C4R

Capacity for Rail

Towards an affordable, resilient, innovative and high-capacity European Railway System for 2030/2050

Catalogue: Rail Freight Systems of the Future (Final)

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Deliverable 24.2

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Executive Summary

An important target in EU white paper at 2011 was to shift from road freight to rail or waterborne on longer distances. The actual development is not at the moment in line with this. To reach the white paper target, it is necessary to both increase quality and capacity and lower the cost of rail freight. In this report, guidelines and technologies would be proposed for 2030/2050.

To achieve this, SP2: New Concepts for Freight, was split into four work packages; WP21 Progress beyond the state of the art, WP22; Novel rail freight vehicles and WP23; Co-modal transhipment and interchange/logistics, culminating in WP24; Catalogue of specifications.

This document addresses the following objectives of WP24:

- To analyse the potential of newly designed, fully integrated rail freight systems and understand the expected market up take levels;
- To produce a catalogue on rail freight systems to contribute to the Commission's goals for 2030 and 2050 (i.e. achieving modal shift from road to rail) ;

Deliverable 24.2 consolidates and builds on the output produced under SP2 so far, to develop the following catalogue for rail freight systems which meets the requirements and expectations of 2030/2050. The catalogue focusses on rail freight system designs and technological innovations in six key areas as identified in the DOW;

- Freight, modal shift from road to rail
- EU-wide high-speed rail network
- Multimodal TEN-T core network
- Long-term comprehensive network
- Traffic management systems in all modes
- Multimodal transport information

The catalogue contains analysis of the potential market up-take of the new designs for rail freight systems. The results from a comprehensive industry survey have been assessed with the aim to understand the levels of industry receptivity and acceptance in relation to the performance and operational and technological characteristics of the new system designs.

WP 2.1 included an overview of the transport development in Europe in the last decades as well as forecasts for the future. Measures to improve the rail system in the future, has been investigated and some recommendation to develop the system has been made as:

- Heavier and longer trains which utilize the full potential of modern locomotives
- More efficient wagons by higher axle load and wider gauge and better length-utilization
- Improved train performance with electro-pneumatic brakes and automatic couplers
- Improvement of inter modal with automatic terminals for containers and ramping of trailers
- Use of IT-system for planning of transports and information to the customers

In WP 2.2 an overview and assessment including advantages and disadvantages of previously developed wagon systems. Designs and developments from WP22 have been highlighted including;

- For car carrier wagons, 5 bodies with 6 axles for an overall length of 62m
- For container wagons, a standard train composed of slightly rebuilt wagons capable to carry 40' containers or 20' containers plus on every third wagon a 45´container.

- For container wagons, a new design of a five bodies wagon with six bogies for five 45´containers with an overall length of around 72m. This solution aims to reduce the number of bogies and hence the maintenance cost.
- For crane-able semitrailers with a 4 bodies wagon with 6 bogies for four trailers with an overall length of around 67m.
- To reduce significantly the preparation time before the departure of the train with the introduction of an EOT (End Of Train) device.

From the industry survey, participants were asked five questions related to; gauge clearance, axle load, change to priority of path allocation, wagon innovations in freight wagons to accommodate modal shift, freight vehicle improvements still required.

Interesting findings included;

- 60% of respondents thought that it is ‘very’ or ‘moderately’ likely that the axle load increase will be achieved EU wide by 2030.
- From existing wagon designs, the three wagons chosen most frequently to facilitate modal shift were;
    - Special flat wagon with bogies
    - Ordinary flat wagon with bogies
    - Tank wagon
- The three wagon improvements ranked by industry as most urgently required were;
    - Lighter wagons
    - Maintenance Detectors
    - Track Friendly Running Gear

The current situation across the EU concerning a high-speed network has been analyzed including freight services have been identified as a focus towards 2030/2050. Remaining barriers to a high-speed network for freight services have been examined, including rolling stock adaptation, service reliability and capacity constraints.

The conclusion is that the potential for a real high speed network for freight services is limited. The most important consequence of building high speed lines primarily for passenger traffic is that it will increase the capacity for freight and regional trains on the conventional network. Freight trains with higher speeds, in the range of 120-200 km/h, are possible and also used today for specific markets, mostly with classical high performance freight wagons. This can be developed further in the future.

The industry survey incorporated the topics of; achievable higher speed for freight, barriers to an EU wide high-speed network, level of confidence that a high speed network is achievable.

- 120km/h was identified as the most achievable high speed for freight services by 2030.
- Numerous suggestions regarding the barriers to an EU wide high speed network were put forward by industry stakeholders these included;
    - *Path allocation for freight services in comparison to passenger services viewed as a major barrier together with a lack of designated high-speed lines for freight services.*
    - *Maintenance costs, along with the current conflict in maintenance regimes and a lack of maintenance coordination.*
    - *The development of modern IT systems*
    - *Insufficient capacity on some lines and a shortage of capital for its increase, together with a lack of harmonisation of network capacity.*

In WP 2.3 terminal handling has been analysed. Across the TEN-T network, terminals are an essential element to ensure the connection between various modes. Innovation processes and technologies have been examined for numerous terminal typologies along TEN-T modal corridors, including a proposed time frame for each innovation. These included for road-rail and rail-sea terminals operational and technical innovations which deal with the topics of;

- Handling Typology;
- Handling Equipment;
- Handling Layout;
- Terminal Access - ICT technologies;
- Internal Moving Vehicles: Locomotive;
- Technological Systems: Control and security;
- Terminal Working Hour;
- Conceptual Train Side layout;
- Conceptual Horizontal Handling.

For rail-rail terminals the following innovations and technologies were considered;

- Rolling Stock Equipment;
- Marshalling Yard layout: Track operative length;
- Terminal Access ICT technologies: Vehicle identification and transport documentation exchange.

For rail-sea and rail-road terminals the three improvements ranked as most urgently required by industry stakeholders were;

- Automatic ITU and vehicle control and data exchange
- Longer Trains
- 24 Hour working time

For rail- rail terminals the three improvements ranked as most urgently required were;

- Automatic coupling and decoupling
- Automated vehicle identification
- Longer Operative Track Length

Finally the option of automated terminals for liner services with horizontal transfer of containers has been explored including potential benefits such as;

- Cost reduction of terminal handling per unit by approximately 60%;
- Break-even point for intermodal will be reduced from 500 km to 300 km;
- Energy consumption for terminal handling will be reduced by 93% CO_2 emissions in kg per unit will be reduced by 99% with electric propulsion

An overview of EC regulations identified guidance for TEN-T core and comprehensive network development, this should follow a dual layer structure, core and comprehensive wherein the comprehensive network is developed on the basis of the core network meaning that innovations and technologies considered for the core network will also be applicable across the comprehensive network.

Survey responses on the topics of; third party logistics, identification of the main barriers to a comprehensive network and potential advantages of a comprehensive network were examined. Of note, comprehensive network barriers were categorised under 4 subtopics including;

- Economic barriers

    - Costs such as track access
- Political barriers
    - Pressure of local politicians Europe wide for regional passenger trains everywhere
- Barriers to Infrastructure Development
    - An imbalance in infrastructure development
- Barriers to Freight demand
    - Lack of certainty of rail capacity across a calendar year

Several traffic management systems were studied including ERTMS and tracking and tracing technologies, in order to identify possible systems for 2030/2050. Assessment of stakeholder viewpoints on the topics of; ERTMS Level 2 and Level 3 deployment, along with the aspects of big disruption management most critical for freight services was undertaken.

Notably;

- Over 30% of respondents believed that there was less than a 50% possibility that ERTMS level 2 would be operational EU wide by 2030.
- No participants voted for a 80-100% confidence level of Level 3 ERTMS deployment by 2030

A number of options to streamline the multimodal transport information (MTI) process, have been analysed including; data collection, transfer of departure data, intelligent entry and exit gates.

An evaluation of survey responses on the topics of MTI including brokerage systems has been carried out, notable statistics include;

- 80% of participants were unaware of any online brokerage systems
- Regarding data sharing on a database to enable other customers to book free or remaining capacity on freight services - 35% of participants were not permitted to share this type of information

This research will offer valuable input into future activities, both inside and outside of the Capacity4Rail project. Within the project namely this deliverable will feed into;

- WP24- Standards
- WP24- Synthesis
- SP5- WP56- Guidelines and follow up action

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Abbreviations and acronyms

Abbreviation / Acronym	Description
EC	European Commission
C4R	Capacity4Rail
ILU	Intermodal Loading Unit
MTI	Multimodal Transport Information
ERTMS	European Railway Traffic Management System
TEN-T	Trans European Transport Network
EU	European Union
ITU	Intermodal Transport Unit
CEO	Chief Executive Officer
ABS Device	Anti-lock brakes
ITU	Intermodal Transport Unit
GHG	Greenhouse Gases
3PL	Third Party logistics
GPS	Global Positioning System
AEI	Automatic Equipment Identification
GSM	Global System for Mobile Communication
ICT	Information and communication technology
T&T	Tracking and tracing
FTMS	Freight Transport Monitoring System
TCMS	Transport Chain management system
ETA	Estimated Time of arrival
EDI solutions	Electronic data interchange

1 Background

The EC goals for a competitive and resource efficient transport system (EC White Paper, 2011) have been well documented, with targets and measures for rail emphasized. To achieve these goals, the challenges identified in the White Paper are;

Traffic Management

- Development of new technologies for vehicles and traffic management to contribute towards lowering EU transport emissions.
- An increase in efficiency through the improvement of traffic management and information systems
- A decrease in last mile freight journeys, employing intelligent transport systems to reduce delivery times and decrease last mile congestion.

EU wide high-speed network

- An increase in the operation of high speed rail services- it is anticipated that high-speed rail will absorb much of the medium distance traffic.
- Enhancement of infrastructure, an increase in high-speed services will require support from an adequate high-speed network.

Freight, modal shift from road to rail

- Encourage the shift of freight volumes over 300km to more sustainable modes such as rail and waterborne. (30% by 2030 and 50% by 2050).
- Infrastructure investment to accommodate modal shift to rail.
- Development of rolling stock including brakes and automatic coupling.

Multimodal TEN-T core network

- Optimisation of multimodal logistics chains
- Increase in the consolidation of large freight volumes together with an increase in freight multimodal solutions, enhancing the use of waterborne and rail for long haul.
- The development of freight corridors offering reliability, high capacity and low costs leading to optimised energy use, decreased emissions, minimised environmental impacts by shift from road to rail on longer distances

Long-term comprehensive network

- Equal enhancement of non-core infrastructure across Eastern and Western EU.

Multimodal Transport Information

- Development of information technology to enhance more reliable multimodal transfers.
- By 2020, establish a framework for European multimodal transport information, management and payment system.

This deliverable will focus on innovations for the subtopics defined above, which have been developed over the course of SP2 freight and which it is anticipated will contribute towards addressing these challenges.

2 Objectives

The objectives of WP24 are:

- To study and design new concepts for network-based services for fully integrated rail freight systems to meet the requirements of 2030/2050;
- To assess the performance of newly designed fully integrated rail freight systems using a modelling framework;
- To analyse the potential of newly designed, fully integrated rail freight systems and understand the expected market up take levels;
- To produce a catalogue on rail freight systems to contribute to the Commission's goals for 2030 and 2050; and
- To suggest standards for fully integrated rail freight systems.

The aim of Task 2.4.3 is to produce a catalogue for rail freight systems which meets the requirements and expectations for 2030/2050. The catalogue will focus on rail freight system designs and technological innovations in six key areas as identified in the DOW;

- Freight, modal shift from road to rail
- EU-wide high-speed rail network
- Multimodal TEN-T core network
- Long-term comprehensive network
- Traffic management systems in all modes
- Multimodal transport information

For each subtopic, all the rail freight system designs developed during the course of 'SP2 freight' will be consolidated and remaining technological innovations required to meet the White Paper challenges will be identified.

Alongside this, the catalogue will contain analysis of the potential market up-take of the new designs for rail freight systems. The results from a comprehensive industry survey will be assessed with the aim to understand the levels of industry receptivity and acceptance in relation to the performance and operational and technological characteristics of the new system designs. The survey has been widely disseminated among; infrastructure managers, train operators, terminal operators and logistics' service providers, rail equipment manufactures and sellers across Europe.

3 Introduction

This deliverable, (D24.2 Catalogue Rail Freight systems of the Future Final) consolidates and builds on the output produced during; Work Package (WP) 21: D21.2 Requirements toward the freight system of 2030/2050 (Final); WP22 D22.2 Novel Rail Freight Vehicles (Final), WP23 D23.2 Co-modal transshipments and terminals (Final) and WP24 D24.1 Catalogue: Rail Freight Systems of the Future (intermediate). Together with this, a comprehensive survey was conducted to collect information and understand the levels of industry receptivity of acceptance and market uptake in relation to the performance, operational and technological characteristics of the new system designs.

3.1 Survey Development & Implementation

The survey was designed to gain an understanding of the expected industry market up take levels, of the proposed Capacity4Rail freight system designs. The survey consisted of 34 questions, 7 of which were to profile the anonymous respondents and 27 questions which were categorised under the six subtopics; Freight modal shift road- rail, EU wide high speed rail network, Multimodal TEN-T core network, Long term comprehensive network, Traffic management systems, Multimodal transport information as these are in line with the European Commission (EC) goals for a competitive and resource efficient transport system. The questions were prepared based on the findings of previous research predominantly in Capacity4Rail SP2 and some insights from SP3. Lessons learned from other research project such as SPECTRUM that explored rail freight service for non-rail such high value low cargo cargoes such as foodstuffs and white goods; D-RAIL that forecasted freight volumes in 2030 and 2050 and assessed the necessary rolling stock requirements, among others; Marathon that explored and trialled 1.5km long freight operation in 2014 were taken into account.

The survey was carried out using the online survey tool SurveyMonkey, which is a leading provider of web based survey solutions which facilitates survey completion online, with instant access and analysis of the results for the C4R consortium members. SurveyMonkey was successfully used in previous research including (Smartfusion) by the researchers of the current research. The survey was distributed through several means; by project partners and on their websites, on the C4R website, through600 targeted emails to appropriate industry members. Over a period of two weeks from 15th November- 19th December 2016. In total 61 responses were received, we would like to thank all the industry participants for giving up their time to complete the survey and for all the valuable additional comments and feedback provided.

Taking into account the important findings and feedback from the survey participants, the final subsection of each chapter will detail the results of the survey.

3.2 Respondent Profile

The survey was private and confidential and no respondents could be identified individually. To profile respondents, 7 questions were posed on the topics of; respondent role, respondent business area, gender, length of service in the rail sector, country, level of education. These questions were optional as it was preferred that respondents completed the subtopic questions. Regarding respondent business area responses were collected from;

- Freight operators
- Infrastructure managers

- Logistic service providers
- Passenger operators
- Rail equipment manufacturer/seller
- Terminal operator
- Rail freight customer
- Regulation officer
- Consultants
- Operator of intermodal freight brokerage
- Rail business planner & ERTMS expert

From respondents who disclosed their gender 86% were male. Of respondents which communicated their role; 13% were CEO, 36% senior management, 22% middle management, 11% operational, 11% Administrative, 5% Other including fleet manager. A large proportion (83%) of respondents which communicated their length of service in the rail sector had been active for over ten years. With reference to the level of education, of respondents who revealed this, 20% have a Doctorate degree, 38% have a Postgraduate degree, and 23% have a Bachelor's degree. To provide an indication of the geographical spread of the survey, participants were asked which country they reside in. Respondents from Austria, Croatia, Estonia, France, Germany, Iran, Italy, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and UK communicated their location.

4 Freight- modal shift from Road-Rail

At first in chapter 4.1 a summary of the findings in WP2.1 will follow. Then in chapter 4.2 especially the development of inter modal transport will be described including findings from WP 2.2 about wagon improvements. WP3.2 terminal handling will be described in chapter 6.1.

4.1 Requirements toward the freight system of 2030-2050

Two targets in the EU white paper at 2011 were that 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and to triple the length of the existing high-speed rail network by 2030. For high speed rail the target seems to be achievable. The actual development of freight is not in line with the target and at present there are no indications that it will be fulfilled.

The total demand for freight in Europe has increased rapidly in recent decades, but rail freight has lost market share and most of the increase has been handled by trucks. To reach the white paper target, it is necessary to both increase quality and capacity and lower the cost of rail freight.

Much of today's freight train system and infrastructure is based on an old standard 3-4 MW locomotive that means trains of approximately 1,500 gross tonnes and a train length of 650-750 metres. But modern locomotives have a tractive power of 5-6 MW capable of hauling 2,000-2,500 tonne trains of up to 1,050m in length. Not only the tractive power but also the locomotives' axle load is critical for optimal traction. To increase the axle load from normally around 20 tonnes to 22.5 or more on specific lines with track-friendly bogies it is possibly to operate heavier trains.

Concerning the wagons, one important question is whether development will be incremental, as it has been so far, or if it is possible to make a system change. An incremental change means successively higher axle loads, wider gauge, better length-utilization in a given train length, higher payload and less tare weight per wagon, more silent brake-blocks, end of train devices and some electronic sensors. A system change will include electro-pneumatic brakes, disc-brakes, full electronic control of the wagons and load and automatic central couplers. The automatic couplers is the most critical component but important not only because it will make shunting and marshalling safer and cheaper but also because it will make it possible to operate longer trains without problems and introduce electronic braking systems and control and to feed the train with electricity.

Today, most rail operators use electric locos for long haul and diesel locos for feeder transport and terminal shunting. But the duo-loco has now been introduced into the markets, equipped with both normal electric traction and diesel traction. This means that a duo-loco can shunt the wagons itself at inter modal terminals or stop at an un-electrified siding at an industry and change wagons directly. The operators thus need only one loco instead of two and it will also make it possible to introduce new operation principles as liner trains and change wagons along the line.

For intermodal it is important to reduce the terminal costs. With a horizontal transfer technology, which can be fully automated, containers and swap-bodies can be transferred under the overhead contact wires. If the terminals are located on an electrified side track where the train can drive straight in and out onto the line with a liner train. The train can to be loaded and unloaded during a stop of 15-30 minutes. With this system there is no need for a diesel loco to switch the train into the terminal and it also obviates the need to park wagons. The terminals can be made more compact and require less space. With more small intermediate terminals as a complement to the endpoint-terminals this can widen the market for inter modal to shorter distances and more relations.

Most trailers today are not designed to be lifted onto a railway wagon. The trailer market is in practice therefore very limited even at conventional intermodal terminals that have lifting equipment. Solutions where trailers do not need to be lifted but can be rolled on and off can thus widen the market considerably.

Most forecasts show an increase of 60% in total freight demand by 2050. To fulfil the targets in the EU white paper, it is necessary to roughly double rails' market share from 18% in 2014 to at least 36% in 2050. This means that the tonne-kilometres will be 3.6 times as much as today and 2.4 times as much as in a business-as-usual scenario in 2050.

To increase the capacity of the rail system, beside ordinary investments in more tracks, the following measures can be taken: (1) More efficient timetable planning: On double track: Bundling of trains with the same average speed in timetable channels to harmonize speeds. During the day faster freight trains are an option. (2) Use of trains and vehicles with higher capacity: For freight: Longer trains, higher and wider gauge, higher axle load and metre load. For passenger trains: Double-decker and wide-body trains. (3) Differentiation of track access charges to avoid peak hours and overloaded links. (4) Better signalling system, shorter block lengths and in the long term introduction of ERTMS level 3. (5) Adaptation of freight corridors for long and heavy freight trains. (6). Investment in HSR to increase capacity for freight trains and regional trains on the conventional network and in some cases dedicated freight railways.

The planned Rail Freight Corridors (RFC) is promising but there is no common plan to increase the standard in the RFC, which would be desirable. With the measures listed above, longer and heavier trains will make it possible to roughly double the capacity for freight trains without building new railways and in the long term with ERTMS level 3 even more.

Rail has to both compete and cooperate with other modes. There is a strong competition between rail and truck. The truck market is totally deregulated and low-truck companies compete both with rail and with ordinary trucking companies. In Germany the truck length will be extended from 18.75 m to 25.25 m as it already is in Scandinavia. This will lower the cost for transport by truck with 26 % and also lower the market price for transports (Bast 2016).

How can rail meet this challenge and improve the cost efficiency? To introduce longer trains from 650 to 1050 m, which is optimal for one high-power locomotive, will reduce the total operating cost for long haul by 21 % per tonne-kilometres. To increase the axle load from 22.5 to 25 tonnes which reduce the cost for heavy freight with 10 %. To extend the gauge from G2 to GC will decrease the cost with 23 % for voluminous goods. If the cost for transfer one container from road to rail will be reduced from 30 € to 10 € the total transport cost for inter modal can be reduced with 15 %.

Today many wagons are built for 120 km/h which make it possible to increase of the speed for freight trains from 100 km/h to 120 km/h. This can increase the operating costs but at the same time make it possible to operate more freight trains between the passenger trains and increase the productivity with faster circulation of the vehicles and by that lower the capital costs.

About the gauge it is most important to get a rectangular loading gauge with no restricted edges on the top and a higher gauge to accommodate trailers and high cube containers. Also the width is important for wagon-load. This can be done by measuring hinders and eliminate them one by one.

Finally the automatic couplers must be introduced which also make it easier to operate longer trains and introduce EP-brakes. By coupling wagons together with draw-bars the number of automatic couplers which have to be mounted can be minimized.

With measures like this, it will be possible to improve capacity and lower the costs so rail can play a substantial role also in the future.

Table: Today´s common standard, incremental change and system change.

Equipment	**Common standard**	**Incremental change***	**System change***
Wagons			
Running gear	Different	50% Track-friendly	All track-friendly
Brakes	Cast brakes	LL brakes	Disc brakes
Brake control	Pneumatic	Radio controlled EOT	Fully electronic
Couplers	Screw couplers	Automatic couplers on some trains	Automatic couplers on all trains
Max Speed	100 km/h	120 km/h	120-160 km/h
Max Axle load	22.5 tonnes	25 tonnes	30 tonnes
Floor height lowest	1,200 mm	1,000 mm	800 mm
IT-system	Way-side	Some in wagons	All radio controlled
Locomotives			
Tractive effort kN	300	350	400
Axle load	20 tonne	22,5 tonne	25 tonne
Propulsion	Electric	Some duo-locos	All duo-locos
Fuel	Diesel	LNG/Diesel	LNG/electric
Drivers	Always drivers	Some driverless	All driverless
Trains			
Train lengths in RFC	550-850 m	740-1050 m	1050-2100 m
Train weight	2,200 tonnes	4,400 tonnes	10,000 tonnes
Infrastructure			
Rail Freight Corridors	18,000km	25,000km	50,000km
Signalling systems	Different	ERTMS L2 in RFC	ERTMS L3 in RFC
Standard rail weight	UIC 60 kg/m	70 kg/m	70 kg/m
Speed. ordinary freight	100 km/h	100-120 km/h	120 km/h
Speed, fast freight	100 km/h	120-160 km/h	120-160 km/h
Traffic system			
Wagonload	Marshalling - feeder	Marshalling – feeder Some liner trains	Automatic marshalling Liner trains – duo-loco
Trainload		Remote controlled	All remote controlled
Intermodal	Endpoint-trains	Endpoint-trains Liner trains with stops at siding	Endpoint-trains Liner trains fully automated loading
High Speed Freight	National post trains	International post and parcel trains	International post and parcel train network
IT /monitoring systems			

	Some different	Standardized	Full control of all trains and consignments

*) Adapted to market needs in each product and line

4.2 Key Innovation Processes to facilitate Road-Rail freight modal shift

Modal shift is a very slow process today in Europe, as the general trend is a reduction in the size of shipments and an increase in shipment frequency. The challenge is difficult for rail where mass transport is the key to efficiency until totally automated rail transport solutions are operational and competitive which is a long-term vision. For that reason from trainload, wagonload, and intermodal services, intermodal transport has been identified as the best solution to serve the largest potential market for rail freight growth and modal shift.

The most successful inter-modal transport system so far is transporting of containers from ports so called “hinterland traffic”. This has been established by cooperation with shippers, ports and railway operators. The growth has been driven by the expansion of international trade and the containerization of global shipping. Rail can compete with road in sea-rail transports because the goods are already containerized and in the port the containers anyhow must be transferred from ship to rail or truck. In this origin there is no additional cost for terminal handling for rail compared with road.

To get modal shift from road to rail in ordinary inland transport so not so easy because the need of terminal handling and feeder transports in both ends compared with direct truck transport. Combined transport, with swap bodies on flat wagons is regularly growing, but its development is generally slow and penalized by long ramp up periods to reach the breakeven point on new connections. For road-rail hauliers it is also difficult to invest in swap bodies without long or middle term contracts as the use of this equipment for classical road transport would be less efficient due to the loss of payload.

However, transporting complete artics truck or only trailers directly on rail is a different scenario, where the debate relies on the need to transport the tractor or not. It is quite clear that for short runs like crossing the Alps or through the Eurotunnel it is beneficial to have continuous driving and thus keep the tractor and his driver on the roll-on –roll off train. In this kind of connections rail has some kind of natural monopoly. For longer runs it is not competitive to carry the tractor and the driver thus the market is essentially composed of unaccompanied trailers.

For the case of longer runs, two options are offered; a vertical transfer into a pocket wagon or a horizontal transfer on various types of specialized wagons. The advantage of the vertical transfer is that it does not need a specialized terminal but only a specialized spreader equipped with grapple arms as well as twistlocks which are largely used for swapbodies. The trailer must have been designed to be lifted with grapple arms and the extra cost is less than €1000 for a trailer. Unfortunately today only 60000 trailers of that kind are available while there are every day 1.5Million of truck movements in Europe. So the largest market segment to serve is composed of non craneable trailers. Looking towards 2030/2050, to grow this market, both the terminal handling and the wagon design should be considered, as the cost for ILU transfer is critical.

To serve this market segment many types of wagons have been invented:

--The Kangourou wagon where trailers were pushed back by a little tugmaster all along the train and discharged in the reverse way.

--The Cargo Beamer system where the trailer is put in a basket and then the basket is lifted on to the pocket wagon.

--The Modalohr system where the main body of the wagon turns to connect to quay ramps.

--The Megaswing wagon where the main body of the wagon turns and bends to create the ramp put on the ground.

Each of these systems has advantages and disadvantages:

--the Kangourou system is very time consuming to operate

--The CargoBeamer is limited in capacity because of the wagons tare weight but it can be automated to offer a short loading time with a significant investment

--The Modalohr system has a high payload but the terminal investment is relatively high however it is scalable.

The last Modalohr system fully respects the UIC lower gauge and is able to carry P400 trailers in Gauge B+.

Taking into account best practice from previous cases, WP22 'Novel rail freight vehicles' is aiming to conceptually design the rail freight vehicle of the future. The designs aim to increase the useable length of a standard train and lower the LCC of wagons. A number of designs have been put forward including;

- For car carrier wagons, 5 bodies with 6 axles for an overall length of 62m
- For container wagons, a standard train composed of slightly rebuilt wagons capable to carry 40' containers or 20' containers plus on every third wagon a 45´container.
- For container wagons, a new design of a five bodies wagon with six bogies for five 45´containers with an overall length of around 72m. This solution aims to reduce the number of bogies and hence the maintenance cost.
- For crane-able semitrailers with a 4 bodies wagon with 6 bogies for four trailers with an overall length of around 67m.
- To reduce significantly the preparation time before the departure of the train with the introduction of an EOT (End Of Train) device.

Further information on all these developments, including economic analysis and dynamic analysis of various brake shoe and wheel wear and tear, is detailed in D22.2 Novel Rail Freight Vehicles (Final). The view from industry stakeholders on several of these designs collected during the comprehensive survey is described in 4.3

Alongside the necessary operational improvements and implementation of new technologies, to achieve modal shift, customer and market requirements should be considered, together with the issues of cost and service quality. A decrease in both operational and investment costs is required, two approaches to facilitate this are; an increase in competition across the sector. This may be facilitated through further research and development, for example during the Shift2Rail, public private initiative. Another approach may be cost benefit analysis of new technologies and measures prior to implementation. (Islam et al, 2016). Measures to improve service quality may include; streamlining of the planning process, implementation of ICT systems (discussed further in Chapter 8) and an integrated supply chain approach to better meet customer requirements.

4.3 TIME FRAME FOR IMPLEMENTATION OF INNOVATIONS

To encourage modal shift from road to modes deemed more environmentally friendly such as rail, the EC are targeting a standardised approach to both rail gauge and axle load. For rail gauge, a standardised width of 1435mm has been adopted across the TEN-T core network, together with a standard set series of loading gauges;

- UIC A, dimensions 3.15 by 4.32 m (10 ft 4 in by 14 ft 2 in).
- UIC B, dimensions 3.15 by 4.32 m (10 ft 4 in by 14 ft 2 in)
- UIC B+, dimensions up to 4.28 m (14 ft 1 in) it features a width of 2.50 m (8 ft 2 in) to accommodate ISO Containers.
- UIC C, The Central European gauge maximum dimensions 3.15 by 4.65 m (10 ft 4 in by 15 ft 3 in).

For axle load, TEN-T guidance indicates a targeted increase to 22.5 tonnes, Europe wide by 2030. However it is essential to underline that the precise knowledge of the real clearance profile is fundamental specifically for gauge B or B+. More than 90% of the semi-trailers are between 4M and 4M07 so it is compulsory to offer at least P400 to penetrate this huge potential market segment. Solutions are available today to get that information quite rapidly with equipment checking the gauges at 90km/h. From first tests made on certain routes the margins between the announced clearance profiles and the real ones are such that opening those routes to P400 for specific categories of pocket wagons, which characteristics will have to be checked rigorously, would be possible in the short term. This would boost the penetration in that market rapidly as it does not need any investment on the side of the road haulier and would not hinder its competitiveness when operating direct road transport.

In light of progress in WP22, the shortened time to operate the brake test with train connectivity will improve the use of the single track terminals of Cargobeamer and Modalohr and enhance their competitiveness. It is anticipated that these developments will be operational by certain RUs in the near future.

Finally the launch of long distance connections with rolling motorways solutions show:

- A very short ramp up period if the service is reliable
- A capacity to match the marginal kilometre cost a long distance road transport if the train reaches a length of 835m with a toll per train of €2 per train kilometre and classical signalling systems.

This is positive as a target of 1050m trains in 2025 or 2030 is likely if the willingness of developing rail freight as a sustainable transport solution for the future is still a strategic orientation in Europe.

4.4 Industry Survey- Freight Modal Shift from Road- Rail

4.4.1 Industry Survey Results & Recommendations

Five questions in the survey fell under the topic freight modal shift from road-rail, these address; gauge clearance, axle load, change to priority of path allocation, wagon innovations in freight wagons to accommodate modal shift, freight vehicle improvements still required.

Firstly participants were asked, ‘How useful do you think an increase in rail gauge clearance will be in encouraging modal shift from road to rail and why?

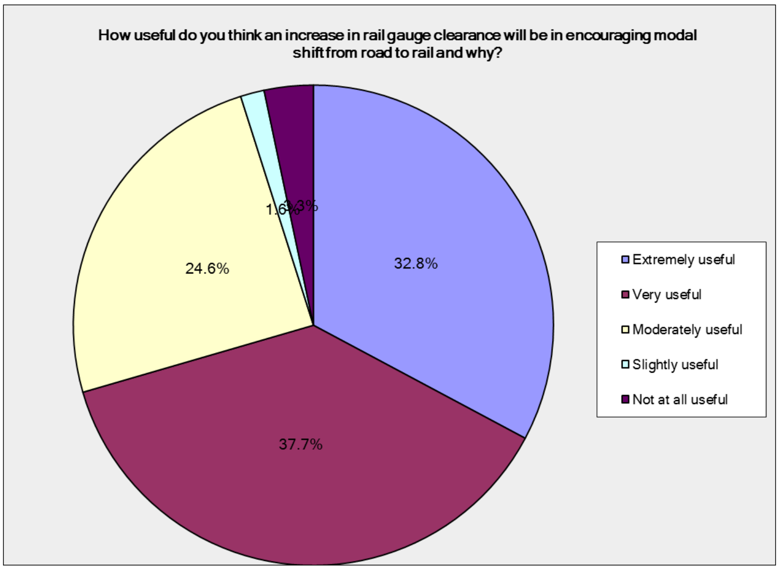

FIGURE 1 INCREASE IN RAIL GAUGE CLEARANCE TO ENCOURAGE MODAL SHIFT

- Figure 1 indicates that 70% of respondents viewed an increase in rail gauge clearance as 'very' or 'extremely' useful to encourage road-rail modal shift. This indicates the importance placed on an increase in gauge clearance by industry stakeholders.
- While only 5% of participants placed less importance on the contribution of gauge clearance to encourage modal shift, viewing it as only 'slightly' useful or 'not at all' useful.

Numerous industry stakeholders offered their expert opinion on the importance of an increase in rail gauge clearance to encourage road-rail modal shift.

Advantages of an increase in gauge clearance were described as;

- *The opportunity for market expansion, offering rail the prospect to tap into the markets currently dominated by road. An increase in gauge will present rail with the opportunity to increase competition with road transport.*
- *A decrease in physical and planning restrictions for the transportation of containers.*
- *A greater share of units will be able to access rail services. Being able to use standard swap bodies/containers will mean that customers do not require bespoke solutions for rail. Offering the same cubic space as the equivalent road unit is important to enable competition.*
- *Allowing for an increase in volumes transported, a higher volume carried can lead to a decrease in costs.*
- *An increase in gauge will eliminate the obstacles for semitrailers to be transferred from road-rail from Scandinavia to Southern Europe, enabling through running to and from Europe with Berne gauge vehicles.*
- *A decrease to the reloading cost at borders, as currently the different gauge width in Spain and Russia is limiting intermodal and conventional rail traffic to/from these areas. The reloading cost at the borders is too high. It should be noted that each time the transport chain is broken leads to increase in lead times, costs and a decrease in punctuality - altogether limiting the possibility for shift to rail*

While numerous considerations were recognised;

- *The increase of rail gauge clearance alone will not be sufficient to encourage major modal shift- an increase in axle load should also be considered.*
- *The high level of expense to implement an increase in rail gauge across Europe.*

In line with published TEN-T guidance on axle load, respondents were asked; how likely do you think it is that an increase in axle load to 22.5 tonnes, Europe wide will be achieved by 2030?

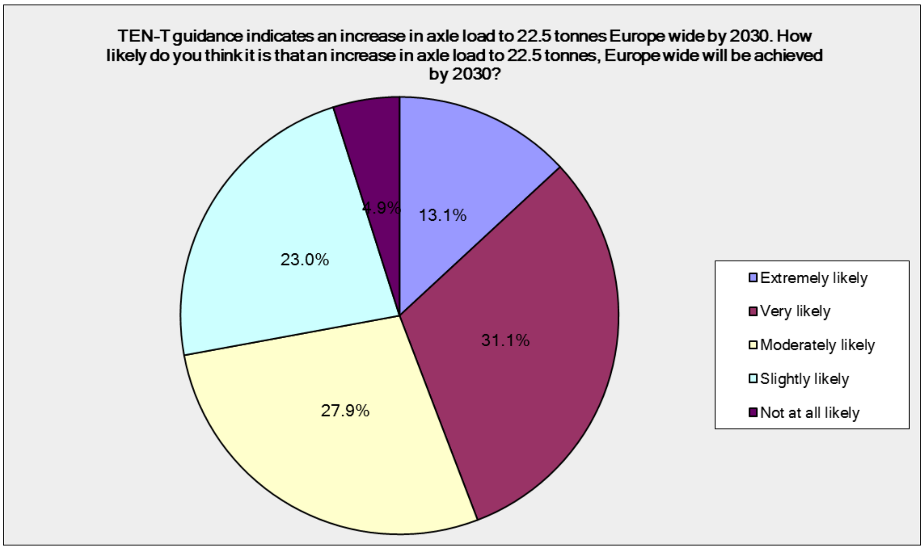

FIGURE 2 EU WIDE INCREASE IN AXLE LOAD TO 22.5 TONNES

- From Figure 2 it can be seen that almost 60% of respondents thought that it is 'very' or 'moderately' likely that the axle load increase will be achieved EU wide by 2030.
- However, only 13% of participants viewed the achievement of TEN-T guidance as 'extremely' likely.
- This demonstrates that although 71% of participants were positive about the possibility of an axle load increase being achieved, of these only 13% were convinced it is extremely likely.

Many of the innovations and technologies put forward during SP2 Freight aim to facilitate rail freight services which are more efficient, reliable, travel at a higher speed and have a quicker turnaround time in terminals. Participants were asked; 'Achieving modal shift by 2030/50 will likely require an increase in freight train movements. How confident are you that rail freight will achieve increased priority during path allocation?'

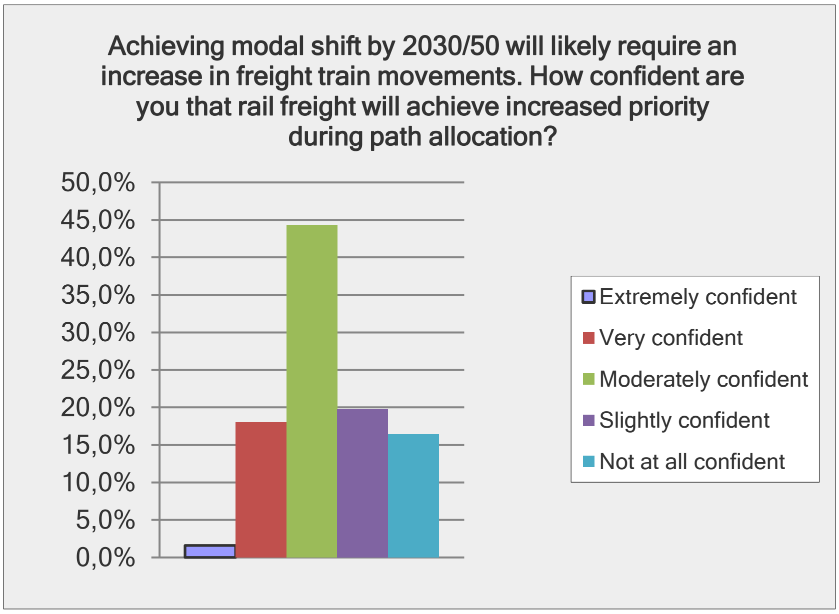

FIGURE 3 AN INCREASE IN PRIORITY FOR FREIGHT DURING PATH ALLOCATION

- Figure 3 indicates that the largest group of respondents (44%) were moderately confident that increased priority during path allocation would be achieved for rail freight services by 2030/2050.
- On the other hand, it should be recognised that 36% of participants were only slightly or not at all confident that increased priority would be achieved by 2030/2050.

To understand which of the freight wagon types currently in use, will be utilised most frequently to facilitate modal shift in the future, industry representatives were presented with a standardised list of wagon types and asked to choose three.

As illustrated in Figure 4 the three wagon types chosen most frequently were;

❖ Special flat wagon with bogies
❖ Ordinary flat wagon with bogies
❖ Tank wagon

- These data provide an indication of the type of goods industry representatives believe will be captured by rail during modal shift; flat wagons to carry boxes, trailers, food, containers and swap bodies, together with tank wagons to transport fuels.
- Refrigerated van was the wagon type chosen fourth most frequently 28%

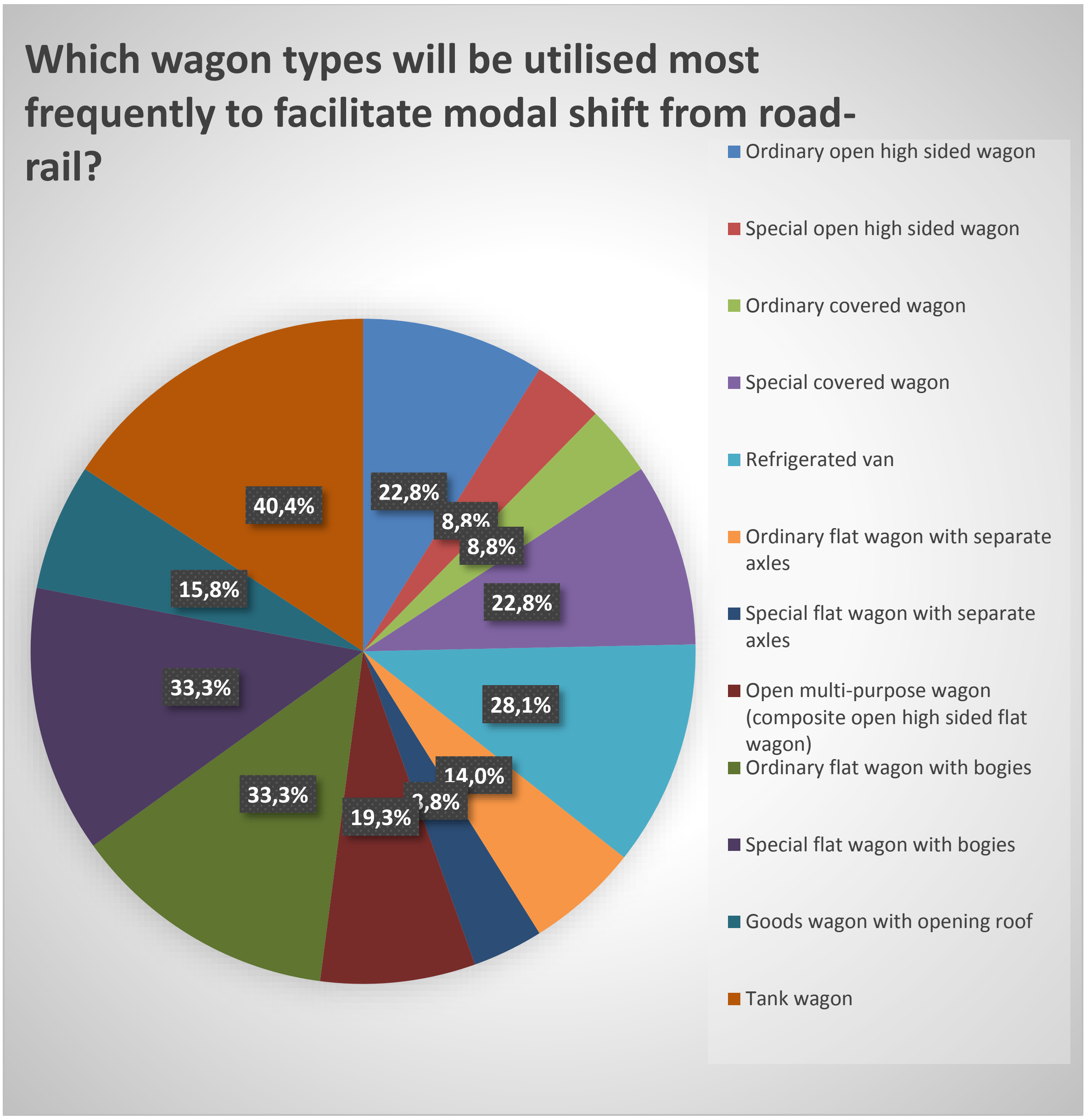

FIGURE 4 TYPE OF WAGON UTILISED MOST FREQUENTLY TO FACILITATE ROAD-RAIL MODAL SHIFT

Feedback from industry partners on this topic was highly varied; some participants highlighted the wagon type(s) they believed should be utilised most frequently while noting the choice of wagon is dependent on commodity carried. Wagon types included; box and hopper wagons with bogies, wagons for intermodal traffic and flexible to carry tank containers, the range from 20 to 45 foot containers and taut liners both standard and mega.

On the other hand an argument for complete wagon redesign was put forward- *Redesign is required if rail is to compete better for pallet, parcel and roll-cage movement. Bogies/axles is a minor issue. The key issue is the size, shape and ease of access of the load carrying part of the wagon.*

In line with the work undertaken in WP22, which has examined wagon design to enhance its carrying capacity together with, safety increases in the braking system and the length of the train and the failure detection possibilities. Participants were requested to rank six potential freight vehicle improvements; EP brakes, automatic couplers, end of train device, lighter wagons, track friendly running gear and detectors for predictive maintenance in order of importance where **1 is required most** urgently and **6 least** urgently. Table 1 illustrates the number of responses assigned to each improvement, where two numbers in the position column are the same they received equal number of responses.

Key TR- Total Responses. P- Position.

Improvement	Ranking for Most Urgent '1'		Ranking for '2'		Ranking for '3'		Ranking for '4'		Ranking for '5'		Least Urgent '6'	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
EP Brakes to allow faster brake applications & support longer trains	7	2	2	6	5	5	6	3	7	3	8	2
Automatic couplers with an electrical connection	6	4	8	3	6	3	6	3	10	2	1	6
End of train device to reduce the duration of safety checks prior to departure	4	6	8	3	5	4	8	2	4	4	4	4
Lighter wagons with lower tare and higher payload	10	1	9	2	10	1	9	1	1	6	5	3
Track friendly running gear to achieve higher axle loads and higher speeds as well as causing less track deterioration and wheel damage	7	3	7	4	10	1	3	4	11	1	2	5
To install detectors for predictive maintenance	6	5	11	1	8	2	6	3	3	5	12	1

Table 1 Total responses received for each wagon improvement

To provide a comprehensive view and demonstrate the overall ranking among the improvements, a weighted ranking was calculated. Wherein 6 points were awarded for each response where the improvement had been ranked most urgent. 5 points for a ranking of 2, 4 points for a ranking of 3, 3 points for a ranking of 4, 2 points for a ranking of 5 and 1 point was awarded for each response where the improvement had been ranked 6 or least urgent, the results are displayed in Table 2.

Improvement	Maintenance Detectors	Track friendly running gear	Lighter wagons	End of train device	Automatic couplers	EP Brakes
Total points	159	149	179	120	139	112
Overall Ranking	2	3	1	5	4	6

Table 2 Weighted ranking of wagon improvements

- This is of interest as even though maintenance detectors received only the fifth highest total of '1' most urgently required rankings. When all the rankings are considered maintenance is second overall behind lighter wagons.

- Likewise, detectors for predictive maintenance received the highest number of responses for ‘6’ least urgently required (see Table 1), however when taking into consideration a weighted ranking EP brakes was placed sixth.

Recommendations from industry participants on the topic of freight wagon improvements are defined into two topics; suggestions for wagon improvement and external factors. Suggestions for wagon improvement included;

- *Connected Wagons for quicker brake tests and with only one operator (the driver)*
- *Lighter wagons would suppose the rule ""minimum 4T/axle"" to be superseded (see TSI wagons directive)"*

Attention was drawn to external factors such as;

- *Basic infrastructure quality as the most important aspect today to be able to shift. We have a tendency to focus on high tech solutions, and they are going to be able in the future, but today we need to get the trains running on our existing tracks - tracks that today need maintenance/switches that need to be updated (in the north with electrical heating) etc.*
- *There is no "one size fit all" solution. The cargo carrier design evolves with limitations set by the infrastructure.*
- *The business risks connected to political risk are under estimated and most innovation end up in the famous "death valley"*

5 EU-wide high speed rail network

5.1 INTRODUCTION

The term ‘high speed’ has different definitions dependent on country location and service type under discussion. For this study, the definition of high speed is taken from Annex I of the TSIs for high speed lines;

— Specially built high-speed lines equipped for speeds generally equal to or greater than 250 km/h,
— Specially upgraded high-speed lines equipped for speeds of the order of 200 km/h,
— Specially upgraded high-speed lines which have special features as a result of topographical, relief or town-planning constraints, on which the speed must be adapted to each case.

The railways were previously very strong in the mail and express freight market but have increasingly lost their position to air cargo and road haulage. The best known high-speed freight train is France’s TGV mail train, which carried mail on the French high-speed lines. The trains had a maximum speed of 270 km/h and their design is based on the TGV passenger train version. These trains are however no longer in service, so today it does not exist any real high speed freight trains in Europe.

That means that high speed services are primarily associated with passenger services, not freight. Some examples of fast freight exist for example in France with speeds of up to 200km/h for example Sernam services, discussed in further detail in 5.3. Although currently, the main advantage to freight services of the high speed line network is that high-speed lines free capacity for more freight trains on the conventional lines when the fastest passenger services moves to high speed lines.

Table 3 provides an overview of the current European high-speed network, where it can be identified that Spain has the highest km of high speed tracks.

	Italy	Spain	France	Germany	United Kingdom
Kilometers of high-speed tracks	920	3100	2030	1330	109
Competition	Yes	No	No	No	Yes, but not on the same lanes
Max. speed Km/h	300	320	320	300	300
Average Speed km/h	173	222	216	145	180
Punctuality	87%	98.5%	92.5%	79%	90%

TABLE 3 OVERVIEW OF THE EUROPEAN HSR NETWORK IN 2016, TRAFIKVERKET

5.2 BARRIERS TO AN EU WIDE HIGH SPEED FREIGHT NETWORK

As EU high speed freight services are not widespread, this is an area, which will remain a focus towards 2030/2050 this subsection identifies some of the barriers which remain, segmented into topics of; Rolling stock adaptation & Service Reliability, and Capacity constraints. These will be expanded on in section 5.3 with the results and feedback from the industry survey.

Characteristic of *high-speed* freight traffic, i.e. freight traffic at speeds over 200 km/h, is that the rolling stock consists of modified passenger rolling stock, not further developed freight wagon designs. *Express* freight traffic, on the other hand, in the speed range of 120-200 km/h, uses mostly rolling stock based on conventional freight wagons, but adapted to higher speeds, and sometimes stock based on passenger train concept.

5.2.1 ROLLING STOCK ADAPTATION & SERVICE RELIABILITY

As acknowledged, high-speed rail freight is not common across Europe, to achieve widespread high speed services; one area which will need to be addressed is the adaptation of rolling stock to higher speeds. Additionally, the Intermodal Loading Units (ILU) would need to be adapted to the higher speeds. A curtain side trailer for example, cannot be transported at speeds of 160 km/h. Changes to wagons and ILU would also impact on the operations at the terminals. Terminals might need to adapt to new wagon and ILU designs. The costs for investments in this infrastructure would be very high.

The technical characteristics of the tracks are different according to the speed authorized: maximum load per axel above 250km/h is 170KN and beyond 250km/h but above 190km/h 180KN is accepted. These limits hinder the use of high speed tracks by heavy loaded wagons which can reach 22,5T. Of course, most of intermodal traffic is limited to 120km/h because of the maintenance cost of the wagon and the higher frequency of their overhaul. If we consider the average load of a 40' container around 22T a 60' wagon would be loaded at 33T with a dead weight of 20T the load per axel of this double bogie wagon is under 18T but if the containers are fully loaded the payload is 60T and the weight per axel is 20T per axel above the 18T limit. This shows that a difficulty may occur but it is theoretical as high speed cargo usually has a low density.

A major area for concern, is elsewhere: how to ensure reliability and long term solution for customers. For high speed freight services, the question remains whether freight purchasers would be willing to pay the price related to decreases in wagon load capacity together with higher freight rates.

When considering the perspective of a freight purchaser and their incentive to choose an express or high speed rail freight transport solution, the cost of the transport would be of lesser concern than normally. The time factor is the crucial part, the cost for the transport is "neglectable" based on the fact that the cargo itself in most cases has the character of being a low weight minor shipment. In general terms – within the European railway network - it would be difficult for a high speed rail freight solution to compete with air freight or road freight solutions.

Rail freight wagons have rapidly increased costs of maintenance above 120km/h and increasing restrictions to maximal load per axel above that limit. So we have to consider that freight will accept to pay a high price to guarantee reliability.

5.2.2 Capacity constraints for freight trains on high speed lines

Mixing traffic running at 300km/h and freight trains running at 120km/h is possible only if very few high speed trains use the high speed track. Figure 5 illustrates possible free run of freight trains mixed with high speed trains. If there is one high speed passenger train per hour it is possible to operate one freight train per hour in 120 km/h in 150-250 km before it must be overtaken. It is possible but with higher frequency of the passenger trains it will be more complicated. One of the ideas to build real high speed lines is to separate trains with different speed which increase capacity on both the new line for high speed trains and the old line for freight and regional trains which have more equal average speed.

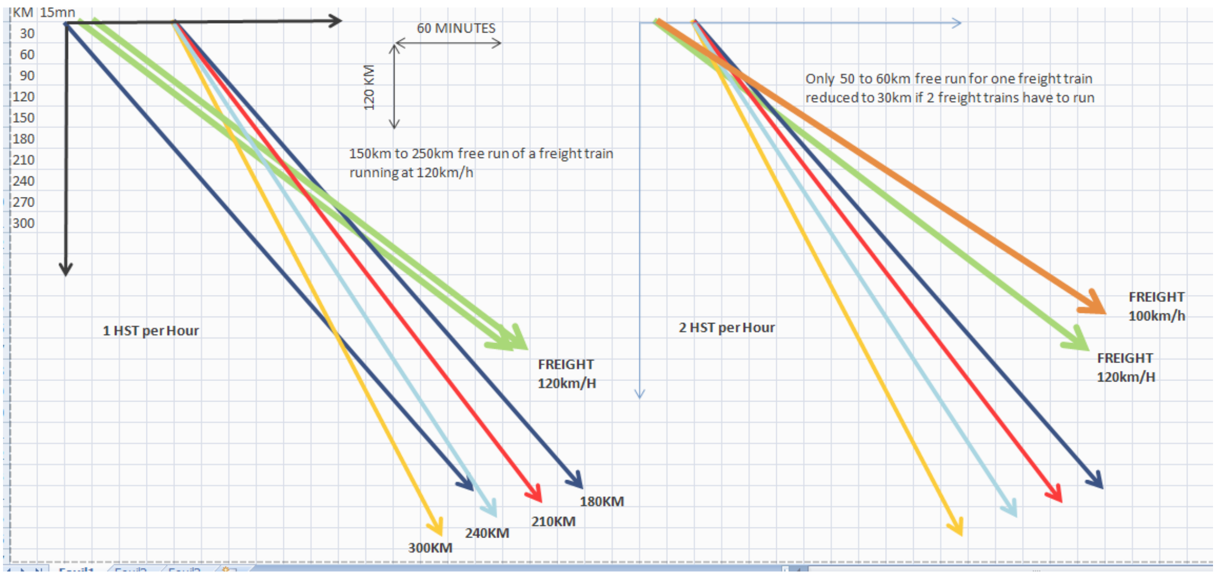

Figure 5 Graph to illustrate 120km/h freight trains mixed with 300km/h high speed trains

Real high speed lines adopted for passenger traffic are built with wide curve radius to admit the high speed, but many times with steeper grades than ordinary lines to avoid tunnels and bridges. Grades in the range of 25-35 ‰ are common and are no problem for a powerful passenger train. On conventional lines, adapted to mixed passenger and freight trains, the maximum grades often are in the range of 10-12.5 ‰. For that reason, ordinary freight trains with tractive effort dimensioned for the conventional network, cannot operate on high speed lines.

However, some high speed lines are built with the same grades as the conventional lines. One example is in Germany where some high speed lines are being used for freight trains mostly during the night time when there are no or very few high speed passenger trains.

Detailed analysis of high speed freight services, running at the regular high speed of the track indicates that competition exists with large air planes used for freight. At present, the design of high speed services means that it is impossible to transfer the air plane containers carrying the cargo inside the high speed train.

A new study of a specific high speed train, was necessary to overcome this problem in order to have a transformable high speed train able to carry passenger and to change quickly into a freight carrier. Unfortunately the overall market demand for newly designed high speed trains has not been sufficiently attractive to motivate manufacturers to undertake the study. For that reason high speed freight, for example small parcels, paying a higher price and handled in small pallets could be transported in a small dedicated part of the train. This could be a profitable business model disappearing when the need of more passenger seats becomes urgent. Moreover the cost of the tolls on high speed lines and the charges linked to the operation of high speed traffic leads to a very challenging business model.

For all these reasons and having explored the distances between the main urban concentrations in Europe, demonstrates that a classical freight train running at 200km/h (leading to 180km/h in average) was an efficient solution within a range of 1100km with a 22h00 departure and an arrival at 4H00 leaving sufficient time for collection and delivery. 22H00 departure allows you to gather and sort the parcels or pallets. Arrival at 4H00 in the morning allows you to distribute at 8H00 in an area of 200km. So 6H of running at 180km/h equals to around 1100km travel which is very good for connection between main urban European areas in a night jump. The solution was tested in France with classical freight wagons for general cargo running at 200km/h only equipped with ABS devices and a BB22200 classical electric locomotive. This train was able to carry 110T of payload. If the reliability of such a train is insured which means to allow secured paths for such trains not only on the high speed line but also on the last miles to reach their destinations. The competition with a Boeing 747 dedicated to freight was balanced with such a service.

5.3 Industry Survey- EU wide high speed rail network

5.3.1 Industry Survey Results & Recommendations

Three questions in the survey fell under this topic, exploring an industry perspective on an achievable high speed for freight services, barriers to operational high-speed freight and the level of confidence that high speed freight will be achieved in the EU.

Figure 6 shows the industry perspective on an achievable maximum high speed for freight services by 2030 across the EU core network.

- The chart reveals that the majority of participants (40%) believe that 120km/h is the most achievable high speed for freight services.
- While 20% of respondents were slightly more optimistic as they viewed 140km/h as attainable.
- These results are of interest as they allow a comparison between the industry perspective on attainable high speed for freight services and research perspective. C4R D21.1 discussed the requirements towards the freight system of the future but did not put a figure on an attainable high speed for freight services, only passenger (200km/h or 250km/h). While the SPECTRUM

project set the benchmark of at least 140km/h for freight services. Together with this, Sernam trains were running at 220km/h with 110T of cargo on HS Lines in a competitive way with classical wagons slightly modified as long as the train remained on the HS line with a passenger priority.

- An observation to consider- *actual attained velocity can be considered of greater importance than maximum speed, as a higher speed is worthless if freight services are always timetabled into loops.*

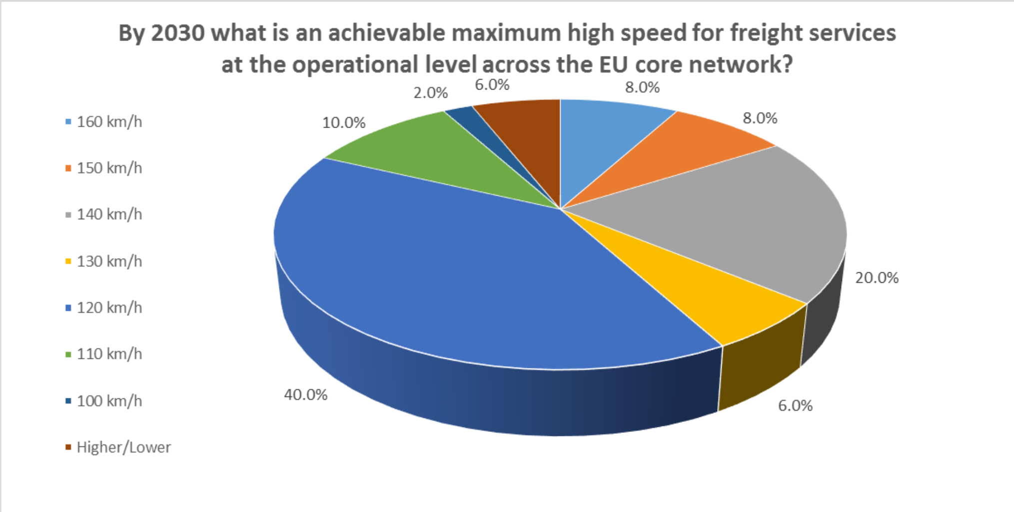

FIGURE 6 AN ACHIEVABLE MAXIMUM HIGH SPEED FOR FREIGHT SERVICES BY 2030

A free text question was incorporated, to allow participants to give their opinion on what they identify as the **largest barriers** to operational high-speed freight services.

From an ***infrastructure perspective*** the subsequent comments were put forward;

- *A lack of infrastructure capacity for freight services, in particular the competition from passenger services and in urban areas.*
- *Path allocation for freight services in comparison to passenger services was viewed as a major barrier together with a lack of designated high-speed lines for freight services.*
- *A lack of implementation of new technologies (for track, crossovers, transport, communications) in the whole network or corridor together with a lack of balanced development and lack of funding for large infrastructure investment.*
- *Maintenance costs, along with the current conflict in maintenance regimes and a lack of maintenance coordination.*
- *High speed freight services required infrastructure modernisation- a lack of funds to invest was highlighted as a main obstacle.*
- *If 120km/h freight trains are not achieved, it was argued that an increase in freight train parking capacity will be required.*
- *A current lack of unification of width, gauge, electrification and signalling systems.*

Participants were also asked to consider the major barriers within the **timetabling process,** responses included;

- o *Path allocation, including mixed traffic with a focus on blending freight with passenger services. The continued prioritisation of passenger services and conflicts with passenger demands.*

- *The requirement for a true on stop shop process*
- *The development of modern IT systems*
- *The redesign of the international timetabling process- some view the process as extremely lengthy with a lack of flexibility.*
- *A lack of coordination between operators and countries*

Regarding **network capacity** the following hurdles were distinguished;

- *A lack of discussion among national network managers*
- *Insufficient capacity on some lines and a shortage of capital for its increase, together with a lack of harmonisation of network capacity.*
- *Achievement of intelligent ERTMS signalling with traffic management layer in operation along with alert notifications and disturbance handling.*
- *Prioritisation of passenger traffic and the influence this has on the ability to obtain reliable train paths throughout the whole year.*
- *Bottlenecks and a lack of terminals in certain locations- this could be addressed through the creation of new freight end points and an increase in double tracks.*
- *Current speed of freight services- higher speed would lead to an increase in capacity and improve the overall capacity of the network.*

For **rolling stock**, obstructions to achieving high speed freight services were categorised as;

- *A lack of demand for rail freight services closely linked to a lack of funds to invest in rolling stocks where investment is required in bogies, brakes and wheel set.*
- *Outdated vehicle development- designs to increase vehicle utilisation, increase vehicle capacity and volume are required.*
- *Achievement of automatic coupling*
- *Lack of fast, modern, rolling stock to transport containers and swap bodies.*
- *Low brake capacity, the requirement for no composite block brakes in a winter climate and brake development to decrease braking distances.*
- *High maintenance costs*

We asked industry experts what the main obstacles are to **meet the demand for reduced journey times**? Their responses are summarised below;

- *Brake capacity on wagons and current braking distances*
- *Path allocation and prioritisation of passenger services*
- *Reliability of freight services and a lack of efficiency*
- *Length of time taken for administration activities*
- *Achievement of better signalling and rolling stock technologies- e.g. ERTMS signalling with a traffic management layer.*
- *More powerful haulage*
- *The maximum speed of freight wagons*
- *Bottlenecks and a lack of network capacity*

Participants were questioned 'how confident are you that EU wide high speed rail freight services are practically achievable by 2030?' the results are presented in Figure 7.

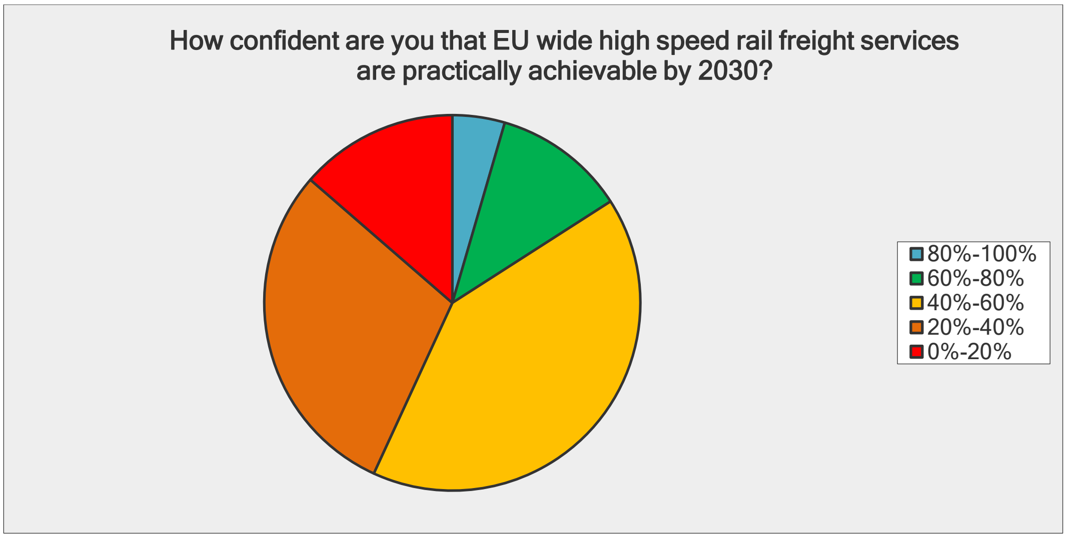

Figure 7 Level of confidence in the achievement of EU wide high speed rail freight services by 2030

- Figure 7 shows that the majority of participants (40%) were only 40-60% confident that high speed freight is achievable by 2030.
- Of note only 4.5% of respondents were 80-100% of operating high-speed freight by 2030
- Perhaps of greater concern, 13% of respondents voted for 0-20% of services being practically achievable.
- In line with the EC White Paper targets of an EU wide high speed rail network these results are of interest as they provide an excellent reference of the industry viewpoint.

Feedback from stakeholders as to why high-speed freight is not attainable included;

- *This would require long-term, stable, and common determination from the industry, the EEU, and the member states to provide the conditions allowing appropriate investment.*
- *Lot of countries are not ready to invest in that field*
- *Focus should be placed on freight running without stops together with better efficiency of existing rolling stock. In this scenario, 100km/h would suffice.*
- *Too much protectionism and lobbying done by the large state owned railway companies like SNCF.*
- *Reversing priority from passenger to freight is a political address (hence it is also a question with demagogic content)*
- *There are possible markets for high-speed parcels type rail services. Other conventional freight services carrying containers or swap bodies - there are major challenges around increased turbulence at stations and increased fuel use and damage to the track (resulting in higher track access charges).*
- *Today each country within EU is suffering from big internal issues to handle. The conflict about the scare resource - money - is big. I have a hard time seeing that the European countries should be able to agree about a mutual strategy. From my point of view, it is more likely that some main corridors could be developed north - south and east – west.*

6 Multimodal TEN-T core network

In WP 23 case studies of various terminal typologies: Rail to Road, Rail to Sea and Rail to Rail were examined. All case studies are located along TEN-T multimodal corridors.
In particular, as shown in Figure 8, for the type Rail to Road the Duss terminal in Riem (Munich) is on the crossing of Scandinavian - Mediterranean and Rheine- Danube corridors, while the NV Combinant terminal, IFB Zomerweg, HTA-Hupac, all in Antwerp are located on the North sea - Baltic and North Sea – Mediterranean corridors. For Rail to Sea, the terminal Noatum Prince Felipe in Valencia is on the Mediterranean corridor. Finally, for the Rail to Rail the marshalling yard of Hallsberg is located on the corridor Scandinavian - Mediterranean.

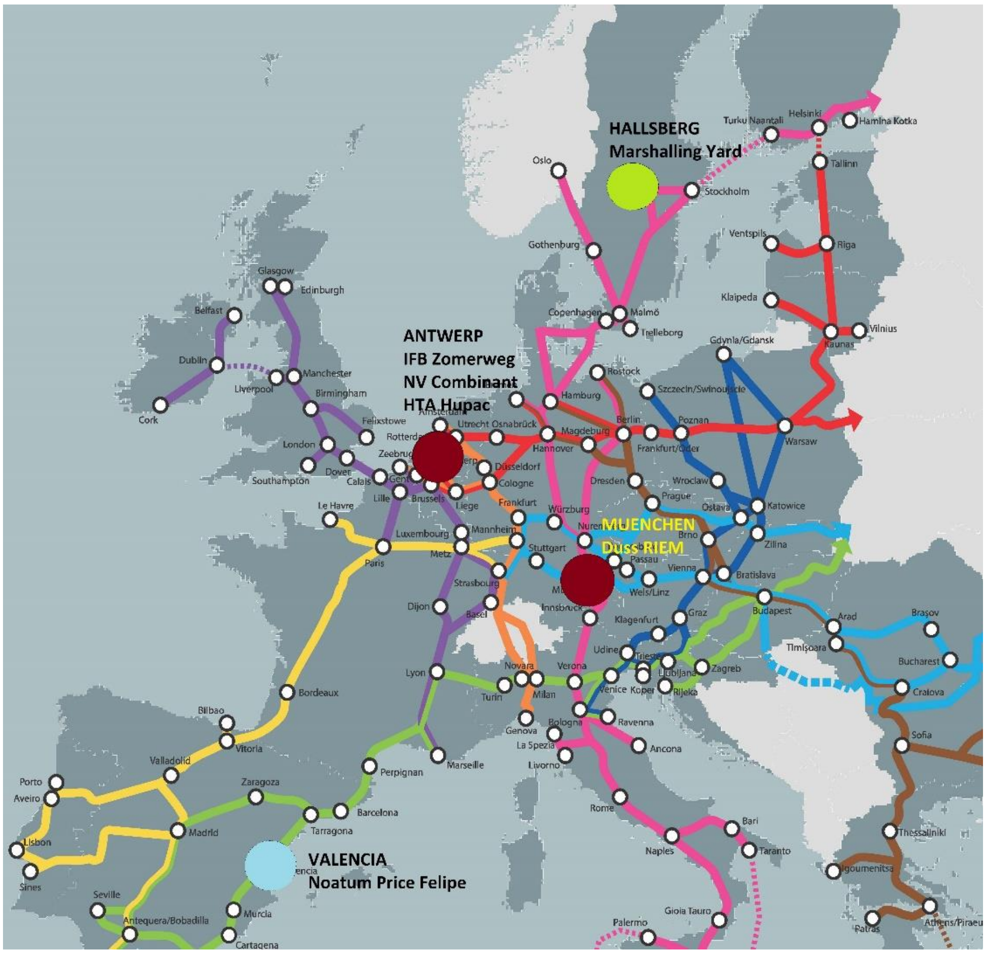

FIGURE 8 WP23 TERMINAL CASE STUDY DISTRIBUTION ON TEN-T CORRIDORS.

6.1 KEY INNOVATION PROCESSES, TECHNOLOGIES AT TERMINALS

Key innovations were identified for the three typologies of terminal that have been evaluated in the carried out cases studies.

Concerning Rail to Road terminals and Rail to Sea terminals innovations deal with the following topics:

• Handling Typology;

• Handling Equipment;

• Handling Layout;

• Terminal Access - ICT technologies;

• Internal Moving Vehicles: Locomotive;

• Technological Systems: Control and security;

• Terminal Working Hour;

• Conceptual Train Side layout;

• Conceptual Horizontal Handling.

Based on the main temporal scenarios defined in WP 23, two conventional time horizons, a middle term horizon (2030) including incremental change starting from the present situation and a long term horizon (2050) including more radical system changes have been determined. Moreover, 2030 is also the year in which multimodal TEN-T corridors will enter into service.

Table 4 identifies the innovative operational measures and innovative technologies applied in the middle and in the long term for intermodal Rail to Road terminals.

Intermodal Rail to Road terminal in Munich (DUSS Riem) and Antwerp (NV Combinant, IFB Zomerweg, HTA-Hupac)			
2030		2050	
Innovative operational measures	*Innovative technologies*	*Innovative operational measures*	*Innovative technologies*
Faster and fully direct handling Automatic ITU and vehicles control and data exchange No locomotive change Long train,[avg 1500m] H24 working time	Automated fast transtainer Intermodal complex spreader Duo loco Fast Automated gate	Horizontal and parallel handling Faster and fully direct handling Automatic ITU and vehicles control and data exchange	Automatic systems for horizontal parallel handling

TABLE 4 TIME HORIZON OF KEY INNOVATIONS FOR RAIL- ROAD TERMINALS

Table 5 highlights the innovative operational measures and innovative technologies applied in the middle and in the long term for intermodal Rail to Sea terminal.

Intermodal Rail to Sea terminal in Valencia (Noatum Principe Felipe)	
2030	2050

Innovative operational measures	*Innovative technologies*	*Innovative operational measures*	*Innovative technologies*
Automatic brakes on wagons, Self-propelled wagons, Automatic coupling and decoupling, 1500 m track operative length, H24 working time, Automated vehicle identification.	Automated fast transtainer, Intermodal complex spreader, Duo loco, Automated gate.	Horizontal and parallel handling, Automatic ITU and vehicles control and data exchange, No locomotive change,	

Table 5 Time horizon of key innovation for Rail to Sea terminal.

Table 6 shows the innovative operational measures and innovative technologies applied in the middle and in the long term for Hallsberg marshalling yard.

Marshalling Terminal in Hallsberg (Hallsberg Marshalling Yard)			
2030		2050	
Innovative operational measures	*Innovative technologies*	*Innovative operational measures*	*Innovative technologies*
H24 working time,	Automatic brakes on wagons, Automatic coupling and decoupling, 1500 m track operative length, Automatic wagon identification		Self-propelled wagons, Duo propulsion locomotives, Driverless locomotives,

Table 6 Time horizon of key innovation for Rail to Rail terminal.

6.2 Recommendations- Contribution of a multimodal TEN-T core network towards the White Paper Goals

Within a multimodal network like TEN-T network, terminals are an essential element which ensure the connection among the various modes.

However terminal handling is an interruption in the transport chain and has no value in itself, with terminals, the transport chain can be optimal by combination of the best modes on each link to minimize costs. The aim of terminal handling is that it must be as smooth and cheap as possible, so it will be easy to change mode if required.

Another reason, which has gathered importance because of the climate crisis to use terminals, is to use the best mode on every link to reduce energy consumption and GHG.

Therefore, in view of the realization of a multimodal network, which is the TEN-T network, intermodal terminals represent a key element for its success. Nevertheless, the fact that trucking does not need as much terminal handling is one reason that it has been so successful.

For rail, there is also an internal terminal system for production of rail transports with no interface to the customers like marshalling yards and shunting areas, building and splitting trains of wagons and for optimize the train system especially for wagonload.

Innovations in terminal handlings must reduce cost, shorten the time, lower energy consumption and GHG, get rid of damages and make administration and control of the transport chain better.

At the end, it will be recognized as a success if the terminal handling will not stand out as anything special for the customer.

The study of the implementation of the selected new technologies and operational measures in the case studies terminals, has indicated a general increase of the key performance indicators and, consequently, an increase of the terminal performances. The handling technology of the future has positive effects on the speed of terminal operations and consequently on handling time per ITU. Selected innovations demonstrated their capability to improve terminal performance. The outputs obtained from key performance indicators demonstrate that innovations are able to increase the overall performance of a terminal, enabling an increase in flows, in terms of wagons and trains, as well as in a reduction of the duration of various operational phases, see Deliverable D23.2 for detailed results.

The extensive implementation of the innovative operative measures/technologies along the intermodal terminals along the core network will improve these nodes, which ensure the connection between different modes and contribute to the EU's sustainable mobility and climate change objectives.

6.3 Industry Survey- Multimodal TEN-T Core Network

6.3.1 Industry Survey Results & Recommendations

As discussed in 6.1 and 6.2, WP23 identified key operational and technological innovations for terminal typologies to increase the level of automation at terminals. For Sea Rail and Road Rail terminals, participants were invited to rank potential terminal improvements in order of importance where **1 is required most urgently** and **11 least** urgently. Table 7 illustrates the number of responses assigned to each improvement, where two numbers in the position column are the same they received an equal number of responses.

Key TR- Total Responses. P- Position.

Improvement	Ranking for Most Urgent in order																					
	Ranking for '1'		Ranking for '2'		Ranking for '3'		Ranking for '4'		Ranking for '5'		Ranking for '6'		Ranking for '7'		Ranking for '8'		Ranking for '9'		Ranking for '10'		Least Urgent	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
Faster and fully direct handling	5	3	5	3	6	2	2	4	2	4	0	6	3	2	0	4	1	5	1	4	2	2
Automatic ITU and vehicle control and data exchange	10	1	9	1	3	5	1	5	3	3	1	5	0	5	2	2	0	6	1	4	1	3
Longer trains	5	3	4	4	7	1	5	2	2	4	1	5	4	1	2	2	1	5	1	4	2	2
24 hour working time	3	4	6	2	5	3	6	1	1	5	2	4	2	3	2	2	3	3	0	5	0	4
Horizontal and parallel handling	1	6	1	6	1	7	4	3	5	2	4	2	1	4	2	2	1	5	1	4	0	4
Automated fast transtainer	1	6	1	6	1	7	5	2	3	3	4	2	2	3	2	2	4	2	1	4	1	3
Intermodal complex spreader	0	7	1	6	0	8	0	6	3	3	3	3	3	2	3	1	2	4	4	1	1	3
Dual mode- Electric Diesel Locomotive	6	2	3	5	3	5	4	3	6	1	1	5	1	4	3	1	2	4	2	3	1	3
Automated gate	2	5	3	5	4	4	1	5	1	5	4	2	2	3	2	2	6	1	2	3	2	2
Automatic systems for horizontal parallel handling	2	5	3	5	2	6	1	5	1	5	5	1	4	1	1	3	2	4	3	2	3	1
Other	0	7	0	7	0	8	0	6	0	6	0	6	0	5	1	3	0	6	1	4	1	3

Table 7 Total responses assigned to each rail sea & rail road terminal improvement

- From Table 7 it can be seen that 'Automatic ITU and vehicle control and data exchange were ranked as most urgently required with the highest number of responses for ranking '1' and '2'.
- For ranking 3-11, there was great variation in the improvement, which received the highest number of responses including; longer trains and dual mode electric diesel locomotive.

In order to determine a comprehensive view and demonstrate the overall ranking among the improvements, a weighted ranking was calculated. Wherein 11 points were awarded for each response where the improvement had been ranked as required most urgently. 10 points for a ranking of 2, 9 points for a ranking of 3 etc. and 1 point awarded for each response where the improvement had been ranked 11 or required least urgently, the results are displayed in Table 8.

Improvement	Automatic ITU and vehicle control and data exchange	Longer Trains	24 hour working time	Dual mode-Electric Diesel Locomotive	Faster & Fully direct handling	Automated gate
Total points	273	253	232	231	211	169
Overall Ranking	1	2	3	4	5	6
Improve-ment	Automatic systems for horizontal parallel handling	Automated fast transtainer	Horizontal and parallel handling	Intermodal complex spreader	Other	
Total points	154	148	139	91	7	
Overall Ranking	7	8	9	10	11	

TABLE 8 WEIGHTED RANKING OF SEA-RAIL AND ROAD-RAIL IMPROVEMENTS

- Data in Table 8 reveal Automatic ITU and vehicle control and data exchange as the improvement identified as most urgently required by industry participants.
- It is notable that, 24-hour working time received only the fourth highest total of ‘1’ most urgently required but in the overall ranking, it is third.
- Also of interest, longer trains has the third highest number of responses in the category ‘1’ most urgently required yet in the weighted ranking it has the second highest points total behind automatic ITU and vehicle control and data exchange.
- Recommendations from industry members regarding Rail-Sea and Rail-Road terminals included; the liberalisation of port handling- with the aim to end the Docker’s monopoly. Together with, a decrease in the union's congested status for the workers in terminal facilities.

In a subsequent question, respondents were encouraged to rank potential terminal improvements for Rail-Rail terminals, in order of importance where **1 is required most urgently** and **8 least** urgently. Table 9 illustrates the number of responses assigned to each improvement, where two numbers in the position column are the same they received an equal number of responses.

Key TR- Total Responses. P- Position.

Improvement	Ranking for Most Urgent in order															
	Ranking for '1'		Ranking for '2'		Ranking for '3'		Ranking for '4'		Ranking for '5'		Ranking for '6'		Ranking for '7'		Least Urgent	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
Automatic brakes on wagons	5	3	2	5	4	3	2	5	3	3	2	4	3	3	3	3
Self propelled wagons	2	5	3	4	2	5	3	4	2	4	3	3	6	2	4	2
Automatic coupling & decoupling	9	2	8	2	6	1	4	3	1	5	1	5	1	5	2	4
Longer operative track length	5	3	6	3	5	2	6	1	2	4	4	2	3	3	1	5
24 hour working time	2	5	9	1	4	3	5	2	6	2	2	4	1	5	2	4
Automated vehicle identification	10	1	2	5	5	2	5	2	2	4	6	1	1	5	0	6
Driverless Locomotives	0	6	2	5	4	3	5	2	3	3	2	4	7	1	6	1
Dual mode, electric diesel locomotive	3	4	6	3	3	4	2	5	8	1	4	2	3	3	4	2

Table 9 Total responses assigned for each rail-rail terminal improvement

- Table 9 identifies automated vehicle identification and automatic coupling and decoupling as the two improvements rated as most urgently required.
- Of interest, although it could be considered an innovation to increase automation within terminals, driverless locomotives did not receive any responses in the most urgently required category.

As with other questions, which had requested a number of improvements to be ranked in order of importance, a weighted ranking was also calculated, the results are displayed in table 10.

Improve-ment	Automatic coupling & decoupling	Autom-ated vehicle identifi-cation	Longer operative track length	24 hour working time	Dual mode, electric diesel loco-motive	Automatic brakes on wagons	Driverless Loco-motives	Self propelled wagons
Total points	195	177	169	162	148	115	101	97
Overall Ranking	1	2	3	4	5	6	7	8

Table 10 Weighted ranking of all rail-rail improvements

- it is interesting to note that although 24 hour working time and Driverless locomotives received some of the lowest responses within '1' most urgently required category, a weighted ranking places them 4th and 7th in order of importance.
- These results indicate a well defined trend that industry participants identify automation within rail-rail terminals as the improvement most urgently required.
- Recommendations from stakeholders included; the streamlining of operations before departure which take a significant time and for which the connected wagons equipped with certain devices could reduce it significantly in the short term.
- A suggestion for a road map for implementation of automated couplings was put forward, in order to ensure large implementation of the equipment so that it can be introduced as an operational measure.

In line with one of the innovations explored in WP23 for all terminal types '24 hour working time' which implies that an increase in the number of terminal personnel would be required. The following question was posed 'How confident are you that the European rail sector currently possess a sufficient number of highly skilled personnel to be able to operate Hub terminals 24 hours a day? The results are shown in Figure 9

- The chart illustrates that the majority of participants (48%) are moderately confident that there are a suitable number of skilled personnel within the EU rail industry to fulfil the role, should hub terminals move into 24-hour operation.
- While 25% of respondents are 'very confident' and 9% 'extremely confident'. These results indicate that the industry stakeholders surveyed were largely positive about the level of skilled personnel available for terminal operation. This implies that from a personnel perspective, moving to 24-hour operation at hub terminals should not be delayed by a skills shortage.

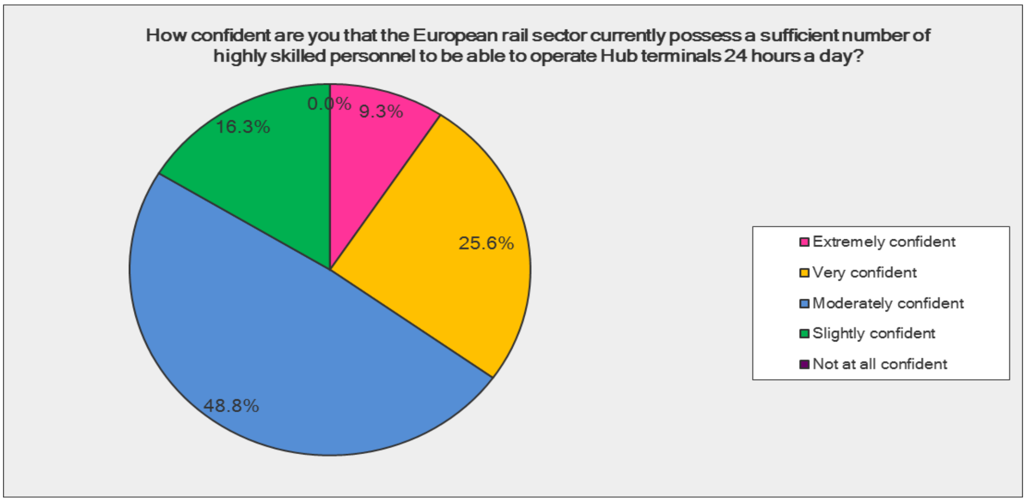

FIGURE 9 LEVEL OF CONFIDENCE IN AVAILABILITY OF SKILLED PERSONNEL TO OPERATE HUB TERMINALS 24/7.

Within a multimodal network, there is a perception that rail offers less clear information on costing than some of its competitors. To gain industry comment on this, participants were asked; 'What is your view on how achievable it is that operators using rail in a multimodal transport chain will be able to offer all unit freight price/ per origin(O)/ destination (D) for multimodal door-to-door goods transport by 2030?

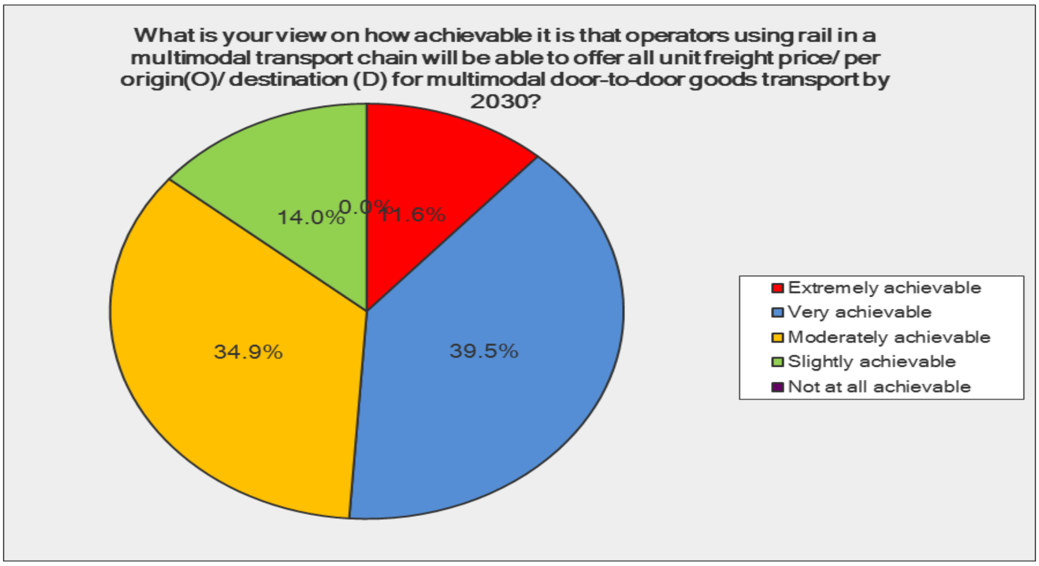

Figure 10 Level of confidence in achievement of a unit freight price per o/d for multimodal goods by 2030

- From Figure 10 it can be seen that 84% of participants view the prospect of producing a unit freight price per o/d for multimodal goods as at least moderately achievable by 2030. Of these 50% of respondents, believe that it could be very feasible.

Valuable feedback from industry stakeholders on this issue included;

- *It should be a main objective and will probably require European help.*
- *Will require Government policy shift on timetabling and access charges to allow consistency but operators could partly do this today.*
- *This is possible now - but many customers who are booking slots on trains (as opposed to whole trains) do not want this.*
- *Customers require clear and accurate pricing when comparing with road solutions*
- *Where there is a will there is a way to deliver it, if there is no willingness on all sides then it will not happen.*

7 Long Term Comprehensive Network

7.1 Key Innovation Processes, Technologies related to a long term comprehensive network

In the introduction section we discussed briefly (TEN-T) core and comprehensive networks. The planning, development and operation of TEN-T networks contribute to the attainment of major European Union objectives. These objectives include allowing the seamless, safe and sustainable mobility of persons and goods, ensuring accessibility and connectivity for all regions, and contributing to further economic growth and competitiveness in a global perspective and should be achieved by establishing interconnections and interoperability between national transport networks in a resource-efficient and sustainable way. For example, rail interoperability could be enhanced by innovative solutions aimed at improving compatibility between systems, such as on-board equipment and multi-gauge rail tracks further discussed in chapter 9.

EU Regulation 1315/2013 establishes guidelines for the development of a TEN-T network, comprising a dual-layer structure consisting of the 'comprehensive network' and the 'core' network, the latter being established on the basis of the former. The comprehensive network (specified in the maps and listed in Annex I and Annex II part 2 of the regulation) consists of all existing and planned transport infrastructures of the TEN-T network, as well as measures promoting the efficient, socially and environmentally sustainable use of such infrastructure (e.g. railway and waterways). The Regulation stipulates that it shall be identified and developed in accordance with Chapter II of the development of the comprehensive network that stipulates the provisions and priorities. The dual-layer TEN-T network structure includes:

- The gradual development of the TEN-T network shall be achieved, in particular, by implementing a dual-layer structure for that network with a coherent and transparent methodological approach, comprising a comprehensive network and a core network.
- The comprehensive network shall consist of all existing and planned transport infrastructures of the TEN-T network as well as measures promoting the efficient and socially and environmentally sustainable use of such infrastructure. It shall be identified and developed in accordance with Chapter II.
- The core network shall consist of those parts of the comprehensive network which are of the highest strategic importance for achieving the objectives for the development of the TEN-T network. It shall be identified and developed in accordance with Chapter III of the Regulation.

Chapter II elaborates (in Articles 10 to 37) the general provision and priorities of comprehensive networks consisting of infrastructure for all modes: air road, rail, waterways, maritime and multimodal as well as other aspects such as telematics, sustainable transport, urban nodes, environmental protection etc.

Particular attention can be given to Article 10 that sets General Priorities:

1) In the development of the comprehensive network, general priority shall be given to measures that are necessary for:

(a) ensure enhanced accessibility and connectivity for all regions of the Union;

(b) ensure optimal integration of the transport modes and interoperability within transport modes;

(c) bridge missing links and removing bottlenecks;

(d) promote the efficient and sustainable use of infrastructure and increasing capacity;

(e) improve or maintain the quality of infrastructure in terms of safety, security, efficiency, climate, and the quality of services and continuity of traffic flows; and

(f) implement and promote innovative technological development.

2. In order to complement the measures set out above, particular consideration shall be given to measures that are necessary for:

(a) ensuring fuel security through increased energy efficiency, and promoting the use of alternative and, in particular, low or zero carbon energy sources and propulsion systems;

(b) mitigating exposure of urban areas to negative effects of transiting rail and road transport;

(c) removing administrative and technical barriers, in particular to the interoperability of the TEN-T network and to competition.

The key innovations on TEN-T Core network and time horizon for their implementation is elaborated in Section 6.1 AND 6.2 respectively, and these are applicable across the comprehensive network as well.

7.2 Industry Survey- Long Term Comprehensive Network

7.2.1 Industry survey results & recommendations

As discussed in 7.1, the EC has defined clear guidelines for the development of a TEN-T corridor network with a dual layer structure of 'core' and 'comprehensive' network. To gain an understanding of the industry viewpoint of 3PL/integrator within a comprehensive network, participants were asked; how important is it that 3PL/integrator operates train services rather than contracting to a separate operator? The results are illustrated in Figure 11

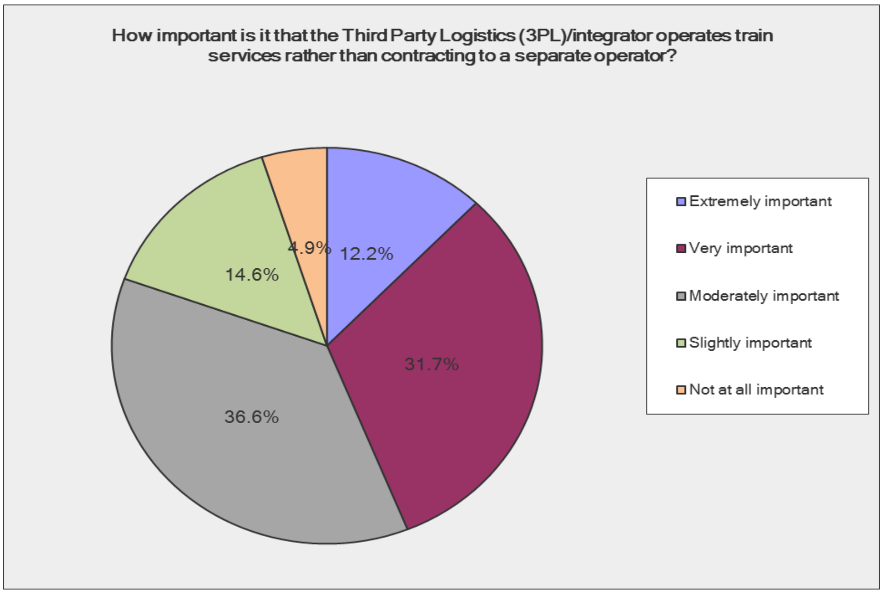

Figure 11 Level of importance of 3PL operating train services

- Figure 11 reveals that over 40% of respondents viewed this as either 'very' or 'extremely' important, while a further 36% identified it as moderately important.

These figures suggest that from an industry perspective, high value is placed on an integrator or 3PL across the comprehensive network, this is supported by the following comments;

- *This is important to ensure an intermodal approach, not only from the wagon perspective.*
- *3PLs and similar bodies have the necessary experience and customer base to allow full length, fully loaded trains, which is necessary to be affordable to customers. Only a full train will, in effect, be cost effective at today's road /rail cost differentials. 3PLs have a big role in doing that. It does not follow that they then have to drive the train themselves- all kinds of different partnership models ought to be available, this is something, which commercial parties could look into.*
- *There is a role for a 3PL but this is not the only model. The key challenge is who takes the risk of filling the train for new services.*

As the EC targets a long term comprehensive network, industry members were asked what they view as the main barriers to this. Responses can be categorized into 4 subtopics as follows;

Economic barriers

- *Infrastructure cost and contingency v road*
- *Costs such as track access*
- *Competition from road- low cost road transport from Eastern Europe*
- *A high number of interfaces, slow down the speed and increases the costs*
- *Sub optimizing- too many parties involved which destroys small margins*

Political barriers

- *Pressure of local politicians Europe wide, for regional passenger trains everywhere*
- *Road is cheap, governments prefer to prioritise passenger services*
- *Political differences which shape railway decisions and can lead to a lack of market opening*
- *Unhelpful national operators and a lack of competent bureaucrats in the EU*
- *The interference between a strong business case of upgrading some other line than fully committing to upgrade the comprehensive network.*
- *Differences in legislation and train path allocation processes that differ from country to country- lack of unified regulations*
- *Competition from the national network- a clear separation of infrastructure and operations is required*

Barriers caused by Infrastructure Development

- *Lack of investment in the less used regional lines*
- *An imbalance in infrastructure development*
- *Lack of high quality infrastructure and the existence of missing links within the comprehensive network*
- *Lack of IT integration*
- *More efficient SWL traffic with automated processes*

Freight Demand

- *Lack of certainty of rail capacity across a calendar year- this makes it more difficult to obtain investment from the private sector*

A logical subsequent question asked participants what benefits they would like to achieve or gain from a long term comprehensive network, responses can be categorized into 3 subtopics;

A large number of respondents referred to a change in market share for rail as an advantage of an improved comprehensive network;

- *Being able to shift demand from road to rail*
- *Diversion of routes, would lead to potentially new market shares*
- *An increase in the volume of goods transported*
- *Development of rail market share*
- *An increase in the volume of traffic and satisfied customers*
- *The possibility to better address the demand of existing and potential new customers without the direct connection to the core network*

Economic benefits

- *An increased fill rate of train leading to lower unit costs*
- *A reduction in costs and time savings*
- *Ease of capacity planning, efficiency and hence lower costs*

Increase in efficiency & reliability

- *Efficient operating schedules offering huge gains for RUs (reduction of costs, better service leading to increase in revenues)*
- *An increase in logistics efficiency*
- *The fulfillment of the timetable, just in time*
- *More reliable journey times*
- *An increase in efficiency offers a bigger possibility of investment*
- *Better reliability with improved possibilities to monitor trains and it is easier to establish new rail services*

8 Traffic management systems in all modes

The EC challenges for the development of traffic management systems (TM), were discussed in chapter 1 including developing a multimodal transport chain where rail, as a partner, will play a major role between terminals/hubs to terminal/hubs and the final customer will be connected by another transport mode for example road. In this case the hubs will be a modal (or intra-modal) transfer point. To achieve an efficient and effective transport system to meet the needs of the modern supply chain, all of the actors of the chain must be linked with a traffic management and information system that will ensure safety, optimal asset (vessels/vehicles and infrastructure) utilisation and overcome the barriers during the modal transfer including interoperability issues.

8.1 Key Innovation Processes &Technologies for Traffic Management Systems

The European Rail Traffic Management System (ERTMS) is a traffic management system developed to greatly enhance safety, increase train efficiency and enhance rail cross-border interoperability. This will establish and develop TEN-T as well as comprehensive networks in Europe by replacing signalling equipment with digitized mostly wireless versions and by creating a single Europe-wide standard for train control and command systems. ERTMS consists of two main components: the European Train Control System (ETCS) - a standard for in-cab train (i.e. vehicle on-board) control, and GSM-R- the GSM mobile communications standard for railway operations (Infrastructure Manager i.e. IM). Interoperability is an essential element of rail freight competitiveness, which implies a strong coordination between infrastructure managers and a standard control command system. Two factors should also to be taken into consideration, the timing of the coordination and the cost of the ERTMS.

One of the problems that the multimodal transport system faces, is the introduction of information and communication technology (ICT) based services: Shippers and freight forwarders require real-time tracking & tracing (T&T) information about the position of their consignments while on a multimodal transport haul. In addition to track and trace, condition monitoring and security issues need to be addressed to position rail at a level where it can compete with the road transport sector on product and service grounds. T&T and monitoring technologies constitute the core of such automated real-time information systems. While a range of different technologies for the tracking, tracing and monitoring of mobile resources is provided, only limited systematically compiled information is available about their performance and suitability for multimodal transport. In this respect, the best-known T&T technologies are the Global Positioning System (GPS) and Automatic Equipment Identification (AEI) and their localization within the Global System for Mobile Communication (GSM).

For 2030/2050, one approach may be the coordination of tracking and tracing systems together with terminal operations in particular intelligent entry/exit gates. This would allow the possibility to increase automation throughout the transshipment process and decrease terminal opening hours, as terminal operations could be based on train arrival times collected through real time train monitoring.

For rail freight services, transport operators are obliged to reply to the requests of the shippers quickly, in the short term, requests can be very varied with no average, this should be considered during traffic management system development. A system, which has the capability to address this and to elaborate trans-European paths rapidly, would be beneficial. Alongside this, harmonizing the process and the software to elaborate new paths between IMs is important with a system, which has the ability to adjust slightly certain passenger paths, to avoid important disruptions of paths on long distance transport.
The second important point is the cost of ERTMS which appears very heavy to keep freight competitive, specifically when it is to be adapted on existing electric locomotives which have a long life. The connections between the corridors and the industrial clusters, which may be apart from the corridors, have to be equipped with dual signaling system to enable a smooth delivery.

One example of a model for rail-multimodal traffic management system, was presented in WP21 wherein the findings from the completed project FTMS - Freight Transport Monitoring System (EC funded D2D project – implemented during 2002-5) were investigated. An FTMS will gather information about the movement of cargo through a position data network utilising a number of different sensors. This will ensure that information is available in the appropriate formats in all transport chains. The system can be used to monitor the actual transport operations and to provide feedback if schedules are not adhered to. The FTMS system has been designed to be a European global commercial service that will be able to provide status information to a number of subscribers, i.e. by many TCMS installations and other systems used for intermodal transport chain management. By being generic, the FTMS should be envisioned as a service that could be used by anyone transporting cargo in the physical infrastructure monitored by the FTMS. The FTMS should also be an open system and should have the capability to receive status information from a number of sensor technologies such as Automatic Equipment Identification, position sensors for cargo and load units, and transport means.
TCMS - Transport Chain Management System (D2D project)
The Transport Chain Management System will be provided with transport status information by the FTMS to be used for managing multimodal door-to-door transport operations. The main functions of the TCMS are:

- Organize and initiate transport
- Monitor and control operations
- Visualize the transport status (including position of cargo, ETA, etc.).
- Exchange product- and transport documentation (product certificates, quotations, proof of delivery, invoicing information, etc.).

TCMS can handle all types of information related to managing such operations efficiently and handles all types of documents that are necessary to perform the transport and to evaluate the performance over time.

8.2 Industry Survey- Traffic Management System in all Modes

8.2.1 Industry Survey Results & Recommendations

As examined in 8.1 ERTMS is a system, which aims to enhance safety, increase efficiency and decrease time spent at border crossings. Initially the EC aimed for 50% implementation across nine corridors by 2030. However, in January 2017 the EC acknowledged that these targets were unrealistic (rail technology magazine, 2017) and set a new deadline to install ERTMS on 50% of routes covered by nine core network corridors by 2023 with the final deadline 2030.

As a result of these developments, the feedback from industry is highly topical. The question was posed "how confident are you that ERTMS level 2 will be deployed EU wide by 2030?" The results are highlighted in Figure 12.

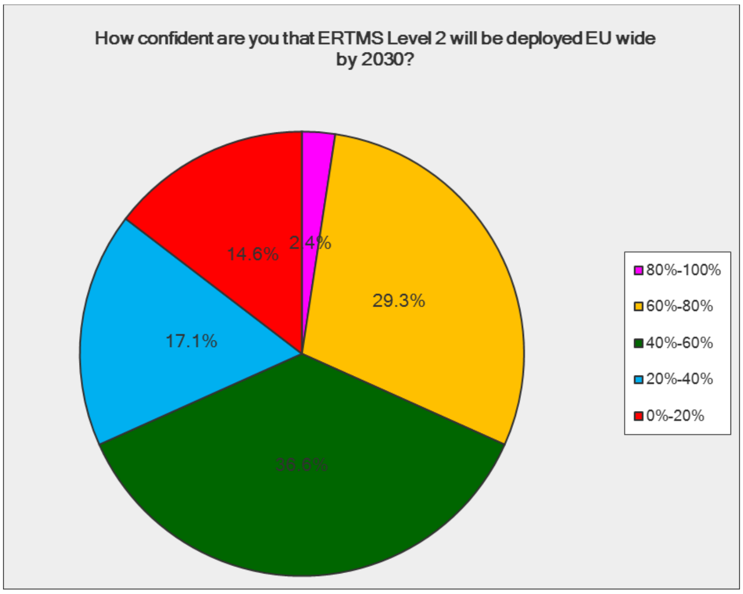

Figure 12 Level of confidence in deployment of ERTMS level 2 EU wide by 2030.

- Remarkably over 30% of respondents believed that there was less than a 50% possibility that ERTMS level 2 would be operational EU wide by 2030.
- While only 2% of participants had an 80-100% confidence level in the EC meeting what are now their revised targets.

ERTMS level 3 is currently the least developed level, but once deployed it is anticipated that it will build on levels 1 and 2, containing a complete radio based system with balises for position reference but with the removal of track circuits/axle counters. It will facilitate moving block that allows trains to 'close up' when running at slower speed. It will be possible for trains to supervise and report its completeness with no need for any kind of trackside signals or train detection system.

Participants were invited to give their opinion on, 'how confident are you that ERTMS level 3 will be deployed EU wide by 2030? A clear trend can be highlighted from the industry responses illustrated in Figure 13 the majority of participants had a very low level of confidence in the achievement of ERTMS level 3 EU wide by 2030 this is supported by statistics;

- No participants voted for a 80-100% confidence level of Level 3 deployment
- 44% of participants communicated a 0-20% confidence level.

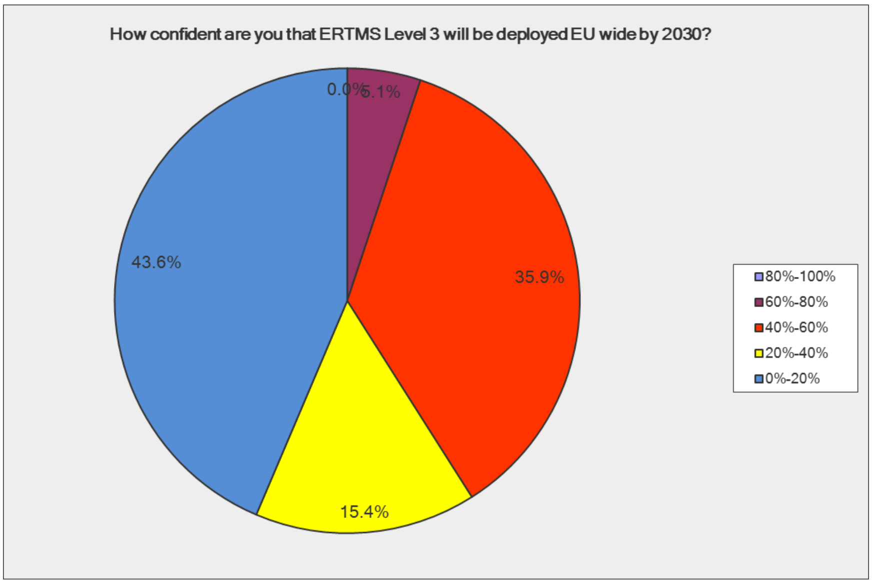

FIGURE 13 LEVEL OF CONFIDENCE IN ERTMS LEVEL 3 DEPLOYMENT EU WIDE BY 2030

Several respondents offered valuable comments on this topic;

- *No need of ERTMS for Freight*
- *Depends on which system and when Germany install, and if operators can finance ETCS.*
- *There is a lack of understanding as to what Level 3 offers. There is an illusion that it is all about moving block. It isn't. It is about capital cost saving, flexibility, sustainability (less copper etc) and reliability. Therefore people don't have the right business plan. Similarly, there is a lack of understanding about so-called ERTMS Regional. It is merely a way of reducing the infrastructure capital costs even more*
- *At present no real technical solutions for ERTMS Level 3 are existing - therefore implementation by 2030 cannot be expected*
- *There is no business case for comprehensive deployment on all lines - likely on main lines only*
- *If we continue like this, it will takes us another 20-30 years to roll out ETCS. L2 has typically less performance than traditional systems due to more restrictive braking curves! L3 requires end of train devices which railways are not willing to buy.*

Addressing a different aspect of traffic management, participants were asked for their viewpoint on which aspect of the big disruption process is most critical for freight services. Big disruption was classified as; unplanned events that require a change to the way in which resources were originally planned and managed. The management of large disruptions involves RUs and in some cases several IMs. Respondents were requested to rank aspects of the big disruption process in order of which are the most critical for freight services. Where 1 is most critical and 6 is least critical. This supports some of the research undertaken in SP3.

Aspect of big disruption process	Ranking for Most Critical in order											
	Ranking		Ranking		Ranking		Ranking		Ranking		Ranking	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
Crew delay or unavailability	6	3	7	2	4	4	10	1	5	3	5	3
Train failure in station	1	5	6	3	3	5	9	2	9	1	9	2
Train failure during journey	7	2	6	3	9	2	6	4	5	3	3	5
Infrastructure degradation	6	3	8	1	11	1	7	3	2	4	3	5
Withdrawal of a path because of track works without reasonable notice	12	1	6	3	3	5	4	5	8	2	4	4
Other causes- Strikes, external factors such as weather	5	4	5	4	7	3	1	6	9	1	10	1

TABLE 11 REVEALS THE NUMBER OF RESPONSES ASSIGNED TO EACH ASPECT OF THE BIG DISRUPTION PROCESS, WHERE TWO NUMBERS IN THE POSITION COLUMN ARE THE SAME THEY RECEIVED AN EQUAL NUMBER OF RESPONSES.

Key TR- Total Responses. P- Position.

Aspect of big disruption process	Ranking for Most Critical in order											
	Ranking		Ranking		Ranking		Ranking		Ranking		Ranking	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
Crew delay or unavailability	6	3	7	2	4	4	10	1	5	3	5	3
Train failure in station	1	5	6	3	3	5	9	2	9	1	9	2
Train failure during journey	7	2	6	3	9	2	6	4	5	3	3	5
Infrastructure degradation	6	3	8	1	11	1	7	3	2	4	3	5
Withdrawal of a path because of track works without reasonable notice	12	1	6	3	3	5	4	5	8	2	4	4
Other causes- Strikes, external factors such as weather	5	4	5	4	7	3	1	6	9	1	10	1

Table 11 Total Responses Assigned to Each Aspect of the Big Disruption Process

Aspect of big disruption process	Ranking for Most Critical in order											
	Ranking		Ranking		Ranking		Ranking		Ranking		Ranking	
	TR	P	TR	P	TR	P	TR	P	TR	P	TR	P
Crew delay or unavailability	6	3	7	2	4	4	10	1	5	3	5	3
Train failure in station	1	5	6	3	3	5	9	2	9	1	9	2
Train failure during journey	7	2	6	3	9	2	6	4	5	3	3	5
Infrastructure degradation	6	3	8	1	11	1	7	3	2	4	3	5
Withdrawal of a path because of track works without reasonable notice	12	1	6	3	3	5	4	5	8	2	4	4
Other causes- Strikes, external factors such as weather	5	4	5	4	7	3	1	6	9	1	10	1

Table 11 demonstrates that withdrawal of a path because of track works without reasonable notice is considered the most critical aspect of the big disruption process for freight by industry stakeholders as it has received the highest number of '1' responses. This result is in line with industry response to an earlier question about the implementation of an EU wide high speed network where maintenance and a lack of maintenance coordination was highlighted as of importance to industry members.

In order to determine a comprehensive view, and demonstrate the overall ranking among the aspect most critical for freight services, a weighted ranking was calculated. Wherein 6 points were awarded for each response where the improvement had been ranked most urgent. 5 points for a ranking of 2, 4 points for a ranking of 3 etc. and 1 point awarded for each response where the improvement had been ranked 6 or least urgent, the results are displayed in table 12.

Aspect of big disruption process	Infrastructure degradation	Withdrawal of a path because of track works without reasonable notice	Train failure during journey	Crew delay or unavailability	Other causes- Strikes, external factors such as weather	Train failure in station
Total points	**148**	**146**	**139**	**132**	**114**	**102**
Overall Ranking	**1**	**2**	**3**	**4**	**5**	**6**

TABLE 12 WEIGHTED RANKING OF MOST CRITICAL ASPECTS OF THE BIG DISRUPTION PROCESS

The results display that from an industry viewpoint, the two aspects of the big disruption process most critical for freight services are; infrastructure degradation and path withdrawal because of works without reasonable notice. Also of note, the aspect 'Other' received the highest number of responses for 6 least critical, yet in the overall ranking it was ranked 5th. Alongside this, infrastructure degradation collected the highest number of responses for the critical ranking '3' yet in the overall ranking it was first.

9 Multimodal Transport Information

In the White Paper (2011), the EC outlined their vision for an overall framework for information exchange between different actors, where logistics stakeholders along the supply chain are linked electronically by standardised electronic documents (Multimodal e waybill). Together with this administrative procedures would be streamlined with the implementation of a single window (single access point) and one stop shop for administrative and legal procedures.

Today, a number of Multimodal Transport Information (MTI) systems exist which can be categorised into; freight resource management systems, terminal and port information communication systems, freight and fleet tracking and management systems and applications and integrated operational informational/information exchange platforms. Across the transport chain, MTI consists of a variety of needs for a freight purchaser, railway undertaking and terminal operator consists of a variety of different needs. The possibility of real time tracking and tracing of where is cargo currently is located and when it could be expected to arrive (the ETA) is critical. Meaning that MTI needs to provide information not only on the basis of where the cargo is currently located but also in a wider context including relevant information to the rail operator and the arrival terminal. This should include information regarding type of cargo, type of loading unit, type of wagon.

Currently, this kind of information is sent between the various stakeholders (freight purchaser, undertaking, terminal operator) "manually" by various forms of EDI-solutions for example; Hermes VPN, COTIF/CIM, CIM/SMGS, ORFEUS, ISR, USE-IT, Rolling Stock Reference Database, Train Information System, X-Rail. For further information please refer to D21.2 (2017).

9.1 Key Innovation Processes & Technologies in Multimodal Transport Information

To visualise the operational process at a terminal for combined transport and the data flow consider the illustration below.

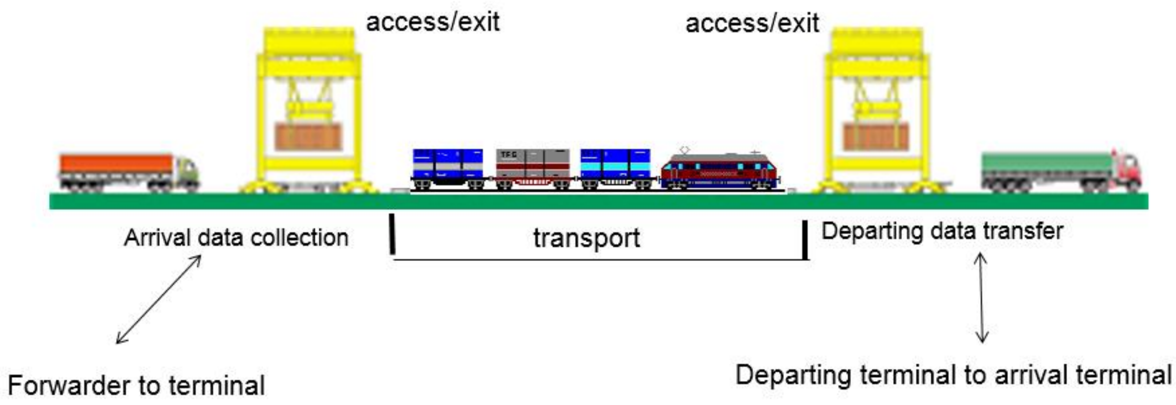

Figure 14 Simplified overview of data flow at a combined terminal

For several of the sub processes illustrated in Figure 14 innovations and technologies have been proposed to streamline the flow of transport information. During 'arrival data collection' if relevant data could be gathered and compiled when an intermodal loading unit (ILU) arrives to the terminal, the time it takes to load the ILU onto a pre-planned dedicated wagon would decrease.

For the transfer of 'departure data', to increase efficiency if data could be transmitted automatically on train departure without any errors to the receiving terminal, this would also increase the efficiency at the receiving terminal. Streamlining both the arrival and departure data processes would lead to a decrease in the dwell times for trains, trucks and ILU as a whole.

It is widely recognised, that incorrect ILU data at the terminals creates major bottlenecks within the freight chain and is a key barrier to improving the speed and efficiency of multimodal rail freight transport. An innovation to address this would be the development of intelligent entry and departure gates at the terminals together with establishing a common standard/interface to transmitting data between the terminals. This would incorporate intelligent gates equipped with cameras that not only have the capability to take a photograph of the ILU but are also able to analyse the information obtained and use this information appropriately.

It is anticipated that intelligent entry and departure gates would provide a benefit to terminal operators during the centralized load planning of the departing train as this would simplify the process, together with accelerating the availability of in-/outbound train documentation. Alongside this, as a result of the train documentation being available more quickly an automatic comparison could be carried out between the pre-defined data sent from the forwarder to the terminal meaning that deviation reports could be created instantly. As a result, if corrective action was required this could be deployed much more quickly. Another benefit to terminal operators of this improvement would be on train departure, as when the loaded train departs relevant data could be sent immediately to the terminal of arrival. This would improve efficiency at the arrival terminal, both for unloading the units and it would allow earlier planning of the best use of the wagons once they have been unloaded.

For example, today when entering certain car parks your car plate is automatically read and the barrier opens. The same should apply at train entrance as well as the truck entrance with the reading of the swapbody or container number and code and the identification of the truck and the wagon; with the identification of the ILU all transport data should become available to enable a smooth process to start. Pre-arrival information should have been given at the departure yard for the train with an ETA updated during the travel progression in order to prepare actions in the terminal. During the process in the terminal the data concerning the travel of the ILU should be updated and sent to the operator of the next link of the transport chain and to the customer for their information.

Figure 15 illustrates some of these data attached to a typical multimodal transport unit. Currently this information is registered and forwarded on manually at the departing terminal and forwarded on manually to the arrival terminal.

If the information attached to the ILU could be gathered and analysed automatically, the estimated time of arrival (ETA) to the final point of delivery would be much more easily predicted and the time from departure to ETA would be shorter. This would be advantageous to all the stakeholders along the transport chain. Another benefit would be a decrease in the number of manual errors, which today affects the transit time, the loading- and unloading time required at the terminals.

FIGURE 15 DATA LABELS ON A TYPICAL MULTIMODAL TRANSPORT UNIT

A further development to encourage road- rail modal shift, is the development of fully automated terminals, to decrease terminal handling costs. Fully automated terminals exist now, but only for very large terminals. If this could be developed and applied to terminals with smaller demand, which run services over shorter distances, it may address the issue of high costs for ILU transfer. Currently ILU transfer is one of the largest contributors to overall intermodal transport costs, with ITU handling alone totaling circa €30. Measurable achievements estimated for a future system for automatic horizontal terminal handling in combination with liner trains include:

- Cost reduction of terminal handling per unit by approximately 60%;
- Break-even point for intermodal will be reduced from 500 km to 300 km;
- Energy consumption for terminal handling will be reduced by 93% CO2 emissions in kg per unit will be reduced by 99% with electric propulsion

For further information, refer to WP21, D21.2.

9.2 Barriers to an EU Multimodal Transport Information System

Despite EC investment in numerous research and development projects (Belogic, Freightwise, Viwas, Comcis, Welcom, FMan, MTrade, Themis), several barriers remain before a fully automatic system for freight can be realised. Barriers are varied and depend on geographic location, transport mode, and stakeholders, however the main barriers inhibiting MTI can be categorised as user based, technology based, policy and operational.

In section 9.1 it was highlighted that multimodal transport unit data is currently captured and transferred manually. From a technology perspective, it can be argued that the main barrier is not a lack of technology, the obstacles lie within interoperability and compatibility between different transport modes and IT platforms along the multimodal chain. This was stressed in the EC e-Freight Roadmap developed in May 2013, highlighted as a lack of coordination of developments across modes, countries and stakeholders.

Another issue can be identified as a lack of standardisation both in the format of data and in the method by which it is transferred leading to the problem of low compatibility and a lack of interconnectivity. As highlighted in the Freight and Logistics Action Plan, (2007) another technological barrier is data security. Insufficient standardisation, data security and privacy issues were emphasised, this raises questions such as who owns these data at each point along the transport chain and who is responsible for it? Subsequent to data security is the issue of data sharing, this was an issue explored during the industry survey to gain a consensus on the willingness to share data so that other customers could book remaining capacity. The results are presented in 9.3.

From a user perspective, one of the restraints identified is the size of the company, as in comparison to large multinationals, smaller companies are restricted by the financial and human resources they can contribute to deploying MTI systems. Alongside this, a progressive attitude is required by company management with regards to investment, as it will also require recruitment of specialist staff to operate the system, which may be another obstacle for smaller businesses. It should be noted that all barriers have close links for example user perspective problems are closely linked to policy barriers, as a lack of standardisation across countries, between technology interfaces and amongst infrastructure, ultimately influences user operation of MTI systems. From a policy perspective, improved policy coordination is required to overcome the barrier of an individual approach to multimodal transport by each member state. For the EC to reach their target of a one stop administrative shop, a transnational policy is required including standards on privacy, data sharing and data transfer which considers all modes, stakeholders and countries.

9.3 Industry Survey- Multimodal Transport Information

9.3.1 Industry Survey Results & Recommendations

In sections 9.1 and 9.2 some of the innovation processes in multimodal transport innovation have been discussed, together with the identification of remaining barriers. To gain an insight from rail operators, infrastructure managers, terminal operators etc. on this topic, a series of questions were presented.

Firstly 'numerous platforms exist which act as an online brokerage system for multimodal transportation. Please list any that you are aware of below'

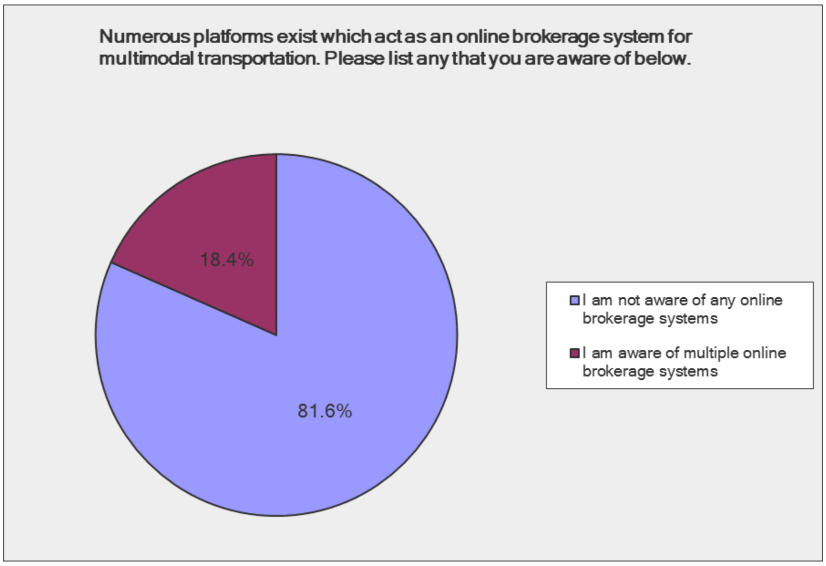

FIGURE 16 RESPONDENT AWARENESS OF ONLINE BROKERAGE SYSTEMS

As illustrated in Figure 16 the responses demonstrate a clear trend, in that over 80% of participants were unaware of any online brokerage services. Helpful comments from respondents indicated brokerage systems that they were aware of as;

- Freight Arranger
- Freightliner offers brokerage to its customers in the UK on all intermodal services

These systems offered services including; costing, door to door transport service availability, route comparison, most cost efficient route.

For participants who do not use an online brokerage system the question was posed, "If you have not used an online booking platform please explain why not and whether you plan to do so in the future" responses included;

- *Tool not necessary*
- *No need for our business*
- *We run block trains for one customer*

One proposal to increase the use of online brokerage systems in the future was put to respondents; 'One option proposed for the future, is to increase the use of online brokerage systems so that other customers could book any free/remaining capacity i.e. return transport. What type of information would you be willing to share on such a database?

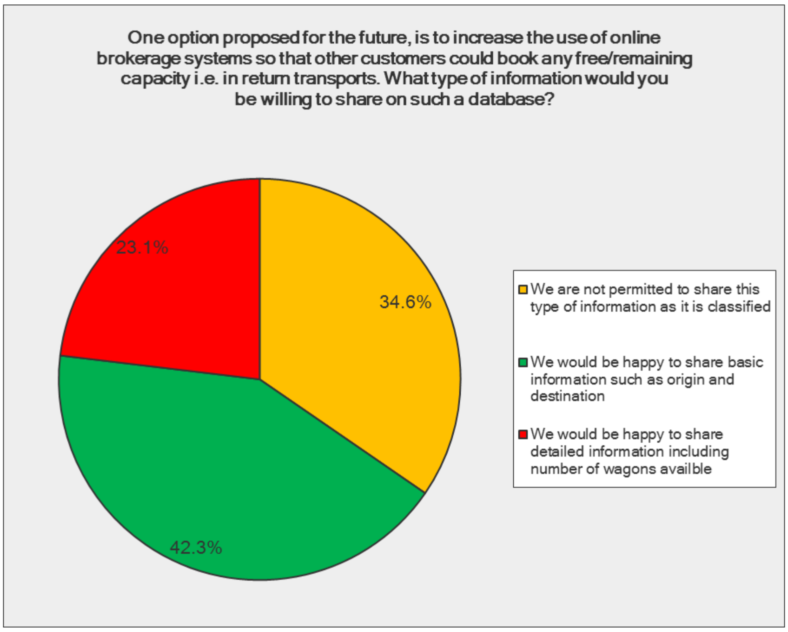

FIGURE 17 LEVEL OF INFORMATION SHARING IN A POTENTIAL ONLINE DATABASE

- The results display a clear trend that 35% of participants are *not* permitted to share this type of information.
- While 42% of respondents would be happy to share information such as origin and destination. These results suggest one way forward for an increase in the use of online brokerage systems.

Valuable comments on this topic included;

- *I think the issue here is that brokerage only works where there are operators who are prepared to take risk on filling trains. In most cases, the rail haulier will be looking for train fill from contracted customers, or see previous comments on 3PLs. So we need to get the structure of services right before online brokerage can really find its feet.*
- *I have my clear doubts about the potential for on line brokerage system - the market needs to decide to go intermodal or not!*

10 Summary & Conclusions

10.1 Summary & Conclusions

This deliverable has addressed two of the main objectives for WP24;

- To analyse the potential of newly designed, fully integrated rail freight systems and understand the expected market up take levels
- To produce a catalogue on rail freight systems to contribute to the Commission's goals for 2030 and 2050

Output produced under SP2 to date has been consolidated to develop a catalogue for rail freight systems for 2030/2050. Wherein rail freight system designs have been presented under six subtopics; freight modal shift from road-rail, EU wide high-speed network, Multimodal TEN-T core network, Long term comprehensive network, Traffic management systems in all modes, Multimodal Transport Information in line with the EC White Paper (2011) challenges.

The results from a comprehensive industry survey to determine the potential market up take of the new designs developed during the course of SP2 freight, offer an informative overview from industry on the level of receptivity and acceptance of the system designs in relation to performance, operational and technical characteristics.

Freight modal shift from road to rail and other environmentally friendly modes, was identified as one of the central challenges of the White Paper (2011). From SP2, important innovations put forward to encourage modal shift related to wagon design, included;

- For car carrier wagons, 5 bodies with 6 axles for an overall length of 62m
- For container wagons, a standard train composed of slightly rebuilt wagons capable to carry 40' containers or 20' containers plus on every third wagon a 45´container.
- For container wagons, a new design of a five bodies wagon with six bogies for five 45´containers with an overall length of around 72m. This solution aims to reduce the number of bogies and hence the maintenance cost.
- For crane-able semitrailers with a 4 bodies wagon with 6 bogies for four trailers with an overall length of around 67m.
- To reduce significantly the preparation time before the departure of the train with the introduction of an EOT (End Of Train) device.

Analysis of industry feedback identified from current wagon designs; Special flat wagon with bogies, Ordinary flat wagon with bogies, Tank Wagon as the three wagons which would be utilised most frequently to facilitate modal shift from road to rail. These results offer an indication of the type of goods industry representatives believe will be captured by rail during modal shift; flat wagons to carry boxes, trailers, food, containers and swap bodies together with tank wagons to transport fuels.

Industry participants were asked to rank wagon improvements for 2030/2050. It can be concluded that the improvement identified as 'most urgently' required by industry was the design of lighter freight wagons. The list below highlights all the wagon improvements as ranked in order of importance by industry participants.

1. Lighter wagons
2. Maintenance detectors
3. Track friendly running gear

4. Automatic couplers
5. End of Train Device
6. EP Brakes

To achieve an EU wide high-speed network, SP2 recognised the need to adapt freight rolling stock and infrastructure to operate at high speed. For rolling stock this included; adaptation of curtain siders to high speed, brake capacity of the wagon, achievement of automatic coupling. While infrastructure adaptations included; implementation of new technologies, solution to the current lack of standardisation and axle load. Alongside this, a lack of targeted infrastructure investment was highlighted by a number of respondents as one of the barriers to attaining a high-speed freight network.

Important conclusions from the industry survey analysis indicated;

- 120km/h as an achievable high-speed for freight services across the network by 2030
- It is notable that only 4.5% of participants were 80-100% confident that this would be achieved

Terminals play a vital role to ensure the connection between different modes within a multimodal TEN-T core network. WP23 explored case studies of various terminal typologies each located along TEN-T multimodal corridors and proposed innovations to increase terminal efficiency. Innovations for Rail-Road and Rail-Sea Terminals included;

- Handling typologies
- Handling equipment
- Handling layout
- Terminal Access- ICT technologies
- Internal Moving Vehicles- Locomotive
- Technological Systems: Control and Security
- Terminal Working Hour
- Conceptual Train Side Layout
- Conceptual Horizontal Handling

While for rail-rail terminals/marshalling yards, the following innovative operational measures and innovative technologies were put forward;

- Rolling Stock Equipment
- Marshalling Yard layout- track operative length
- Terminal Access ICT technologies: Vehicle identification and transport documentation exchange.

Feedback from industry concluded that the innovations for rail-road and rail-sea terminals most urgently required are;

- Automatic ITU and Vehicle control and data exchange
- Longer Trains
- 24 hour working time

For Rail-Rail Terminals;

- Automatic coupling and decoupling
- Automated vehicle identification
- Longer operative track length

Finally the option of automated terminals for liner services with horizontal transfer of containers has been explored including potential benefits such as;

- Cost reduction of terminal handling per unit by approximately 60%;
- Break-even point for intermodal will be reduced from 500 km to 300 km;
- Energy consumption for terminal handling will be reduced by 93% CO2 emissions in kg per unit will be reduced by 99% with electric propulsion

Increased automation across all terminal typologies is of high importance to industry for the rail terminal design of 2030/2050.

EU regulation stipulates that TEN-T network development will follow a dual layer approach, alongside the core network, a comprehensive network with equal enhancement of non-core infrastructure across Eastern and Western Europe will be developed.

To achieve this, interconnections and interoperability between transport networks, transport modes and different countries are required. For rail, interoperability can be enhanced through;

- Improving compatibility between multimodal transport systems
- Standardisation of rail gauge
- Standardisation of traffic management systems
- Standardisation of legislation and track access charges

It can be concluded that the main benefits of a comprehensive network for the freight industry would be the potential to increase market demand, economic benefits such as cost reduction and increase in efficiency and reliability.

Looking towards 2030/2050 barriers to a comprehensive network still to be addressed were classified by industry as;

- Economic- Infrastructure and track access costs
- Political- prioritisation of freight services
- Infrastructure- Lack or imbalance of investment
- Demand for freight services- lack of certainty of freight services

The development and implementation of new technologies to increase efficiency in multimodal transport was recognised in the White Paper as a challenge for traffic management systems. WP21 explored and reviewed numerous systems for traffic and operational development and operations and planning including the impact of ERTMS on freight capacity.

It was concluded that;

- A better signalling system, shorter block lengths and in the long term introduction of ERTMS level 3 as one of the most important needs for operational development 2030/2050.
- The main barriers to developing information and communication technologies and services are; a lack of training, the conservative attitude of incumbents and low profitability in the sector. To address this, these gaps must be addressed to achieve modal shift.
- Real-time monitoring systems including both on board and wayside mounted systems should be considered vital for rail freight services 2030/2050.

Notable findings from industry regarding ERTMS implementation include;

- 36% of participants were 40-60% confidents that ERTMS level 2 will be deployed EU wide by 2030

- Notably, only 2% of respondents were 80-100% confident of the achievement of EU wide deployment

For deployment of ERTMS, level 3

- No participants were 80-100% confident of EU wide deployment of ERTMS level 3 by 2030
- 44% of respondents communicated a 0-20% confidence level

To increase efficiency along multimodal transport chains, the EC are targeting new technologies for multimodal transport information (MTI) and a framework for a MTI management and payment system by 2020. Within WP21 a review of several systems for freight train monitoring and real time information management was carried out and an example of a Freight Transport Monitoring system developed and implemented during the EC funded D2D project (2002-2005) was presented. The FTMS has the functions of; organise and initiate transport, monitor and control operations, visualise the transport status and exchange product and transport documentation. Looking towards 2030/2050 it was concluded that;

- For rail to compete with road it has to take advantage of the IT and MTI possibilities to ensure it has an efficient means of transport control
- Rail continues to develop as a new intermodal transport mode consequently the development of MTI technologies are of high importance.

Important findings from industry regarding multimodal transport information systems;

- 81% of respondents were not aware of any online brokerage systems
- 35% of participants would not be permitted to share any information in a database of an online brokerage system which could be implemented to book free or remaining capacity on rail services.

10.2 Final Remarks

Task 24.3 has combined input from WP21, WP22, WP23 and WP24 together with the results from an extensive industry survey to produce a unique and thought provoking set of results for each aspect of the rail freight system of the future in particular;

- Future wagon designs to encourage modal shift and industry input regarding the wagon innovations required most urgently.
- Technological and operational innovations for various terminal typologies and industry viewpoint on the terminal innovations required most urgently.
- A review of traffic management systems and MTI including ERTMS deployment and innovations to streamline the flow of information within terminals.

This research will offer valuable input into future activities, both inside and outside of the Capacity4Rail project. Within the project namely this deliverable will feed into;

- WP24- Standards
- WP24- Synthesis
- SP5- WP56- Guidelines and follow up actions.

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