FERRMED Study of

TRAFFIC AND MODAL SHIFT OPTIMISATION

in the EU

Summary of the Study

Promotion du Grand Axe Ferroviaire de marchandises
Scandinavie-Rhin-Rhône-Méditerranée Occidentale A.S.B.L.

FERRMED

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What is FERRMED?

FERRMED is a multisectoral non-profit Association that was founded by the private sector in Brussels on the 5th of August 2004 to improve rail freight transport efficiency and industrial competitiveness in Europe and neighbouring countries.

The main target of FERRMED at that time was to look for a reticular and poly-centric priority rail network at EU level (with common and ambitious standards defined by our Association), instead of developing only "priority projects" (mainly trans-border sections).

FERRMED promotes the implementation of common technical railway standards, the so-called *"FERRMED Standards of Reference/Recommendations"*, the improvement of the connections of Ports and Airports with their respective hinterlands, the full implementation of "FERRMED Corridors" (for freight, considering only the most important part of the EU Railway Core Network) and the conception of a Great Rail Freight Axis: Scandinavia-Rhine-Rhone-Western Mediterranean.

Another key FERRMED objective is the optimisation of the full logistics chain considering combined transport, appropriate intermodality, reducing costs, increasing quality, assuring traceability and reliability, accomplishing lead times and timetables, and improving management procedures in the transport systems, within the framework of 5G and the Circular Economy.

FERRMED has carried out or commissioned several more studies like the "FERRMED freight wagon concept", "FERRMED freight locomotive concept" and the "FERRMED Study of the Southern section of the Mediterranean Corridor".

In June 2019, with the support of the European Commission, FERRMED has launched the "FERRMED Study of Traffic and Modal Shift Optimisation in the EU" that was completed in October 2023, The conclusions of the Study could facilitate the establishment of coherent transport network improvement plans at EU level, to attain the EU targets for railway transport by 2030 and the Green Deal environmental achievements regarding the EU land transport system.

After 19 years, FERRMED has many contacts, members, and partners everywhere, and we look forward to consolidating our presence across the EU and even Eurasia.

Foreword

Mr. Joan Amorós
FERRMED President
General Coordinator of the Study development

The land freight transport in the EU is facing strong challenges in the first third of 21st century: In spite of the impact of COVID-19 pandemic, the demand for freight transport is expected to grow by more than 50 % until 2050, according to the European Commission (Reference Scenario 2020, Energy, Transport and GHG Emissions – Trends 2020).

The main question is how the EU transport network can absorb this important increase of volume and how to achieve the basic objectives of the European Green Deal in all that concerns inland transport.

Decarbonisation is passing in a significant amount, through transport. In the case of freight transport and logistics, decarbonisation can only be achieved by further reducing the environmental footprint of individual modes and by having a better balance of share among modes.

In fact, over the past 20 years, there has been no substantial change in the market share of the various modes of freight transport. In the case of rail and combined transport, this is due to the lack of adequate infrastructure and operation management for freight trains, insufficient number and capability of intermodal terminals, bottlenecks solving and lack of a coherent integrated land freight transport plan at EU level, to meet the targets originally set out in EC (2011) White Paper on Transport Policy and in the European Comission (2019): The European Green Deal, COM/2019/640 final.

For all these reasons, FERRMED launched in June 2019 the "FERRMED Study of Traffic and Modal Shift Optimisation in the EU".

The basic objectives of the Study are:

- To investigate the distribution of current freight transport volumes in the multimodal TEN-T Network.
- To identify the EU Strategic logistics hubs.
- The definition of appropriate scenarios of traffic share and traffic increase in the inland transportation modes.

- To define a new concept of intermodal terminals.
- To develop a Fast, Flexible, Integrated, Rail-Road System of Transport (+FIRRST), as a novel way of organising multimodal rail-road transport in the form of "Mobility as a Service" (MaaS).
- To investigate what should be the adequate rolling stock.
- To analyse the capacity of the transport system (bottleneck solving and additional intermodal terminals according to the expected traffic of the different scenarios).
- To propose the establishment of a "Priority investment Plan for EU integrated land freight transport", with first priority for sections with the highest freight volumes.

After more than four years of work (more than 45.000 hours) of an international team composed by 24 experts (engineers, economists and geographers), 12 students with two Universities involved, Antwerp and Barcelona, as well as a consultant company, MCRIT, the Study has been concluded in 2023. As far as we know, there has never been a study or any research undertaken, with inventories of road and rail infrastructures as well as intermodal terminals, with the level of detail achieved in the FERRMED Study.

The main conclusions are:

- **Investing in 23 % of the EU Extended Core Network generates 101 % of total net present value (NPV).** Slightly positive NPVs in further 39 % of the network are offset by negative NPVs in the remaining 38 %.

- **Implementing the Fast Flexible Integrated Rail-Road System of Transport (+FIRRST)** to move all kind of ILUs (semi-trailers, containers and swap bodies) to different destinations in the form of "Mobility as a Service" (MaaS), is the best way to boost the stagnant share of the railway in land freight transport.

- **Properly interlinking the identified EU Strategic logistic hubs and key interconnection nodes with the +FIRRST system**, including the new intermodal terminal concept, is key for the achievement of Green Deal targets on transport **(52 % operational cost reduction and 77 % externality outback)**.

- We expect that the analysis, conclusions and recommendations of the Study will provide insights and relevant evidence to materialise the Greening Freight Package and to establish the adequate guidelines for a true integration of the freight transport in Europe.

Summary of the Study

1. BACKGROUND

1.1. Performance and environmental impact of the European land freight transport system

In the year 2021, total freight transport performance in the EU-27 was almost **2.4 trillion tonne-kilometres,** of which roughly **77 % were transported by road, 17 % by rail and 6 % by inland waterway**[1].

In spite of the environment-friendly efforts made by the sector, the impact of heavy-duty road vehicles on the environment is still severe: some **210 million tonnes of CO2** per annum, representing **26 % of total greenhouse gas (GHG) emissions of the road transport sector** as a whole[2].

On the other hand, the **lack of flexibility** in freight train management and the **shortage of adequate intermodal infrastructure**, do not facilitate the growth of combined transport.

1.2. Present conditions of the European land freight transport system

In the EU, according to the "World Economic Forum"[3]:
- 24 % of freight vehicles run empty;
- The loading of the rest is, on average, of 57 % in terms of weight capacity;
- Overall efficiency is hence only 43 %.

1 EU Transport in Figures 2023 (Table 2.2.1)
2 EEA (European Environment Agency) Transport and environment report 2021. Decarbonising road transport -the role of vehicles, fuels and transport demand (EEA Report No. 02/2022)
3 FERRMED Conference (2019) Opening speech of Mr. Antonio Tajani MEP, Chairman of the Committee for Constitutional Affairs, Former President of the European Parliament. https://www.weforum.org/agenda/transportation/

2. COMPREHENSIVE PLAN OF MODAL SHIFT OPTIMISATION

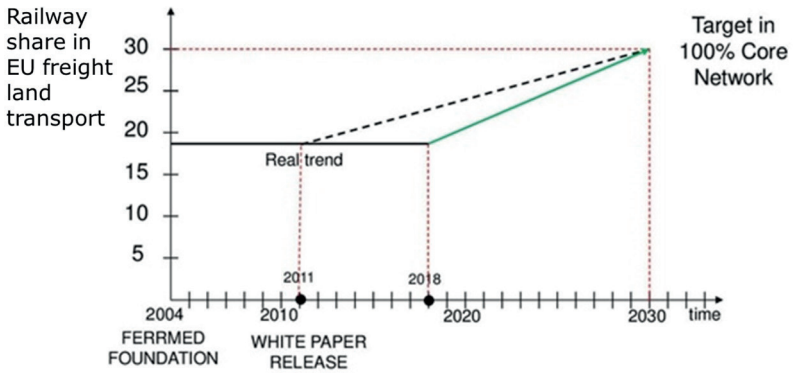
2.1. Starting points

Considering:

- The performance of the EU land freight transport system and its environmental impact
- The economic growth and the resulting growth in freight transport demand expected between 2021 and 2030
- The present inefficiencies of the rail freight transport system
- The waste of economic resources in unprofitable investments
- The lower specific energy consumption and external costs of combined transport versus the road

Under the scope of the "European Green Deal", a comprehensive plan at EU level of modal shift optimisation, aiming for an integrated land freight transport system, is urgently needed.

Figure 1
Railway share real versus planned



2.2. Key messages

- Under the framework of the European Green Deal, to concentrate efforts on achieving the "EC (2011) White Paper on Transport Policy" targets in the most heavily used sections of the corridors of the Core Network already defined by the EC (EU Backbone Network).
- To advance the implementation of innovative actions in the railway system (infrastructure – operation – rolling stock), seeking more flexibility and drastic operating cost reduction.
- To compel automation, "intelligent freight trains" and "intelligent intermodal terminals".
- To develop a new concept of intermodal terminals, avoiding shunting movements.

- To integrate the rail-road transport system in the form of "Mobility as a Service"(MaaS).
- A mandatory Action Plan at EU Extended Core Network level, led by the European Commission (EC), previously agreed by the European Parliament (EP) is urgently required.

2.3. Eurasian transport system challenges

The continuous increase in trade between Eurasian countries[4] (EU and North Africa included) require strengthening of the performance of the global transport interconnection system, particularly railway, where it is necessary to identify strategic hubs and implement shorter transit times and long, compact, and intelligent trains, as well as smart and efficient intermodal terminals and ports. This is key to reducing logistics costs and environmental impact.

3. OBJECTIVES OF THE STUDY

3.1. Preliminary

Considering that there has been no increase in EU rail freight share in the last 15 years (17.9 % in 2005 and 17.3 % in 2017) and that the EU Transport Extended Core Network is too vast (c.80,000 km), **the shift from road to rail requires the concentration of investments in a selective part of the main corridors of the Extended Core Network. To identify** the most heavily used sections in the EU land transport network and **the best procedures to transfer freight from road to rail**, FERRMED has initiated a major study highlighted below.

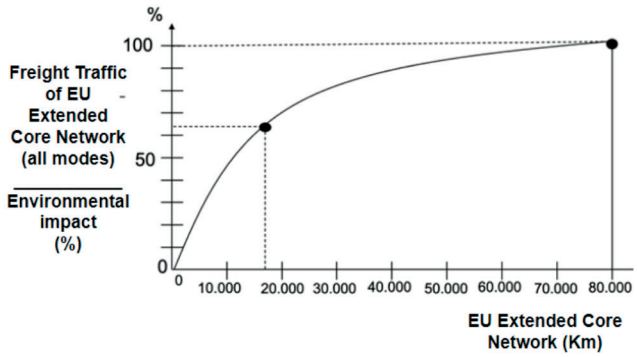
3.2. Basic objectives

The objectives of the study are:

- **To identify current total freight transport by mode** in the main corridors of the EU Core Network (EU Backbone Network);
- **To identify the main logistic hubs in the EU;**
- **To define a new integrated Rail-Road system of transport for freight;**
- **To propose an Action Plan to achieve the EC (2011) White Paper on Transport Policy targets by 2030** (30 % of inland freight transport over 300 km carried by rail or barge) **and "Green Deal" targets,** in the most heavily used sections of the corridors, covering 65 % of the traffic (tonne-kilometres) related to the EU Extended Core Network.

4 According to China National Railway Co., the Trans-Eurasian railway network performed unexpectedly well under the severe constraints imposed by the measures against the COVID-19 outbreak. In the first half of 2020 the Eurasian land bridge responded remarkably to the surging demand for rail freight in both ends of the Eurasian Continent, producing overall growth of 50 % in China – Europe container traffic over the same period the previous year.

Figure 2
FERRMED approach to achieve the 30 % of railway share over total long-distance inland freight in the EU



3.3. Main topics considered in the shift to rail

- We do not conceive having road competing against rail; we consider the railway as the main complement to road traffic. In most cases, road is best for short distances and for the first and last mile. **Railways should be at the service of the road as the most flexible mode,** suitable for carrying heavy goods vehicles (HGVs) and trailers/semi-trailers, swap-bodies and containers for long distances on request (and/or point-to-point traffic).
- To achieve the appropriate shift from road to rail, considering a new, fast and flexible way to manage freight trains, "**combined transport" (CT) is key, mainly unaccompanied CT**.

Example of a train carrying semi-trailers and containers with Sdggmrss T3000e wagons.

4. BASIC STRUCTURE AND CONTENTS OF THE STUDY

- Identification of EU Extended Core Network sections with most cargo movements (all transport modes) → "Backbone Network" (65 % of the Extended Core Network transport) (c.80,000 km of corridors analysed, equivalent to c.200,000 km of individual modes: rail, road and IWW);

- Determination of main strategic logistics hubs;
- Analysis of the key intermodal terminals and main interconnection links, back-up links and feeder links in the "Backbone Network". Bottleneck analysis;
- Definition of the "FERRMED Fast, Flexible, Integrated Rail-Road System of Transport (+FIRRST)";
- Best routes inside the "EU Backbone Network" for interconnection with the Eurasian Transport System;
- Socio-economic and environmental impact assessment;
- Action Plan.

5. TASK FORCE

It has been a major study work. The task force involved consisted of:

- **24 experts:** academics, engineers, economists, geographers and senior analysts from all over the EU
- **12 students:** from Economics, Engineering and Geography Faculties
- **2 Universities involved:** Antwerp University and Barcelona University
- **1 Consultancy:** MCrit
- **45,000 work hours spent:** between June 2019 and October 2023

6. TABLES AND MAPS OF LAND TRANSPORT

Detailed data collection has been carried out, considering 2,608 elementary sections of the EU Extended Core Network Corridors (as average sections of 30 km length).

The sources of data are:

- **Data gathering** from several sources for the **year 2015** (or 2018), mainly **UN-ECE, EUROSTAT, CEDR, OPEN RAILWAY MAP, OPEN STREET MAP** for road and rail.
- **Complementary** data obtained from **national sources** wherever necessary (e.g. Italian toll motorways association, Croatian national transport model, etc.).
- **Inland waterway** transport calculated using an **assignment** model based on **origin-destination matrices** obtained from **national sources**
- **Validation of data** by national experts + filling of gaps

7. DETERMINATION OF EU BACKBONE NETWORK

The EU Backbone Network has been determined by examining the combined transport volume of each elementary section (rail, road and IWW) of the EU Ex-

tended Core Network (ECN). A threshold of 122,000 tonnes/day are required in each elementary section to form part of the Central Backbone Network. All sections with transport volumes above this threshold make up 65 % of the TEN-T ECN (in blue on the map below).

For peripheral countries, we consider as second priority those sections with transport performance over 65 % of the ECN related to the corresponding Member State (in red on the map).

Figure 3
Transport performance

EU Core Network (aggregated): **77,240 km**
EU Central Backbone Network: **18,040 km (23,3 %)**
EU Extended Backbone Network: **8,500 km (11 %)**
Backbone Network 65 % threshold: **122,000 tonnes/day**

The corresponding ECN threshold of 65 % of transport performance in each Member State is detailed in the following table.

Table 1
Country thresholds in 1,000 tonnes/day

Austria	116	Germany	172	Finland	31	Lithuania	63	Portugal	28
Belgium	180	denmark	119	France	128	Luxembourg	204	Romania	73
Bulgaria	35	Estonia	62	Croatia	21	Latvia	43	Sweden	50
Switzerland	155	Greece	39	Hungary	174	Netherlands	213	Slovenia	92
Czech Republic	155	Spain	100	Italy	161	Poland	83	Slovakia	72

8. DETERMINATION OF STRATEGIC SOCIO-ECONOMIC HUBS

To identify and determine the EU hubs, 4 factors were used as selection criteria: Input-Output flow, Manufacturing Gross Value Added (GVA), Population and a Combined Index.

- **Inflow-Outflow:** total freight volumes (to destinations at a distance of 300 km and more from the centroids of the hub's NUTS 3 components) handled per day resulting from the OD matrix.
- **Gross Value Added (GVA) manufacture:** value added of manufactured goods produced in an area or an economic sector.
- **Population:** First filter to select the main EU urban agglomerations as candidates to become a Hub. For the Strategic Hubs, the population of their corresponding urban agglomeration had to exceed 1 % of the EU population (4.5 m inhabitants). For the EU Interrelated Hubs, their population had to be between 0.5 and 1 % of the EU population (over 2.2 m inhabitants).
- **Combined Index:** value resulting from combining the Population, GVA and Input-Output flow values. Using the combined index, the main 30 logistics hubs are identified and duly listed in the following chart.

Figure 4
Combined index

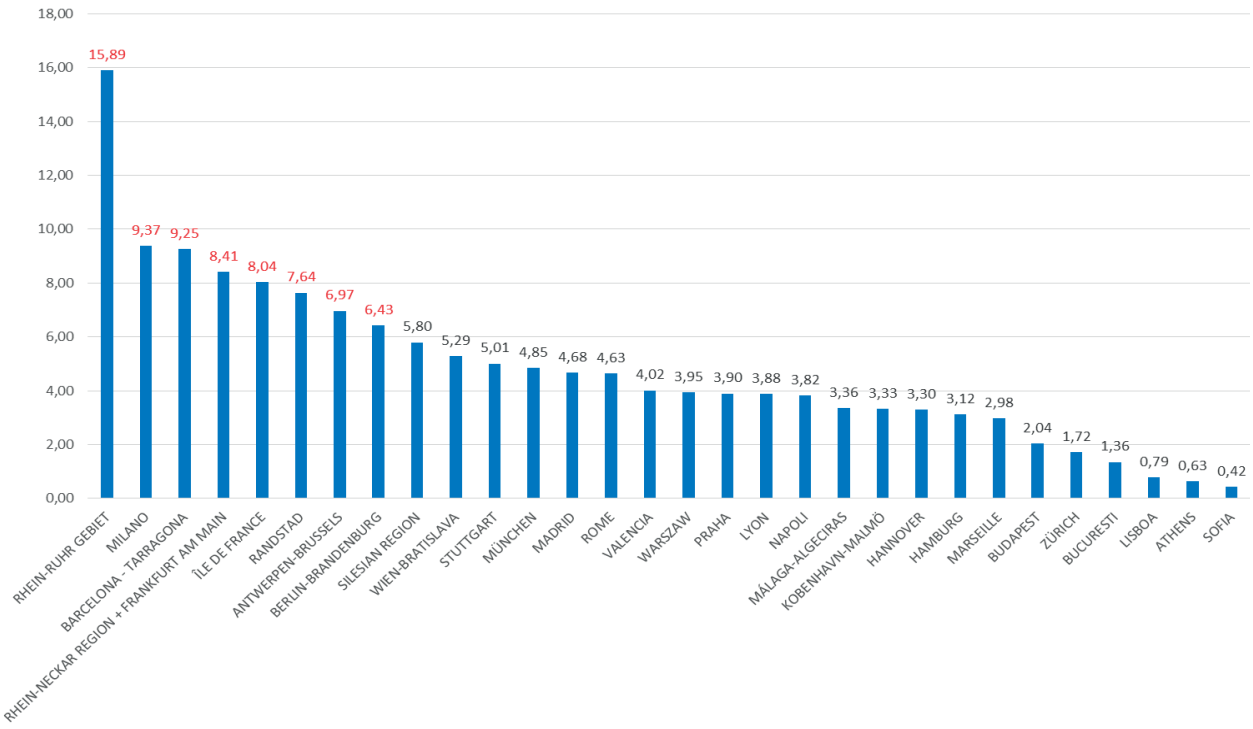
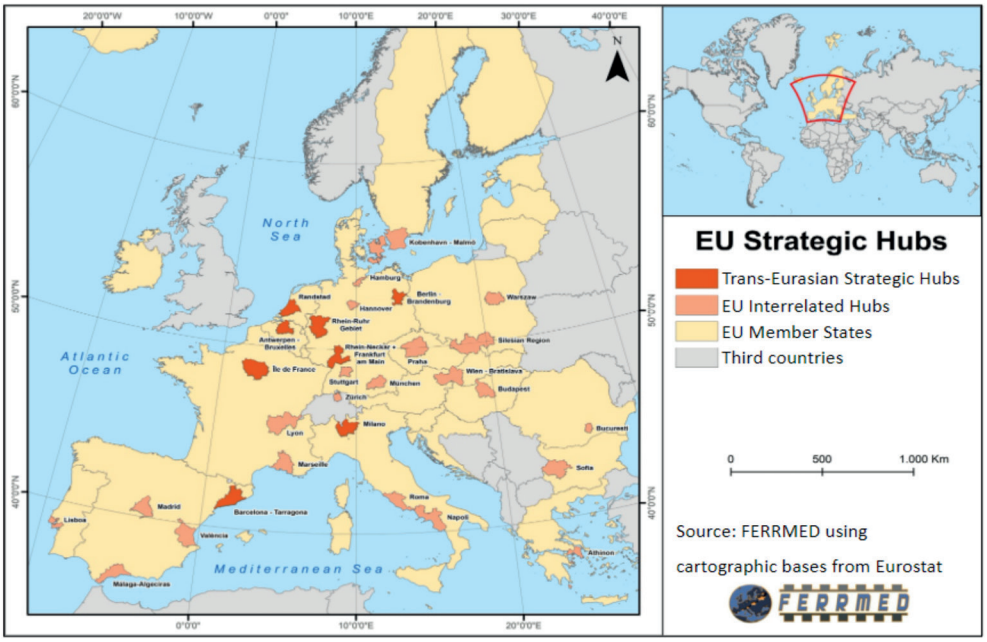


Figure 5
EU Strategic Hubs



Source: FERRMED

9. DATA COLLECTION FOR INTERMODAL TERMINALS IN THE EU ECN

Exhaustive analysis of all existing intermodal terminals (those handling ILUs, ie semi-trailers, containers and swap bodies) in the EU Extended Core Network (ECN) has been carried out using the following basic properties:

1. Contact information
2. Modes served
3. Opening hours for loading/unloading
4. Total terminal area (m^2)
5. Configuration: Dead-End / Pass-Through
6. Number and usable length of tracks (m), for loading/unloading (L/U)
7. Number and usable length of tracks (m), for marshalling/shunting
8. Number of gantry cranes
9. Number of reach stackers
10. Available services

According to the data collected, a preliminary classification of the existing intermodal terminals was performed:

Table 2
Classification of the existing intermodal terminals in the EU

Classification of L/U		Europe	Share (%)
< 250 m	A	127	19.7
251 m - 500 m	B	280	43.5
501 m - 700 m	C	163	25.3
701 m -750 m	D	47	7.3
> 750 m	E	27	4.2
	total	**644**	**100**
	pass through	79	**12.3**
	possible pass through	66	**10.2**
	C possible enlargement (750 m)	5	
	Dead end	565	**87.7**

Note: Existing Intermodal terminals in continental EU + Switzerland

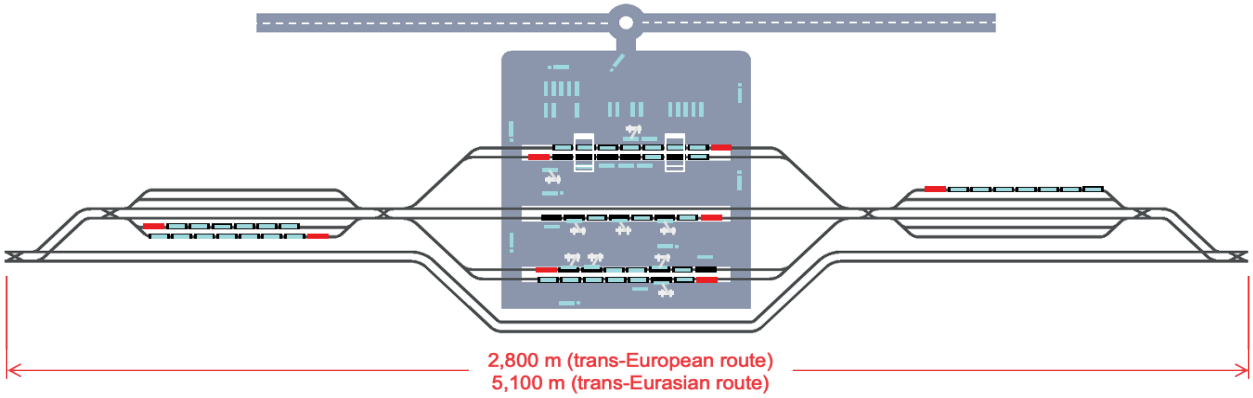
As the table shows, only 12 % of the terminals are pass-through and almost 90 % of the terminals are not suitable for trains of 740 m length. This is a significant handicap, because excessive shunting movements are required.

Figure 6
Map of existing intermodal terminals in the EU

Source: FERRMED

FERRMED proposes a new intermodal terminal concept as set out in the following figure.

Figure 7
+ FIRRST terminals layout concept



Source: FERRMED

The central part of the terminal is the area for loading/unloading tracks. The two buffers are only to park trains if the L/U track area is completely occupied. The length of each buffer is approximately 900 m. This distance, plus the L/U tracks section, allows trains to decelerate from 100 km/h to a complete stop and to accelerate from zero to 100 km/h (in order to create minimum disturbances on the main line).

10. SELECTION AND ANALYSIS OF MAIN INTERCONNECTION, BACK-UP AND FEEDER LINKS

The best existing routes to interconnect the intermodal terminals of the EU logistics hubs have been duly analysed including back-up and feeder routes.

The main data collected are:

- Train length
- Loading gauge
- ERTMS implementation
- International track gauge
- Number of tracks
- Electrification
- Train speed acceptance
- Track gradient
- Operation issues
- Rolling stock issues
- Link section traffic saturation (bottlenecks)

Adequate solutions to solve bottlenecks and any other constraints are duly identified.

11. FORECAST TRAFFIC SCENARIOS AND MODELLING OF ORIGIN-DESTINATION MATRICES

We have built a modelling tool based on Origin-Destination matrices by mode (road, rail, IWW) coming from the ETISplus project (officially used by and for DG MOVE).

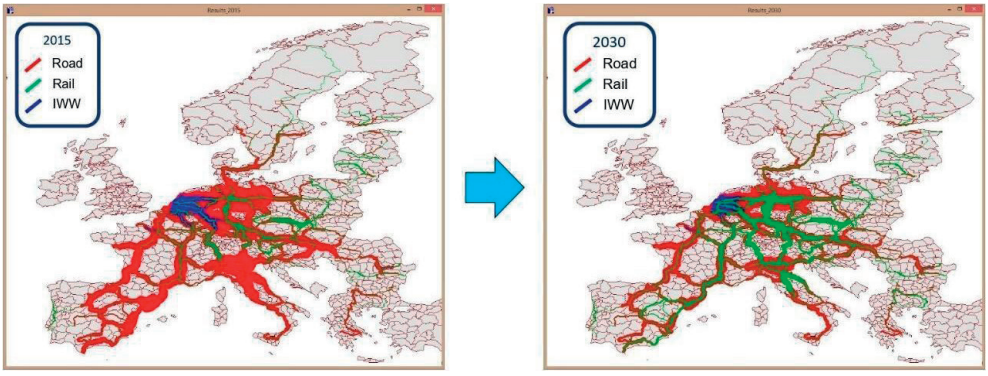
The ETISplus model has been recalibrated using the real transport volume data collected (2015/2018) by the FESDIT team.

To determine the improvements required to absorb traffic onto the railway, according to the EC (2011) White Paper on Transport Policy targets, four different scenarios are considered:

- **Mid term stagnant (2025)**
  - The target is **23 %** of tonne-km by rail on **average in Europe** and in each **individual country** (as much as possible).
- **Long term stagnant (2030)**
  - The target is **30 %** of tonne-km by rail on **average in Europe** and in each **individual country** (as much as possible).
- **Long term (2030) 20 % increase**
  - We start from the 2030 stagnant scenario
  - On top of it we add globally 20 % transport performance in all sections and modes
- **Long term (2030) +20 % with port traffic rebalancing**
  - We start from the 2030 +20 % scenario
  - The assumption that the increase of transport in the Mediterranean – Eurasian route in the future will be: 20 % on the Northern ports and 80 % on the Southern ports, until reaching approximately a 60 %/40 % share north/south.

The evolution of freight transport density by mode from 2015 to the 2030 stagnant scenario is clearly represented in the figure below.

Figure 8
Evolution of freight transport density by mode in the EU



Source FERRMED traffic model

Inflow+outflow volumes for all the main nodes in the EU, in every Member State, have been identified.

The following figures show the inflow+outflow volumes for NUTS 2 (France) and for NUTS 3 (Spain).

The inflow-outflow handled daily in thousands of tonnes, is as follows:

Figure 9
Inflow+outflow volumes handled daily in French regions
FRANCE (NUTS 2) - OVER 300 KM

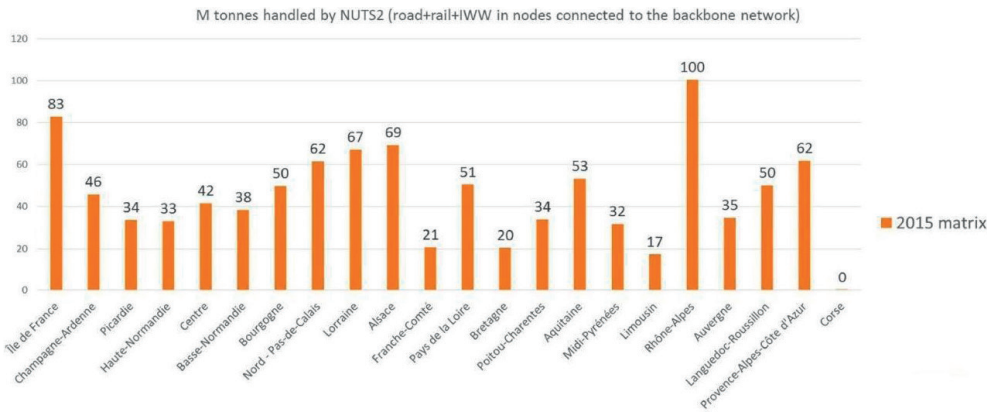
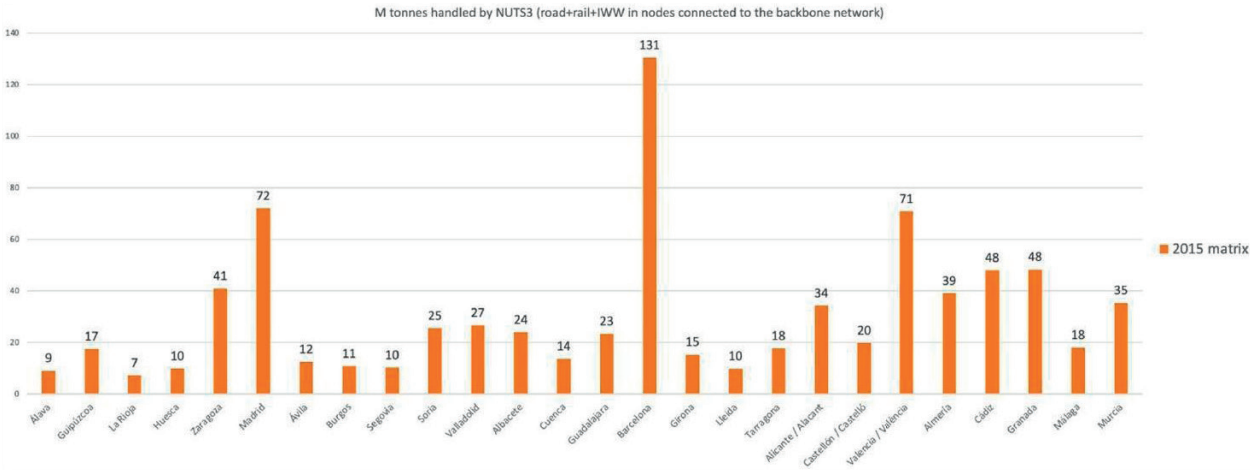


Figure 10
Inflow-outflow handled daily in Spanish provinces
SPAIN (NUTS 3) - OVER 300 KM



12. ANALYSIS OF THE IMPACT OF TRAFFIC SCENARIOS ON INTERMODAL TERMINALS AND INTERCONNECTION LINKS

12.1. Intermodal terminals

The global capacity of the existing terminals in all the EU nodes, by NUTS 2 or NUTS 3 (depending on the country and the inflow-outflow volumes), has been analysed considering the corresponding amount of freight volume, case by case, that must be transported by rail (30 % of the global transport performance rail + road) compared to current rail transport.

First of all, the present capacity of the existing terminals and sidings of manufacturing companies has been calculated (considering 3 shifts on 7 days/week).

We have assumed that point-to-point (ptp) traffic by railway (as it is mainly related to fully-loaded O/D trains) could be only increased by 10 % in central countries and by 30 % in peripheral countries.

The remaining unserved transport volume must be absorbed by the +FIRRST system (on-demand trains and a new intermodal terminal concept). For more details, see section 10 above.

Table 3 shows the example of the Stuttgart node, in which 3 additional +FIRRST terminals are requested in order to absorb the forecast transport volumes for 2030 (values expressed in tonnes per day).

Table 3
Capacity table of terminals for the Stuttgart region (figures in tonnes/day)

Terminal	Global traffic Rail + Road 2015 (30 %)	PTP Rail traffic 2015	PTP		FIRRST		PTP Port Share scenario 60/40	
			2030 Rail traffic stagnant	2030 Rail traffic + Δ20 %	2030 stagnant	2030 Δ20 %	PTP 2030 Δ20 % 60/40	FIRRST 2030 Δ20 % 60/40
STUTTGART	**58,800**	**26,000**	**28,600**	**34,320**	**30,200**	**36240**	**34,320**	**36,240**
Car terminal in Illingen			1,000	1,000			1,000	
DUSS container terminal in Kormwestheim (Stuttgart)			25,760	25,760			25,760	
DP World in Neckarhafen (Stuttgart)			4,200	4,200			4,200	
DUSS container terminal in Neckarhafen (Stuttgart)			5,320	5,320			5,320	
Neckarhafen in Stuttgart			400	400			400	
New +FIRRST mini terminal in Stuttgart					800	800		800
New +FIRRST strategic hub semi-compact terminal in Heilbronn (A6)					18,400	18,400		18,400
New +FIRRST strategic hub terminal between Mühlacker - Illingen					18,400	18,400		18,400
DUSS trimodales container terminal in Heilbronn			2,380	2,380			2,380	
Südzucker in Heilbronn			500	500			500	
Audi car factory in Nekarsulm			450	450			450	
Container-Terminal Hafen Heilbronn			2,380	2,380			2,380	
Neckarhafen in Heilbronn			650	650			650	
Total			**43,040**	**43,040**	**37,600**	**37,600**	**43,040**	**37,600**
Difference			**14,440**	**8,720**	**7,400**	**1,360**	**8,720**	**1,360**

The capacity analysis of the existing intermodal terminals in the EU shows that 425 additional new +FIRRST terminals are required across the EU (plus Switzerland) to accomplish a railway share of 30 % over distances of 300 km as stated in the EC (2011) White Paper on Transport Policy. See Figure 11 for locations of the proposed new terminals.

Figure 11
Location of +FIRRST new terminals

12.2. Interconnection links

Railway traffic growth has been calculated as follows:

- **Freight Trains**
  The number of trains is calculated according to the transport volume of the different scenarios, considering that in 2030 the average net tonnage carried by a train will be 700 tonnes (except in the countries that today have an average of 700 net tonnes or more: in these cases, we keep the present figures, as they are now, for 2030).

- **Passenger Trains**
  Traffic growth to 2030 is calculated according to the EC Staff working document (SWD)[5] estimation of a 24 % increase for conventional lines and 55 % in HSL.

5 Add this as a footnote:
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0005&from=EN

When the total railway traffic on a conventional line of two tracks is greater than 200-220 trains/day, we consider that there is a bottleneck. The corresponding actions to solve existing or forecast bottlenecks have been properly identified and evaluated.

Other key issues analysed are the loading gauge (P400/P410), ERTMS implementation and the availability of 740 m long trains. Suitable actions to implement these infrastructure characteristics have been also duly stated.

See below Table 4 for an example of the table used for the identification of bottlenecks.

Table 4
Existing and forecast railway traffics

From	To	Km	N° of tracks	ACTUAL TRAFFIC 2015			FORECAST TRAFFIC 2025			FORECAST TRAFFIC 2030			FORECAST TRAFFIC 2030 (Δ 20 %)			FORECAST TRAFFIC 2030 (Δ 20 %) + PORT REEQUILIBRIUM (60/40)		
				Passenger Trains / Day	Freight Trains / Day	Total trains / Day	Passenger Trains / Day	Freight Trains / Day	Total trains / Day	Passenger Trains / Day	Freight Trains / Day	Total trains / Day	Passenger Trains / Day	Freight Trains / Day	Total trains / Day	Passenger Trains / Day	Freight Trains / Day	Total trains / Day
Marseille	Miramas	62.1	2	61	25	**86**	67	34	**101**	76	38	**114**	76	46	**122**	76	66	**142**
Miramas	Tarascon	38.5	2	61	28	**89**	67	29	**97**	76	30	**106**	76	36	**112**	76	63	**138**
Tarascon	Avignon	23.2	4	61	41	**102**	67	60	**127**	76	75	**151**	76	90	**166**	76	124	**199**
Avignon	Valence	127.0	4	35	41	**76**	39	75	**113**	43	100	**144**	43	121	**164**	43	153	**197**
Valence	Lyon	104.4	4	129	60	**189**	142	93	**235**	160	119	**278**	160	142	**302**	160	174	**334**
Lyon	Macon	71.0	4	72	72	**144**	79	96	**175**	89	117	**206**	89	140	**229**	89	168	**258**
Lyon	Bourg en Bresse	70.2	2	30	31	**61**	33	31	**64**	37	31	**68**	37	37	**74**	37	37	**74**
Macon	Dijon	125.0	4	96	78	**174**	106	105	**210**	119	129	**248**	119	155	**274**	119	182	**301**
Bourg en Bresse	Dijon	135.1	2	28	37	**65**	31	37	**68**	35	37	**72**	35	44	**79**	35	44	**79**
Dijon	Damblain	110.0	2	4	41	**45**	4	59	**64**	5	77	**82**	5	93	**98**	5	116	**121**
Damblain	Nancy	106.1	2	6	41	**47**	7	56	**63**	7	72	**79**	7	86	**94**	7	108	**116**
Nancy	Metz	55.2	4	89	55	**144**	98	70	**168**	110	88	**198**	110	105	**215**	110	121	**232**
Metz	Thionville	30.9	4	88	95	**183**	97	105	**202**	109	120	**229**	109	144	**253**	109	155	**264**
Metz (CL + HSL)	Strasbourg (CL + HSL)	155.2	4	12	29	**41**	13	31	**44**	15	34	**48**	15	40	**55**	15	45	**60**
Strasbourg	**Basel (Swiss border)**	137.0	2	93	29	**122**	102	31	**133**	115	32	**147**	115	38	**154**	115	44	**159**
Metz	Longuyon	64.5	4	4	20	**24**	4	20	**25**	5	21	**26**	5	26	**31**	5	27	**31**
Perpignan	Narbonne	66.2	2	56	25	**81**	62	60	**122**	69	78	**147**	69	93	**163**	69	128	**197**
Narbonne	Montpeller	96.5	2	85	38	**123**	94	70	**164**	105	91	**196**	105	109	**215**	105	150	**255**
Montpellier	Nimes	57.0	4	89	38	**127**	98	67	**165**	110	88	**198**	110	106	**216**	110	146	**256**
Nimes HSL	Lyon HSL	148.3	2	21	0	**21**	23	0	**23**	26	0	**26**	26	0	**26**	26	0	**26**
Nimes	Tarascon	28.1	4	49	42	**91**	54	77	**131**	61	102	**163**	61	123	**184**	61	163	**224**
Valence	Grenoble	97.0	2	45	4	**49**	50	4	**54**	56	4	**60**	56	5	**61**	56	5	**61**
Grenoble	Montmélian	48.3	2	45	4	**49**	50	4	**54**	56	4	**60**	56	5	**61**	56	5	**61**
Lyon	Ambérieu	54.0	2	67	35	**102**	74	41	**115**	83	48	**131**	83	57	**141**	83	65	**148**
Ambérieu	Montmélian	98.2	2	79	35	**114**	87	41	**128**	98	45	**143**	98	55	**153**	98	61	**159**
Portbou / Cerbère (Spanish border)	Perpignan	48.0	2	6	5	**11**	7	45	**52**	7	70	**77**	7	84	**91**	7	130	**137**
Thionville	**Bettembourg (Luxembourg border)**	27.2	2	144	76	**220**	158	76	**234**	179	76	**255**	179	91	**270**	179	91	**270**
Dijon	Dole	45.2	2	42	11	53	46	11	57	52	11	63	52	13	65	52	13	65

13. OPERATION AND ROLLING STOCK

13.1. FERRMED Fast, Flexible, Integrated Rail-Road System of Transport (+FIRRST)

+ FIRRST System - Introduction

The only way to achieve the EC targets of road freight transfer to rail is to incorporate a system that can move isolated semi-trailers, containers and swap-bodies (ILUs) from/to different destinations in a fast, flexible integrated rail-road system of transport. It is a novel way of organising intermodal rail-road transport in the form of "Mobility as a Service (MaaS). +FIRRST is a combined transport system aligned with the road (as the most flexible mode).

Kind of trains provided

Point-to-Point (Ptp), Stop at Intermediate terminals (Sai) and Stop on Request (Sor).

Network considered (first priority)

EU Backbone Network (Central plus Extended) and additional feeder links. Approx.: **27,000 km**.

+FIRRST System requirements

- **A set of specific intelligent freight trains** (minimum length 740 m), with multipurpose wagons that can carry truck trailers, swap bodies and containers, connecting the EU strategic hubs' intermodal terminals and intermediate terminals in the interconnection links between hubs, throughout the EU Backbone Network.
- **A set of dual locomotives** (electric + electric batteries/diesel) able to carry freight trains of 1,800 – 2,000 t gross weight.
  Note: By letting the train coast while stopping in the terminal tracks, we can use normal locomotives (not dual) as well.
- **A set of "pass-through"** flexible intermodal terminals capable of fast loading/unloading truck trailers and/or containers onto and from freight trains throughout the EU Backbone Network.
- **An integrated rail-road freight flow control system** (in the ERTMS or similar framework) supported by a real time rolling planning concept.

+FIRRST integrated freight control system

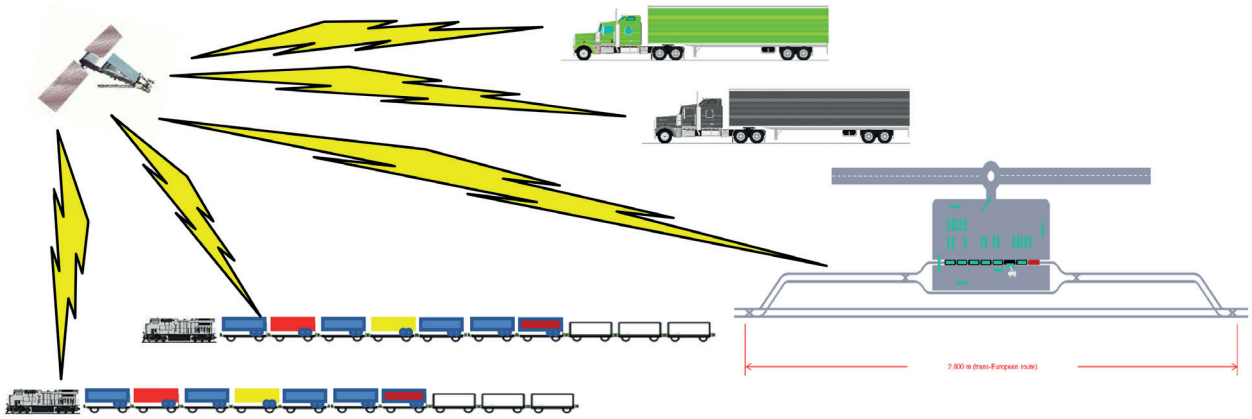
For an optimal functioning of the +FIRRST system, full control of the +FIRRST trains and HGVs in a single database is required. This will allow stops to be set case by case – in the intermediate terminals that are the origin/destination of trailers/containers transported or to be transported – in advance.

Several +FIRRST trains (Ptp, Sai and Sor) will be operative, in a framework of a real time rolling planning concept, interlinking the EU Socio-Economic Strategic Hubs (and related intermediate hubs) defined in the FERRMED Study.

The +FIRRST system will be applied in the Central and Extended EU Backbone Network (approx. 27,000 km).

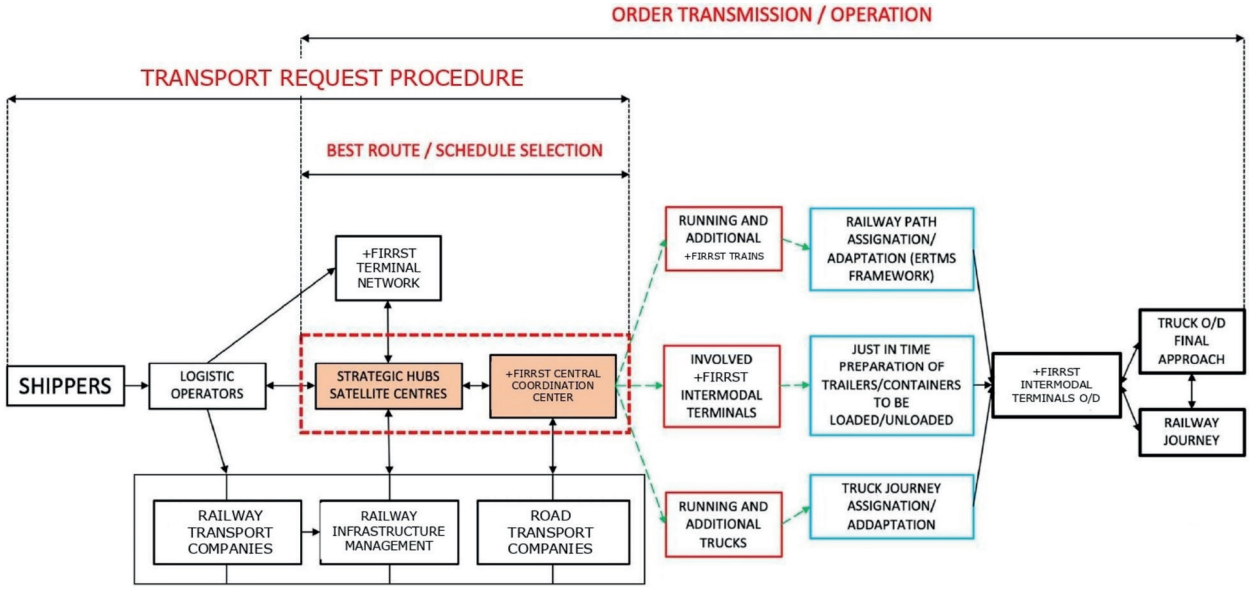
In summary, +FIRRST is a combined transport system at the service of the road (as the most flexible mode), with stops on request (from Ptp to Sal/Sor freight trains).

Figure 12
Real time +FIRRST combined transport management



The +FIRRST system operational procedure, step by step, is formally represented in the following workflow diagram.

Figure 13
+FIRRST System operational procedure

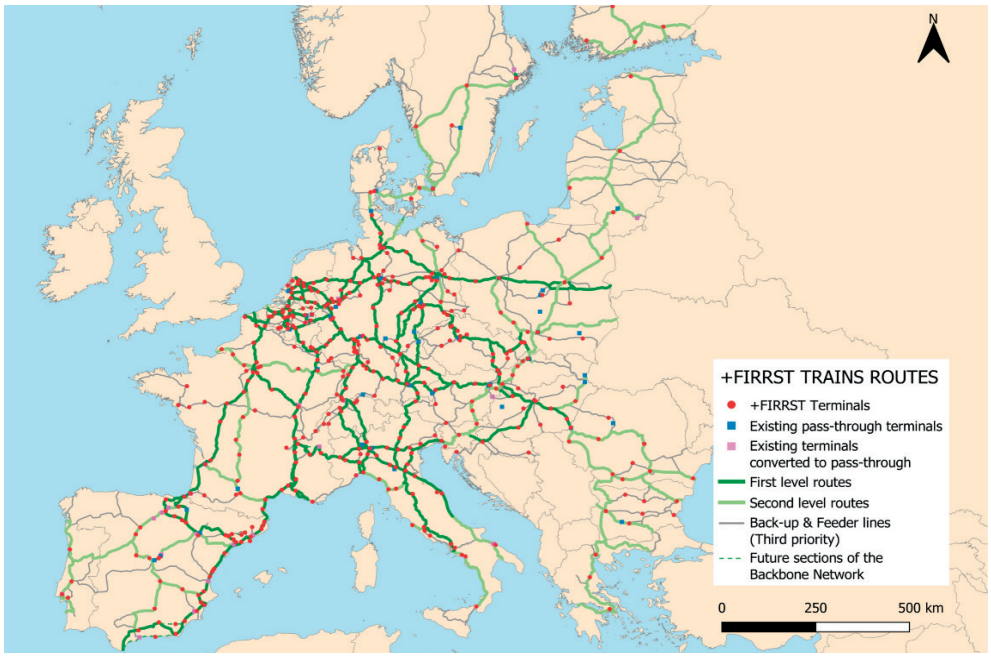


+FIRRST train route definition

+FIRRST train routes will be developed in the corridors included on the Central and Extended EU backbone network, linking the +FIRRST terminals and the existing conventional pass-through terminals.

The Origin/Destination of the trains will be the intermodal terminals of the main EU logistics hubs, with possible stops in intermediate terminals according to real time demand information.

Figure 14
+FIRRST train routes in the EU (approach)



13.2. Test of the +FIRRST system

The Study report suggests that tests of the +FIRRST system will be carried out in order to validate the recommendations below.

- **Key point**
  To select the appropriate TEN-T corridors, linking the suitable terminals of selected strategic socio-economic hubs.

- **Test conditions**
  – High freight transport volume in the sections of the selected corridor
  – Adequate number of existing pass-through intermodal terminals
  – +FIRRST terminals implemented (or simulated)
  – ERTMS (or similar) fully implemented
  – Loading gauge suitable for unaccompanied combined transport

– Intelligent trains including the availability of adequate locomotives and wagons
– Reinforcement of the role of the European Railway Agency (single European railway space); (at least in the corridors where the tests are to be performed)
– +FIRRST Central Coordination Centre operated by the European Agency for Railways (ERA), linked with Member State "satellite" centres

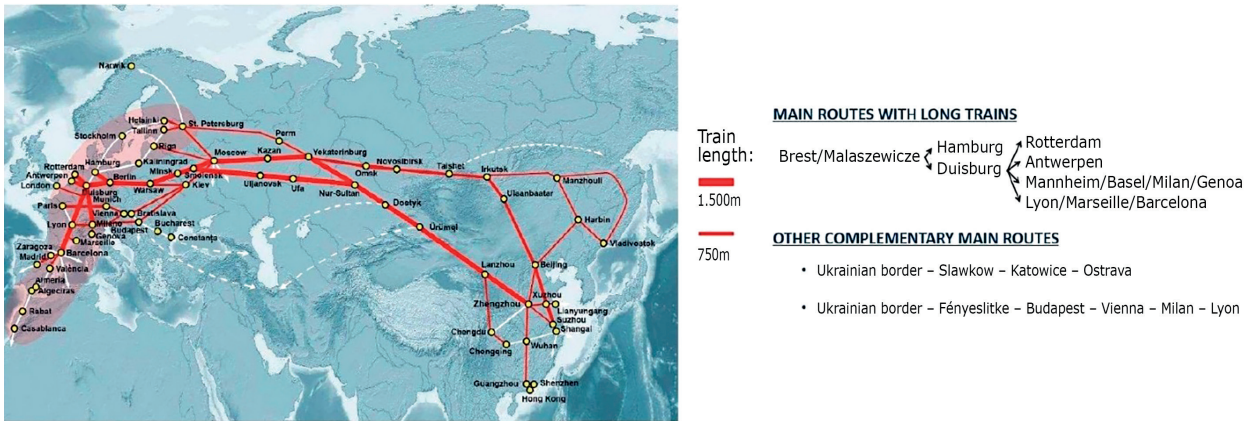
14. TRANS-EURASIAN MAIN RAILWAY NETWORK ENHANCEMENT

FERRMED proposes properly interlinking the EU and Chinese logistics strategic hubs.

In the case of the EU the main logistics hubs are: Duisburg, Hamburg, Rotterdam, Antwerpen, Frankfurt/Mannheim, Milan and Barcelona.

The basic interconnecting routes with 1,500 m long freight trains are duly marked on the map.

Figure 15
Trans-Eurasian Main Routes



The gradual evolution from 600 m to 1,500 m train length must be planned on the aforementioned routes.

See the image below of a test of 1,524 m long trains in France.

Long train test in France.
Freight trains with two engines and 72 wagons, 1,524 metres long and weighing 4,020 tonnes. Trial conducted in France between the towns of Sibelin and Nîmes in the first quarter of 2014. Project Marathon.

15. SUMMARY OF PROPOSED ACTIONS IN THE EU

15.1. Summary of actions

The list of Member State actions identified and additional actions proposed by FERRMED is as follows:

Summary of Member State actions identified

- 12,285 km of new lines
- 44,105 km of upgraded existing lines (ERTMS, P410 loading gauge implementation, 25kV AC, and adaptation of the lines for trains up to 740 m long)
- 46 upgraded existing and new terminals
- **Total: €481.9bn**

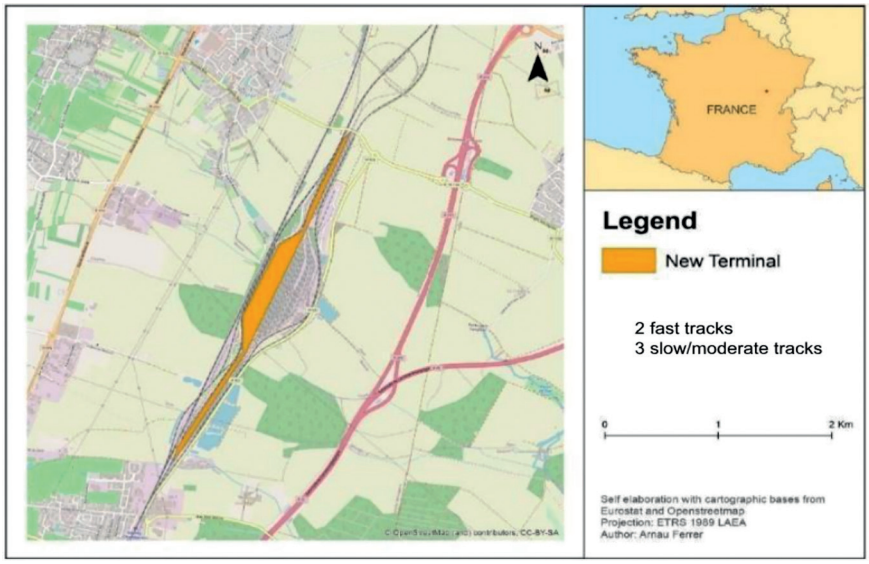
Summary of FERRMED proposed additional actions

- 1,939 km of new lines
- 11,170 km of upgraded existing lines (international track gauge, ERTMS, P410 loading gauge implementation, 25 kV AC and adaptation of the lines for trains up to 740 m long)
- 425 new +FIRRST terminals
- New lines: €31.18bn
- Existing line upgrading: €26.89bn
- New terminals: €11.06bn
- Upgraded terminals: €570m
- +FIRRST system required rolling stock:
  – Electric locomotives (dual types): 950 units, €3.99bn
  – Multipurpose freight wagons: 19,950 units, €3.59bn
- **Total: €77.27bn**

15.2. Examples of proposed actions

15.2.1. INTERMODAL TERMINALS

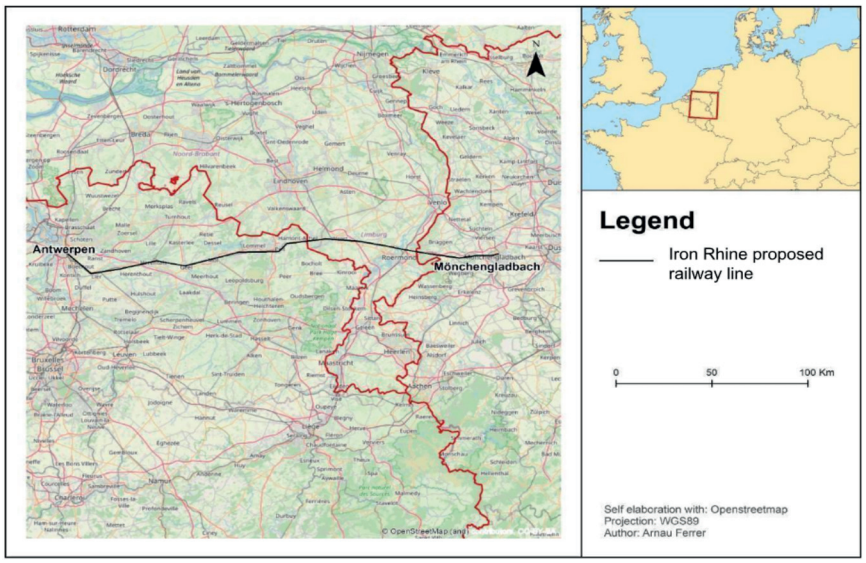
Figure 16
+FIRRST Terminal in Dijon
(Located in an former marshalling yard)



Source: FERRMED, based on OSM and Eurostat cartographic layers

15.2.2. INTERCONNECTION LINKS

Figure 17
New Iron Rhine proposed railway line



Source: FERRMED, based on OSM and Eurostat cartographic layers

16. SOCIO-ECONOMIC AND ENVIRONMENTAL ANALYSIS

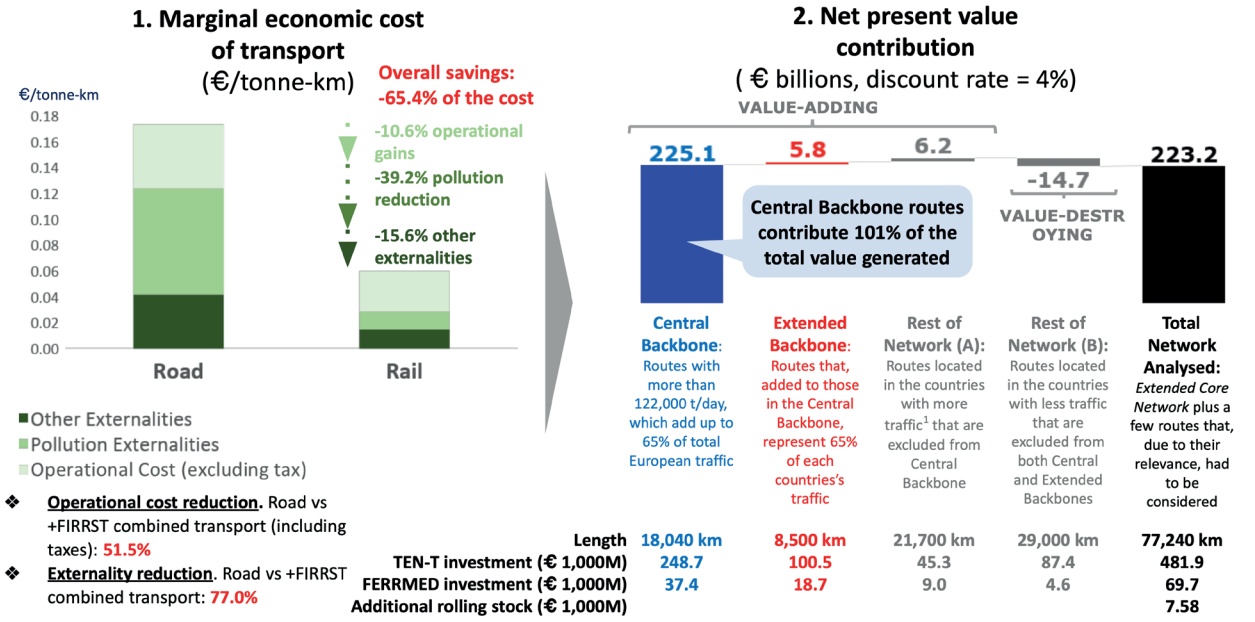
The purpose of this analysis is to assess the socio-economic and environmental impact of FERRMED's recommendations.

Its scope therefore encompasses analyses of:

- Operational efficiency improvements due to the recommended shift from road to combined transport
- Related externality cost reductions (e.g. pollution, CO2, etc.)
- Investment costs required to generate these benefits
- Economic Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR)
- Potential for private investment in +FIRRST terminals

The preliminary socio-economic impact assessment is as follows:

Figure 18
Conclusions of the socio-economic evaluation in terms of NPV



1. The countries within (A) are Austria, Belgium, Czech Republic, France, Germany, Luxembourg, Hungary, Italy, Netherlands, (Slovakia) and Switzerland.

17. MAIN CONCLUSIONS AND RECOMMENDATIONS

17.1. Main conclusions

Investing in 23 % of the EU Extended Core Network generates 101 % of net present value (NPV) contribution, socio-economically and environmentally.
Slightly positive NPVs in further 37 % of the network are offset by negative NPVs in the remaining 38 %.

- **Infrastructure**
  - **First priority** investments in the part of the Extended Core Network that supports 65 % of land freight transport performance (18,040 km, 23 %).
  - **Second priority** to be devoted to sections of peripheral Member States in which is concentrated 65 % of the land freight traffic of the country (8,500 km, 11 %).
  - **Third priority** in the rest of the Network (50,700 km, 66 %).
  - Investments gradually assigned according to transport volume of different sections.
  - **In summary:** To achieve the EC (2011) White Paper on Transport Policy targets, in addition to the actions already identified by EU Member States, some 1,939 km of new lines and 425 new intermodal terminals are required.

- **Operation**
  Gradual implementation of +FIRRST system for freight combined transport in the Central and Extended Backbone Network (c. 27,000 km).

- **Key achievements**
  - 52 % operational cost reduction
  - 77 % externality reduction

17.2. Recommendations

- **To the EC (DG MOVE)**
  To establish a "Priority Investment Plan for EU Integrated Land Freight Transport System" with highest priority where there is the most freight transport.

- **To the European Council and EP**
  To consent to the proposed "Priority Investment Plan for EU Integrated Land Freight Transport System".

- **To the Member States**
  To establish the corresponding national investment plans in accordance with the "Priority Investment Plan for EU Integrated Land Freight Transport System".

- **To the transport sector (logistics operators, transport operators, freight forwarders, ...)**
  To engage in specifying/finalising and implementing +FIRRST.

- **To the EU key associations**
  To agree on common guidelines, aiming for an integrated land freight trans-

port system, with key associations (such as BUSINESS EUROPE, CER, CLECAT, ERFA, ESC, FERRMED, IRU, SME UNITED, UIRR…) to support the "Priority Investment Plan for EU Integrated Land Freight Transport System", including +FIRRST testing in preselected corridors.

- **To the transport sector (logistics operators, transport operators, freight forwarders, …)**
  To engage in specifying/finalising and implementing +FIRRST.

- **To the EU key associations/federations**
  To agree on common guidelines, aiming for an integrated land freight transport system, with key associations (such as BUSINESS EUROPE, CER, CLECAT, ERFA, ESC, FERRMED, IRU, SME UNITED, UIRR…) to support the "Priority Investment Plan for EU Integrated Land Freight Transport System", including +FIRRST testing in preselected corridors.

Full content of the Study in FERRMED website: www.ferrmed.com

IV

Acknowledgements

Undertaking the FERRMED Study of Traffic and Modal Shift Optimisation in the EU, has been possible thanks to the great and, in many cases, altruistic dedication of the FERRMED STUDY INTERNATIONAL DEVELOPMENT TEAM (FESDIT) composed of the following members:

- Ramón Adé, Manager in Logistics and International Trade, General Manager, Terminal Marítima de Zaragoza
- Seyed Mohsemi Abolfazl, Graduate in the field of Civil Engineering for Risk Migration and Master in Science, Antwerp University
- Valentí Ambròs, Industrial Engineer, Adviser to the FERRMED President
- Joan Amorós, Doctor in Industrial Engineering, FERRMED President
- Sven Andersen, Graduate Engineer (Diplom Ingenieur)
- Lluís Bassas, Industrial Engineer, Adviser to the FERRMED President
- Simó Batlle, Civil Engineer and Master in Urban Projects, Head of Planning and Intermodality, CIMALSA
- Pierre Borgoltz, Diploma HEC, Diploma 2e Cycle IEDES and MPA, Former Co-operation Coordination, SENECA. FERRMED Adviser
- Mike Dermardirossian, Master's degree in EU Public Affairs, FERRMED
- Arnau Ferrer, Geographer, FERRMED Senior Analyst
- Pablo García, Master in International Trade, Managing Director, Synergy
- Manuel J. García, Graduate in Economics and Master in Port Management and International Sea Transport, Head of Business Development Intelligence, Port of Valencia
- Àngel Gil, FERRMED Secretariat
- José Antonio Gómez, Industrial Engineer, Deputy Secretary General, FERRMED
- Eduard Gràcia, Economist, FERRMED Adviser
- Efrain Larrea, Transport Planning Engineer, MCrit
- Henry Maillard, Consultance Mobilité. FERRMED Adviser
- Noèlia Martín, Graduate in Economics and Master in Public Management, Strategy Development, Port of Barcelona
- Olaf Meyer-Rühle, Master in Science in Economics and International Development, OMR Conseil, FERRMED Adviser
- José María Ojea, Industrial Engineer, Adviser to the FERRMED President
- Petros Papagiannakis, Civil Engineer, Director General, LFP Perthús
- Olga Perxés, FERRMED Secretariat
- Josep Reyner, Economist, FERRMED Adviser
- Francesc Robusté, Doctor in Civil Engineering, Universitat Politècnica de Catalunya
- Josep Maria Rovira, Industrial Engineer, Secretary General, FERRMED

- Lanfranco Senn, Graduate in Economics and Trade and Master in Regional Sciences, Professor Emeritus, Università Bocconi
- Assumpta Torrent, Journalist, FERRMED Communication and Institutional Relations Manager
- Naya Vallés, Degree in Applied Management, FERRMED
- Joan-Josep Vallvé, Industrial Engineer, Adviser to the FERRMED President
- Thierry Vanelslander, Professor in Applied Economics, Antwerp University
- Edwin Van Hassel, Civil Engineer and Doctor in Applied Economics, Antwerp University
- Hiwot Workie, Civil Engineer, FERRMED

Besides the technical team, we would like to give our recognition to Antwerp University (Department of Transport and Regional Economics) and Barcelona University (Faculty of Geography) for their involvement facilitating the collaboration of different professors, alumni and students. We also appreciate the dedication of MCrit consultancy, which has provided much needed assistance in several matters, particularly in all that concerns modelling of origin-destination matrices, land transport networks, investment needs as well as environmental impact.

In addition, we must mention the close collaboration in the exchange of ideas and concepts of:

- Manuel Alarcon-Espinosa, Europe's Rail
- Giulia Ambrogio, Ambrogio Transporti SpA
- Marc Billiet, Senior Advisor – EU Goods Transport, IRU
- Alba Carré, CEO, CALSINA-CARRÉ
- Carlos Castells, Equimodal
- Denis Choumert, AUTF president
- Josef Doppelbauer, ERA Executive Director
- Gert Fregien, Doctor of Engineering.
- Joerg Greshake, Greenbrier Europe
- Stefan Hagenlocher, HWH Transport and TIS
- Reinhard Hillmann, VTG
- Marc Hunziker, VTG
- Raluca Marian, Director – EU Advocacy, IRU General Delegate to the EU
- Joao Meireles, SIEMENS Mobility
- George Raymond, Railweb
- Mar Rivas, STADLER Valencia
- Isabelle Ryckbost, Secretary General, ESPO
- Anna Samsonova, LOHR Industrie
- Ralf Charley Schultze, UIRR President
- Josep Maria Serena, Industrial Engineer
- Patrick Sluga, SWS PS Power Solutions GmbH
- Godfried Smit, ESC Secretary General
- Ádám Talosi, CEO, EAST-WEST GATE Intermodal Terminal
- Ricard Vendrell, Head of Office representation in Spain, HUPAC
- Marcin Wójcik, Advisor to Matthias Reute

The Study could not have been completed without the sponsorship of CIMALSA, Diputació de Barcelona, Diputació de Girona, Diputació de Lleida, Diputació

de Tarragona and Ferrocarrils de la Generalitat de Catalunya (FGC). We are extremely grateful for their support.

Last but not least, we must express our ongoing appreciation to all FERRMED members for their continuous loyalty to and support for our Association, which makes possible the achievement of milestones like the delivery of this FERRMED Study of Traffic and Modal Shift Optimisation in the EU.

V

FERRMED members and partners

(OCTOBER 2023)

- AEMT-AIE (Agrupació d'Interès Econòmic Empreses Municipals de Tarragona)
- Aeroports de Catalunya
- Ajuntament de GIRONA
- AMEC (Associació Multisectorial d'Empreses)
- ANESCO (Asociación Nacional de Empresas Estibadoras y Consignatarias de Buques)
- ARDANUY Ingeniería, S.A.
- ASCAME
- ASCER (Asociación Española de Fabricantes Azulejos y Pavimentos Cerámicos)
- Asociación Murciana de Logística AML
- Association Internationale pour le Tunnel de Salau
- Autoridad Portuaria de Alicante
- Autoridad Portuaria de Almería
- Autoridad Portuaria de Baleares
- Autoridad Portuaria de Cartagena
- Autoridad Portuaria de Castellón
- Autoridad Portuaria de Valencia
- Autoritat Portuària de Barcelona
- Autoritat Portuària de Tarragona
- AUTOTERMINAL, S.A.
- Ayuntamiento de BAZA
- BARCELONA REGIONAL
- BCL (Barcelona Centre Logístic)
- BEST (Barcelona Europe South Terminal)
- Transports Calsina Carré, S.L.
- Cámara de Comercio, Industria y Navegación de ALMERÍA
- Cámara Oficial de Comercio, Industria y Navegación de CASTELLÓN
- Cámara Oficial de Comercio, Industria, Servicios y Navegación de MURCIA
- Cambra de Comerç de GIRONA
- Cambra de Oficial de Comerç, Indústria i Serveis de LLEIDA
- Cambra de Comerç, Indústria, Serveis i Navegació de REUS
- Cambra Oficial de Comerç, Indústria, Serveis i Navegació de BARCELONA
- CCTT (International Coordinating Council on Trans- siberian Transportation)
- CELSA (Compañía Española de Laminación)
- Centre Européen de Fruits et Légumes
- Cercle d'Infraestructures
- CFL MULTIMODAL S.A.
- Chambre de Commerce du Grand- Duché de LUXEMBOURG
- Chambre de Commerce et d'Industrie de Région Auvergne-Rhône-Alpes
- CIMALSA (Centres Logístics de Catalunya)

- CLECAT (European Association for forwarding, transport, logistic and customs services)
- COE (Cercle pour l 'Optimodalité en Europe)
- COEC (Confederación Comarcal de Organizaciones Empresariales de Cartagena)
- COEIC (Col·legi Oficial d'Enginyers Industrials de Catalunya)
- COIICV (Colegio oficial de Ingenieros Industriales de la Comunitat Valenciana)
- Col·legi d'Enginyers de Camins, Canals i Ports de CATALUNYA
- Colegio de Ingenieros Industriales de Andalucia Oriental
- Colegio de Ingenieros Industriales de la Región de Murcia
- Consorci de la Zona Franca de BARCELONA
- CROEM (Confederación Regional de Organizaciones Empresariales de Murcia)
- Development TGV Languetoc-Roussillon
- East-West Intermodal Logistics Plc. (Hungary)
- EIA (European Intermodal Association)
- Energie TGV
- ERFA (European Rail Freight Customer Platform)
- EUROMEDITERRANEAN BUSINESS ASSOCIATION (Business Eumed)
- Europakorridoren AB
- femVallès
- FemCat (Fundació Privada d'Empresaris)
- FGC (Ferrocarrils de la Generalitat de Catalunya)
- FOC (Fundació Occitano Catalana)
- Foment del Treball Nacional
- FORD
- FUNDACIÓN ICIL (Institut Català de Logística)
- Fundación PROAVE
- GLOBALLEIDA
- Grand Port Maritime de MARSEILLE-FOS
- HUPAC – Intermodal Transport
- IBS (Interessengemeinschaft der Bahnspediteure) e. V.
- ICAB (Il·lustre Col·legi de l'Advocacia de Barcelona)
- ICL Iberia Limited SCS
- INCASOL (Institut Català del Sòl)
- Institut d'Economia i Empresa IGNASI VILLALONGA
- ISL (Isntitute of Shipping Economics and Logistics)
- La Transalpine (Comité pour la liaison européenne transalpine Lyon -Turin)
- LFP Perthus (Línea Figueras Perpignan)
- Logitren Ferroviaria, S.A.
- LOHR Industrie
- Meeting y Salones
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Published by

FERRMED A.S.B.L.
Rue de Trèves, 49 box 7
B-1040 Brussels - Belgium
Tel. +32 2 230 59 50 - Fax. +32 2 230 70 35

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