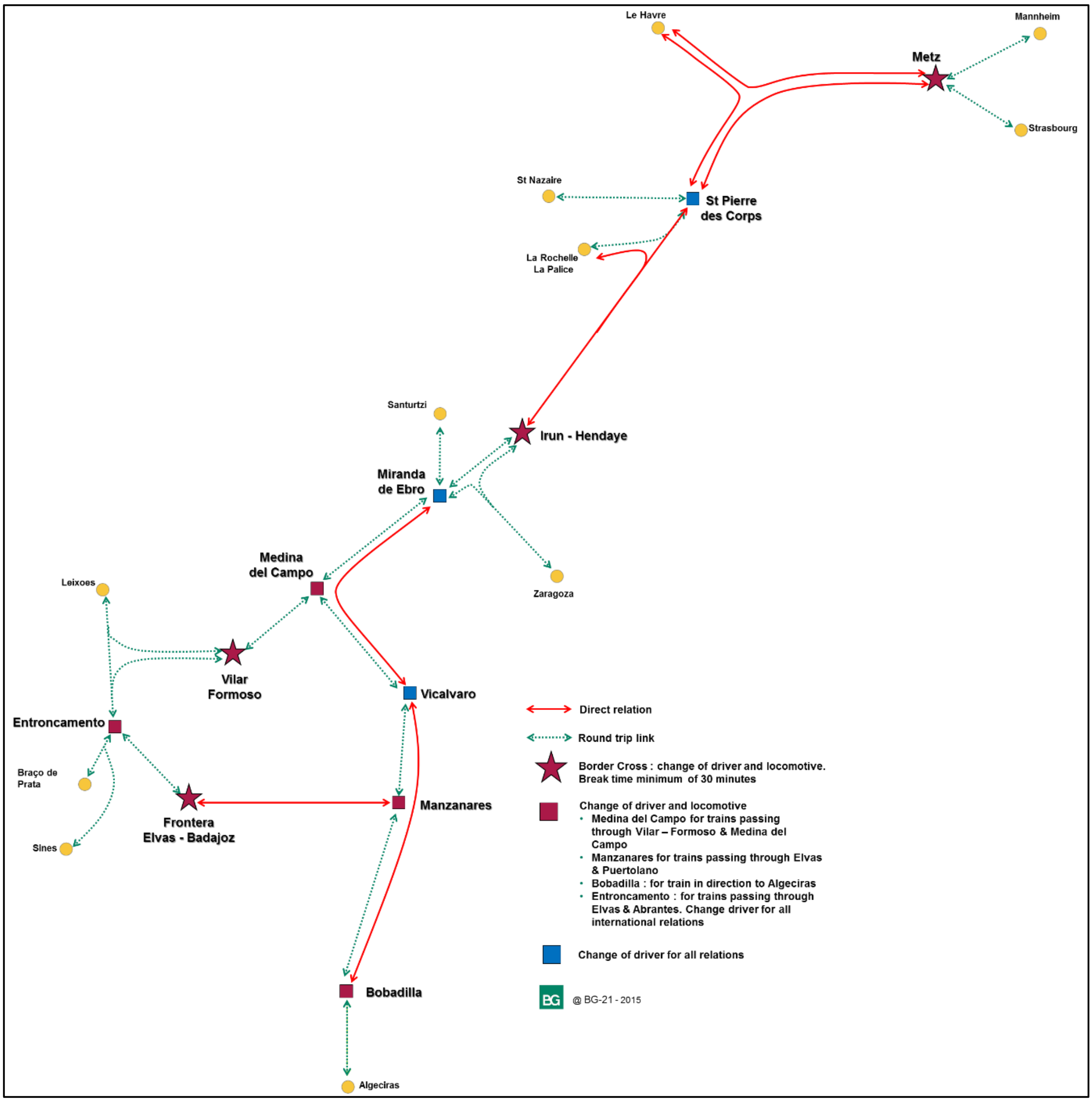

Figure 5 Rail transport plan on the Atlantic Corridor with change locomotive Electric / Diesel

This analysis has shown the multiplicity of interrelations between infrastructure constraints and the variety of operating solutions that have to be considered. They will have different impact for different analyzed relations between nodes of the corridor, including internal relations, thus providing a very detailed diagnosis of operations within the entire corridor.

As stressed before, from a technical point of view, the infrastructure constraints had to be introduced at the level of each section of the corridor, keeping track of these constraints along all the relations between nodes, per types of trains. In doing so it appeared that best solution is very specific to type of relation and type of train considered, and this diversity of situations does not allow introducing a priori simplifications, without impacting the results of choice of "best solution" as far as rail costs are concerned.

It has also to be recalled that, among the infrastructure constraints, the resistance of coupling had to be introduced in the maximum load of trains, and it appeared that such constraint plays sometimes a significant role, for high gradient slopes, occurring mainly in Spain and Portugal.

More specifically, for all the relations and types of trains, different operations solutions to face infrastructure constraints have been analyzed, such as:

- Single electric-4 axles traction in Iberia on electrified network. This situation applies generally to short trains, especially in Iberia due to the fact that several sections are limited to a maximum of 13 wagons.

- Single diesel-6 axles traction in Iberia on electrified network. A locomotive diesel-6 axles allows to increase the number of wagons pulled with one locomotive in relation with the increase of power. This solution appears generally as the best solution for international relations, especially between Portugal and Spain where there are non-electrified sections, which increases the efficiency of this solution. However the relevance of this solution depends on
    - the increase of charge per train for different OD relations, in relation with the power of the locomotive (at least 3 additional wagons for direct train),
    - the additional cost of use of the diesel locomotive (energy, maintenance).

- Generalization of double traction: to be effective, this solution implies an increase of 60% of the number of wagons transported. However, because of the limit of stress on the couplings, this increase is rarely possible in Iberia. Therefore, this solution is not considered in this study.

- Punctual use of double traction when the number of wagons does not exceed 13 with single electric traction. Results show that the reinforcement of traction may be efficient in several cases but each situation is different, the additional costs of double traction having to be compensated. Then the relevance of double traction depends upon :
    - The increase of load of train per OD relation
    - The distance covered with double traction and single traction before and after the reinforcement of traction…

- In a general way, along the Atlantic corridor, a reinforcement of traction on a part of the network involves another reinforcement of traction on another part of network. For example, to extend the benefits of a reinforcement of traction between Madrid and Avila to France or Germany, it is also necessary to perform a double traction between Tolosa and Brinkola. Otherwise, the silhouette of train is defined by the constraint of mass limit on this former section. Situations, where the double tractions are the most efficient solutions, are finally a limited number in Iberia due to successive and frequent slopes along the routes.

Major results at this stage can be formulated as follows:

a) In a general way, the passage via Vilar Formoso represents the main route on the Atlantic corridor, especially for international relations between Portugal and France or between Portugal and Madrid. The passage through Badajoz appears more efficient for relations between an area south of Entroncamento and an area south of Villacanas / Manzanares in Spain.

b) For combined transport and more particularly for automobile transport train, the major constraint is located in Iberia, imposing a limit to the length of train. For light trains, such as for example automobile transport train, the limit of length is the only infrastructure constraint to be considered on the network. It is even possible to lengthen the trains without reinforcement of traction, because of the low mass of the trains.

c) For combined transport, the infrastructure constraints on train operations, including impact upon length of trains, are distributed over the all networks of Portugal and Spain, with succession of slopes along main relations. The result is that, except between Algeciras and Bobadilla where gradient is particularly high, the reinforcement of traction is not an efficient solution for combined transport.

d) Also for this type of trains, electric traction is usually the most efficient in terms of cost. There are only a few OD relations for which, diesel traction along the whole route, allows to reduce the rail cost. It is essentially relations via Badajoz between southern Portugal and southern Spain, because of non-electrified sections between Abrantes and Puertollano.

e) In France and Germany, the level of constraint is lower than in Iberia for this type of train. On the main routes, there is only one section where the mass of train is the first constraint: it is the section between Hendaye and Bayonne. However, this limit has generally no impact on the trains' "silhouette" considering that the level of constraints is stronger in Spain and Portugal. The only impacts are concentrated on relations for which Irun-Hendaye is the origin or final destination.

f) For direct train, the situation is more complex because of the constraints concerning the maximum tractable mass. Generally in Iberia and sometimes also in France and Germany, the first constraint is the limit of mass tractable by one locomotive, the second one is the stress limit on the coupling and the third constraint is the limit of length.

Once the ideal situation is defined, it is then possible to estimate the reduction of costs related to improvements of rail operations due to better organization of transport plan, along main relations and routes of the corridor, without infrastructure investments, which means with the same infrastructure constraints.

Other results were obtained showing that such improvements are already very relevant for many relations, providing a better competitive position of rail against road.

4.1.2 Possible improvements of rail performance versus road, within present network

At this stage the rail costs correspond to an "optimized" cost which might differ from current rail costs. For road costs, it should be remembered that the cost is not proportional to distance. Indeed the driving cycles are taken into account and introduce "threshold" effects in transport costs. Furthermore, there might be significant differences between road and rail routes depending upon the O/D relation[14].

The results are then produced for all relations of the corridor, and can be summarized as follows:

a) For international relations[15], the combined transport train appears better performing than road over longer distances for relations between France and Portugal or north of France and Spain, which means

[14] For example the rail route between Abrantes and Linares goes through Manzanares but by road the route goes through Cordoba. Such differences might complicate the interpretation of the cost results differences obtained. Another example is the significant difference of road and rail routes distances between Madrid and Irun.

[15] Incidentally we note that road is the best solution for national relations in Portugal and in a large part of Spain. Exceptions are only relation between nodes in País Vasco and an area south to Manzanares. In France, combined transport appears more performing than road for long distance relations such as:

- Relations between Lorraine/Alsace (& Germany) with the regions Aquitaine & Poitou-Charentes (La Rochelle) for a broader spectrum of relations, with bigger differences than previously when analysis was conducted with current logistic practices observed. Indeed,

- The rail appears to be the best solution for the majority of relations between France and Portugal, excepted for relations between Leixoes-Porto-Gaia and the region Aquitaine: this is due to the strong constraints on the limit of length of train between Ovar and Porto, constraints resulting in an increase of the rail cost per ton transported.
- For the relations between Portugal and Spain, the combined transport is a better solution for relations between an area situated north and east of Miranda de Ebro and a large part of Portugal (south of Gaia), and for relations from an area north of Pampilhosa and an area around Manzanares[16].
- For a large part of relations between France and Spain, it appears that the combined transport is a better solution, excepted for relations between a region south of Orleans and north of Spain (País Vasco) or south of Poitiers and the entire Spanish network north of Madrid.
- However, for the relation Paris to Madrid, the differential of cost, between rail and road cost, is 13.3 € per ton transported, corresponding only to a difference of 18% in costs.

b) For direct train, the costs are evaluated from a railway siding to a railway siding, in other words without terminal transshipment. In this case, the performance of railway solution appears quite competitive despite transshipment between France and Spain. However, we make the assumption that the operator has sufficient demand of transport to complete the trains. This assumption of "massification" is indeed integrated in the evaluation of rail costs and this is why the railway solutions perform generally better than road solutions. For direct trains transporting heavy products, such as raw materials or building materials, which are low value products, it must also be stressed that the transport distance is generally short, and that for longer distances products which are classified in heavy products categories are indeed often higher value product of the economic branch considered[17].

In any case, the following results show that direct train rail solutions are generally better than road solutions, even for short distances, as a result of the remark concerning sidings. However, the existing infrastructure constraints (especially in Iberia) reduce the attractiveness of rail solutions for direct train in several relations and in particular for the following ones:

- Between southern part of Spain (Cordoba – Bobadilla – Algeciras) and region of Poceirao – Setubal – Sines
- Across the border between France and Spain, due to the necessity of transshipment
- Locally, between Vitoria and Alsasua and Tolosa

c) Concerning automobile transport train, a strong constraint is the length of the train. In France and Germany, the length limit is around 740-750m, excepted for sections Metz Stiring Wendel (710m) and Angers – St Pierre des Corps (680m). In Iberia, this constraint is more restrictive with sections allowing only trains under 500m, between 500 and 550m or over 550m.

- Relations between Lorraine/Alsace (& Germany) with Le Havre and Rouen
- Relations between Lorraine/Alsace (& Germany) with Saint Nazaire in Pays de la Loire
- And, rail and road cost are relatively close for all relations with Ile de France and the north of Region Centre.

[16] Low road accessibility and border of driving cycle from Portugal for node like Manzanares, Puertollano or Linares. The accessibility of Madrid or Cordoba are better. At south, there is the increase of rail cost between Bobadilla and Algeciras due to slopes.

[17] For example, "building materials" category will concern more semi-manufactured construction elements than minerals products or sand which are not transported over long distances. To some extend it is the same thing for agricultural products or some chemical products

Therefore, for this category of train, it very much depends upon the trains' silhouette and the maximum length authorized along the route. This is why the road solutions are better for Lisboa/Apolonia (limit of 340m) or for relation between Algeciras, Bobadilla, Cordoba and the south of Portugal (limit of 400m between Abrantes and Elvas).

To conclude, at this stage of analysis, the rail can be a solution better for the international relations between France and Spain or Portugal. For some relations the constraints of length may change this conclusion, for relations from Lisboa or Porto or when the road route is more direct (example from La Rochelle/ Saint-Nazaire to Madrid/Irun). Between Spain and Portugal, rail solutions can perform better for relations from south of Ovar in direction to the Pais Vasco in Spain.

In contrast, the road solutions are better solution in Portugal where rail is penalized by the successive limit of length of train imposed, especially between Leixoes and Ovar (400m), Entroncamento and Elvas (400), the exit of Sines (480m). In Spain, rail solutions are better than road solution for long distance relation from north of Spain to the south. The case of Zaragoza going to Madrid is special, given that the more direct routes for rail and road don't use the Atlantic Corridor. In France and Germany, the fact that the length of train is over 700m induces higher performance of rail solutions as regards road.

In a general way, the rail is better for the international relations between France and Spain or Portugal. However, the constraints of length may affect this result, for relations from Lisboa or Porto or when the road route is more direct (example from La Rochelle or Saint Nazaire, Madrid-Irun). Between Spain and Portugal, rail solutions are more relevant for relations from south of Ovar in direction to the País-Vasco in Spain.

4.2 The definition of infrastructure investments scenarios for the rail corridor, and their impact on rail operating costs

The definition of investments scenario is based:

- On a review of international transport plans obtained for each of the countries of the corridor by partners of the consortium as well as previous studies and in particular TMS and IDOARC studies for the characterization of the investments projects.
- On an aggregation of projects within scenarios corresponding to different types of infrastructures constraints mentioned earlier.

The table below defines 9 scenarios corresponding to different types of investments aiming at improving constraints in rail operation along the corridor, and including a "do nothing" scenario and a scenario with all type of investments achieved by 2030 along the corridor.

Scenario	Name	Generation matrix	Rail operatings	Y Basque	New line Lisbon/Madrid	Electrification	Lenght of train	Gradients	UIC	ERTMS
Scenario 1	No investment	2030	Ideal Situation × 3 freight types	Basis network (1)	Basis network	Basis network	Basis network	Basis network	Basis network	Basis network
Scenario 2	Y Basque	2030	Ideal Situation × 3 freight types	New lines in Y Basque in UIC gauge	Basis network	Basis network	Basis network	Basis network	Basis network	Basis network
Scenario 3	Lisbon/Madrid	2030	Ideal Situation × 3 freight types	Basis network	New line between Lisbon and Madrid via Caceres in Iberian gauge	Basis network	Basis network	Basis network	Basis network	Basis network
Scenario 4	Electrification	2030	Ideal Situation × 3 freight types	Basis network	Basis network	Electrification between Vilar Formoso - Medina del Campo & Algeciras - Bobadila	Basis network	Basis network	Basis network	Basis network
Scenario 5	Lenght of train	2030	Ideal Situation × 3 freight types	Basis network	Basis network	Basis network	750m on all Spain and Portugal	Basis network	Basis network	Basis network
Scenario 6	Gradients	2030	Ideal Situation × 3 freight types	Basis network	Basis network	Basis network	Basis network	New profile of line between Pampilhosa & Vilar Formoso	Basis network	Basis network
Scenario 7	Extension UIC	2030	Ideal Situation × 3 freight types	Basis network	Basis network	Basis network	Basis network	Basis network	Global extension on Spain and between Pampilhosa and Vilar Formoso	Basis network
Scenario 8	ERTMS	2030	Ideal Situation × 3 freight types	Basis network	Basis network	Basis network	Basis network	Basis network	Basis network	ERTMS on all network
Scenario 9	All Investments	2030	Ideal Situation × 3 freight types	New lines in Y Basque in UIC gauge	New line between Lisbon and Madrid via Caceres in Iberian gauge	Electrification between Vilar Formoso - Medina del Campo & Algeciras - Bobadila	750m on all Spain and Portugal	New profile of line between Pampilhosa & Vilar Formoso	Global extension on Spain and between Pampilhosa and Vilar Formoso	ERTMS on all network

(1) - Existing network

Table 7 Investments scenarios

The results of the impact of each of the scenarios on the rail operating costs, expressed in gain of € per ton and relation is estimated in the table below, for combined transport, the same type of results being also provided for other types of trains.

GAIN In € per ton for continental combined transport	*Base Rail Scenario 2030 : international transport plan*	International Transport Plan and Investment Scenarios - 2030							
		Y Basque	Sines-Lisbon/Madrid	Electrification	Length of train	Gradient	Extension UIC	ERTMS	All investment
Vitoria - Bordeaux	*32.6 €*	7.0 €	0.0 €	0.0 €	0.3 €	0.0 €	5.7 €	0.5 €	7.2 €
Paris - Mannheim	*29.6 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.2 €	0.2 €
Madrid - Leixoes	*39.9 €*	0.0 €	0.0 €	1.3 €	2.7 €	0.0 €	0.0 €	0.6 €	4.3 €
Vitoria - St Pierre des Corps	*41.9 €*	8.4 €	0.0 €	0.0 €	1.6 €	0.0 €	5.7 €	0.5 €	8.6 €
Lisboa - Madrid	*40.7 €*	0.0 €	4.2 €	1.1 €	0.5 €	0.5 €	0.0 €	0.6 €	4.5 €
Leixoes - Vitoria	*41.4 €*	0.0 €	0.0 €	1.3 €	2.7 €	0.0 €	0.0 €	0.7 €	4.6 €
Madrid - Sines	*46.0 €*	0.0 €	8.9 €	1.1 €	0.0 €	0.0 €	0.0 €	0.6 €	9.2 €
Madrid - Bordeaux	*44.9 €*	1.1 €	0.0 €	0.0 €	0.0 €	0.0 €	5.7 €	0.6 €	7.1 €
Le Havre - Mannheim	*35.3 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.2 €	0.2 €
St Pierre des Corps - Mannheim	*35.5 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.2 €	0.2 €
Vitoria - Sines	*47.3 €*	0.0 €	0.0 €	1.1 €	0.0 €	0.0 €	0.0 €	0.6 €	2.6 €
Vitoria - Paris	*49.0 €*	9.4 €	0.0 €	0.0 €	2.5 €	0.0 €	5.7 €	0.5 €	9.6 €
Leixoes - Bordeaux	*59.8 €*	1.2 €	0.0 €	1.3 €	4.1 €	0.0 €	5.9 €	1.5 €	13.5 €
Madrid - St Pierre des Corps	*54.3 €*	1.1 €	0.0 €	0.0 €	0.0 €	0.0 €	5.7 €	0.6 €	7.1 €
Algeciras - Irun	*54.3 €*	1.1 €	0.0 €	1.1 €	0.0 €	0.0 €	0.0 €	0.3 €	2.4 €
Lisboa - Bordeaux	*59.1 €*	1.1 €	0.0 €	1.1 €	0.3 €	0.8 €	5.8 €	1.3 €	10.1 €
Irun - Metz	*44.0 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €
Bordeaux - Mannheim	*43.6 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.2 €	0.2 €
Vitoria - Metz	*58.2 €*	10.6 €	0.0 €	0.0 €	3.6 €	0.0 €	5.7 €	0.5 €	10.9 €
Madrid - Paris	*61.4 €*	1.1 €	0.0 €	0.0 €	0.4 €	0.0 €	5.7 €	0.6 €	7.1 €
Irun - Mannheim	*49.7 €*	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.0 €	0.2 €	0.2 €
Leixoes - St Pierre des Corps	*70.8 €*	1.2 €	0.0 €	1.3 €	6.2 €	0.0 €	5.9 €	1.5 €	15.1 €
Lisboa - St Pierre des Corps	*68.9 €*	1.1 €	0.0 €	1.1 €	1.2 €	1.0 €	5.8 €	1.3 €	10.5 €
Vitoria - Mannheim	*64.4 €*	11.5 €	0.0 €	0.0 €	4.4 €	0.0 €	5.7 €	0.8 €	11.9 €
Leixoes - Paris	*79.1 €*	1.2 €	0.0 €	1.3 €	7.8 €	0.0 €	5.9 €	1.5 €	16.6 €
Lisboa - Paris	*76.4 €*	1.1 €	0.0 €	1.1 €	2.0 €	1.2 €	5.8 €	1.3 €	10.9 €
Madrid - Mannheim	*77.2 €*	1.1 €	0.0 €	0.0 €	1.6 €	0.0 €	5.7 €	0.9 €	8.2 €
Algeciras - Paris	*83.4 €*	1.1 €	0.0 €	1.1 €	0.0 €	0.0 €	5.7 €	0.9 €	8.4 €
Lisboa - Metz	*86.2 €*	1.1 €	0.0 €	1.1 €	3.0 €	1.4 €	5.8 €	1.3 €	11.3 €
Leixoes - Mannheim	*97.5 €*	1.2 €	0.0 €	1.3 €	11.4 €	0.0 €	5.9 €	1.8 €	20.3 €
Lisboa - Mannheim	*92.9 €*	1.1 €	0.0 €	1.1 €	3.6 €	1.6 €	5.8 €	1.6 €	11.9 €

Table 8 Effects Investments scenarios on cost (combined transport)

This shows how important the Y Basque scenario is for relations between Vitoria and nodes north of the Pyrenees such as Bordeaux, Paris, Metz and Mannheim, with a gain between 7 and 11, 5€ per ton. Also important are the gains of the "extension of UIC scenario with around 6€ for all relations coming from Spain and Portugal to the north of Pyrenees (except for relations from/to Irun which is a border point).

The gains for the "length of train scenario are much more variable, from 2 to 14€ per ton depending on the relation, with highest level for relations with Portugal, but also high for relations from Madrid to Paris or Mannheim between 3 and 5€.

The electrification scenario does not appear to bring much rail operating gain, only around 1€ per ton and per relation when relevant, and ERTMS gains are also quite limited per ton and relation.

The "all investments scenario" does bring significant gains per ton from 5 or 6€ per relation and ton transported up to more than 20€ for longer relations such as Leixoes-Manheim, with an effect certainly related to distance, but with also quite important difference between relations, independently of the distance.

The next table provides results in % as regard the total rail cost of the relation, showing relative impact per types of investments which can be very significant, with % above 20% but also a large range of values between 0% and this higher value, depending on the type of relation.

GAIN In % for continental combined transport	GAIN In € per ton for continental combined transport							
	Y Basque	Sines-Lisbon/Madrid	Electrification	Length of train	Gradient	Extension UIC	ERTMS	All investment
Vitoria - Bordeaux	21%	0%	0%	1%	0%	18%	2%	22%
Paris - Mannheim	0%	0%	0%	0%	0%	0%	1%	1%
Madrid - Leixoes	0%	0%	3%	7%	0%	0%	2%	11%
Vitoria - St Pierre des Corps	20%	0%	0%	4%	0%	14%	1%	20%
Lisboa - Madrid	0%	10%	3%	1%	1%	0%	1%	11%
Leixoes - Vitoria	0%	0%	3%	6%	0%	0%	2%	11%
Madrid - Sines	0%	19%	2%	0%	0%	0%	1%	20%
Madrid - Bordeaux	2%	0%	0%	0%	0%	13%	1%	16%
Le Havre - Mannheim	0%	0%	0%	0%	0%	0%	1%	1%
St Pierre des Corps - Mannheim	0%	0%	0%	0%	0%	0%	1%	1%
Vitoria - Sines	0%	0%	2%	0%	0%	0%	1%	5%
Vitoria - Paris	19%	0%	0%	5%	0%	12%	1%	20%
Leixoes - Bordeaux	2%	0%	2%	7%	0%	10%	2%	23%
Madrid - St Pierre des Corps	2%	0%	0%	0%	0%	11%	1%	13%
Algeciras - Irun	2%	0%	2%	0%	0%	0%	1%	4%
Lisboa - Bordeaux	2%	0%	2%	0%	1%	10%	2%	17%
Irun - Metz	0%	0%	0%	0%	0%	0%	0%	0%
Bordeaux - Mannheim	0%	0%	0%	0%	0%	0%	1%	1%
Vitoria - Metz	18%	0%	0%	6%	0%	10%	1%	19%
Madrid - Paris	2%	0%	0%	1%	0%	9%	1%	12%
Irun - Mannheim	0%	0%	0%	0%	0%	0%	0%	0%
Leixoes - St Pierre des Corps	2%	0%	2%	9%	0%	8%	2%	21%
Lisboa - St Pierre des Corps	2%	0%	2%	2%	1%	8%	2%	15%
Vitoria - Mannheim	18%	0%	0%	7%	0%	9%	1%	19%
Leixoes - Paris	2%	0%	2%	10%	0%	7%	2%	21%
Lisboa - Paris	1%	0%	1%	3%	2%	8%	2%	14%
Madrid - Mannheim	1%	0%	0%	2%	0%	7%	1%	11%
Algeciras - Paris	1%	0%	1%	0%	0%	7%	1%	10%
Lisboa - Metz	1%	0%	1%	3%	2%	7%	2%	13%
Leixoes - Mannheim	1%	0%	1%	12%	0%	6%	2%	21%
Lisboa - Mannheim	1%	0%	1%	4%	2%	6%	2%	13%

Table 9 Relative effects Investments scenarios on cost (combined transport)

4.3 The relative improvement of rail operation costs of types of investments against road for corridor relations

This former table was a good transition to assess the improvement of rail competition versus road per relation, taking into account the fact that when comparing to present logistic rail practices, these improvements due to types of investments have to be added to the differences pointed out in the analysis of "ideal situation". In both cases the impacts are also depending very much on the types of relations considered and types of trains. In this synthesis report only results of combined transport train are presented.

The next tables presents such comparison with road, again only for combined transports[18], and recall order of magnitude of difference in rail costs, estimated between current practices and "ideal" situations.

[18] For other types of trains results are in reports.

In € per ton for continental combined transport	Road Cost (40 Tons articulated lorry)	Road Cost 2030 (40 Tons articulated lorry)	Base Rail Scenario 2030 : international transport plan	International Transport Plan and Investment Scenarios - 2030							
				Y Basque	Sines-Lisbon/Madrid	Electrification	Length of train	Gradient	Extension UIC	ERTMS	All investment
Vitoria - Bordeaux	16.3 €	18.3 €	32.6 €	25.6 €	32.6 €	32.6 €	32.3 €	32.6 €	26.8 €	32.0 €	25.4 €
Paris - Mannheim	27.9 €	31.0 €	29.6 €	29.6 €	29.6 €	29.6 €	29.6 €	29.6 €	29.6 €	29.4 €	29.4 €
Leixoes - Madrid	29.2 €	32.9 €	39.9 €	39.9 €	39.9 €	38.6 €	37.2 €	39.9 €	39.9 €	39.3 €	35.6 €
Vitoria - St Pierre des Corps	35.5 €	39.5 €	41.9 €	33.6 €	41.9 €	41.9 €	40.4 €	41.9 €	36.2 €	41.4 €	33.4 €
Lisboa - Madrid	38.4 €	42.4 €	40.7 €	40.7 €	36.4 €	39.6 €	40.2 €	40.2 €	40.7 €	40.1 €	36.2 €
Leixoes - Vitoria	40.0 €	44.1 €	41.4 €	41.4 €	41.4 €	40.1 €	38.7 €	41.4 €	41.4 €	40.7 €	36.7 €
Madrid - Sines	40.0 €	44.2 €	46.0 €	46.0 €	37.0 €	44.9 €	46.0 €	46.0 €	46.0 €	45.4 €	36.8 €
Madrid - Bordeaux	41.4 €	45.7 €	44.9 €	43.8 €	44.9 €	44.9 €	44.9 €	44.9 €	39.2 €	44.3 €	37.8 €
Le Havre - Mannheim	45.5 €	49.8 €	35.3 €	35.3 €	35.3 €	35.3 €	35.3 €	35.3 €	35.3 €	35.1 €	35.1 €
St Pierre des Corps - Mannheim	48.6 €	53.1 €	35.5 €	35.5 €	35.5 €	35.5 €	35.5 €	35.5 €	35.5 €	35.3 €	35.3 €
Vitoria - Sines	54.8 €	60.7 €	47.3 €	47.3 €	47.3 €	46.2 €	47.3 €	47.3 €	47.3 €	46.7 €	44.7 €
Vitoria - Paris	56.0 €	61.6 €	49.0 €	39.6 €	49.0 €	49.0 €	46.4 €	49.0 €	43.3 €	48.4 €	39.3 €
Leixoes - Bordeaux	56.8 €	62.9 €	59.8 €	58.6 €	59.8 €	58.6 €	55.7 €	59.8 €	53.9 €	58.4 €	46.3 €
Madrid - St Pierre des Corps	60.6 €	66.9 €	54.3 €	53.2 €	54.3 €	54.3 €	54.3 €	54.3 €	48.6 €	53.7 €	47.2 €
Algeciras - Irun	64.6 €	71.9 €	54.3 €	53.2 €	54.3 €	53.1 €	54.3 €	54.3 €	54.3 €	53.9 €	51.9 €
Lisboa - Bordeaux	65.4 €	72.6 €	59.1 €	58.0 €	59.1 €	58.0 €	58.8 €	58.3 €	53.3 €	57.8 €	49.0 €
Irun - Metz	68.2 €	75.0 €	44.0 €	44.0 €	44.0 €	44.0 €	44.0 €	44.0 €	44.0 €	44.0 €	44.0 €
Bordeaux - Mannheim	68.2 €	74.9 €	43.6 €	43.6 €	43.6 €	43.6 €	43.6 €	43.6 €	43.6 €	43.3 €	43.3 €
Vitoria - Metz	74.1 €	81.6 €	58.2 €	47.5 €	58.2 €	58.2 €	54.5 €	58.2 €	52.5 €	57.6 €	47.3 €
Madrid - Paris	74.7 €	82.6 €	61.4 €	60.3 €	61.4 €	61.4 €	61.0 €	61.4 €	55.7 €	60.8 €	54.3 €
Irun - Mannheim	78.2 €	86.0 €	49.7 €	49.7 €	49.7 €	49.7 €	49.7 €	49.7 €	49.7 €	49.5 €	49.5 €
Leixoes - St Pierre des Corps	81.8 €	89.9 €	70.8 €	69.5 €	70.8 €	69.5 €	64.6 €	70.8 €	64.8 €	69.3 €	55.7 €
Lisboa - St Pierre des Corps	90.4 €	99.5 €	68.9 €	67.8 €	68.9 €	67.8 €	67.7 €	67.9 €	63.1 €	67.6 €	58.4 €
Vitoria - Mannheim	90.4 €	99.0 €	64.4 €	52.9 €	64.4 €	64.4 €	60.0 €	64.4 €	58.7 €	63.6 €	52.5 €
Leixoes - Paris	95.9 €	105.7 €	79.1 €	77.9 €	79.1 €	77.9 €	71.3 €	79.1 €	73.2 €	77.6 €	62.6 €
Lisboa - Paris	105.1 €	115.8 €	76.4 €	75.3 €	76.4 €	75.3 €	74.4 €	75.2 €	70.6 €	75.1 €	65.5 €
Madrid - Mannheim	109.1 €	120.0 €	77.2 €	76.1 €	77.2 €	77.2 €	75.6 €	77.2 €	71.5 €	76.3 €	68.9 €
Algeciras - Paris	121.0 €	133.1 €	83.4 €	82.3 €	83.4 €	82.3 €	83.4 €	83.4 €	77.7 €	82.5 €	75.0 €
Lisboa - Metz	129.0 €	141.6 €	86.2 €	85.1 €	86.2 €	85.1 €	83.3 €	84.8 €	80.5 €	84.9 €	74.9 €
Leixoes - Mannheim	130.4 €	143.0 €	97.5 €	96.3 €	97.5 €	96.3 €	86.2 €	97.5 €	91.6 €	95.7 €	77.2 €
Lisboa - Mannheim	139.0 €	152.7 €	92.9 €	91.8 €	92.9 €	91.8 €	89.2 €	91.3 €	87.1 €	91.3 €	81.0 €

Table 10 Rail and road cost by scenario on main OD for continental combined transport

In this table, the rail cost becomes overwhelmingly more competitive than road for most relations except for shorter ones. For longer relations such as relations between Spain or Portugal and Germany the relative advantage of rail is already important, in present practice, and this is probably why train from/to

Germany along these relations represent a major part of rail freight traffic observed along the Atlantic corridor.

The next table shows the order of magnitude of differences of costs between current practices and "ideal" situation per relations for combined transport.

Relations	Effect situation ideale (cost model july 2015)
Irun - Metz	-8%
Irun - Mannheim	-8%
Poceirao - Paris	-10%
Vitoria - Paris	-6%
Vitoria - Metz	-7%
Poceirao - Metz	-11%
Poceirao - Mannheim	-11%
Algeciras - Paris	-17%
Algeciras - Irun	-20%
Poceirao - Madrid	-14%
Le-Havre - Mannheim	-6%
Paris - Mannheim	-2%
Madrid - Mannheim	-11%
Vitoria - Mannheim	-7%
Vitoria - Leixoes	-16%
Irun - Madrid	-10%
Leixoes - Mannheim	-13%
Leixoes - Paris	-13%
Paris - Madrid	-11%
Leixoes - Madrid	-19%

Table 11 Effects of ideal situation on rail cost

The following two tables show the synthesis of simulations results of scenarios for direct trains and automobile trains. They point out how rail becomes in general more competitive compared to road (road cost takes into account that truck charges are different for heavy goods), differentiating by relations, and by type of product.

The next table is for automobile trains where more relations appear not to be competitive (note that for automobile trains the "length of train" scenario has a relative high impact for many north-south relations), and the following one for direct trains, for which rail appears to be in a very good position versus road, but under the hypothesis that direct door to door connections are possible with rail sidings at both ends.

In € per ton for automobile transport train	Road Cost (automobile transport lorry)	Road Cost 2030 (automobile transport lorry)	Base Rail Scenario 2030 : international transport plan	International Transport Plan and Investment Scenarios - 2030							
				Y Basque	Sines-Lisbon/Madrid	Electrification	Length of train	Gradient	Extension UIC	ERTMS	All investment
Vitoria - Bordeaux	29.0 €	32.5 €	51.3 €	31.6 €	51.3 €	51.3 €	46.5 €	51.3 €	38.1 €	49.8 €	31.0 €
Paris - Mannheim	49.1 €	54.3 €	46.1 €	46.1 €	46.1 €	46.1 €	46.1 €	46.1 €	46.1 €	45.5 €	45.5 €
Madrid - Leixoes	52.0 €	58.2 €	73.0 €	73.0 €	73.0 €	69.6 €	57.4 €	73.0 €	73.0 €	71.4 €	52.9 €
Vitoria - St Pierre des Corps	62.6 €	69.5 €	75.9 €	52.3 €	75.9 €	75.9 €	67.2 €	75.9 €	62.8 €	74.4 €	51.6 €
Lisboa - Madrid	67.7 €	74.5 €	74.0 €	74.0 €	62.2 €	71.1 €	63.7 €	74.0 €	74.0 €	72.5 €	54.2 €
Leixoes - Vitoria	70.5 €	77.5 €	76.8 €	76.8 €	76.8 €	73.4 €	60.3 €	76.8 €	76.8 €	75.0 €	54.9 €
Madrid - Sines	70.5 €	77.7 €	87.9 €	87.9 €	63.7 €	84.9 €	75.2 €	87.9 €	87.9 €	86.4 €	55.5 €
Madrid - Bordeaux	72.9 €	80.3 €	82.0 €	79.4 €	82.0 €	82.0 €	73.3 €	82.0 €	68.9 €	80.5 €	57.3 €
Le Havre - Mannheim	79.4 €	86.7 €	61.2 €	61.2 €	61.2 €	61.2 €	61.2 €	61.2 €	61.2 €	60.6 €	60.6 €
St Pierre des Corps - Mannheim	84.7 €	92.5 €	61.9 €	61.9 €	61.9 €	61.9 €	61.9 €	61.9 €	61.9 €	61.4 €	61.4 €
Vitoria - Sines	96.7 €	106.7 €	91.3 €	91.3 €	91.3 €	88.4 €	78.1 €	91.3 €	91.3 €	89.7 €	71.7 €
Vitoria - Paris	98.1 €	107.7 €	94.9 €	68.0 €	94.9 €	94.9 €	82.7 €	94.9 €	81.7 €	93.3 €	66.9 €
Leixoes - Bordeaux	100.3 €	110.7 €	124.4 €	121.4 €	124.4 €	120.9 €	97.6 €	124.4 €	110.5 €	120.3 €	75.8 €
Madrid - St Pierre des Corps	106.5 €	117.3 €	106.7 €	104.1 €	106.7 €	106.7 €	94.0 €	106.7 €	93.5 €	105.1 €	78.0 €
Algeciras - Irun	114.4 €	126.8 €	100.8 €	98.2 €	100.8 €	98.2 €	93.1 €	100.8 €	100.8 €	99.9 €	85.4 €
Lisboa - Bordeaux	115.5 €	127.7 €	120.7 €	118.0 €	120.7 €	117.7 €	104.0 €	120.7 €	107.3 €	117.1 €	81.7 €
Bordeaux - Mannheim	119.1 €	130.4 €	83.2 €	83.2 €	83.2 €	83.2 €	83.2 €	83.2 €	83.2 €	82.6 €	82.6 €
Irun - Metz	119.3 €	130.8 €	80.4 €	80.4 €	80.4 €	80.4 €	80.4 €	80.4 €	80.4 €	80.3 €	80.3 €
Vitoria - Metz	129.7 €	142.5 €	119.6 €	88.7 €	119.6 €	119.6 €	103.0 €	119.6 €	106.5 €	118.1 €	87.2 €
Madrid - Paris	131.4 €	144.9 €	125.6 €	123.0 €	125.6 €	125.6 €	109.7 €	125.6 €	112.5 €	123.9 €	93.6 €
Irun - Mannheim	136.8 €	150.2 €	97.5 €	97.5 €	97.5 €	97.5 €	97.5 €	97.5 €	97.5 €	96.9 €	96.9 €
Leixoes - St Pierre des Corps	143.5 €	157.5 €	154.3 €	151.3 €	154.3 €	150.8 €	117.9 €	154.3 €	140.4 €	150.2 €	96.4 €
Vitoria - Mannheim	157.9 €	172.5 €	136.3 €	104.5 €	136.3 €	136.3 €	119.6 €	136.3 €	123.1 €	134.1 €	103.4 €
Lisboa - St Pierre des Corps	158.8 €	174.4 €	147.1 €	144.3 €	147.1 €	144.1 €	124.5 €	147.1 €	133.7 €	143.5 €	102.4 €
Leixoes - Paris	168.5 €	185.0 €	177.5 €	174.5 €	177.5 €	174.1 €	133.3 €	177.5 €	163.7 €	173.3 €	112.0 €
Lisboa - Paris	184.6 €	202.9 €	167.4 €	164.7 €	167.4 €	164.4 €	139.9 €	167.4 €	154.0 €	163.7 €	118.0 €
Madrid - Mannheim	191.2 €	209.8 €	167.1 €	164.4 €	167.1 €	167.1 €	146.8 €	167.1 €	153.9 €	164.7 €	130.0 €
Algeciras - Paris	212.6 €	233.4 €	175.6 €	173.0 €	175.6 €	173.0 €	157.2 €	175.6 €	162.4 €	173.1 €	136.2 €
Lisboa - Metz	226.0 €	247.4 €	194.0 €	191.2 €	194.0 €	191.0 €	160.2 €	194.0 €	180.6 €	190.3 €	138.8 €
Leixoes - Mannheim	228.2 €	249.9 €	228.0 €	225.0 €	228.0 €	224.5 €	171.8 €	228.0 €	214.1 €	222.9 €	148.8 €
Lisboa - Mannheim	243.5 €	266.9 €	211.8 €	209.1 €	211.8 €	208.8 €	178.2 €	211.8 €	198.4 €	207.4 €	154.9 €

RAIL BEST SOLUTION

ROAD BEST SOLUTION

Table 12 Rail and road cost by scenario on main OD for automobile transport train

In € per ton for direct train	Road Cost (dry bulk lorry)	Road Cost 2030 (dry bulk lorry)	Base Rail Scenario 2030 : international transport plan	International Transport Plan and Investment Scenarios - 2030							
				Y Basque	Sines-Lisbon/Madrid	Electrification	Length of train	Gradient	Extension UIC	ERTMS	All investment
Vitoria - Bordeaux	13.3 €	14.9 €	19.1 €	9.6 €	19.1 €	19.1 €	19.1 €	19.1 €	10.9 €	18.6 €	9.5 €
Paris - Mannheim	22.3 €	24.7 €	11.9 €	11.9 €	11.9 €	11.9 €	11.9 €	11.9 €	11.9 €	11.7 €	11.7 €
Madrid - Leixoes	23.6 €	26.5 €	20.2 €	20.2 €	20.2 €	20.1 €	20.2 €	20.2 €	20.2 €	19.9 €	19.0 €
Vitoria - St Pierre des Corps	28.5 €	31.7 €	27.0 €	16.8 €	27.0 €	27.0 €	27.0 €	27.0 €	18.8 €	26.6 €	16.7 €
Lisboa - Madrid	30.0 €	33.2 €	22.9 €	22.9 €	20.0 €	22.9 €	22.9 €	22.9 €	22.9 €	22.5 €	19.7 €
Leixoes - Vitoria	31.2 €	34.5 €	21.5 €	21.5 €	21.5 €	21.3 €	21.5 €	20.1 €	21.5 €	21.1 €	19.4 €
Madrid - Sines	31.3 €	34.6 €	27.8 €	27.8 €	20.5 €	27.8 €	27.8 €	27.8 €	27.8 €	27.5 €	20.2 €
Madrid - Bordeaux	32.3 €	35.8 €	30.7 €	29.8 €	30.7 €	30.7 €	30.7 €	30.7 €	22.3 €	30.1 €	21.1 €
Le Havre - Mannheim	35.3 €	38.7 €	16.4 €	16.4 €	16.4 €	16.4 €	16.4 €	16.4 €	16.4 €	16.2 €	16.2 €
St Pierre des Corps - Mannheim	37.7 €	41.3 €	17.0 €	17.0 €	17.0 €	17.0 €	17.0 €	17.0 €	17.0 €	16.8 €	16.8 €
Vitoria - Sines	43.1 €	47.9 €	29.1 €	29.1 €	29.1 €	29.1 €	29.1 €	28.9 €	29.1 €	28.7 €	26.4 €
Vitoria - Paris	43.8 €	48.3 €	32.6 €	22.2 €	32.6 €	32.6 €	32.6 €	32.6 €	24.5 €	32.2 €	22.1 €
Leixoes - Bordeaux	44.7 €	49.6 €	39.6 €	38.5 €	39.6 €	39.6 €	39.6 €	39.0 €	31.3 €	38.7 €	29.0 €
Madrid - St Pierre des Corps	47.5 €	52.6 €	38.9 €	38.1 €	38.9 €	38.9 €	38.9 €	38.9 €	30.7 €	38.4 €	29.6 €
Algeciras - Irun	51.1 €	56.9 €	37.1 €	36.1 €	37.1 €	36.7 €	37.1 €	37.1 €	37.1 €	36.7 €	35.0 €
Lisboa - Bordeaux	51.7 €	57.4 €	42.3 €	41.2 €	42.3 €	42.3 €	42.3 €	42.3 €	34.0 €	41.3 €	31.6 €
Bordeaux - Mannheim	53.3 €	58.6 €	23.5 €	23.5 €	23.5 €	23.5 €	23.5 €	23.5 €	23.5 €	23.3 €	23.3 €
Irun - Metz	53.4 €	58.8 €	24.2 €	24.2 €	24.2 €	24.2 €	24.2 €	24.2 €	24.2 €	24.1 €	24.1 €
Vitoria - Metz	58.2 €	64.2 €	40.0 €	29.4 €	40.0 €	40.0 €	40.0 €	40.0 €	31.9 €	39.6 €	29.3 €
Madrid - Paris	58.8 €	65.2 €	45.0 €	44.4 €	45.0 €	45.0 €	45.0 €	45.0 €	36.8 €	44.5 €	35.8 €
Irun - Mannheim	61.4 €	67.7 €	28.6 €	28.6 €	28.6 €	28.6 €	28.6 €	28.6 €	28.6 €	28.3 €	28.3 €
Leixoes - St Pierre des Corps	63.6 €	70.2 €	47.8 €	46.7 €	47.8 €	47.8 €	47.8 €	47.2 €	39.5 €	46.9 €	37.4 €
Vitoria - Mannheim	70.1 €	77.1 €	45.1 €	34.3 €	45.1 €	45.1 €	45.1 €	45.1 €	36.9 €	44.4 €	34.0 €
Lisboa - St Pierre des Corps	70.5 €	77.9 €	50.5 €	49.4 €	50.5 €	50.5 €	50.5 €	50.5 €	42.2 €	49.5 €	40.4 €
Leixoes - Paris	74.9 €	82.7 €	54.1 €	53.0 €	54.1 €	54.1 €	54.1 €	53.5 €	45.8 €	53.1 €	43.7 €
Lisboa - Paris	82.2 €	90.8 €	56.8 €	55.7 €	56.8 €	56.8 €	56.8 €	56.8 €	48.5 €	55.8 €	46.7 €
Madrid - Mannheim	85.2 €	93.9 €	58.3 €	57.7 €	58.3 €	58.3 €	58.3 €	58.3 €	50.1 €	57.5 €	48.9 €
Algeciras - Paris	94.1 €	103.8 €	67.6 €	67.0 €	67.6 €	66.4 €	67.6 €	67.6 €	59.3 €	66.7 €	57.1 €
Lisboa - Metz	100.2 €	110.4 €	65.0 €	64.0 €	65.0 €	65.0 €	65.0 €	65.0 €	56.7 €	64.0 €	55.0 €
Leixoes - Mannheim	101.3 €	111.5 €	67.9 €	66.9 €	67.9 €	67.9 €	67.9 €	67.3 €	59.6 €	66.7 €	57.3 €
Lisboa - Mannheim	108.2 €	119.2 €	70.6 €	69.6 €	70.6 €	70.6 €	70.6 €	70.6 €	62.3 €	69.4 €	60.3 €

RAIL BEST SOLUTION

ROAD BEST SOLUTION

Table 13 Rail and road cost by scenario on main OD for direct train

5. Profit and Loss of competitiveness expected per type of investment

In this last task we introduce the traffics in tons for exchanges between European regions, so that it is possible to assess the total gains expected from increase of rail performances related to types of infrastructure investments along the corridor, and from modal shift from road to rail generated by these increase of rail performances for different types of products or different types of trains.

The reference scenario for such assessment is the ideal "situation" defined in the former task for the year 2030, without any new infrastructure investment so that each "type of investment" scenarios (8 of them when excluding the "do nothing" scenario) can be assessed and compared against this same reference, to finally produce a comparison between gains expected from each scenario.

As far as demand is concerned a first preliminary work is then to project O/D flows at horizon 2030, and then to select those relations that will use the Atlantic corridor, for road and rail, before proceeding to the modal split in the simulations of the reference and the eight investment types scenarios. Demand projections are done using the UE socioeconomic scenario ("lost decade scenario") for population and economic context evolution until 2030, and the transport costs defined earlier[19].
As far as modal split is concerned, the model of BG[20] is applied at EU scale and is particularly adapted for introduction of detailed cost functions using operations research techniques for choice between logistic door-to-door solutions[21].

In a second step the scenarios are assessed and compared, in terms of tons transferred to rail from road, and gains obtained in relations with types of investments.

Note that in the report, tasks 5 and 6 are grouped, and ERTMS is treated as a specific investment scenario all along the study within different tasks.

Therefore the task 5/6 is structured as follows
- projections of demand to 2030, per type of product and identification of trade relations using the corridor.
- results in terms of modal shift for the different scenarios and gains expected.

5.1 Demand projections per types of products, and characterization of trade relations using the corridor

The projection of demand is made using EU economic scenario with the following rate of growth for GDP

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[19] Note that generally transport of road costs are supposed to increase and rail costs to decrease due to increase of performances related to increase of competition within the European Rail market. But the "ideal" situation does reflect better organization of rail transport in a context where operating conditions have been taken into account in detail as far as infrastructure constraints are concerned. On the other hand, recent evolution of road price, truck load, and difficulties to introduce more taxes do not push to consider a significant road cost increase. Such hypothesis do correspond to hypothesis of recent evaluation of major European projects as well as to the recent "note de cadrage" of RFF.

[20] This model, LOGIS has been applied to major European and French transport projects (GPSO, LNMP, LTF, CFAL for France, Eufranet, New Opera for rail freight EU projects as well as the present IWW and Ports study of the EU Commission. The generation part of this model has been quoted in different places of TMS study.

[21] This techniques consist in identification of best solution for mode choice (and combination of mode) and choice of rotes using "minimal path algorithm" within a transport graph (the transport network representation).

Country	2010	2020	2030	2050	2010-2030%	2030-2050%	2010-2050%
BE	356	413	479	671	1,50%	1,70%	1,60%
DE	2 495	2 742	3 014	3 488	**0,95%**	**0,73%**	**0,84%**
ES	1 045	1 267	1 537	2 003	**1,95%**	**1,33%**	**1,64%**
FR	1 900	2 269	2 717	3 685	**1,80%**	**1,54%**	**1,67%**
IT	1 549	1 728	1 928	2 497	1,10%	1,30%	1,20%
NL	582	659	746	966	1,25%	1,30%	1,27%
PT	173	194	217	279	**1,15%**	**1,27%**	**1,21%**
UK	1 698	2 039	2 449	3 522	1,85%	1,83%	1,84%
Other EU15	1 462	1 700	1 981	2 711	1,53%	1,58%	1,56%
EU15	11 258	13 011	15 068	19 822	**1,47%**	**1,38%**	**1,42%**
EU12	946	1 152	1 405	1 725	**2,00%**	**1,03%**	**1,51%**
EU27	12 205	14 162	16 473	21 547	**1,51%**	**1,35%**	**1,43%**
CH	415	458	506	571	1,00%	0,60%	0,80%

Table 14 GDP per country

Transport demand is projected per O/D trade relation, region to region for 16 types of product aggregation for bulk and non-bulk products: the bulk products are defined using NSTR classification a proportion of low value products and products of higher value especially for longer distances. Therefore, only part of this category will be assigned to direct trains transporting heavy products. In the transport material category of products only part of tonnage concern transport of automobile, the rest concerning parts transported as manufactured products, eventually in units, not in automobile trains[22].

These transport flows projections are differentiated between different types of relations according to the use of the corridor as done in TMS study, with:

- Internal relations which are relations between regions crossed by the corridor
- External relations which means relations with one extremity in a region of the corridor
- Transit relations with origin and destination outside the corridor regions, but using the Atlantic corridor.

These distinctions will be used for the simulation of modal split for the reference scenario ("ideal situation") and the types of investments scenarios.

5.2 Projections of modal split for different scenario and gains expected

5.2.1 Global results for rail traffic

The first step for final results of assessment of impact of infrastructure investments is the estimation of the modal shift related to each investment scenario defined earlier in task 4[23].

[22] The details of projections are provided in Deliverable 5.

[23] Note that there are in D4 detailed fiches with maps for each of these scenarios.

The valuation of the gains for each scenario is just the difference in costs per ton transported by road and rail as regards common base scenario, weighted by the volume of tons, transferred. This valuation is done per O/D relation, region to region, and aggregated in the following tables per main types of international relations[24].

The table below provides the rail traffic projections associate to different scenarios if investments

Tons in millions		SCN 1 : BASE	SCN 2 : Y Basque	SCN 3 : Lisboa - Madrid	SCN 4 : Elect	SCN 5 : 750m	SCN 6: Gradient	SCN 7 : UIC	SCN 8 : ERTMS	SCN 9 : TOTAL
International flows with at least 1 km on the corridor	France - Europe	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.1	10.1
	Total transpyrenean flow (ATL paths)	5.0	6.2	5.2	5.1	6.0	5.1	9.2	5.4	12.7
	Transpyrenean - Spain	*4.5*	*5.6*	*4.6*	*4.5*	*5.2*	*4.5*	*8.2*	*4.7*	*10.7*
	Transpyrenean - Portugal	*0.5*	*0.6*	*0.6*	*0.6*	*0.8*	*0.6*	*1.0*	*0.6*	*2.0*
	Iberian flows	1.3	1.4	1.6	1.4	1.7	1.4	1.3	1.4	2.4
TOTAL		16.3	17.6	16.8	16.5	17.7	16.4	20.5	16.9	25.2
Effects of scenario on rail traffic (tons) on the corridor			1.2	0.5	0.2	1.3	0.1	4.2	0.5	8.9
Effects of scenario on rail traffic (variation on total) on the corridor			8%	3%	1%	8%	1%	26%	3%	54%

In the final results, this table shows that the difference in tons between the base scenario[25] and the "total scenario 9" with all infrastructure investments is 8.9, from 16.3 to 25.2 MT over the perimeter, which represent an increase of 54%. Most of the increase in tons comes from Trans Pyrenean relations with 12.7 MT, and in particular for relation with Spain.

The measure of the impact per type of investments which is illustrated in the diagram below, points out the impact of UIC scenario as the most important in tons gained by rail, followed by 750m scenario and Y Basque scenario. The impact of Lisbon Madrid scenario in tons appears fairly low, but this is mainly due to configuration of the network around Lisbon, and the fact that performance increase of the relation between Sines and Madrid, is not limited because of the fairly low level of traffic assumed to be generated by the port[26]in 2030.

[24] Again details are provided in D5.

[25] It has to be recalled that the "base scenario 1", taken here as reference has been defined from "ideal situation" as regards rail operations without investments; this corresponds already to an improved of the situation of rail in the competition with road as compared to a "trend evolution" (unchanged modal share up to 2030) of the observed present situation.

[26] In fact no specific assumptions have been made upon the development of the role of the ports, as an European Gateways in the world market for example

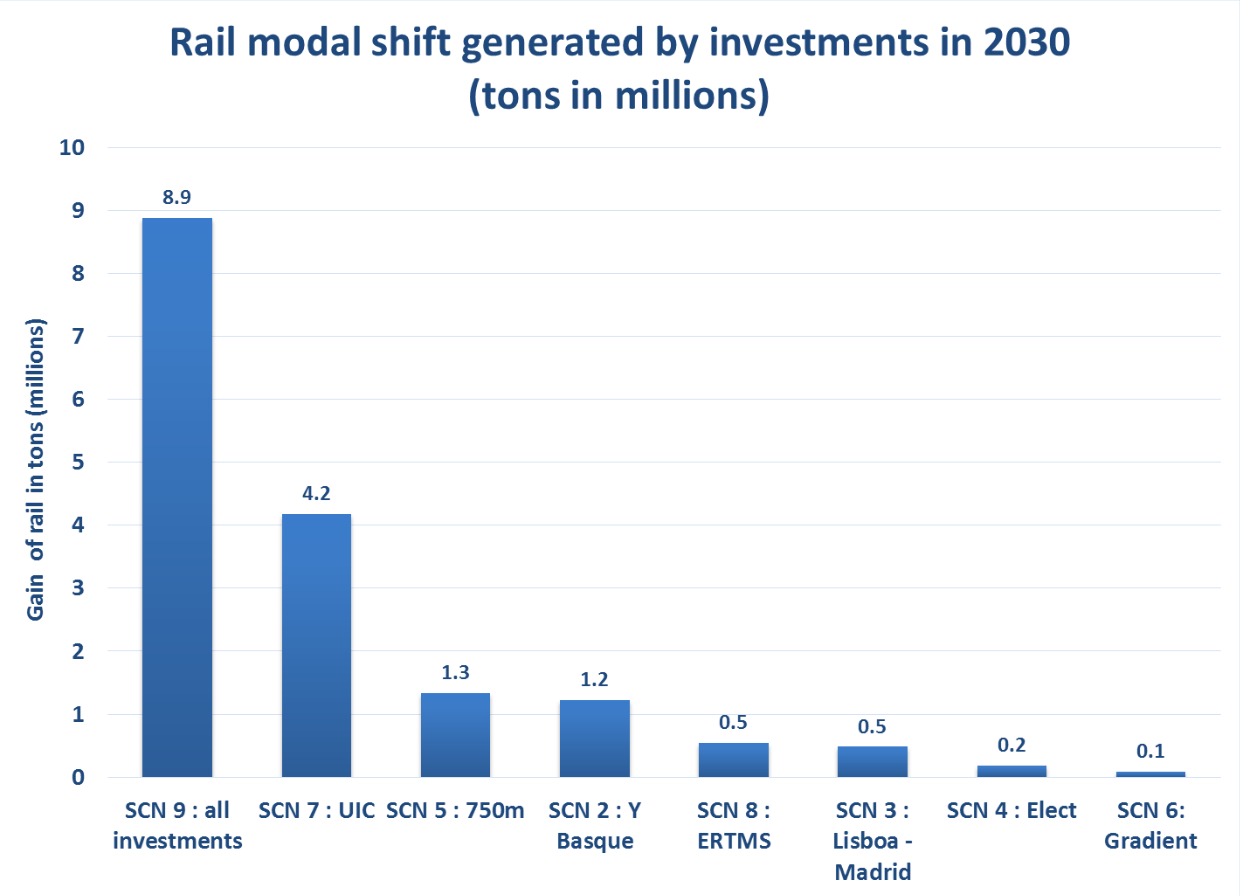

Figure 6 Rail modal shift generated by investments

5.2.2 Results for modal share, per scenario

As a result of the analysis it must be stressed that rail modal share become much higher with 13% for the whole perimeter as compared to 9% in the base scenario for the total perimeter of the corridor. When focusing upon results of trans Pyrenean relations then the gain of modal share is even much more important increasing from 8% to 17% for relations with Spain and from 5% to 19% for Trans Pyrenean relations with Portugal, which are on longer distances. For Trans Pyrenean relations the modal share of rail increases this is a gain of 11 points for all Trans Pyrenean relations

When looking at results for specific types of investments the results are:

- a gain of 2 points of modal share for the corridor perimeter related to UIC scenario, which correspond to a gain of 6 points from 7 to 13% for the trans Pyrenean relations
- a gain of 1 point of modal share for the corridor perimeter associated to the possibility to run 750 m train south of Portugal, which correspond to a gain of 3 points, from 7% to 9% for trans Pyrenean relations, without having UIC gauge in Spain and Portugal since each scenario is considered independently of each other.

Modal share of rail in %		SCN 1 : BASE	SCN 2 : Y Basque	SCN 3 : Lisboa - Madrid	SCN 4 : Elect	SCN 5 : 750m	SCN 6: Gradient	SCN 7 : UIC	SCN 8 : ERTMS	SCN 9 : all Investments
International flows with at least 1 km on the corridor	France - Europe	14%	14%	14%	14%	14%	14%	14%	14%	14%
	Total transpyrenean flow (ATL paths)	7%	9%	8%	7%	9%	7%	13%	8%	18%
	Transpyrenean - Portugal	*5%*	*5%*	*6%*	*5%*	*7%*	*5%*	*9%*	*6%*	*19%*
	Transpyrenean - Spain	*8%*	*10%*	*8%*	*8%*	*9%*	*8%*	*13%*	*8%*	*17%*
	Iberian flows	3%	3%	3%	3%	4%	3%	3%	3%	5%
TOTAL		9%	9%	9%	9%	9%	9%	11%	9%	13%

Figure 7 Rail traffic by international relations and scenarios

5.2.3 Gains in transport operations as compared to road.

As far as gains are concerned from the modal shifts expected because of increase of rail performances versus road, the total gain between "no" investment scenario and "all" investments scenario is estimated to 140 Million € per year. This estimation is made only taking into account direct operating cost but not environmental costs which would impact positively such result or "congestion costs" which will depend also upon related passenger traffic evolution[27], and play again in favor of such infrastructure rail investments.

The ranking between scenarios is similar to what has been obtained from the traffic modal shift, with, however differences in relative value since these results are obtained through simulations of all operations related to different infrastructure constraints and not deduced from average costs applied to different levels of traffic. From this table the results are 52 million gain, per year, for UIC scenario and 18 million for the possibility to run 750m trains. Effects of the lengthening of trains in Iberia is limited because the recurrence of strong slopes

[27] This is out of the scope of the study

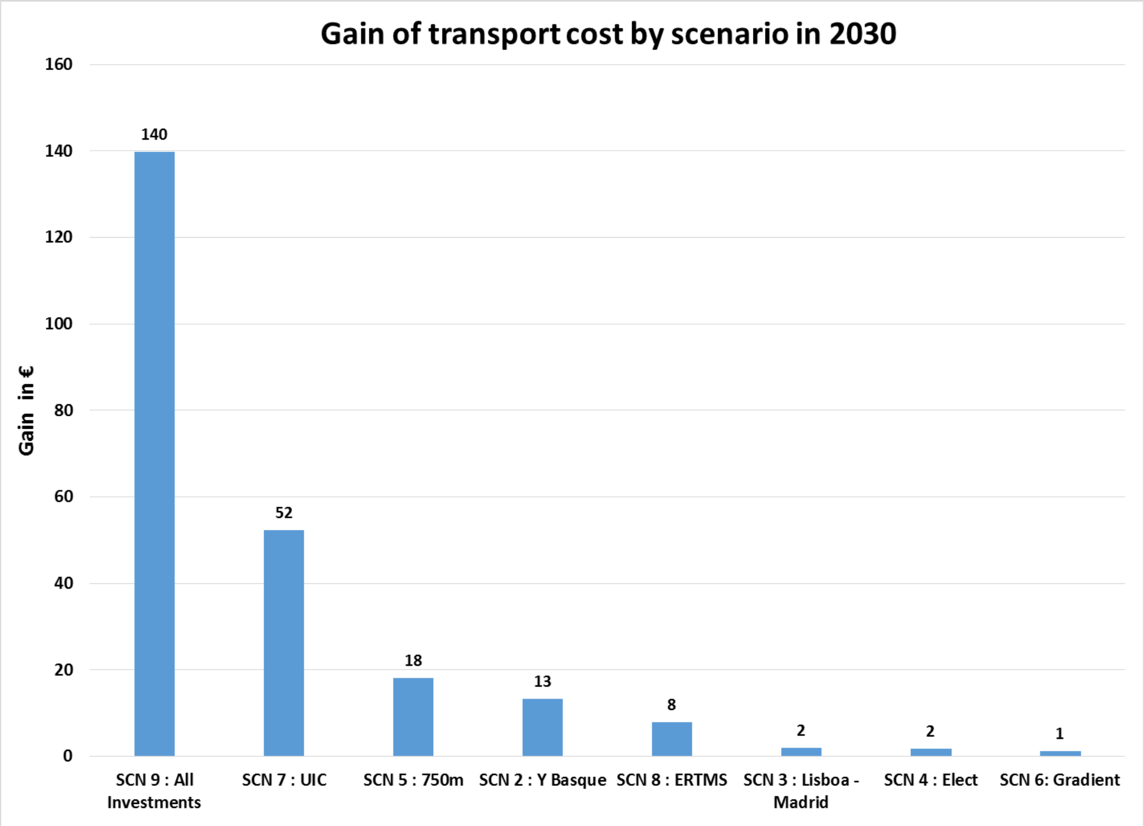

Figure 8 Gain of each scenario on transport cost (rail + road)

Conclusion: general comment and recommendations

The analysis of infrastructures' constraints impact upon the rail operations' performances show that infrastructure investments can

- Improve significantly operating rail performance
- Modify modal shift along the Atlantic Rail Freight Corridor in 2030, which is the horizon taken for planning the CNC (Core Network Corridor), and in particular the multimodal CNC 7 which is the Atlantic CNC.

However, this impact depends very much upon

- the "type" of infrastructure investments, which have been categorized in 7 types, plus the "no-investment" scenario and the "all investments" scenario (for 9 scenario in total)
- the relation considered, which are the international relations of RFC 4 for which international slots can be prearranged and proposed by the Atlantic EEIG to rail operators, but also all the O/D trade relations between regions of Europe which might use the corridor only on part of their routes[28].
- the type of train operated, in relation with the type of product transported[29].

But what has been shown also is that rail operation improvements are also possible, as regards the existing practices, with the existing infrastructure, impacting also significantly the competitiveness of rail versus road: such possible improvements have also been pointed out for different relations, and types of product, in an attempt to define what could be called an "ideal" situation as regards rail operation organization[30]. This is the result of the fact that even though difficult operating conditions exist[31], the length of trade relations between the North and the South of Europe using the trade corridor, result in economies of scale for the rail which often will compensate these operating handicaps, located mainly south of Pyrenees, in the competition versus road. Such compensations do not appear easily in a transport diagnosis of possible performances unless operations are planned at long distance EU level, which is the level of cooperation of IM of the RFC 4 for international slot supply along the Atlantic corridor.

Therefore, the recommendations of the study for EEIG can be formulated as follows:

1 Recommendations to improve existing situation and stimulate implementation of more efficient transport plans.

This concerns transport operations along main relations of the corridor, as they have been presented in task 4:

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[28] These have been classified in "internal", "external", and "transit" relations, when origin and destination are within the corridor, or only one point of the two, or none of them, but with routes partially along the corridor (not using Mediterranean border point).

[29] General cargo, which eventually can be transported in "units" (Combined Transport), for industrial and agricultural products, bulk transport of heavy goods in direct trains, Automobile trains, since Automotive industry is very much integrated within EU market and in particular for relations with Spain and Portugal.

[30] The qualification of "ideal" situation is not here the result of an "optimization" process, in a mathematical sense, but just the result of possible improvement of transport scheme (localization of change of driver and locomotive, reinforcement of traction, use of type of locomotive…) based on expertise of the consortium.

[31] and will still exist in the future when they are due to natural and geographic characteristics which cannot be changed such as mountainous and difficult plateau relief.

- This can be done with dissemination of best practices for operations[32]
- This can also be done by taking into account best practices in the prearrangement of slots, such as time required for operations in singular points of the network which appear to be the most relevant as regards rail operation performance along the relations of the corridor.
- And this can been done by facilitating plans for reinforcements of traction, with availability of supplementary locomotives in certain places[33] or leasing of certain types of locomotive with adapted power of traction

Already at this stage, the development of a "slot market" taking into account operating constraints can stimulate improvement of operating performances, in relation with developments of new services for rolling stock.

2 Recommendations for planning process of the corridor, which is indeed closely linked to the development of "slot market" of the corridor.

One major difficulty when planning a corridor is to appraise correctly the transport market[34] which will be using the corridor and to adapt to its needs for the present and for the future. Slots, and in particular international slots, reflect an equilibrium between demand and a supply of rail services along the corridor[35], and guarantee quality of rail services in a cooperation context of Infrastructure Managers, which is also a context for negotiation[36] of priorities for international freight and adaptation to operating constraints.

Therefore recommendations can be:

- To take into account a prioritization of projects along the Atlantic corridor based upon a differentiation of types of investments
- To adapt the "planning of slots" along the corridor to the expected volumes of demand and expected modal shift[37], which is an indicator towards the planning objective.
- To associate stakeholders to such planning, in order to have them better informed of potential and ongoing improvements and to stimulate more performing transport plans of railway undertakings;

These two types of recommendations show how corridor planning is closely related to slots' planning in short, medium and even long term. "Slots markets" for international relations do provide appropriate measures to corridor demand and quality of slots reflects the performance and guarantee of performance of rail operation along the corridor.

However, a last point must also be integrated in the process of planning the corridor, which will then bring a "door to door" consistent approach of the transport along the corridor.

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[32] At this stage we can recall that some observed existing best practices validated indeed the diagnosis made for "ideal" situation.

[33] This has been promoted for the Brenner route where important ramp exist on the actual line.

[34] This is why internal, exchange and transit types of exchanges relations, region to region have been defined.

[35] This is also why RFC KPI (which are slots KPI, Key Performance Indicators) are important KPI of corridors, beyond the sole analysis of infrastructure supply.

[36] Note that international freight trains are supposed to have priority over passenger trains in a "priority freight corridor" (White paper and TEN-T directives) except versus HST, when conflicts appears.

[37] Note that these were estimated at the level of trade relations between regions of Europe, and not only for relations between nodes of the corridor, as the slots' definition and prearrangement are supposed to intervene (although cooperation of slots between corridors are envisaged for RFC 4, in particular for extension of reservation towards North of Europe and Germany).

3 Recommendations for rail terminal connections.

Infrastructure have been considered along the corridor but not for "last kilometre terminal connections". These concern industries' sidings and connections of intermodal platforms to the rail corridor for ports and combined transport terminals. For ports, these connections are often integrated as part of planning of port development and introduced as such as candidate projects[38] for corridor planning. However, this is not always the case for intermodal terminals.

- Use of EU demand/performance of operations data produced for the Atlantic corridor to improve dialogue and cooperation for a door to door planning at regional level, so that a dialogue on planning combined transport services can be initiated as regards existing/future demand and rail supply/ "slots performances" expected along predefined relations[39] .
- Geocoding the corridor network in order to bring a common, consistent, global framework for integration of costs of such terminal connections in the corridor planning. Such analysis (which requires certainly to be further detailed and deepened depending upon local context) can also help to foster cooperation and orientate stakeholders to concrete actions as regards terminal connections, with common tools of appraisal, valid at EU level.

Other types of recommendations could concern slot pricing adapted to performance of the relations of the corridor, as well as estimation of user "capacity" to contribute to investments, using results of the study, but such recommendations certainly go beyond the present situation of pricing infrastructure along a corridor.

For all these recommendations the main goal is to develop a more objective perception of possible rail performances, with better adapted organization of operations stimulating more initiatives in regional investments for terminal connections. It is clear that a gap exist between the actual performance, the possible performances today and the future possible performances, in a European perspective, as the results of the study point out.

Another goal is to point out how such corridors analysis can help in the planning of corridors, which is the first step of the planning of TEN-T, according to new directives set up by EU.

[38] For example in EU "call for projects".

[39] Note that planning of local services, logistic and collection/distribution services, is also important.