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Foreword

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LIST OF ACRONYMS

DC	Distribution centre
EC	European Commission
ERTMS	European Rail Traffic Management System
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HSR	High-Speed Rail
HV	High Value
ICT	Information and communication technology
ILU	Intermodal loading unit
IM	Infrastructure manager
IT	Information technology
ITS	Intelligent Transport Systems
LD	Low Density
LDHV	Low Density High Value
NSTR	Nomenclature uniforme des marchandises pour les Statistiques de Transport, Revisée (i.e. Standard Goods Nomenclature for Transport Statistics)
P&G	Procter & Gamble
RNE	RailNetEurope
RU	Railway Undertaking
TEN-T	Trans-European Transport Networks

EXECUTIVE SUMMARY

Introduction and methodology

Modern manufacturing processes and supply chains require efficient and reliable delivery of goods. This yields opportunities for the rail freight sector to grow, partly due to increasing road congestions, but mainly due to the need for reliable, cost competitive, reliable and environmental friendly transportation of goods.

The project, SPECTRUM, aims at developing a rail freight offering that provides higher speed services for time sensitive, high value and low density goods (time sensitive LDHV-goods) with the performance characteristics resembling those of a passenger train. SPECTRUM takes a longer term, radical and first principles approach to the delivery of a new rail freight product and service offering, which can compete with road- and air freight transport in the growing logistics sectors where rail freight traditionally has little to offer.

The objective of Work Package 1 (WP1), logistics and market research, is to define the market opportunities for the time sensitive LDHV-goods to be transported by using innovative rail concepts. The focus on both the extension of rail services already existing in the early 21st Century and on the design of more visionary rail logistics services. This work package sets the framework for the new concepts to be elaborated and designed further in the next work packages. To enable this, broad technological and operational requirements for the new rail freight concepts are defined. The work is structured into the following four tasks.

- Global trend analysis and transport demand analysis (using top-down approach);
- Market intelligence interviews and case studies (using bottom-up approach);
- Synthesis of market opportunities into logistics concepts and business-economic models;
- Technological and operational requirements drawn from potential SPECTRUM freight rail concepts.

Global trends analysis

The logistics and market analysis in WP1 sets the first crucial step that determines which part of the future freight and logistics market can be served by the innovative rail freight offerings. It starts with an elaboration on global trends affecting the rail freight market and a general transport demand analysis. These analyses are the basis for:

(1) Estimating the market potential for rail freight logistics offerings;

(2) Input for the conceptual design both from a logistical and business model perspective and

(3) Their operational and technological requirements.

Definition of time sensitive LDHV goods

An assessment is made of the types of cargo that can be addressed by the SPECTRUM rail freight concept. The indicators used are volumetric weight (kg/m3), weight value (Euro/kg) and whether or not the goods are time sensitive for example including perishable products. The data used are based on trade data, transport statistics and studies on freight characteristics. The following set of criteria has been used to define time sensitive, low density, high value goods (time sensitive LDHV goods):

- Goods with a density including packaging (i.e. gross-weight) below 250 kg/m3 are considered as time sensitive LDHV-goods in this study, except live animals, transport equipment, tractors and explosives.
- Goods with a density between 250 and 300 kg/m3 and with a value of €0.50 per kg or higher (i.e. trade value, excluding taxes and not the retail value) are considered as time sensitive LDHV-goods in this study.
- Perishable goods with a density above 300 kg/m3 and a value below €0.50/kg are also considered as time sensitive LDHV-goods in this study. Examples of this category are dairy products, horticulture products, fresh and frozen fruits/vegetables and meat.

Market intelligence

The market intelligence focuses on the potential transport demand from a bottom-up approach. This gives more detailed information on the types of the time sensitive LDHV goods that can be transported by rail, as well as the transport requirements from the perspectives of the key market players. The market intelligence has been derived from:

- Survey and interview results obtained from previous and currently running European research projects and publications;
- Interviews with potential users of the SPECTRUM rail freight concept (i.e. shippers and transport operators).

Based on the market intelligence reviews and interviews, it can be concluded that there is enough volume potential for launching new rail services for the time sensitive LDHV goods in Europe as long as requirements of the shippers are fully addressed met on a sustained basis. The most important logistic requirements concern reliability, transit time and costs of the transport services.

Case studies

A total of four case studies have been carried out with active participation of the SPECTRUM input partners:

- Procter & Gamble (P&G): Transport of various low-density, high-value goods over distance and into urban conurbations.
- FloraHolland: Transport of temperature controlled flowers and plants, representing 60% of the EU horticultural market.
- EURO CAREX: Airfreight within a network of airports.
- Innovatrain: Transport of consumer goods and parcels using rail in innovative and competitive services.

Business-oriented projects like RETRACK and CREAM have proven that a successfully developed business cases requires details to be worked out at the lowest level, including financial arrangements between partners engaged in the transport logistics chain. Therefore, in addition to the macro business modelling approach, which is applied in the global trend analysis and transport demand analysis aforementioned, a micro business modelling approach is employed on each of the four case studies in order to get to the level a feasible business model requires.

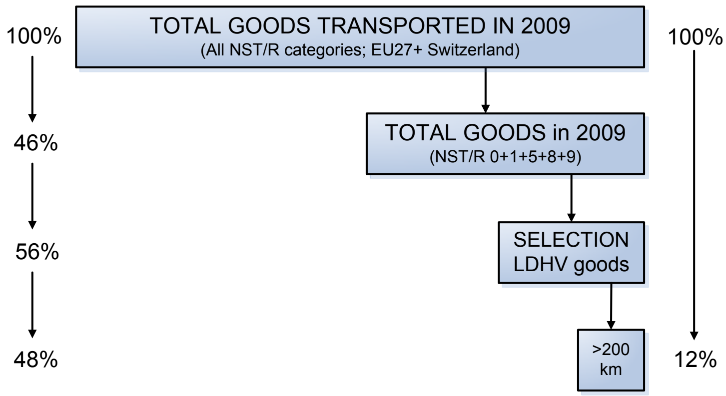
Logistics requirements and SPECTRUM's role in improving logistics concepts

The new technologies and service concepts which are developed in SPECTRUM must improve rail transport services in ways that allow rail entering the market segments in which it could not compete with road transport using orthodox technology or business systems, or in which it already has a share but can improve its competitive position in the market. Here, the potential contribution of the SPECTRUM innovative offering to the freight market is explored. Besides, many quality parameters in the logistic requirements are often correlated. The first step in synthesising market opportunities of the SPECTRUM offering has been to create a common understanding of the logistic requirements. This piece of analysis investigates these quality parameters that are referred to in the SPECTRUM project plan.

Transport demand analysis

The transport demand analysis aims at estimating the potential demand for time sensitive LDHV goods in Europe (i.e. EU-27 and Switzerland). The analysis has been done using freight transport statistics and existing macro models. It focuses particularly on road transport, since this is the sector where transportation of most of the time sensitive LDHV goods takes place currently, and where shifts to rail transport be could be made possible in the future. The chosen time horizon for the transport demand forecast is 10-20 years: 2020 for the medium-term forecasts and 2030 for the long-term forecasts.

The figure below indicates the potential market for the time sensitive LDHV goods that are currently being transported by road over distances of 200 km or greater and that have the potential to be shifted to rail transport. As can be seen, the potential time sensitive LDHV market in EU-27 and Switzerland is about 12% of total freight in 2009. This is almost 1.9 billion tonnes in terms of originating cargo. The transport demand analysis provides a general view of the potential market segments that are eligible for the SPECTRUM rail freight concept.



A selection has been made of the volumes of the LDHV commodities being transported in the EU by road, which is about 12% of all freight flows transported by road. In WP 4, Synthesis and Evaluation, the actual potential will be determined out of this 12% freight flows, taking into account the market conditions.

In various stages of the study corridors have been identified to either to geographically pinpoint market prospects for SPECTRUM concepts, or to make detailed analyses. The final group of corridors aims to identify the most promising areas to develop business cases for SPECTRUM solutions, which will be carried out in WP2. The corridors should however not been considered as final project recommendations nor should the project focus on the total corridor length, but rather look at service areas within or around the corridors.

In order to identify interesting corridors to be incorporated in the case studies, the top 50 largest flows of the LDHV commodities are identified and grouped in different categories taking into account several factors such as the difference between domestic and international flows, various distance bands and whether the transport flow is port related or not.

The following corridors are selected as the interesting corridors to SPECTRUM:

- Ferry connections in Scandinavia
- Transalpine corridors in relation with Lombardia, Italy
- Corridor between Central Romania and Lombardia, Italy
- Corridors between Spain and France
- Corridors between Spain and Portugal
- Corridor between Northwest France and Northwest Germany

In addition, a specific case for extra EU flows has been analysed in relation with Turkey. Large flows are being transported by road between North-Western EU and Turkey, which could be bundled onto a SPECTRUM rail service to a hub in for instance Budapest.

Transport service linking intermodal terminals and urban area:

The option of linking intermodal terminals with urban areas by a SPECTRUM rail offering is analysed. After assessing the intermodal terminal network, its accessibility and density, implications for the Spectrum service are drawn.

The catchment areas served by intermodal rail terminals should cover a country as much as possible. An optimal balance should be found between minimising the number of terminals and the number of kilometres driven by road, and maximising the number of customers to be served. The choice of using an intermodal rail terminal or not will depend on different factors, one of them being the total transport time and costs compared to road only transport. For example, if total transport distance is long while the distribution centre or production plant is located near an intermodal rail terminal (i.e. within the 50 km range), rail based transportation connecting this intermodal rail terminal is preferred. However, if the total transport distance is relatively short, road transportation might be more attractive in terms of time and costs, since rail would involve more transit time, handling time and higher direct costs together with inventory implications. The total door-to-door transport distance, costs, reliability and time are thus relevant factors to take into account. On some areas it might not be possible, feasible or desirable to have rail terminals due to geographical limitations (e.g. mountains).

The SPECTRUM rail offering in and around urban areas must:

- Be able to operate and run optimally in parallel with passenger trains (having comparable acceleration, speed and braking features) and use available passenger quality train paths;
- Have a rail network that connects well with the intermodal rail terminals or in close proximity to low cost terminals and facilities;
- Have the ability to load and unload within urban areas at low cost and with very short final road delivery journeys;
- Have small trains that run frequently and with unfailing reliability;
- Reduce costs, improve productivity and be capable of providing additional services such as high speed delivery.

The operational and technical requirements for a SPECTRUM train

The requirements for a Spectrum train have been studied in detail. In summary, the requirements are identified, addressing the following interrelated aspects:

<u>Border-crossings</u>: The concrete requirements for a SPECTRUM rail offering depend on the actual use of the train. To avoid information problems, the SPECTRUM train operation should be suitable for a cargo waybill

with electronic data exchange, and should be provided with a positioning system. This positioning system should allow real-time information exchange between the engaged stakeholders such as the shippers, receivers and railway undertakings and the infrastructure managers concerning the actual position of the train.

The technical problems occur mainly due to the diverging characteristics of the railway infrastructures in the countries concerned. A SPECTRUM train operation should therefore be easily capable of operation in the different railway infrastructures in the countries served.

Interoperability: Regarding the aspect of interoperability, the actual requirements for a SPECTRUM rail offering would depend on the countries to be served and the types of goods to be transported (and therefore the types of wagon/rail vehicle to be used). The more countries served, the higher costs will be placed for the adaptations on trains in order to ensure complete interoperability between the countries. Therefore, it does not seem viable to develop a rail service suitable for all systems in the continent. The SPECTRUM train operation should be in its general design adaptable to most EU countries (at least those ones with the standard gauge). The specific adaption should be made only for the countries to be served in operation. The need therefore is for a certain form of modular design concept of the vehicles and its support systems.

Other operational features: The operational features of a SPECTRUM rail offering should fulfil at least the following requirements:

- Maximum service speed of at least 140 km/h.
- Locomotive/traction power of more than 5 MW (for a train with weight being about 1000 tons).
- Acceleration of about 0.5 m/s2 with equivalent high performance braking including regenerative and disc brakes.

It should be noted that these requirements have been formulated based on basic time-tabling exercises. More detailed assessments will be done in the concept development in WP2.

Rolling stocks: The rolling stock needs to fulfil the logistical and operational requirements stated above. In particular, the running gear with axles, bogies, braking system, and the traction system need to be adapted to achieve the level of operational and commercial performance required. In addition, the rolling stock needs to be in accordance with the TSI (Technical Specifications of interoperability). Because of the many necessary changes this suggests a long period of approval process.

Rail terminals: The most important requirement for rail terminals is the fast access to the terminals with short transhipment time in order to guarantee that the time gained through faster operation on the tracks is not lost again during terminal handlings. Therefore, several options for optimisation of terminals can be considered, including access with train momentum, horizontal transhipment or hybrid-power locomotives.

Operational regulations: In regulations concerning rail traffic management, freight trains often get low priority because they are slower and have lower acceleration and deceleration performance than most passenger trains. The operation of a SPECTRUM rail service is expected to possess at least some characteristics of a passenger train. Therefore, many traffic management regulations need to be adapted in the near future, in a way that trains are no longer prioritised by train type (i.e. passenger trains or freight trains), but rather they are prioritised by the characteristics of the train operations such as maximum speed, acceleration and braking performances.

SPECTRUM's competitive position – cost assessment by the business-economic model

For the SPECTRUM offering to obtain a credible and accepted position in the transport market, the innovation will need to improve quality parameters (e.g. reliability, safety, flexibility) and/or reduce costs. SPECTRUM's business economic model focuses on costs. It compares operational costs of the SPECTRUM services with its alternatives that use existing technologies. These alternatives are either uni-modal road transport, intermodal transport or conventional rail transport. This is a preliminary assessment of the commercial viability of the SPECTRUM services and it serves to identify market segments, to which the introduction of SPECTRUM can produce promising benefits.

Potential Impact

The contribution of the SPECTRUM rail offering will depend on the characteristics of the markets. It will have to meet the diverse logistics requirements of the shippers involved..The focus will be paid primarily on reliability, punctuality, transit time, costs, conditioning measures, service availability and service flexibility. This will be assessed in WP4 in the macro business model (see D1.3.1, a separate document).

The expected impacts of the SPECTRUM rail offering should be well demonstrated. This will justify the potential extra investments and higher operational costs derived from the new technologies and logistics concept employed in the service offering.

Benefits will be most evident if the SPECTRUM service is introduced for an operation dedicated to one client and using rail sidings/terminal equipment on his premises, or if the service is applied on supply chains with high freight demand over distance (e.g. the automotive industry).

The benefits will be less evident when impact is measured on a supply chain on a global scale. Last but not least, it is the challenge of the transport and logistics service providers to incorporate the SPECTRUM offering in their service portfolio in a way that benefits to their clients can be maximised while additional costs can be minimised.

It is expected that the freight flows will generally grow at an above average rate in the coming decades. Specifically, the potential is about 1.9 billion tons, which is 12% of the freight flows. Under a less ambitious target where road freight flows are studied at a distance of over 300 kilometres (as referred to in the DG MOVE White Paper), the market potential is about 1.4 billion tons, which is 9% of the total road freight flows.

Conclusion

We conclude that the SPECTRUM concept has a huge demand to satisfy, and this demand is in alignment with the broad concept of a freight train that performs similarly to a passenger train offering faster, more reliable and flexible railfreight services.

Introduction and methodology

1.1 Background

Modern manufacturing techniques and logistics require reliable, time sensitive delivery of time-sensitive lower density and higher value goods. This presents a market opportunity for rail freight to grow, partly due to increasing congestion on roads, and mainly due to the need for the reliable and environmentally friendly transport of goods. At the same time, to meet customer requirements, rail freight has to rise to the challenge of providing a reliable and available service as well as complying with other market demands. Depending on the market segment these may be faster transport time, specialised handling systems, tracking and tracing, greater flexibility, lower prices or premium services. Furthermore, in congested situations rail freight may have a competitive advantage compared to other modes of traffic.

One of the EC objectives presented in the 2011 White Paper is to shift 30% of current road freight transported over 300 km to other modes such as rail or waterborne transport by 2030 and more than 50% by 2050. In order to achieve this and to make rail competitive to road transport, an improved railway system for different markets is required.

SPECTRUM aims to develop a rail freight train/system that provides a higher speed service for high value, low density and time sensitive goods with the performance characteristics of a passenger train. SPECTRUM takes a longer term, radical and first principles approach to deliver a new rail freight offering that can compete with road and air in the growing sectors of logistics where rail freight has traditionally little to offer.

The SPECTRUM team is working towards a freight train that:

- Behaves like a passenger train in terms of installed power, speed, acceleration, braking, momentum: allowing full scheduling on inter-urban and suburban train networks.
- Has a standardised and universal power supply system for the delivery of power to temperature controlled containers (reefers) in a controllable fashion.
- Is able to operate over a wide range of national domestic and international lines and routes without constraint.
- Is of a modular design that can address inter-modal and logistics (palletised goods) markets.

1.2 Examples of existing and past initiatives

The idea of developing higher speed rail services for freight transport in Europe and technologies that could make these a reality (such as different wagon sets or transhipment technologies) have been put forward before. For example, Hanenburg, et al (1997) has carried out a research regarding the transportation of goods via Schiphol, the Netherlands by using High Speed trains (HST) from NS Cargo, which was the Dutch railway undertaking at that time. The study looked at the market potential for such HST service, costs for service operation, as well as the degree of cooperation between the stakeholders along the chain. Other studies that address the topic of high speed (rail) transport are, among others, Geskus (1995a), (1995b), (1995c), Gouin (1996), Mulders (1997), Riet (1996), Zijp (1995). Several examples are presented in this report. The SPECTRUM project does not aim to provide a bibliographic overview of past ideas, technologies or solutions, nor an assessment of their real-life performance or future prospects. The project rather focuses on the development of a limited number of solutions that, when bundled into one or more SPECTRUM solutions, respond to the specific needs of the identified cargo currently transported by road that could potentially be attracted. The research team uses knowledge about previous ideas in the development and assessment of the SPECTRUM concepts.

1.3 Objective

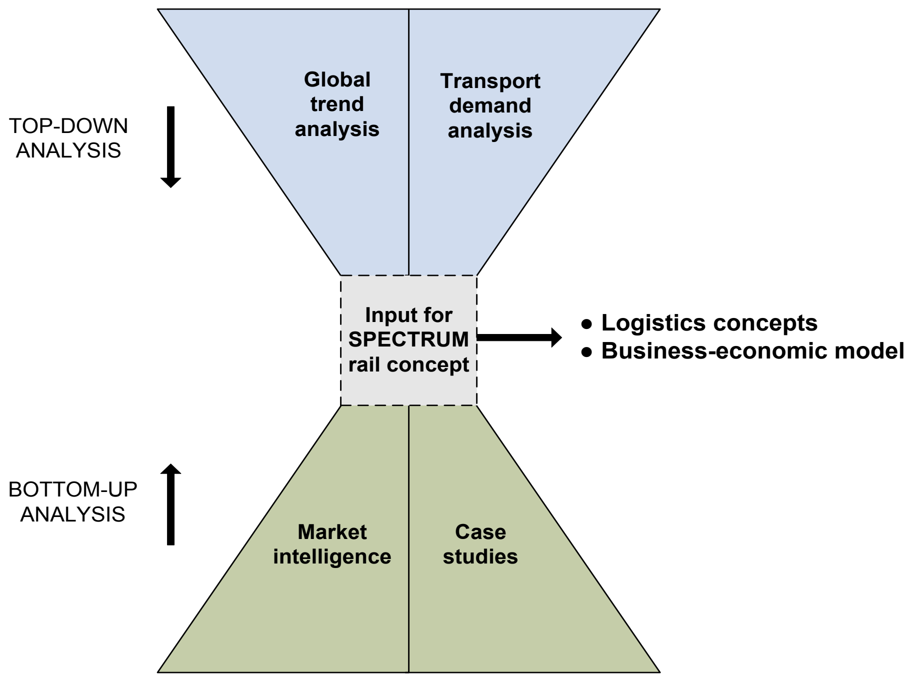
The objective of WP1 Logistics and market research is to define the market opportunities for time-sensitive, low-density, high-value (time sensitive LDHV) goods transport to be served by new, innovative rail concepts. There has been a focus both on extension of the rail services that are already in place in the early 21st Century and for more visionary/"blue sky" rail logistics services. This work package has thus to set the framework for the detailing of the concept in the next work packages. To enable this, the technological and operational requirements for the new concept(s) have been defined.

1.4 METHODOLOGY

The logistics and market research is the crucial first step that determines which part of the future freight and logistics market can be served by innovative rail freight offerings. The work in structured in four tasks (see Figure 1.1):

- Top-down: Global trend analysis and transport demand analysis;
- Bottom-up: Market intelligence interviews and case studies;
- Synthesis of market opportunities into logistics concepts and business-economic models;
- Technological and operational requirements drawn from potential SPECTRUM freight rail concepts.

Figure 0.1: Synthesis of top-down and bottom-up analyses



The new rail freight concept has been subjected to different technological, operational and organisational requirements than conventional rail offers. The analysis on those aspects constitutes an elaboration for the selected segments of crucial logistics requirements such as:

- Logistics Intelligence & Communication
- Safety & Security
- Service availability, & Reliability
- Frequency, Transit time, Speed
- Pricing Strategies & Logistics costs

After the analysis all facts of the logistics and distribution systems that shippers or goods owners organize for different goods types were summarized and presented in a way that they can be adopted in the next steps of the project.

The results of the analysis were used to define the requirements and sort them according to geographical transport relations and the respective market segments to give an overview on the existing structures and to provide a sound basis for the upcoming development of concepts. The analysis of the technological and operational requirements focused on and provided answers to the following questions:

- What are the operational and technical requirements of the new logistics concepts, in order to fit the new concepts into the existing rail operations and infrastructure?
- What feasible adaptations are necessary for the existing rail operations and infrastructure in order to more comfortably and easy fit the new logistics concepts into the existing rail system?

- How does the industry distinguish and prioritise between high frequency and high volume/low cost commodities?
- What are the implications taking into account a reference corridor (corridor analysis) on which refrigerated cargo is transported or which originates or has its destination in an urban area? Do logistics networks in and between urban conurbations follow a corridor structure at all?
- What is the ideal structure of an intermodal terminal network in terms of accessibility and density?

1.5 Definition of Time-sensitive, Low-density, high-value goods

First off time-sensitive and/or low-density, high-value goods have been defined. This analysis has been based on Eurostat Intra- and Extra EU trade data and results from the EC ETISplus project. The indicators used are weight density (kg/m3) in terms of packaged goods as they are transported. The value of the goods is expressed in trade value excluding taxes (Euro/kg).

The following set unit of criteria have been followed in the mentioned order:

- Goods with a density including packaging (i.e. gross-weight) below 250 kg/m3 are considered time sensitive LDHV-goods in this study, except live animals, transport equipment, tractors and explosives.
- Goods with a density between 250 and 300 kg/m3 and with a value of €0.50 per kg or higher (i.e. trade value, excluding taxes and not the retail value) are considered time sensitive LDHV-goods in this study.
- Perishable goods with a density above 300 kg/m3 and a value below €0.50/kg) are also considered time sensitive LDHV-goods in this study. Examples of this category are dairy products, horticulture products, fresh and frozen fruits/vegetables and meat.

Table 1.1 presents examples of products within a weight density range. It should be noted that these values should not be considered as definite figures as they correspond to specific data sets and are highly dependent on the definitions of the indicators and changes in the way products are transported. The data used are based on trade data, transport statistics and studies on freight characteristics:

- Volumetric data: Knight et al., 2010. Assessing the likely effects of potential changes to European heavy vehicle weights and dimensions regulations, Interim Report.
- Volumetric value: EUROSTAT Statistical Books, 2010. Intra- and extra-EU trade data.
- Knight et al., 2010. Assessing the likely effects of potential changes to European heavy vehicle weights and dimensions regulations, Interim Report.
- Rodrigue, J.P., 2010. Maritime Transportation: Drivers for the shipping and port industries, International Transport Forum 2010, OECD.

Table 0.1: Densities of different products

Density* (in kg/m3)	Type of products (examples)
>350	Cement, sand, gravel, ore, coal, basic chemicals, metal products, rice, coffee, frozen meat, etc.
250-350	Oil products (e.g. olive oil), wood pulp, frozen fish, specific fresh or frozen type of fruits, nuts and vegetables
200-250	Electrical and non-electric machinery and appliances, leather products, specific manufactured metal products, plastic material, spices, textile products (e.g. blankets) and unmanufactured tobacco.
150-200	Beer, wine, non-alcoholic beverages, manufactured tobacco, other non-edible raw vegetable and animal materials (e.g. seeds and flowers).
<150	Other manufactured articles (from jewellery to video games), textile products (e.g. hats, bags and tents), footwear, furniture, other manufactured articles (from umbrellas to artificial flowers), clothing.
* Including packaging	

Source: based on the Eurostat Intra- and Extra EU trade data and the EC ETISplus study

Table 1.2 presents the type of goods selected for this study as time sensitive LDHV goods, taking into account the criteria presented above. These are goods that (1) can be transported in small units; (2) are close to the end consumer in supply chain terms (i.e. finished and almost finished goods); (3) are non-bulky products and are sometimes time-sensitive. In other words: **consumables, parcels and (time-critical) palletised cargo**.

Table 0.2: time sensitive LDHV and perishable goods selected

	NSTR 3 (description)	Average density (kg/M3)	Average value (€/kg)	Perishable goods
Perishables	Butter, cheese, other dairy produce	436	€ 2.40	√
	Milk and cream, fresh	436	€ 0.49	√
	Fruit, frozen, dried, dehydrated; prepared and preserved fruit	401	€ 1.08	√
	Coffee	385	€ 2.61	√
	Meat: fresh, chilled or frozen	385	€ 2.48	√
	Meat: dried, salted, smoked; prepared or preserved	379	€ 2.93	√
	Food preparations n.e.s.	375	€ 1.62	√
	Margarine, lard and edible fats	342	€ 0.88	√
Density >230 and <300 kg/m3 & value ≥ €0.50	Other alcoholic beverages	289	€ 3.80	
	Finished and semi-finished products of non-ferrous metals (except manufactures)	282	€ 3.70	
	Copper and copper alloys (unwrought)	282	€ 5.53	
	Zinc and zinc alloys (unwrought)	282	€ 1.68	
	Lead and lead alloys (unwrought)	282	€ 1.79	
	Aluminium and aluminium alloys (unwrought)	282	€ 1.75	
	Printed matter	282	€ 3.25	
	Cocoa and chocolate	282	€ 2.99	
	Prepared and preserved vegetables	280	€ 0.93	√
	Other non-ferrous metals and alloys thereof (unwrought)	280	€ 20.97	

	Wood and cork manufactures, excluding furniture	271	€ 0.56	
	Tubes, pipes and fittings	258	€ 1.41	
	Other fruit and nuts, fresh	258	€ 1.04	√
	Fish, crustaceans and mollusc, (fresh, frozen, dried, salted or smoked)	257	€ 3.42	√
	Other manufactured goods not classified according to kind	257	€ 2.76	
	Paper and paperboard, unworked	256	€ 0.67	
	Crustaceans and mollusc, fish, prepared or preserved	256	€ 3.69	√
	Dried vegetables	256	€ 0.58	
	Hops	256	€ 3.63	
	Citrus fruit	256	€ 0.73	√
	Other vegetables, frozen	256	€ 1.01	√
	Paper and paperboard manufactures	256	€ 1.42	
	Medicinal and pharmaceutical products; perfumery and cleasing preparations	252	€ 14.41	
	Plastic materials, unworked	245	€ 1.65	
	Tea, mat, spices	231	€ 2.93	
	Iron and steel castings and forgings	231	€ 2.55	
	Unmanufactured tobacco and tobacco refuse	231	€ 3.63	
Density ≤230 kg/m3	Non-electrical machinery, apparatus and appliances, engines, parts thereof	223	€ 10.78	
	Textile yarn, fabrics, made-up articles and related products	214	€ 4.23	
	Other cereal preparations	212	€ 1.66	
	Eggs	205	€ 1.42	√
	Leather, manufactures of leather and raw hide and skins	205	€ 8.17	
	Man-made fibres	190	€ 1.72	
	Manufactured tobacco	180	€ 16.90	
	Beer made from malt	180	€ 0.64	
	Non-alcoholic beverages	180	€ 0.15	
	Wine of fresh grapes, grape must	180	€ 2.00	
	Electrical machinery, apparatus and appliances, engines, parts thereof	178	€ 15.94	
	Glassware, pottery and other manufactures of minerals	175	€ 1.94	
	Semi-finished products and manufactured articles of rubber	171	€ 4.01	
	Other non-edible raw vegetable and animal materials n.e.s.	161	€ 2.15	√
	Finished structural parts and structures	151	€ 2.11	
	Other manufactured articles n.e.s.	131	€ 9.61	
	Travel goods, clothing, knitted and crocheted goods, footwear	109	€ 14.98	
	Furniture, new	103	€ 3.10	
Density: Including packaging Value: trade value, excluding taxes				

Source: based on the Eurostat Intra- and Extra EU trade data and the ETIS study

2 Global trend analysis

2.1 Introduction

The logistics and market analysis started with an elaboration on global trends affecting the rail freight market and a general transport demand analysis. These analyses are the basis for:

(1) Estimating the market potential for rail freight logistics offerings.

(2) Input for the conceptual design both from a logistical and business model perspective.

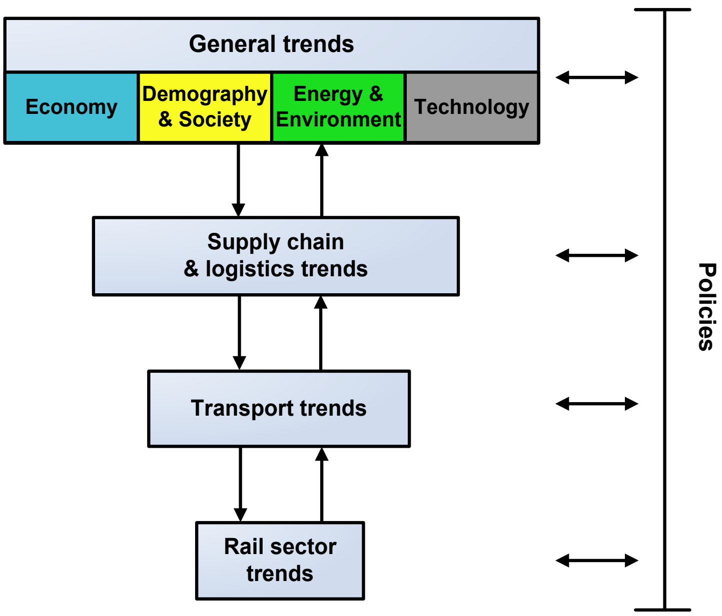
(3) Their operational and technological requirements.

Global trends like the sector-wide embracement of intelligent communication technologies, innovative logistical structures, strong economic development in emerging markets in Central and Eastern Europe, shifting perceptions and decision making in modal choices and possibly reverse off-shoring of production will provide new opportunities for rail services.

The trends observed can be classified in 4 main categories (see Figure 2.1):

- General trends, divided in four categories:
  - Economy;
  - Demography & Society;
  - Energy & Environment;
  - Technological development.
- Supply chain and logistic trends;
- General Transport trends;
- Rail sector specific trends.

Figure 2.1: Global trends



The trends are presented in a hierarchal division. This represents the interrelationships between general trends and sector specific trends and between the different levels of sector specific trends. Based on the trends at the different levels and the goals and objectives of the public and private sector stakeholders, policies may be implemented (e.g. road pricing). These policies could, consequently, also have an impact on the trends at the different hierarchal levels.

The trends have been analysed in light of the main transport drivers for the sectors that have been identified in a variety of policy and strategy documents such as the European Commission's 2009 publication "The Future of Transport" and the 2011 White Paper "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system".

The impacts of the trends on the market potential of the SPECTRUM rail freight concept have been analysed in the following terms:

- Freight flows:
    - Changes in existing flows;
    - Areas or goods types that may be expected to grow, stagnate or diminish;
    - New freight flows that may be expected.
- Freight characteristics:
    - Changes of the value content of the goods;
    - Potential markets and growth conditions for different freight types, in particular LDHV goods.

2.2 GENERAL TRENDS

2.2.1 Economic trends

The following economic trends have been identified as being relevant for the SPECTRUM rail freight concept.

Economic growth

Despite the crisis that started in 2008, the European Union's economy continues to grow albeit at a slower rate and it is probable that this will be the case in the longer run. Despite a number of years that show a decline in GDP, the net effect measured over a number of years, is positive. As a general trend it is expected that in case of economic growth also the value (and volume) of the goods to be transported will increase. Two reasons may lie at the root of this: (1) a general price increase due to economic growth and growing demand for goods and (2) a tendency towards a higher proportion in the purchase of high value or even luxury goods due to increased wealth per capita. The higher demand for goods in general will have an impact on the total value chain and transport sector, while the LDHV segment will profit from the demand for goods with a higher value.

Globalisation of trade

Trade has become highly globalised. Despite temporary downturns such as the economic crisis that started in 2008, EU external trade and transport are expected to continue growing. Growing international trade will cause an increase in transport demand. Shifting trade patterns could however lead to a decline in trade flows to and from Europe but this is very unlikely given the scale of the European market.

2.2.2 Demographic & social trends

The following demographic & social trends have been identified as being relevant for the SPECTRUM rail freight concept.

Population growth and demographic changes

The world population is expected to exceed 9 billion by 2050. This is a significant increase from 7.0 billion people in early 2012. This will have a strong impact on world consumption and freight transport. An extra increase in the demand for LDHV goods is expected when prosperity levels (GDP per head / purchasing power) increase.

Demographic changes in Europe might lead to shortages on the labour market and rises in transport costs unless these threats are mitigated by higher productivity in both equipment and personnel and wholly new approaches to commercial rail freight operations are introduced.

Urbanisation

The European population is becoming increasingly urbanized. This suggests that mobility in and to urban areas will increase, leading to higher congestion levels, fuel consumption and emissions of pollutants. The options to connect long-distance rail freight lines and services with urban or regional distribution networks are expected to regain attention.

Individualisation

Developed economies are faced with individualisation due to increased prosperity and a higher educational level. The specifications of products are becoming more and more tailored to specific consumer demands. As these products better match the needs of customers, the value will be higher, which will lead to a stronger importance of LDHV goods.

Changing work patterns

Demand for flexible working patterns by both workers and employers is set to gather pace in the coming years and will play a greater role in the employment relationship. It is thought part-time working will continue to grow as well as the ability to work from home, which is has been facilitated by developments in IT.

This will invariably have an influence on the passenger transport flows and patterns. One possible development is that peak times in passenger transport will be more spread (peak spreading/shoulder peaks) out over the day and the week, thus relieving the transport system and presenting new opportunities for freight services to be operated.

2.2.3 Energy & environmental trends:

The following energy & environmental trends have been identified as being relevant for the SPECTRUM rail freight concept.

Energy availability and alternative energy sources

Rising energy consumption and declining availability of fossil fuels leads to higher energy prices. As the transport sector accounts for 67% of the final demand for oil, transport prices are likely to increase. Further introduction of new (alternative) fuel types and energy sources (e.g. bio fuels and electric propulsion for vehicles) are expected in the future. The impact of alternative fuels on the rail freight market is expected to be limited. However, rail can exploit its green credentials by the use of electric traction with inputs from a wide variety of fuel (gas/coal/oil/nuclear) and primary energy sources (hydro, wind, tidal). This is a major advantage that rail has over all other modes and needs to be exploited.

Pressure to reduce carbon emissions, waste and resources

The growth of world population is expected to have a tremendous impact on global resources, putting more pressure on the need for a more sustainable transport system. Studies have shown that rail freight transport is considered and promoted as being a cleaner mode than road transport although recent studies such as STREAM International Freight 2011 (CE Delft 2011) reveal that the environmental performance depends heavily on scale, use factors and load factors on the transport assets.

In addition, trucks have become significantly cleaner because of new technology and strict regulations on the environmental performance. Developments like hybrid locomotives and moves away from diesel fuel will also contribute to these developments. In case of demand for greener transport, freight transport by rail has an advantage, although improvements into the environmental performance of rail freight are needed. Important drivers at this moment are congestion and sustainability, both offering chances for innovative rail concepts.

2.2.4 Technological trends

The following technological trends have been identified as being relevant for the SPECTRUM rail freight concept.

Technology driving economic development

Technological developments are drivers for economic development, both in terms of productivity and efficiency increases but also for new business models. These trends have impacts on the types and transport requirements of products and supply chain structures to produce and distribute them. Specific technology trends in the rail sector are described below.

E-commerce

E-commerce is a specific technology driven trend that has significant impact on the transport sector and poses additional challenges to the ambition of the rail sector to gain market share in the LDHV-goods. The opportunity to place a buying order on the web from anywhere at anytime and the expected delivery times and tracking & tracing transparency capabilities are at odds with the current state of play in rail freight transport.

Rail has seriously failed to recognise this and other major structural changes and appears unable or unwilling to move away from an over dependency on large flows of lower value high volume commodities. To re-position itself to become a credible competitor for LDHV traffic and commodity traffic a major structural shift within the industry is needed.

2.3 Supply chain and logistics trends

The following supply chain and logistics trends have been identified as being relevant for the SPECTRUM rail freight concept.

Changes in production systems

European integration and globalisation led to a deflection of economic activity, meaning a shift of some sourcing and production to locations outside the EU. Some important reasons for this shift of sourcing and production locations abroad include:

- Proximity to (potential) clients
- Changed economic climate
- Reduced total costs (mainly labour costs)
- Supply and/or quality of human resources/skill base and labour adaptability
- Supply of raw material or semi-finished products
- Locations of other (similar) production facilities/intra-industry concentrations
- Political incentives (e.g. overt subsidies, free trade zones and national policies to industrialize)
- Less restrictive environmental regulations
- Access to new technologies effectively leapfrogging existing technologies
- Rapid product development cycles and innovation
- The adoption of JIT and advanced manufacturing techniques and technologies
- Access to international shipping/container services at attractive and sustainable freight rates.

Comparative cost advantages play an important part. Given liberalised markets, a similar productivity across the world and commoditised products, countries having a relatively large amount of a certain resource (human resources, energy, raw material etc.) required to make a product, compared to others, are likely to export products predominantly made of these resources to the other countries.

This is a result of the different scarceness of resources, which is reflected by costs (prices). This helps to explain why countries where the population consists of a large number of blue-collar employees are likely to make labour-intensive products (e.g. China). If transport costs are low, and if there are no trade barriers, such comparative cost advantages will determine international trade patterns to a large extent. Nevertheless, the significance of the other factors listed above should not be neglected.

Focusing on the member states of the European Union, some industries have already almost completely moved outside the EU (e.g. manufacturing of shoes, textiles), whereas the location structure of others can be characterised by global production networks with an intense internal exchange of components and semi-finished products (e.g. automotive or chemical industry).

Today, due to a couple of effects (e.g. higher energy prices and labour costs) going hand in hand with globalisation, for some of the goods, the trend might be reversed, so that there would be in-sourcing/in-shoring instead of outsourcing/off-shoring (i.e. reverse sourcing of manufacturing and production activities). This will have an effect on origins/destinations of freight flows, and logistical parameters, respectively. Among other factors In-shoring may include:

- Lower logistical risks/reliability and direct access to logistics service providers
- Shorter delivery times to domestic clients
- Quality issues
- Improved time-to-react (flexibility)
- More chances to establish a quality management across the supply chain
- Improved intra-company communication (language, culture, media)
- Legal certainty

Recently some experts refer to the increased congestion of the European transport infrastructure when considering the reverse sourcing of production activities. In the longer term, road and rail infrastructure may not, using present methods, systems and business models, be able to cope easily with the increase in freight traffic, which is already the case around agglomerations such as London, Paris, the Randstad area in the Netherlands, Rhein-Ruhr, Milano, and along some European transport corridors without radical changes to infrastructure management, capacity allocation and expansion together with massively improved train performance.

The supply and production networks would have to adapt to the capacity of infrastructure or use alternative transport modes. This would mean regional supply and production networks consisting of a larger number of less specialised production facilities, supplied by local suppliers, and serving local customers. The reduced international division of labour could lead to a loss in economic welfare, which would be accepted if there were no feasible alternatives, or if sustainability became the dominant public concern.

Such a scenario would have different effects on the transport economy: there would be more continental, and less intercontinental cargo, which would lead to reduced volumes in air cargo and sea freight. Additionally, this would imply reduced average transport distances, and more regional freight transport. Customers would become used to shorter lead times and lower “commodity kilometres” as a consequence.

If rail freight transport services are to participate in the growth of such segments of the freight transport market, they will have to offer fast and frequent connections that are economically viable on short distances (also when carrying smaller volumes of cargo), and they will have to operate on rail networks with a large number of regional access points. In other words, time accessibility and spatial accessibility of the services should be high.

Recent infrastructure trends demonstrate the reverse of this requirement with the elimination of sidings, terminals, lines and routes and the concentration of functions into fewer larger facilities. The endemic focus on cost cutting and the elimination of lines and sidings over several decades across Europe now effectively bars rail from certain markets without significant infrastructure re-investment and the use of different technical, commercial and operating models to reinstate capacity and capability.

But, the current state of research reveals that, despite the logistical challenges and other negative implications of globalisation, the majority of European companies that chose to shift their production facilities to foreign countries may not choose in-shoring when reconsidering its location structure. The relocation rate has shown one digit rates throughout the last decades.

Most of the relocations have occurred due to mistakes made in the initial location decision process, with managers focussing too much on labour costs. Furthermore, most of the in-shoring in production concerned relocations within Europe, so relocations from Asia are comparatively rare. Many of the industries have become footloose (which does not exclude a temporal relocation).

Shift of Chinese industries to the west

Due to both the increase in labour costs in the coastal areas of China and the aim of capturing the potential market in the hinterland, the production facilities and economic development has been gradually shifting from east China towards west China. For example, Unilever has moved six factories from Shanghai to more than 1000 kilometre west to the city of Hefei and Hewlett Packard has opened up a major computer-manufacturing base in Chongqing in Southwest China. These are high volume examples and other sectors may elect to follow them or seek alternatives.

In order to facilitate this development, the central government has been expanding and improving the infrastructure in the west regions through its ‘China West Development’ programme and new transport centres and logistics hubs are emerging. According to the market study conducted by Transport Intelligence (2011), western China is well placed to host a larger share of manufacturing in the near future.

The shift of production towards West China offers the transportation of goods between China and Europe a new alternative. Traditionally, goods are transported by deep sea, but as production centres move westwards, the concept of transportation of goods by rail land bridges across middle Asian countries and Russia to the EU countries becomes more realistic.

Such a rail link could provide shorter lead times than maritime transport. In April 2011, DB Schenker conducted an experiment by transporting cargoes from the southwest city Chongqing to Duisburg by rail. It took 16 days over 10,300 kilometres crossing through Mongolia, Russia, Ukraine and Poland, which is significantly faster than transport over sea, especially from this increasingly important production base.

Most goods transported from China to Europe by deep sea shipping services are containerised cargoes. In the western regions, the sectors producing technological high value products such as electronics and car components are growing. This seems to indicate a potential scenario for the transportation of more LDHV goods by rail to and throughout Europe. Whilst this may be a significant initiative at a global level intra-European freight traffic stil offers opportunities for rail in relation to high value time sensitive commodity flows and traffic where at present it has a limited or no active participation.

Products, orders and deliveries

The following four points are pertinent: (1) more product customisation; (2) toward increasingly compact products (this is expected to improve the cost-benefit ratio of express delivery by decreasing the transportation cost share); (3) the increasing value of products requires rapid transportation, because companies want to reduce the interest costs bound up in stock and inventories; (4) more varied, frequent, faster and more reliable deliveries; more focus on service quality rather than on delivery price.

Again, the extra value that is created may accrue to the HV segment. Rapid transportation may create possibilities for transport by rail, given an area where this has a comparative advantage above road transport. Such areas may exist, where for example it is easier for trains to penetrate and operate in urban areas or where certain inter-urban roads are heavily congested. These advantages need to be identified and innovative options developed including small austere terminals deep within conurbations through which traffic can be moved (containers/swap bodies/trailers) with minimal environmental impact and with a distinct cost advantage.

City logistics

The increasing urbanisation of the population raises the importance of city logistics concepts such as freight consolidation schemes and the interfaces with long-distance transport networks and services. Benefits can only be realised with the existence of efficient connections between rail networks and urban transport networks. A brief introduction to the concept, characteristics and developments in urban freight transport is presented in the Annex.

The challenges for a SPECTRUM rail freight concept connecting to city logistics concepts and facilities relate to better supply chain integration, connecting information flows and overcoming barriers such as the available urban rail infrastructure, noise constraints, security through the whole transit and high levels of routine reliability. Rail needs to match (as a minimum) the best of road freight and aspire to outperform it on cost, service capability, capacity and environmental impact. It has to offer attractive options for transport users, cargo owners and transport service providers.

2.4 TRANSPORT TRENDS

The following transport trends have been identified as being relevant for the SPECTRUM rail freight concept.

Change in freight characteristics

Throughout the last decades, in Europe, there have been changes in the characteristics of freight. These changes in the characteristics of freight had an effect on transport and logistics. This effect is called the “goods structure” effect. At first, this phenomenon could be noticed in Western Europe and, after 1990, also in the Central & Eastern European countries.

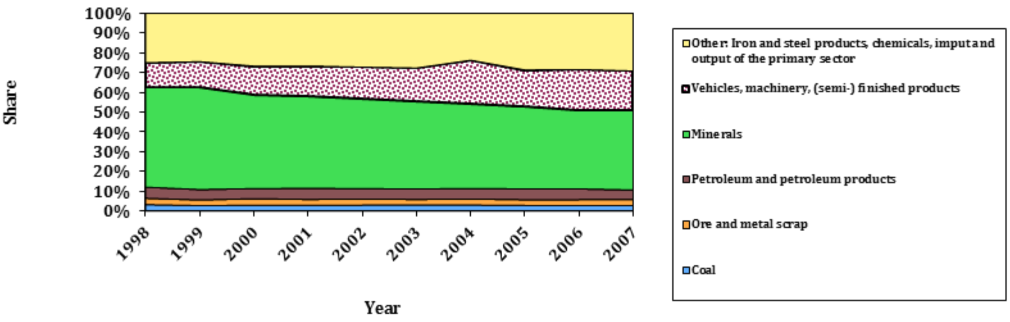
The effect was caused by economic development where the emphasis of the economic activities is continuously being shifted from the primary (agriculture, mining) and secondary (manufacturing) sector to the tertiary sector (retailing and wholesaling, service industry). In highly developed countries, the majority of people are employed in the tertiary sector, which means that the economy imports most finished goods (consumer goods).

Raw materials are hardly processed by the industries in these countries, which rather processes semi-finished products to assemble high-tech devices. So there is a different production structure, compared to economies that are in the process of industrialisation.

Moreover, in these countries or regions, people are getting used to a higher standard of living, and have higher demands on the supply of goods. For instance, the consumer behaviour tends to request an “anywhere, anytime” availability of high quality goods, and a wide range of products in general. User expectations have been driven to high levels that may not be sustainable in the face of changing energy, environmental and economic positions.

Resulting from the socio-economic development, a shift can be observed: There is less bulk traffic to be carried, and more general cargo. In more detail, as the steel industry, the primary industry, and the building industry have lost a notable part of its importance, so the total transport volume consists of less coal, ore and petroleum products and fewer minerals. For example in Germany, between 1998 and 2007, the share of these goods in total inland transport volume continuously diminished from almost 63% to less than 51% (see Figure 2.2).

Figure 2.2: Freight transport in Germany by the inland transport modes road, rail and inland waterway



(Source: BMVBS (ed.), Verkehr in Zahlen 2008/2009, Hamburg 2008)

Because of their low value, these bulk goods are sensitive to high transport costs, so they require low cost transport. Also, bulk is usually transported in large volumes, as larger volumes are ordered. It has lower demands on transport service quality (speed, punctuality), because the supply and demand flow to/from the industrial facilities is largely continuous and the value s of the load play a minor role.

Taking into account the features of the transport modes, this leads to a high affinity to railway (and inland waterway) transport, which has had its strengths in the cost-efficient carriage of larger volumes. These transports offer a wholly different logistical performance than those being mostly covered by road transport, which are more diverse, driven by shorter lead and response times, intermittent and lower in volume terms in terms of individual shipments but which in aggregate make up a very large market where rail has minimal participation.

On the other hand, the international division of labour allows for a concentration of the manufacturing sector in Europe in terms of adding value to almost finished goods. The inbound and outbound flow of goods then consists of general cargo, including machinery, vehicles, semi-finished and finished goods.

Looking at the freight transport volume by type of goods, for all transport modes, this is the category of cargo that had the highest growth rate in the last years. Again referring to the example of Germany, the share of this type of cargo increased from 12 % in 1998 to 20 % in 2007 (see again figure 2.2, second tier from the top). And the share of other goods processed on higher value-added steps like fine chemicals, steel products and foodstuff also increased.

General cargo has a lower density (expressed in kg/m3) and a higher value (expressed in €/kg). Due to the latter, it is less sensitive to transport costs than bulk. Because of the high capital value of the cargo, it requires a faster and much more time-definite delivery. The impact of capital costs dominates the impact of transport costs, which leads to a choice of fast and expensive transport options (e.g. air cargo). In addition, shippers and consignees usually request flexibility in transport planning and execution.

As a trend for the transport industry, this means that the cargo consists more and more of smaller and lighter goods. Instead of full truckloads, smaller lot sizes of general cargo need less-than-truckload transport services. Today, these consignments are mostly transported in groupage, pallet or parcel networks using consolidation hubs. The changed goods structure has a much higher affinity with trucks, which offer smaller capacities, a faster delivery, and a more flexible deployment.

Loading units

The global market has recorded a growing relevance of the container as the preferred loading unit. The possibility to move trailer-sized loads of freight seamlessly among different modes of transports has revolutionized international flows by virtue of consistent reductions in:

- Door-to-door transport: the average time in port decreased from 3 weeks (pre-container scenario) to 18 hours or less.
- Labour costs: the productivity grew from 0.627 tons per man-hour (pre-container scenario) to 4234 tons per man-hour.
- Cargo loss and damage.

Essentially the container made shipping and the following inland leg of transport much faster and cheaper. At a global scale, the annual rate of growth of containerised trade has been equal to 12% in the 2001-2005 time-frame and is estimated to be 6.5% per year until the end of 2011. The share of goods carried by containers is around 80% in the developed countries and around 30% in developing countries, suggesting that a continuous diffusion of this type of loading unit will continue to take place.

The growth of container traffic is also confirmed by the evolution of orders for the following years, that envisage an increase of the container capacity of the world fleet from 16 million TEUs (2011) to 19 million TEU (2014), equalling a 18% growth in 3 years. However there have been some recent and serious changes in the structure and nature of the container-shipping sector with some lines departing from the business due to low prices, over capacity and rising operating costs. Major adjustments and mergers may lead to the emergence of a few very large shipping groups or lines. This in turn may induce the arrival of new entrants operating in niche sectors/commodity areas.

Increased use of optimised loading units such as hi-cube containers and low-axle vehicles (which increase space of vehicles inside the weight limit of vehicle type) and the use of longer and heavier vehicles have an impact on the transport market and can provide benefits for intermodal transport.

Rail has not always been ready to recognise or respond these changes leading to a loss of market share. Road transport has been much more adaptable and pro-active in the development of new technical and commercial offers as shippers' requirements have emerged and evolved.

Intermodal transport/decision making in modal choices

To assess the potential for a modal shift from road and air to railway transport, it is necessary to know which features of the SPECTRUM train concept could be decisive for logistics decision-makers, when they are considering alternative transport options. The so-called modal choice is mainly based upon costs and service levels. In all, the decision between road (and air, respectively) and railway transport depends on:

- The overall existence of a modal choice on the transport route requested.
- The level of transport costs (main course haulage plus pre- and on-carriage plus eventually additional costs for transport equipment).

- The level of costs for transhipment for switching between modes (namely intermodal load transfer from road to rail and vice versa).
- The level of transaction costs (costs of gathering information on the transport options, costs of establishing a business partnership, costs of checking the business partners…) compared.
- The level of service quality (transit time/lead time/speed, transport reliability, delivery accuracy/quality, flexibility, readiness of information).
- The costs of adapting the system (opportunity costs or sunk costs e.g. for unused capacities like trucks, locked-in effects e.g. when investing in intermodal equipment).
- Lack of experience and expertise with certain transport modes.
- Risk aversion in the rail sector.
- Poor perception of rail's capabilities and a belief that rail is only of interest in long haul corridors with large train formations.

It is certain that there are trade-off relationships between the factors identified above. For instance, even if transport plus handling costs are lower in intermodal transport than in road transport, the perceived poor level of service of the intermodal transport may deter a shipper from using intermodal services.

Also the cost and service performance of intermodal transport has to reach a certain degree, to persuade a reluctant shipper to consider the intermodal option in more detail. An essential requirement is the overall existence of modal choice, which must be perceptible to the logistical deciders. The difficulty of finding accurate information on services, schedules, space availability, pricing and tracking are key current indictments against rail.

To rank the importance of the factors, door-to-door transport costs are important to logistical decision-makers. These represent the total cost, covering both the pre- and post-haulage for the initial and final leg of the transport chain, transhipment, and the provision of the loading unit. Unfortunately many shippers tend to focus solely on the line haul element when making modal choices.

Service reliability, above all reflecting the degree of punctuality, is the outstanding service criterion, and in some cases, even more important than the price. Transport safety is also a decisive factor for the carriage of chemicals and offers an opportunity for rail to exploit.

Flexibility has several dimensions: the frequency of departures, the situation of departure times, the ability to deal with varying shipment sizes/capacities, the ability to recover in the case of delays, the availability of backup transport options, or the ease of switching to other transport modes.

Flexibility is also regarded as of higher significance to logistical decision-makers. Transport characteristics (transport route, type of cargo, specific needs of a shipper etc.) determine whether transit time is a highly important service aspect. To a certain degree, a longer transit time, when using railway transport can be offset by a reduced level of transport costs and an improved reliability.

For LDHV goods, transit time is of higher importance than for bulk for example. In this market segment, tracking and tracing of cargo is "a must" more than an instrument to obtain a competitive advantage in the European door-to-door transport market. Operators of rail freight services should be aware that the demand side fears a more complex transport planning and transport operation, which could make the use of a new transport system such as the SPECTRUM service inconvenient unless this point is fully recognised and addressed. Convenience must therefore be provided by the supplier, so that the user of the service does not have to organise pre-/on-carriage, handling, transport equipment etc. on his own unless this preference is an option to be exercised.

If the SPECTRUM trains are addressed to shippers, the latter require a door-to-door transport service, with an all-inclusive price. Moreover, sufficient general information about the transport option should be provided. This can occur through websites, brokerage services, direct selling, leaflets, road shows, or promotion centres. The marketing of the SPECTRUM rail freight services must be aware of this.

In the context of convenience for the clients, the accessibility to the transport system plays an important part. A dense network with a high spatial accessibility (many access points per area) not only reduces pre- and post-haulage distances (and costs) in intermodal transport, but also facilitates transport planning. It also reduces the risk of failure in comparison with smaller numbers of larger nodes and is an advantage to be maximised

Finally, an improved image can result from the use of environmental-friendly transport. The environmental benefits of rail freight transport solutions are nowadays welcomed by the logistical decision-makers, but not at the expense of costs. The features of the SPECTRUM train must fit the profile of these factors, which may vary over time, e.g. through the emergence of new environmental issues. Rail has a bank of green credentials (energy efficiency, multiple energy/fuel capability, reduced noise etc. it needs to market more aggressively.

Logistical decision-makers consider reorganising their transport chains and their modal options when their clients put pressure on them and when problems arise with respect to the availability of existing transport capacity. These are external push factors, causing a need to switch. But a reduction of service quality in road transport (e.g. created by road congestion) has not resulted in a significant modal shift.

So road congestion alone will not lead to an increased acceptance of SPECTRUM rail freight services. Rail should not depend on increasing road congestion hampering its primary competition as a means of securing more traffic. It is rather the awareness of competent and attractive optional intermodal transport services and its providers (and the marketing of these) that could lead to a higher use of intermodal transport.

Modal choice decision makers must be convinced, as their identification with the intermodal transport concept and their willingness to accept changes are important success factors. IT-based management decision-support tools like the “AWAK” or “SPIN” (“Scanning the Potential of Intermodal Transport”) tools could display the economic, societal, or environmental benefits of using intermodal transport, even expressed in hard factors (monetary values). As, often, the shippers decide on the transport mode, such a tool has to take into account their specific needs. Who actually controls the modal choice and pays the freight charges needs to be convinced that rail and inter-modal options have the potential to fulfil demanding service requirements as well as the existing road based alternative.

Synchromodality

In Europe, the logistics sector confronts a number of challenges including (a.) rising demands for more complex transport- and logistics services; (b.) growing transport demand in the coming 20 years; (c.) increasing infrastructure bottlenecks in the medium and long term; and (d.) higher societal pressure for more sustainable transport system.

In view of this an innovative concept called ‘synchromodality’ or ‘synchromodal transport’ has been initiated in recent years in the Netherlands. Synchromodality exists when supplies of services by different modes of transport are synchronised to the extent that all together they are seen as one coherent transport product. This transport product fulfils every time the transport requirements of the shippers in terms of price, lead-time, reliability, and sustainability. This gearing concerns not only the planning and the implementation of the services, but also the information exchanges over the services.

The core of the synchromodality concept is that the gearing within and between the goods flows, the transport chains, and the infrastructure chains is made such that goods volumes can largely be consolidated and the unused capacities of the transport modes and of the infrastructures can better be utilised. It leads to the outcome that at any moment, a suitable mode of transport (road, waterway, rail, or air transport) can be allocated given the demand from the shippers and the nature of their products. And this is aimed to lead subsequently to growing transport volumes and lower external costs.

The underlying goal of synchromodality is to offer greater flexibility in transport choices, improve the reliability, shorten the lead-time in the transport chains, and increase the utilisation of road, rail and inland waterway. Synchromodal transport has been recognised in the Netherlands and a number of stakeholders in Europe as a solution to tackle the above-mentioned problems in infrastructure and transport services. It is also seen as a means that offers many opportunities for more efficient and economic growth in general. In 2011, a roadmap to synchromodality has been developed, and action-lists and potential pilots have been brought forward[1].

Emphasis on safety and security

A trend that focuses more on security and safety will be beneficial to rail transport. Rail is not only a safer transport mode compared to road transport, but rail transport is also more controllable due to the fixed route and loading and unloading locations. It is unlikely that the shipper will base (part of) his decision for a transport mode on the safety argument, unless the goods of concern are chemicals or other hazardous materials. As for the security of HV goods, this could play a significant role in the final decision to choose a particular transport mode.

New freight transport systems and intelligent transport systems (ITS)

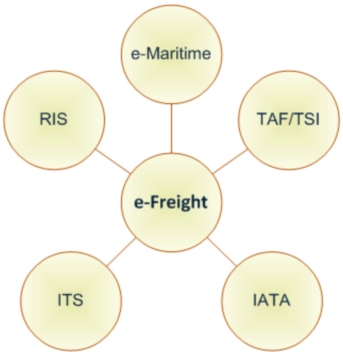
[1] See TNO report: Implementatie roadmap Synchromodaliteit, TNO-060-DTM-2011-01485, 29 April, 2011

The information flow between the actors along the transport chain is often fragmented. This causes missing and incorrect data and unnecessary delays. This is especially true for transport chains where more than one transport mode is involved. Moreover, the information flow between carriers (shipping companies, rail freight and trucking companies, airlines), transport operators/freight forwarders, providers of transport equipment services, shippers and terminal operators, is not standardised, because these actors each have their own methods, protocols and traditions of information exchange and information processing. This is especially true as the continental transport economy does not rely on standardised structured messages. Differing information and communication equipment is used (paper, phone, fax, telex, email, stand-alone computer software, proprietary computer messaging standards etc.). This has become a problem for the introduction of advanced ICT systems, as necessary tailor-made interfaces are very costly. But advanced ICT systems are required: There is a specific need for more (and more accurate) information in complex (i.e. multimodal) transport chains, as compared to unimodal door-to-door transport.

Intelligent Transport Systems (ITS) integrated telecommunications, electronics and information technologies (telematics) are applied to the transport system, in order to plan, design, operate, maintain and manage transport systems. ITS can be regarded as an important means to increase efficiency, quality, safety, security, and environmental performance of transport. Thus, the further development, enhancement and application of ITS belongs to the goals of the European Commission in freight transport policy, as stated in its Freight Transport Logistics Action Plan (COM(2007) 607 final), or its Action Plan for the Deployment of Intelligent Transport Systems in Europe (COM(2008) 886 final).

ITS systems are predominantly focussed on road transport, there are however similar initiatives for other transport modes, such as SafeSeaNet/e-Maritime (maritime transport), River Information Services (inland waterway transport), TAF/TSI (railway transport), or the e-freight initiative taken by the IATA (air transport). For rail, the key problem is getting shippers to recognise the existence of such systems and to realise the advantages of using them.

Figure 2.3: E-freight context



(Source: http://efreightproject.info)

The European e-Freight project is aimed at achieving paperless and electronically documented freight transport processes, irrespective of mode. The vision is an “Internet for cargo” system, where all transport-related information is securely available on-line. Thereby, all mechanisms shall be technology independent.

By 2009, the European Commission came up with a roadmap for the implementation of e-Freight, where five goals were outlined. One of the goals is the development of a European Single Transport Document for the carriage of goods, irrespective of mode, easing the switch between the transport modes. Transport documents such as orders, loading lists, consignment notes, freight bills or invoices, are required to follow the movement of goods.

Such transport documents are normally specific to the different transport modes. Multimodal transport documents exist, but they are not widely used in electronic format. Thus, a single European transport document (waybill) in an electronic format is needed that can be used in all transport modes (thereby facilitating multimodal freight transport).

The e-Freight standard transport document describes the agreement between the transport user and the transport service provider. It can be generated in the planning process and be communicated to all parties involved in the transport execution. Apart from the consignor, the consignee and the carrier, it includes a detailed description of the cargo as well as the conditions under which the transport should take place and can support different ITS services. This can also be linked to emerging concepts such as e-seals to reinforce security.

With regard to the Single Transport Document, the European Commission is willing to provide all necessary legislative support. This should include the development of a new liability regime for multimodal transport, which has to precede the Single Transport Document.

2.5 RAIL SECTOR TRENDS

The following rail sector trends have been identified as being relevant for the SPECTRUM rail freight concept.

More efficient use of existing infrastructure

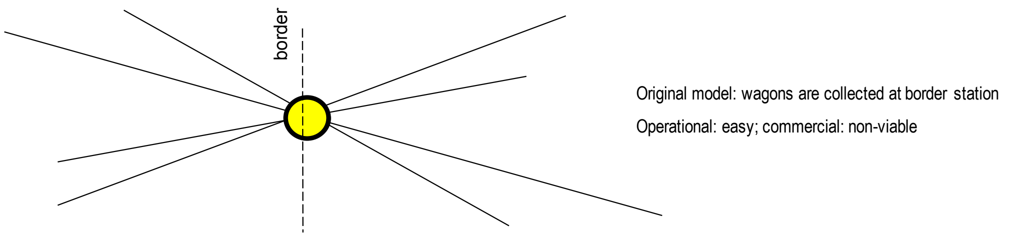
The passenger and freight traffic on the main railway lines is increasing, particularly around the big rail nodes. This is especially the case in Western Europe. Passenger transport is generally given priority over freight transport. The railway infrastructure often cannot be expanded rapidly. In Central and Eastern Europe, there is less congestion on the rail network.

As regarding the availability of rail transport capacity, the Central and East European railway market offers more possibilities from the point of view of railway capacity. In any case, existing railway infrastructure needs to be used efficiently. For example, if an operational and safety system such as ERTMS would be widely introduced, rail transport capacity will increase. In that case better and more dedicated transport solutions can be offered.

Interfaces between the operations

Cross-border traffic in rail freight is steadily increasing. This is especially true for the European Union and the countries of the North American Free Trade Agreement which are becoming more and more economically integrated. In Germany, for example, more than 50% of all rail freight is international. In the traditional model, which originated in times when there was one national railway undertaking in each country. The national Railway Undertaking (RU) of one country collected the wagons for a neighbouring country from different origins all over its network at a border station to a neighbouring country. The wagons were handed over to the national RU of the second country and distributed by this RU to the different destinations in its network (see Figure 2.4).

Figure 2.4: Traditional operational model for cross-border traffic



(Source: Railistics)

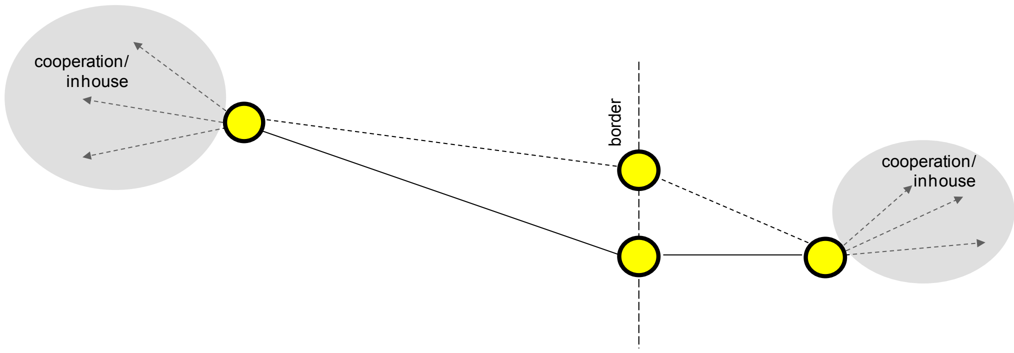
The main problems of this traditional model were problems in communicating information between the different parties involved in the process. The national systems of planning train paths and dispatching trains were different, so a high degree of planning and coordination between the different RUs and infrastructure managers (IMs) was necessary.

In practice the communication and coordination were often not working at the desired level. Train delays and cancellations were often communicated too late or not at all. This lead to additional costs because train staff and locomotives had to wait at border stations awaiting instructions and authority to move and impacting on the amount of time they were productive. The use of differing technical standards and protocols also imposed delays as each national routine was completed thereby imposing delay. Road freight is not subject to such requirements and as a consequence has secures an advantage.

Current operational models help to avoid these problems. The European and North American railways are increasingly using a new operational model of direct cross-border trains. In this model the wagons of the neighbouring country are collected at marshalling yards within the countries. Direct cross-border trains connect these marshalling yards. These trains are mostly equipped with interoperable locomotives and don't need to stop at the border station.

Figure 2.5 shows this operational model.

Figure 2.5: New operational model for cross-border traffic



(Source: Railistics)

Increasing necessity to integrate passenger and freight transport

Especially within Europe the densely used networks for mixed traffic face operational problems resulting from the different characteristics of passenger and freight transport (e.g. speed, acceleration and braking).

The requirements of passenger and freight transport on the railway infrastructure are very different. On less heavily used lines, the common use of these by passenger and freight trains is normally not a big problem, but on heavily used main lines this can pose problems.

The main problem is the different speeds of (generally faster) long distance passenger trains and inter-urban trains and freight trains, but also the different stopping patterns of regional trains calling all/many stations. It would be preferable for long distance freight trains to have no intermediate stops or be queuing as a result of interaction with regional or stopping passenger services. In most cases freight trains have to wait while passenger trains are passing.

Another problem is that freight trains need more flexible timetables, because the actual departure of a freight train depends on many variables, e.g. the need of the shipper, the loading process and necessary waiting times because of passing passenger trains. Whereas passenger trains have a fixed timetable and should stick to it, in order to make the customer an attractive offer. Some rail freight operators run services on passenger type fixed schedules on the basis that any missed or delayed cargo can be accommodated on following services. The ability to offer a multi-departure option or offer delivery to a terminal close to that specified could allow rail to retain cargo in spite of delay or disruption.

Generally the ideal solution for these problems would be the effective separation of passenger and freight on different lines. This is often not possible. In these cases, a more flexible operation is often required. For freight trains there could be several freight priority slots distributed over the day. These slots can be used flexibly for freight trains if necessary. With this solution the differing requirements of passenger and freight trains can best be accommodated. The ability of freight trains to use passenger quality train paths together with a technical and operational capacity to use passenger service infrastructure (e.g. passenger loops) would open up options not normally undertaken.

Increased use of telematics applications and planning and process software

The importance of telematics applications and software solutions in rail freight is, as in other industries, steadily growing. One very important item is the ex-ante simulation in major railway infrastructure projects.

In major projects of new construction and upgrading of rail infrastructure, the future operational needs should be defined and an operational concept should be developed and simulated on the planned new infrastructure.

With this procedure, the real needs for the new infrastructure can be identified and the infrastructure can be designed and sized correctly. After this ex-ante simulation, the infrastructure should be re-planned. Without such a simulation the infrastructure is often not suitable for the actual operation after upgrading. The new infrastructure:

- Might not be used appropriately.
- Might not be able to handle all traffic with sufficient quality.
- Might be incorrectly located.
- Might be use of capital for marginal benefits.

An estimate by Railistics (project partner) came to the conclusion that all TEN-T railway projects in Romania could be built at costs 30% lower if this procedure had been used, or similarly with the same budget 30% more infrastructure could be upgraded.

High-speed Systems

High-speed freight trains may be competitive towards some airfreight. The Carex concept is that inter urban rail transport by using the European high-speed rail network to carry airfreight pallets and containers over distances of between 300 and 800 kilometers could be competitive.

This would involve: (1) a "modal shift" from trucks and short-/mid-range aircraft to high-speed trains wherever competitive (2) the availability of airport-based air/rail terminals connected to high-speed rail links and (3) services tailored to suit the logistics chains and transport plans of integrators, with priority given to express freight in order to guarantee next-day delivery, followed by less urgent air cargo freight

The High-Speed Rail programs are one of the most relevant developments in terms of infrastructure spending in the recent years at a global level. The realisation of HSR services has brought new and growing competition towards other transport modes (both air and road) on routes that it was not possible to connect in less than 5-6 hours before.

The expansion of HSR networks is being debated in all areas of the world. In the USA, the HSR development is still a long-run process; despite the Obama Administration putting a major focus on this subject. A number of debates – which, as in other countries of the world (e.g. UK) revolve around the cost/benefit balance of the relevant HSR spending – have somewhat undermined the political acceptance of the HSR program.

In China, huge HSR development plans exist that aim to redesign the whole rail network. The growing wealth of China, and in particular its political and social structure, facilitates development in times that are unthinkable in other countries. After the opening of the first HSR line in 2008 (Beijing-Tianjin), China has realised a 6920 km HSR network in two years, and investments for 900 billion Yuan (almost 100 billion Euro) are already planned by the Chinese government. The goal is to extend the HSR network by 2020 in order to connect all cities with more than 500,000 inhabitants, thus reaching 90% of Chinese population.

Europe has been the birth ground of HSR development; 60% of the world HSR networks are in Europe. Many lines have been completed recently, and others are in an advanced stage and are estimated to be completed circa 2020. This development is governed by a number of EC provisions (namely Council Directive 96/48/EC and Council Decision 2002/735/EC) that define the Trans-European high-speed rail network and the technical standards to achieve the interoperability of such network at the design, construction and operational stages.

Different innovative technical solutions are being developed in European countries, such as the Automotrice à grande vitesse in France – a new TGV generation capable to reach 350-360 km/h. Russia is also planning to extend an HSR network based on the Sapsan experience – the HSR service between Moscow and St.-Petersburg started in 2009. Switzerland is the focus of the application of HSR concepts to freight transport. Completion of the Alptransit project is expected in 2017 and it will allow a speed of 250 km/h in tunnels below the Gotthard and the Loetschberg for passenger trains and 160 km/h for freight trains.

Promotion of dedicated rail freight corridors

The evolution of the European rail network has been historically conceived and planned according to both a “corridor” approach” and a “network” approach. Since 2001 (with the Commission’s White Paper) a “Dedicated Freight Network” concept has been explored in order to develop a network made partly of dedicated lines (at the international level) and partly of mixed traffic lines. The planning of a Dedicated

Freight Network was indeed one of the three key actions envisaged in the 2001 White Paper, together with the integration of rail transport into internal markets, and the optimisation of the use of infrastructures by opening up the markets.

The concept of a Dedicated Freight Network consisting of international corridors has recently been replaced by the concept of a “European rail network for competitive freight”, conceived in order to address the requirement of a more efficient provision of service by the rail infrastructure operators to the rail operators.

This system still envisages an appropriate treatment of freight trains in terms of allocation on lines that cater also for passenger traffic, by introducing the concept of “priority freight trains”, those that transport time-sensitive goods, in order to allow priority freight trains to have guarantees in terms of service provided by the infrastructure.

This is essential to enable them to gain in competitiveness with respect to trucks. The EU is working towards the creation of a rail network giving priority to freight, including the realisation of a number of international freight-oriented “corridors” - at least one in each EU Member State by 2012.

The Regulation concerning a European Rail Network for Competitive Freight (Regulation EC 913/2010) entered into force on 9 November 2010. The Regulation requests Member State to establish international market-oriented Rail Freight Corridors to meet three challenges concerning:

- The European integration of rail infrastructures by strengthening co-operation between Infrastructure Managers on investment and traffic management.
- A balance between freight and passenger traffic along the Rail Freight Corridors, giving adequate capacity and priority for freight in line with market needs and ensuring that common punctuality targets for freight trains are met.
- The intermodality between rail and other transport modes by integrating terminals into the corridor management and development.

Rail Corridor Governance

Throughout the process of law making in the sector of European rail freight transport, a new type of governance practice has emerged. This type of governance focuses on the application of legislations on selected corridors (sometimes also called networks or principle routes).

According to Zhang (forthcoming), the identification of the corridors seems to be based mainly on social-economic interests of the EU (e.g. the TEN-T network is identified by filling the missing linkages with the peripheral areas) and the volumes of freight movements along the corridors (e.g. the ERTMS corridors, the TREND corridors).

In addition, the corridor governance also reflects different ways of cooperation between the actors. Practices like TEN-T corridors or ERTMS corridors deal with allocations of financial aids from the EU down to the member states; therefore they show stronger relationships between policymakers at the EU level and those at the national level.

Practices like RNE corridors development reveal more cooperation between the member states; the EU policy makers exert little influence in the working of RNE corridors. Practices like RETRACK corridor or CREAM corridor (mostly EU-funded research projects) indicate a much higher level of involvement from the private sectors.

Nevertheless, a lack of consistency has been observed among some of the corridor-groups in terms of geographical layouts and the objectives. For example, ERTMS corridors are established particularly to standardise the rail safety systems between member states, while RNE corridors are launched for harmonising the European train path allocation and path application system.

IT cross-border traffic management

The development of interoperable and attractive multimodal transport services rely more and more on the availability of modern tools that aim at ensuring the shift from "modes of transport" to "Intelligent Transport Systems" as foreseen by the EC. In today’s logistics real-time status information on transport movements are essential, especially for transport modes, which show great irregularities, as this is still the case for most rail freight services throughout EU.

Moreover, the current status of cross-border rail freight operations, due to the lack of diffused cooperation between RUs, vastly increases the risk of delays, making the lead time for freight consignment very uncertain, thus hindering the attractiveness of rail freight.

The adoption of IT in cross-border traffic management is a clear trend towards the simplification of train handover, a factor of cooperation between rail stakeholders. Many tests were made in the past as outcome of EU projects and alliances between IMs ad RUs, not only to establish new IT systems for cross-border operation management, but also for tracing the train path along international corridors.

This trend now seems to be established, especially thanks to a higher degree of cooperation between railway undertakings, which have to collaborate in "selling" the same product (i.e. "One-Stop-Shop" concept in international rail freight) along the corridor, and which have to ensure reasonable quality standards (punctuality, reliability, ex-post assistance, etc.) to their customers.

Further rail liberalisation

Further rail liberalisation means not only separation of transport operations from infrastructure management, but also a split of rail passenger and rail freight operations. This is expected to lead to more competitive and better rail freight services. In order to address a decline in market share, the European Commission declared a state of emergency in European railways.

In July 1998, the commission presented three new proposals aimed at making existing legislation more effective. On February 2001, the Council adopted the three directives known as "rail infrastructure packages".

The first package was launched on 15 March 2003[2] of the Trans-European Rail Freight Network (TERFN), based on the provisions of the Railway Directive 91/440/EEC of 1991, permitting open access for national rail services across EU. This first package is supported with three directives that include:

- Directive 2001/12/EC is designed to clarify the formal relationship between the state and the infrastructure manager and the railway undertakings (operators);
- Directive 2001/13/EC sets out the conditions for freight operators to be granted a license to operate services on the European rail network;
- Directive 2001/14/EC introduces a defined policy for capacity allocation and infrastructure charging.

The practical implementation of the first railway package provision is still on-going but the effects are visible and encouraging. Importantly, a 2006 review of the first railway package found that the relative position of railways towards other transport modes had stabilized and halted the decline in rail market share observed between 1970 and 2000. Indeed between 2000 and 2005 member states in which non-incumbent railway undertakings performed significantly better in terms of rail freight performance than member states in which the market was still dominated by a monopoly.

The second package is composed of measures to revitalise the railways by building an integrated European railway area, in particular by quickly opening up the international rail-freight market, by proposing a new directive on railway safety and the establishment of a European Railway Agency. This second package is supported with three directives and one regulation that are based on the guidelines of the transport White Paper as described below:

- Directive 2004/51/EC (a revision to Directive 91/440) opens up both national and international freight services on the entire European network from 1 January 2007;
- Directive 2004/49/EC (the Railway Safety Directive) lays down a procedure to obtain safety certificate for every railway company to run on the European rail network;
- Directive 2004/50/EC (on interoperability) harmonises and clarifies interoperability requirements;
- Regulation (EC) 881/2001 sets up the European Railway Agency to coordinate groups of technical experts seeking common solutions on safety and interoperability.

The third railway package adopted by the EU in March 2004[3], proposes opening up international passenger rail services within the Community from 2010 and the introduction of a certification system for locomotive drivers. Two directives and a regulation in relation to freight are noted and briefly described below:

- Directive 2007/59/EC introduces the conditions and procedure for the certification of train drivers (and crews) operating locomotives and trains;
- Directive 2007/58/EC sets up the allocation of railway infrastructure capacity and the charging system for using the railway infrastructures; it also envisages opening the market for international passenger services to competition from 1 January 2010;

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[2] http://ec.europa.eu/transport/rail/packages/2001_en.htm

[3] http://ec.europa.eu/transport/rail/packages/2007_en.htm

- Regulation 1371/2007 on rail passengers' rights and obligations – to ensure basic rights of passengers (with regards to insurance, ticketing and for passenger with reduced mobility) are respected.

Despite the progress made through the implementation of these packages, they were not wholly adopted by all member states. Lack of resources, insufficient political determination, conflicts of interests or influencing by major stakeholders are some of the identified barriers towards pursuing of a single European railway market.

Nevertheless the EU maintains that the creation of an integrated railway market is a key factor in boosting its efficiency and competitiveness, as well as a further step in ensuring sustainable mobility in Europe.

Alliances forming

Within Europe, alliances take shape. For example, Xrail is a production alliance for wagonload traffic and aims to render international wagonload traffic by rail more customer-friendly and efficient. The alliance strives to increase the competitiveness of wagonload traffic in Europe significantly, thus helping take traffic off the roads and protect the environment. The alliance is made up of the following seven partners: CD Cargo, CFL cargo, DB Schenker Rail, Green Cargo, Rail Cargo Austria, SBB Cargo and SNCB Logistics. Xrail addresses the operation of international wagonload traffic between the rail freight operators and is planning to develop and introduce a planning system that will rapidly allow free range wagons to be moved across various national territories and link together services and connections to offer a range of solutions to shippers.

The alliance is not targeting block train transport or combined transport using swap bodies. The commercial part of wagonload traffic, such as customer liaison and pricing, remains the direct responsibility of each of the participating railway undertakings, who continue to compete with one another. However, all Xrail partners commit to maintaining the high standards of quality and service for the customers, as defined within the alliance.

Changes in the Railway Undertaking market

The RU market is evolving at present into a market seemingly with a limited number of large undertakings (still linked to their respective national governments despite the requirements of the EC to adopt the reform packages of the past decade) and a large number of smaller niche players. DB Schenker, Rail Cargo Austria, SNCF, PKP Cargo, Trenitalia Cargo and Green Cargo are companies that belong at present to the select group of large RU that might survive in this competitive market.

Most of these incumbent companies are not known for being very innovative. SNCF for example has been slow to adopt the necessary administrative, organisational and commercial reforms required and is losing market share to new operators in both the domestic and international markets as well as being under severe modal pressure form road transport.

Many of the smaller railway undertakings are micro-operations based around a defined location or geographical area (shunting at a plant or facility), offer specific services (contractor shunting in public rail yards) or key line haul operations. Some rail freight undertakings offer third party contract traction services for train line haul and have complied with rules governing this activity now allowed as a result of the reform packages.

The playing field is not yet completely level despite the good offices of the various national regulators and the incumbents still retain significant behind the scenes power and influence which can constrain the new competitors. The emergence of new privately owned railway undertakings of varying types and capabilities suggests that there may well be rounds of consolidation for financial and competitive reasons. The emergence of regional operators under private ownership is a potential future development as operators exploit their freedoms in relation to operations and manpower compared with the incumbents who may be willing to cede such operations to lower cost operators.

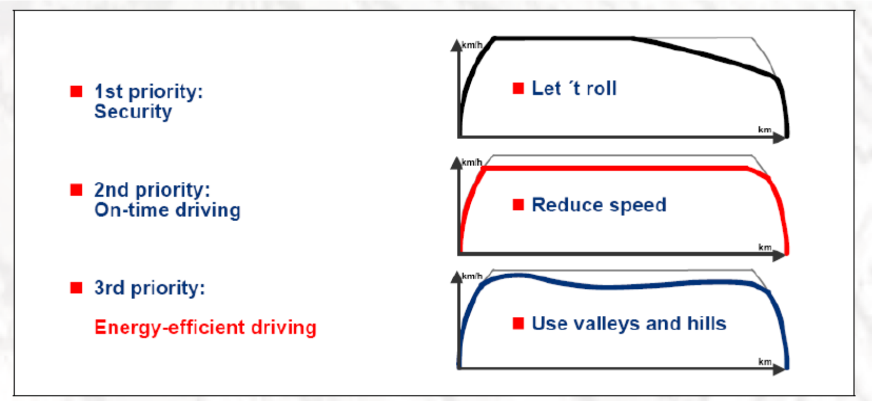
Energy efficient driving

The costs for energy are steadily increasing. Even railways as one of the most energy efficient modes of transport are hit by this development. Energy costs are therefore an increasingly important issue and the reduction of energy consumption increasingly the focus of Railway Undertakings (RU) in order to reduce costs and become more competitive.

On the other hand there is an increasing pressure to reduce greenhouse gases to save the climate and to reduce other emissions for ecological reasons. One possibility to reduce energy consumption is by designing more energy efficient vehicles and more efficient propulsion systems. The other possibility is more energy efficient driving. There are three ways to realize energy efficient driving:

- Training programs for drivers (theoretical and practical);
- Special timetables indicating the driver the best time for acceleration and braking and the best speed;
- Special on-board devices like advice systems for drivers or energy meters.

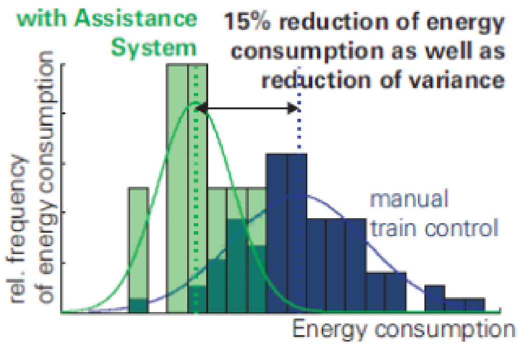
Figure 2.6: Possible energy saving driving styles



(Source: Deutsche Bahn)

An example for an advice system for train driver is the project ENA-flex-S of TU Dresden. Within this project a driver assistance system for energy efficient train control was developed. The system gives the driver advice about the start of coasting. In a practice test a 15% reduction of energy consumption could be realised.

Figure 2.7: Possible energy saving driving styles



(Source: TU Dresden)

2.6 IMPACTS ON THE RAIL FREIGHT MARKET

From the trends described in the previous sections, a number of expected impacts can be defined for the rail freight market in general and the market opportunities of SPECTRUM rail concepts specifically. The following table summarizes these impacts.

Table 2.1: Generalised conclusions of impacts of trends on freight flows and freight characteristics

Conclusions	
Freight flows	
Changes in existing flows	• Economic trends will cause a general increase in the demand for transport in the coming years, but also changing origin-destination patterns with an increasing spread of terminals including micro and austere terminals. • Urbanisation will lead to an increase in flows to and from and within urban areas and even more congested access roads.
Areas or goods types that may be expected to stagnate or diminish	• General cargo (often containerised/modulalrised) will rise. This cargo will consist more and more of smaller and lighter goods. • Transport of bulk goods may decrease largely in response to energy sector changes. • Trade flows to and from Europe could change when production is shifted to other areas such as western China.
New freight flows that may be expected	• Regional freight flows will rise. • Transport orders may become smaller but more frequent. • Supply chains trends such as synchromodal booking will become an extra planning option. • High-speed rail freight could become a competitive alternative to airfreight and scheduled international trucking within defined market parameters.
Freight characteristics	
Changes of the value content of the goods	• Economic trends may cause price increases for goods in general. When purchasing power per head increases, there may be an additional increase in the demand for LDHV goods. • Higher prosperity and individualisation will lead to more tailor-made and valuable goods. • Greater variety due to customisation creates a higher value type of goods
Potential markets and growth conditions for different freight types	• The share of LDHV goods transported in the total transport volume will rise. • In case of higher road transport prices (e.g. because of new toll levies), rail transport will become competitive on shorter distances but should not rely on the discomfiture of road transport to secure more traffic. • More dedicated orders and a-modal booking can be beneficial to LDHV transport by rail. • Urbanisation is beneficial to solutions that aim at optimizing city logistics. Innovative train and terminal concepts will be needed • More congestion on roads in and around urban centres and inter-urban motorways is an advantage to rail transport.

3 Market intelligence

3.1 INTRODUCTION

The transport demand analysis presented in the previous chapter, provided a general view of the potential market segments eligible for the SPECTRUM rail freight concept. The market intelligence, on the other hand, focuses on the potential transport demand from a bottom-up approach. This will give more detailed information on the type of LDHV goods that could be transported by rail and the requirements from the point of view of the key market players.

The market intelligence has been derived from:

- Desk research and interview results obtained from previous and currently running European research projects and publications.
- Interviews with potential users of the SPECTRUM rail freight concept (i.e. shippers and transport operators).

3.2 MARKET INTELLIGENCE RESULTS FROM OTHER PROJECTS

Other European research projects, such as RETRACK, RE-ORIENT, TREND and COMPETE have conducted several surveys and interviews with key market players in different market segments. These studies provide useful information on demand issues, such as the obstacles encountered, the needs and the requirements of the shippers and transport operators. The main conclusions (related to the transport of LDHV goods) drawn from these studies can be summarized as follows[4]:

- The **most important requirements** of shippers are (in order of importance):
  - *Reliability of service*: intermodal rail transit time has to be competitive with road. However, consistently and unfailingly reliable transport (i.e. arriving at the agreed time) is for many shippers even more important than the transit time itself. This is especially the case in the automotive industry, which is the industry with the largest share of 'just-in-time' (JIT) and 'just-in-sequence' (JIS[5]) delivery. The electronics industry (especially end products) is also highly organised with JIT production structures. The critical issue with these types of deliveries is not the speed of the delivery, but the routinely high reliability of the transport.
  - *Costs of door-to-door delivery*: rail transport is often, but not always, more expensive than road transport, especially for relatively short distances. In general, low overall costs can be reached when combining rail volumes on a corridor and much more intensive use of the rolling stock and traction assets to levels well above that assumed as a norm or maximum at present using orthodox equipment and operating methods.
  - *Service availability*: service availability at the origin point seems to be just only slightly more important than the availability at the destination point. Rail needs to be a real 24/7 option for shippers if it is to begin to compete with road freight which is generically more reactive and responsive to traffic requests on spot and short term bases.
  - *Safety and security*: reducing the chance of losses, theft and damage. This is especially important for the transport of high value goods. In general, rail freight transport has a competitive advantage over road transport with regard to safety (less chance of shifting in wagons) and security (less chance of theft).
- In intermodal rail transport, there is often a lack of technical and administrative interoperability and coordination between countries (such as different energy and signalling systems, time consuming paperwork at the borders, differing technical inspection requirements and lack of communication with the border staff). This increases the chance of experiencing delays.

  A train making several scheduled stops also has the likelihood of a greater chance of encountering a hold-up with the consequent impact on schedules. However, due to increasing congestion on the roads, road transport is also experiencing more in transit delays and thus more costs (i.e. additional fuel and labour costs).

  In some market segments, such as the food retail sector, a delay in delivery and distribution of goods is a serious weakness. This is especially the case for the transport of perishable goods. If these goods are not delivered on time, there is a bigger chance that these cannot be sold at all. A new rail freight service

[4] Source: D1.4 Logistics requirements new rail freight service, RETRACK, 2007.

[5] Just-in-sequence is a combination of just-in-time delivery with production line sequencing of delivered items. A customer will notify a supplier of the items needed and the sequence based on the customer's manufacturing schedule, the supplier will then put together the shipment with the items in the appropriate sequence and deliver them to the customer (sometimes directly to the assembly line).

should focus on these issues and be able as a minimum to match the service and product offers of the road transport sector.

- Potential customers want to increase flexibility in logistics processes in order to meet changes in demand (e.g. re-route and/or create additional capacity). On this aspect, rail transport at present offers limited flexibility in reserving additional train capacity in a short time frame (few hours). Very short term train paths can be arranged and are likely to be an increasing service requirement.

  Rail will have to match the spot or very short term demands for movement if it is to compete with road. In cases where train capacity cannot be reserved, road transport becomes the default option. This weakens rail's competitive positioning with shippers if routine transport request cannot be accommodated. Nevertheless it can be made complementary if rail takes the basic volume and road the varying volume. The contrary is in most cases not economic for the rail operator.

- Shippers want to reduce the complexity of their transport chain. Intermodal rail transport creates additional complexity. This complexity can be solved by involving freight operators or system integrators that use intermodal rail transport and guarantee a certain service level.

  The use of more "friendly" service arrangement packages (e.g. Freight Arranger®) to identify available services, space availability, schedules and pricing should help to ease this concern and also bring rail into line with competing modes.

- More regular rail freight services are needed. Companies interviewed for the RETRACK project mentioned the need for a frequency of at least one, but rather three times a week (for containers and swap bodies). The service should preferably have a fixed starting date and time throughout the week. On other links services involving several train departures and arrivals per 24-hours will need to be offered.

- There seems to be lack of capacity (e.g. wagons, equipment and tracks) and outdated rail infrastructure (causing derailments) in Europe. The long life of railway rolling stock and traction assets is a major problem. Rail assets can last for 25+ years but road transport turns over its technology in 5-7 year periods. It is not possible for rail assets to be considered equal to the latest road offering in response to shipper's requirements if the rail vehicle is over ten years old and largely un-modified.

- There is often no track-and-trace equipment available on trains, resulting in trains that cannot be found (when necessary) and difficult real-time communication with the rail service providers. Clients want to be informed quickly when there are delays in the service and the actions to respond from disruption are taken. This can be done using tracking and tracing and other real-time communication equipment as intermodal operators are implementing since some years. Tracking and tracing needs are vitally important for the transport of containers and swap bodies. In addition to track and trace condition monitoring and security issues need to be addressed to position rail to a level where it can compete on product and service grounds with the road transport sector.

3.3 INTERVIEWS

A number of (telephone) interviews have been carried out with potential users of the SPECTRUM rail freight concept, such as cargo owners and logistic service providers. After explaining some of the aimed generic features of the rail freight concept (e.g. high speed, high reliability, possibility of transporting temperature controlled goods and long-distance transport as well as urban distribution), the following questions have been asked:

- Would your organisation make use of the SPECTRUM rail freight concept if it was in operation?
- For which type of products would your organisation use or not use this rail concept (e.g. due to the time sensitive characteristics of the products)?
- For time critical products, sometimes a premium is paid in order to deliver the goods faster. Which of the identified products fall under this category? And for which is cost competitiveness more important?
- How much could be transported (e.g. in tonnes, TEU, pallets and/or share of the total volume normally transported)?
- What are the current bottlenecks for not using rail transport for these goods?
- What are the requirements of your organisation?
- What product and service attributes would you require of a rail freight service to convince you of the capabilities of rail?

A broad variety of shippers and transport / logistics service providers have participated in the market intelligence interview round:

- B.Braun: B.Braun is a shipper/producer of a range of high value medical products;
- BLT: a logistics service provider/freight forwarding company;
- GLS: GLS is a parcel and express service provider active in 42 European states;
- Kautetzky Internationale Spedition GmbH & Co. KG
- Lekkerland: Lekkerland supplies both food and non-food products to various stores located in urban areas all over the Netherlands (varying from the city centres of large cities to petrol stations);
- MS Mode International: MS Mode is a company in the fashion retail sector with approximately 400 stores throughout (West-) Europe;
- Royal FrieslandCampina: is a multinational dairy company[6], whose products are sold in over 100 countries;
- Shuttlewise (intermodal service provider): a Dutch intermodal operator, which owns an operational branch in Italy, currently manages few clients carrying temperature-controlled goods. Shuttlewise organises shuttle intermodal trains along Benelux-Germany-Italy corridor.
- Viessmann: shipper/producers of heating systems;
- VTL: VTL is a groupage network/co-operation of freight forwarding companies;
- Wim Bosman: Wim Bosman is a logistic service provider in the Netherlands that operates world wide as part of the Mainfreight team. Within Europe, Wim Bosman performs amongst others: national distribution, international groupage transport, European express distribution, etc.

[6] The product range of Royal FrieslandCampina consists of baby and infant food, milk-based drinks, cheese, milk, yoghurts, desserts, butter, cream, milk powder, dairy-based ingredients and fruit-based drinks.

3.4 RESULTS FROM INTERVIEWS

The following sections present the main results obtained from the market intelligence on the market potential, opportunities and barriers of the SPECTRUM rail freight concept. Whenever possible (due to confidentiality), the original comments from the interviewed companies are given, excluding repetitions of the same arguments.

3.4.1 Type of products

A number of target market segments where innovative rail services can be a real alternative have been defined. These are:

- General cargo:
    - Palletised cargo;
    - Swap bodies carrying general cargo (e.g. parcels/boxes);
    - Containers (ISO and European dimension)
    - Groupage of general cargo currently transported in semi-trailers;
- Food products, such as confectionery and drinks;
- Horticulture products (e.g. flowers);
- Fresh-, cooled and deep frozen products needing to be conditioned at 5 degrees Celsius and -20 degrees Celsius respectively;
- Medical pharmaceutical products sometimes needing temperature controlled equipment;
- Spare parts (e.g. for heating technology) and the automotive sector.

One of the interviewed companies mentioned that the use of a SPECTRUM rail concept would not depend on the type of products, but rather on the location of the service (e.g. near the DC's/shops).

These commodities are part of the selection of LDHV commodities.

3.4.2 Reasons to use the SPECTRUM rail concept

Almost all of the interviewed companies mentioned that if a SPECTRUM rail concept would become available within 5-10 years, they would consider using the service. The main reasons to use the SPECTRUM rail concept for LDHV goods presented are:

- The need for reliable transport modes.
- The need for fast transport.
- The need for cost competitive transport modes: most interviewed companies are interested if the rail service would be at least at the same price level as road transport and has similar and/or faster transit times, but is reliable and environmental friendly.
- The possibility to use swap bodies (with grappler arm or other lifting devices for cargo handling) on trains.
- For the transport of large volumes of cargo per consignee.
- For terminal-terminal services.
- The SPECTRUM rail concept could compete in specific circumstances with airfreight transport.

Only one company indicated not to be interested in the SPECTRUM rail freight concept. This company states that their transport volume is too small for a rail service. Another company mentioned only being interested for international transport and not for national transport.

In the view of some interviewees for national distribution, distances are relatively short, so it will be difficult to make up for the additional costs that are incurred for terminal handling which is needed two times unless asset productivity is much higher and more rail based trips are achieved per unit time to win the cost advantage. Also, additional handling implies additional risk of errors, such as delays or damages. Rail needs to get its cost base down through better product and service presentation allied with intensive use of the rail vehicle assets with minimal dwell times.

The distances for international transport are generally longer. However, the international rail freight service needs to be competitive in terms of total lead times and costs.

3.4.3 Time versus cost competiveness

Several interviewees indicated that for goods requiring a maximum transit time of 24 hours a premium is normally charged. The premium depends on the delivery times. Of the LDHV goods, only the *additional late shipments* of the different categories fall under time critical deliveries.

For deliveries longer than 24 hours, normally, no surcharges are paid. Most of the LDHV goods are more cost sensitive. For these deliveries, the cost aspect is considered more important than the transit time. In this case, if the transport costs by train are higher than by trucks, there seems to be no reason to have them delivered by trains.

One of the exceptions to this rule is when considering the expected road congestion in the coming years. If road congestion increases and it would take longer to transport goods with road than with rail (which also increases the road transport cost), then rail will become more attractive for these type of products. However rail should not rely upon the discomfiture of its primary competition and expect traffic to automatically transfer to rail.

Another exception is when looking at the total costs. If the costs of a stock keeping location can be reduced, because the shorter transit time by using train can be met, rail transport becomes interesting and potentially competitive as well.

3.4.4 Potential volume

The interviewees indicated that the potential volume for the SPECTRUM rail freight concept is difficult to estimate, especially because the concept has not been developed yet. This will mainly depend on the costs versus the service level between the SPECTRUM rail concept and road transport.

The volumes and/or shares mentioned during the interviews are very diverse: from 200 kilograms per day (for late shipments) to 1,500 swap bodies per day for terminal-terminal services. One of the interviewed companies mentioned that if the DC's and shops would be relatively close to a railway terminal and the service requirements are met, then they would consider transporting all their products by rail. This has implications for the type and location of future terminals to accommodate and service any new train concepts and services.

3.4.5 Bottlenecks in the rail sector for the transport of LDHV goods

The current bottlenecks seen by the surveyed companies are:

- Additional handling costs and time: intermodal rail transport is considered by some to be cost and time consuming: using trucks for the pre- and end-haulage, requires additional handling and thus additional costs. Also if a terminal is relatively far, a 24 hour door-to-door transit time will be difficult to reach, allowing thus only for 48 hour transit times. This suggests a degree of inflexibility to work around terminal times and preferred delivery slots at shippers/customers preferences. These items will need to be examined to identify if rail based solutions could work in this context. Also, trucks may lose time in traffic jams, but using intermodal solutions may incur time penalties in handling but these can be minimal. Rail-based inter-modal chains need to be transparent so that any delay incurred by the pre/end haulage, terminals and shipper is not automatically left at the feet of the rail service providers.
- The density of the rail terminal network: often the distance between the nearest rail terminal and the point of delivery is too large. In these cases, the potential time advantage in pure transport is lost due to the re-loading of goods again on to trucks and the long pre- and end-haulage distance. This may have implications for new terminals and also the service times at existing terminals.
- The rail sector is considered by some to be inflexible and/or unreliable (e.g. labour dispute). For time critical products on shorter distances, railway is not currently considered as an alternative for road transport. In case of congestion: a truck has the flexibility to deviate from its original time scheme. With railway transport this flexibility can be lost using current operational and technical models.
- The opening and closing times of many intermodal terminals does not fit with the needs of the clients. The move to 24/7 operation may become mandatory. All major terminals need to be open and not limited to one original owner.

- The unwillingness of some intermodal transport operators to adapt the transport schedule for smaller shipments. This is a commercial risk that could be influenced by responses and requests from the shippers. The greater share of the market is made up of many small and intermediate shippers/receivers whose pattern of operations does not readily align with the production and operational pattern of the rail operators who remain solidly fixed on a supply side position.
- Ordering and providing wagons is considered to be complicated and time consuming. It could and should be a lot easier. Models from North America might be usefully investigated to identify how this process could be made much more efficient. The use of fixed formation wagon sets might also be considered.
- Failures experienced during other projects focusing on shifting cargo from road to rail. One of the interviewed companies mentioned that they tested this possibility. However, because the service did not meet the company's demand with regard to reliability and flexibility, the project was stopped. These deficiencies need to be recognised and addressed as a fundamental re-positioning strategy within the rail freight sector.
- Infrastructural investments needed and related costs: there is the necessity to invest in new wagons. Normally, these investments come from the intermodal operator or a leasing company and, in the present economic scenario no additional tariffs for intermodal haulage are realistic unless there are specific service, quality, availability and security benchmarks which could generate a premium income stream.
- Specifically for pharmaceutical product, there are additional requirements in terms of seamless monitoring of temperature (temperature range set for the temperature in the loading space) using sensors and data loggers and quality standards and regulations (GMP, HACCP, AMWHV) that have to be strictly complied with. In these markets it would be expected that the intermodal load transfer and delivery in the destination must be taken/arranged by the SPECTRUM train service provider.

3.4.6 Market requirements

The interviewed companies have mentioned the following needs and main requirements:

- Transport must be reliable: the reliability of the rail service must be kept at least at the same level of as road transport (minimum 95% of the goods delivered within an agreed number of hours timeframe). This should not be a goal, but a requirement. If deliveries of consumer goods to shops located in the city centres with time-windows are taken as an example, the goods need to be delivered on time with a maximum 2 hours deviation.

  If the goods arrive late, the delivery must take place on the next day (i.e. higher costs and time loss). This might be offset by moves to spread and incentivise logistics delivery windows ahead of the morning and after the evening peak commuter flows including appropriately safeguarded night-time deliveries.
- The rail service should be cost competitive with road transport (including the additional handling costs). Some of the interviewed companies mentioned that they would consider a slower (e.g. 1 day longer) door-to-door SPECTRUM rail concept for non-time sensitive products, only if the costs advantages would be significant. For time critical products, fast and reliable transport is more important than the costs. Rail needs to outperform road transport on the terminal to terminal times by exploiting its inherent speed and energy advantages.
- The rail service should have competitive transport times compared to road. For some products a <24-hour transit time service is needed. Rail needs to develop a competitive and attractive capability to participate in this market.
- The rail service should be agile and flexible (be available on demand 24/7).
- The rail service should have frequent departures to reduce the time spend at the hubs. This argues against the case for large trains with extensive loading and discharge times and supports shippers/receivers requirements for frequent replenishment.
- The rail terminals or loading points should be close to the DC's, logistics parks and the customers of the companies to avoid time and costs consuming pre- and end-haulage.
- Ability to transport different type of temperature controlled products at the same time (e.g. fresh and frozen goods requiring different temperatures).
- The need for an integrated door-to-door concept: from the DC to the customers.

- Increase the possible destinations: for example using freight trains able to load and unload goods wherever there are rail tracks. This raises issues of local distribution and collection at such locations together with security and environmental issues such as noise generated by truck arrival and departure.
- Extend the opening and closing times of the rail terminals. 24/7 should be the target to sweat the assets in the terminals and the supporting rail and road services.
- Safe and secure transport is required: high quality standards are required, for example, to transport of foodstuff, spare parts and pharmaceutical products. Condition monitoring and security need to be in place through the whole transit.
- Incorporate the service with a last-mile solution: conventional railway transport cannot usually perform the last mile distribution to a store. Therefore, some facilities at the railway station or terminal would be needed, where the goods can be transferred from the train to another vehicle (e.g. an electrical truck).

  If these facilities would be extended in such a way that they could be used as a temporary storage location, then it would be possible to transport the goods by train during the night (no or less passenger trains travelling) if daytime train paths were not available.

  The goods can then be transported from the storage facility to the stores during the day (e.g. within the daily delivery time-windows). It is important to recognise that delays in deliveries and collections between the terminal and consignor/consignee are not always attributable to the rail component of the inter-modal service.
- Build and integrate new business parks around rail sidings where this is feasible. The use of alternative (shorter) train configurations might be a more cost effective means of getting rail into play in this sort of scenario. The cost of civil infrastructure to accommodate large orthodox trains could be a deterrent to such proposals.
- The rail infrastructure and the trains (e.g. wagons) need to be improved considerably. Wholly new concepts and methods of operation need to be tested to maximise competitiveness.
- The control and planning of trains also needs to be reviewed to bring a greater dynamism to this area of operations with a much more interventionist style to drive up train productivity and spread costs.
- Rail also needs to develop a capability to be able to respond rapidly to spot or short-term traffic offers or it risks losing traffic governed by such conditions to road as the default option. The ability to bid for, fix, trade and swap train paths is an area that needs to be developed to support rail's aspirations in volatile markets.
- Railway infrastructure is expensive to build and upgrade. Methods to simplify connections to lines governed by complex signalling and power supply issues might be usefully investigated.
- The identification and re-commissioning of old and disused rail head facilities might also be usefully undertaken to determine if any of these offer opportunities for the development of new terminals and logistics parks.

3.5 CONCLUDING REMARKS

Based on the market intelligence reviews and interviews there is enough potential to launch a new rail services for LDHV goods in Europe, if the needs of the shippers are met.

- Reliability is considered to be the most important requirement. For many shippers, this is even more important than the transit time itself. A minimum of 95% of the goods delivered within an agreed number of hour timeframe is an absolute imperative.

  Especially, considering that road congestion is expected to increase (causing more delays), rail transport can have a competitive advantage but rail needs to address its own reliability and consistency position and performance.

  SPECTRUM should focus on how to set-up a reliable rail concept in order for it to be successful (e.g. using track and trace possibilities and an interventionist management position to react rapidly when goods cannot be delivered on time).

  Shippers need to be informed in the event of service disruption and a revised estimated time of arrival. Shippers above all in this situation need to be kept fully informed. This may point to their being able to interrogate shipment status independently of the service provider using models from other sectors notably air freight and small lot logistics.

- Most of the products shipped by the surveyed companies are not highly time critical. This means that the goods can be transported within a 24 to 48 hour transit time using the necessary transport equipment (e.g. condition monitoring equipment). Therefore, the SPECTRUM rail concept should start by focussing on the transport of these types of goods but the aspiration to improve upon this should be retained. The surveyed companies requiring a maximum transit time of 24 hours (e.g. for additional late shipments), stated that they would leave the transport to road express logistics providers unless rail could provide a routinely reliable convincing alternative.
- The conclusion stated above indicates that the costs for the rail service should be equal or lower than road transport. Only for time critical deliveries can the costs be higher and express logistics providers usually do these. On the other hand, when looking at the total costs (e.g. including inventory costs and additional costs caused by increasing road congestion), the costs of the rail service can be lower if a high reliability can be routinely assured.
- One possible method to decrease the transport unit cost by rail for a company is by increasing the volume transported per train. However, in the LDHV market this is one of the main challenges. Most of these companies have frequent shipments with small volumes. These volumes cannot fill a dedicated orthodox long locomotive hauled train. Therefore, bundling of goods is required if the goods are to be transported by rail. Bundling of goods can increase the total cargo transported and decrease the costs.

  This may be achieved by increasing the number of possible loading and unloading points, for example using existing or building new rail sidings near business parks where trucks and trains can load and unload goods rapidly. Changes to load factors, cut-off points for acceptance and the tolerance of variable load factors using regular scheduled trains may have to be accepted if rail is to become a recognised and credible player in this field.

4 Case study results

4.1 INTRODUCTION

Four case studies have been carried out with the active participation of the SPECTRUM input partners. Business oriented projects like RETRACK and CREAM have showed that, in successfully developing business cases, this needs to be worked out in detail at the lowest level including financial arrangements between partners in a transport logistics concept.

Therefore a micro approach has been used besides the macro approach applied in the Global Trend Analysis and the Transport Demand Analysis in order to get to the level of a feasible business model. The following business cases have been analysed:

- **Procter & Gamble (P&G)**: Transport of various low-density high value goods over distance and into conurbations and/or urban agglomerations.
- **FloraHolland**: Transport of temperature controlled flowers and plants, representing 60% of the EU horticultural market.
- **EUROCAREX**: Airfreight within a network of airports.
- **Innovatrain**: Transport of consumer goods and parcels using rail in innovative and competitive services.

The case studies have been carried out according to the 'Case Study Guidance' document (see Annex). Below each case study a brief description and the summarised results are presented. The full case studies are documented in individual reports.

4.2 PROCTER & GAMBLE

4.2.1 Description

Procter & Gamble Co. (P&G) is a multinational corporation that manufactures a wide range of fast moving consumer goods. Before 1992, almost each European country had a P&G production plant that served the demand of that specific country. Since 1992, with the opening of the borders and because of cheaper transport costs, this pattern changed.

There are now specialized production plants and National Distribution Centres, where the goods of each specialized production plant are bundled and distributed to the customers and/or other P&G production plants. This emphasises the impact that new developments in the transport sector could have on a company like P&G.

In the year 2008, P&G started the TINA project (Trains, Intermodal, a New Approach). The objective of this project is to achieve a 30% shift from road transportation to an intermodal set-up by 2015 from a starting position of 10% in 2008. The main objective of this case study is to examine the possibility for P&G to further extend the use of rail transport in their European transport operations and the conditions to accomplish this objective.

For this case study the selected route was: Amiens (France) – Mechelen (Belgium) – Euskirchen (Germany). When taking costs into account, door-to-door road transport (current situation) is noticeably cheaper compared to rail transport. The main influencing factor behind this is the high costs for pre- and end haulage due to the relatively large distance between the selected production plants/DCs and the chosen rail terminals.

In general, this is one of the main barriers for many companies wanting to use intermodal options. When these costs are not taken into account, rail transport becomes cheaper and potentially P&G could transport 87% or more of their cargo by rail.

The high costs for pre- and end haulage can be reduced using an existing rail terminal closer to the production plants/DC of P&G. or using P&G road transport assets to better effect on short distance terminal deliveries. Another possibility is using horizontal transhipment systems that can be installed next to a railway siding (close to the P&G locations) or on a truck.

The Metrocargo system and the Innovatrain container mover handling device are two of these systems. Evidently, a transport operator would have to invest in new infrastructure if needed (e.g. rail tracks) and the new transhipment system. The handling costs that are currently charged for these new systems to the clients (e.g. P&G and other companies located near them) are similar to those charged at traditional rail terminals.

The time comparison also showed that road transport is more than two times faster than rail under the current standard rail situation. If a faster transhipment method would be used, like horizontal transhipment and the long pre- and end haulage would be avoided, the transport times with rail would decrease significantly. However, it would still take longer than road transportation.

This depends on the train size to load and discharge and shorter trains might be an appropriate option to consider. Since reliability is one of the most important requirements for P&G (and not speed) and their products are not time-critical, rail transport could be an attractive option for the transportation on this network.

4.2.2 Results

The cost comparison between road and rail provided useful information about the main factor influencing the higher costs for rail, namely the high pre- and end haulage costs. In general, this is one of the main barriers for many companies wanting to use more intermodality. In further tasks of the SPECTRUM project, the different possibilities presented in this case study to overcome these barriers (e.g. the Metrocargo system and the Innovatrain rail concept) will have to be further analysed.

One has to keep in mind that the calculations have been based on one selected route. The outcome might be different for other corridors. Especially with relatively short distances (<200km), where road transport might be more attractive than rail freight transport, unless rail has a product and service offer that can compete fully at this sort of distance threshold.

However, P&G has different specialized production plants in many countries, most of them being more than 200 km from each other. This potentially makes rail transportation an attractive solution, if the main barriers can be overcome. An important issue to keep in mind is the impact of a new SPECTRUM rail concept on a company like P&G. Three possible impacts could be expected:

- On the short-term: more intermodality. This could be achieved by using more rail transportation for relatively long distance trips using the traditional rail concepts.
- On the medium-term: possible investments by logistic operators in new technologies and/or infrastructure and that could be used by clients such as P&G.
- On the long-term: possible changes in the location of the production plants and/or distribution centres, where it is more convenient.

4.3 EURO CAREX

4.3.1 Description

The air freight industry has to operate and interact with different type of players, making it a complex, open and dynamic market. Pricing in the air freight industry can be considered as market based and not cost based, since different commodities on the same route may be charged at widely different rates with no marked differences apparent in the costs of handling and freighting them. EURO CAREX is investigating the setting up of a reliable, secure and fast overnight rail transport service for this complex transport sector.

EURO CAREX is a European rail freight transport service that will use the existing high speed rail network to connect the different CAREX air-rail terminals or rail ports, located close to airports. The concept is to carry airfreight pallets and containers with time-sensitive, low density and high value goods using high-speed trains over distances between 300 and 800 kilometers. These goods are traditionally transported by airfreight and express cargo companies with aircrafts or trucks (with an airway bill). Around 50% of air freight in Europe is currently being trucked (called air trucking).

During a first phase of the project that runs until 2015, the EURO CAREX rail service will link the airports of Amsterdam-Schiphol, Liège, Lyon-Saint-Exupéry, Paris-Roissy-CDG, the London Airport Area and Germany (Cologne or Frankfurt). In the future, the network may be extended as far as Italy and Spain.

This case study analysed the link between two of the rail ports expected to operate during the first phase of the project: London and Amsterdam. This route has been chosen in part because of the volumes of airfreight transported along this link by road and in part because of the current travel time spent between these two locations. The new rail freight service between these two locations will be almost twice as fast on a point-to-point basis as the transport time spent using a truck. This is especially interesting for the express cargo sector.

EURO CAREX is expected to offer three types of services with differentiated rates:

- The "Express" service operates for reserved freight flows on the assigned train, with next-day delivery, guaranteed lead times and flexible volume commitment. This new high-speed service is set at a higher price comparing to the other services and is intended to capture freight flows currently being transported mainly by aircraft (expected to charge around 10% less than the real airfreight tariffs for express cargo transported by air);
- The "Rapid" service operates for reserved freight flows on the assigned train, with next-day delivery and guaranteed lead times, but with the possibility that flows may not travel on the assigned service, depending on train capacity. For this type of service, the price point is lower than that for the Express service, and is designed primarily to capture trucked airfreight flows (expected to charge around 10% above the real air freight trucking rates);
- The "Deferred" service is designed for freight flows travelling without reservation for delivery lead times of between one and three days, with no guaranteed lead time and availability governed by train capacity up to 2 days (yield management). This service is set at a low price point to attract freight flows currently travelling by HGV (expected to charge just below the tariffs for the “Rapid” service).

4.3.2 Results

A market study performed for Amsterdam CAREX summarizes the main advantages of the EURO CAREX high-speed rail service[7]:

- A higher reliability expected in time performance levels compared to road and conventional rail transport due to the absence of traffic jams and by travelling at night.
- Rail transport can be more environmental friendly than road transportation.
- Once in the train, products are more secure than in a truck.
- Travelling at higher speeds decreases the throughput times on long hauls, enabling the creation of new markets.
- Using rail transport could be cheaper in the future compared to road transport (i.e. absence of fuel surcharges and European road pricing measurements).
- There is a key issue in airfreight that alternative services are available if a booking is missed on a certain designated flight. If rail services are only rotating once or twice per 24-hours then this is a disadvantage.

These advantages are essential for the transport of time sensitive LDHV goods. However, the use of the EURO CAREX high-speed rail service between London and Amsterdam will ultimately depend on the main requirements of the shippers.

For some products (such as express cargo), reliability and the total door-to-door transit time is more important than the costs. In this case, the EURO CAREX high-speed rail service could succeed by transporting the cargo in around half of the time compared to road haulage. It does still however need a road pre/end haulage component or linkage to other rail networks.

For goods with urgency, but not necessarily having to arrive in 4 hours (i.e. air trucking cargo), a 10% increase compared to air freight by truck could be unattractive. However, the EURO CAREX service becomes attractive when considering the expected increase of the road transport costs in the future and the decreasing reliability due to congestion.

On the other hand, to be able to attract less urgent freight flows currently travelling by HGV (‘deferred’ service), EURO CAREX will have to decrease the rates a lot more than just below the rates that will be charged for the ‘rapid’ service. For these goods, costs are the main influencing factor. The current transport costs using a conventional truck for the route London-Amsterdam are 5 times cheaper than the expected rates for the ‘rapid’ service.

Besides reliability, low costs and door-to-door transit times, the market players in the air freight sector also require: track and tracing systems, back up systems in case of calamities, safe transport of goods, possibility to transport temperature controlled and normal ULD’s and/or other type of transport units (e.g. ‘Danish trolleys’).

The EURO CAREX concept will also need low noise transport equipment since the train will be travelling at night. Moreover, a mental shift will be needed to shift the LDHV goods from road to rail, since rail operators are not considered (correctly) by the shippers and logistic providers as market orientated.

These requirements are important for the SPECTRUM project. In order to attract sufficient LDHV volume to the rail transport market, changes in the traditional rail sector will be essential. The EURO CAREX concept will have to overcome the main barriers experienced in the rail sector and introduce a high-speed rail service that could meet the requirements of the players in this complex and dynamic sector.

[7] Source: Chapter 5, Market analysis qualitative findings, Districon, 2011.

4.4 FLORAHOLLAND

4.4.1 Description

FloraHolland is based in the Netherlands and it is the largest flower auction organisation in the world. FloraHolland has five fully owned auction houses, located in Aalsmeer, Naaldwijk, Rijsburg, Bleiswijk, and Eelde, and one joint-venture Rhein-Maas auction house in Herongen, Germany.

These market places are well connected into a single logistics network. In 2010, FloraHolland traded about 12.3 billion floricultural products. Of all the exported volume 98% has been delivered by road and less than 1% by rail transport. The main activities of FloraHolland are:

- Logistics provider for in-house distribution.
- Facility management.
- Clearing house.
- Auction and intermediary organisation.

The GreenRail initiative, which FloraHolland launched together with a few other partners, concerns the transportation of ornamental plants by rail across long distances from the Netherlands to Italy. The reasons for choosing the route to Italy is because of the maturity of the railway connection from the Netherlands towards Italy, the availability of the rail freight services to Italy, and the big export market for the floricultural industry in Italy.

This secured GreenRail for the minimum threshold for piloting. In the year of 2009, a total of 80 containers of plants have been transported by rail using the existing shuttle services from the market. GreenRail demonstrated that it is possible to have a commercial proposition with rail transport for time critical perishable products. The key is to separate predictive part of the fast moving products and the less predictive part of the fast moving products.

In GreenRail, FloraHolland acted as a supply chain facilitator where it controlled the logistical information flows and contracts, bridged know-how's from the different segments and used them to develop intermodal rail solutions.

The chain coordination and operational management was outsourced to E-Logistics Control. The rail service was operated by HUPAC and the pre- and post legs were taken care of by 3PLs such as Van der Slot Transport, Ewals, and GAP.

The container used in GreenRail was specially designed for carrying floricultural products in order to provide maximum capacity for the roll cages (43). The built-in cooling system in the container saves cargo space and combines maximum cooling capacity with energy economy, which allows the plants to be chilled for 10 successive days.

The GPS/GPRS system allowed the shippers to monitor the location of the container, and to adjust the condition inside of the container when needed. During the execution GreenRail has encountered the following barriers and issues:

- Lack of confidence from both the floricultural industry and the rail freight sector in transporting perishable products by rail;
- Little understanding from the rail sector of the logistic requirements for perishable cargoes;
- Few initiatives and business developments by the rail cargo industry;
- Insufficient communication between players along the entire supply chain;
- One standard service level (low by comparison to road) for all products offered by the rail sector;
- Inconvenient opening time at the destination terminals;
- Long waiting time during the rail transport; and
- High cube containers cannot be transported on all rail tracks throughout Europe.

The most important logistic requirements for transporting floricultural products are:

- Reliability (most important);
- Price;
- Time;
- Service flexibility;
- Sustainability;
- Availability of service.

Several measures, ideas and lesson-leant from GreenRail that can be useful for Spectrum are:

- Assign a single point of contact that coordinate the entire intermodal supply chain for the shippers;
- Maximise overall operational performance (e.g. road, rail, terminal) to ensure reliability for the door-to-door transport. This implies a much more responsive and interventionist management posture within the rail sector to ensure transits are completed with minimal delays and disruption.
- Minimise supply chain costs by selecting the right partners;
- Provide a flexible rail service booking system for the shippers;
- Make contingency plan for rail transport to minimise the effect of sudden events and secure the reliability;
- Build extra intermodal rail terminals or pilot using mobile inter-modal equipment ahead of infrastructure investment (e.g. Containerlift) to accommodate increasing continental flows from the Netherlands to the European hinterland.

The potential to extend the GreenRail initiative can be realised by focusing on exploring the following possibilities:

- Larger European market: not only plants towards Italy can be carried by rail, but also some other EU countries such as Poland, Hungary, and Romania could be explored. The real test is to break back into sophisticated transport markets covering most of Western Europe and roll back the dominant market share held by near universal road transport.
- Higher volume of plants to be shifted from road to intermodal rail transport. This would require more cooperation from the larger European customers.
- Identify more market segments to be transported by rail, from plants to flowers, fruits and vegetables, foodstuffs, dairy products, and even electronic consumer goods. This requires a proactive stance from all stakeholders along the chain and especially the rail operators and associated consolidators/3PLs.
- Developing the rail freight transport in terms of train speed and seamlessness of acquiring and using train paths.

A comparison is made between uni-modal road transport and intermodal rail transport in terms of costs and transit time on the route Rotterdam – Busto Arsizio. With regard to total operational costs, intermodal rail transport is more efficient than road transport accompanied by two truck drivers.

But compared to road transport with only one truck driver, intermodal rail transport becomes less cost efficient. It should be noted that this comparison is made under the pilot situation where only 80 containers of plants were transported in the pilot year.

In practice, the pulling of more cargoes from the flower exporters would lead to higher scale economy, and subsequently the cost advantage of intermodal rail transport is expected to become more apparent than that of road-only transport.

Regarding total transit time, it takes longer for plants to be transported by intermodal rail than by road. Compared to the one-truck-driver scenario, it takes about twice as long to have the plants transported by rail. Compared to two-truck-drivers scenario, it takes 60 % more time by intermodal rail transport.

As analysed in the case study, the ornamental plants belong to the more predictable fast moving products and the shelf-life of plants can go up to a few months. Therefore, longer transit time (as long as it's predictable) forms little problem for ornamental plants transport. In conclusion, it is not the time but the reliability that determines that the freshness and the commercial value of the products in the market.

4.4.2 Results

This case study proves that it is possible to have a commercial proposition with rail transport for time critical perishable products over longer distances throughout Europe. The critical factors that have contributed to the success of GreenRail and could lead to further development of this concept in the LDHV market are summarised in the following:

- Distinguish the differences in logistic requirements between the predictive part of the fast moving products, which can be ordered more upfront (e.g. plants) and the less predictive part of the fast moving products, which needs to be ordered at latest moment (flowers). Start planning a rail service proposition for the predictive part of the fast moving products. This makes the synchro-modal transport possible where exporters (or chain coordinators) can determine at any moment the right transport mode that best meets the requirements of the customers. This suggests that the rail product and service offer has to be competitive or better on cost as well as being as attractive in transit times as the road based competition. Rail should be able to exploit its speed and energy efficiency endowments to achieve this.

- In the time critical floricultural market segment, reliability is still the number one requirement over price and time. The products need to be delivered not too early since the flower shops are still closed; but also not too late since the shops are already opened. The just-in-time mentality needs to be carried by the stakeholders along the intermodal transport chain.
- Bundling of goods is a necessity to realise low costs and commercially viable rail freight services. Involvement and cooperation of big European market players are a must in this if the rail market of the floricultural products is to be further explored. The bundling of floricultural products with other time critical LDHV products which have similar or non-conflicting logistic requirements can also be considered where flow origins and destinations are congruent.
- A comprehensive contingency handling plan mitigates the effects of sudden incidents and helps secure the level of reliability of transport and safety level of products. It is an enabler for a sustainable modal shift. Communication with the stakeholders and short response time are crucial for a good execution of the contingency plan.
- Technology plays a role in facilitating the use of rail services for time critical and temperature controlled products. A special designed reefer container with energy efficient built-in cooling system offers maximum capacity for the flower roll cages and constant temperature control for successive ten days. The GPS/GPRS system allows shippers monitoring the real-time location of their containers and to adjust the condition inside the containers whenever needed.
- Attention could be focused, on train paths for freight with fewer or no intermediate stops, coordinated terminal opening time, availability of continental rail terminals close to the shippers' premises, upgrade of rail lines to allow 45ft continental containers, flexible service booking systems, and differentiated service levels offerings to the customers to meet the different logistic requirements.
- No modal shift without mental shift. The traditional perception from the floricultural sector, and perhaps also other sectors that deal with fresh and perishable products, is that road transport is the only solution. It is however wholly dependent on liquid hydrocarbon fuels at a reasonable price.

The longer-term availability and security of supply, before any consideration of emissions compliance, suggests the road sector has major endemic problems if it insists on maintaining this position. Continued direct communication with the sector to clarify misunderstandings and to minimise unnecessary negative criticism helps the sector to be open for the possibility of rail transport as an alternative.

4.5 INNOVATRAIN

4.5.1 Description

InnovaTrain is a company that developed an innovative logistical rail freight solution based on the concept of a cargo shuttle train. This solution was implemented in practice. The "RailXpress Cargo-Shuttle" is currently running between the Eastern and Western parts of Switzerland. It has been operating successfully for two years now (launch in 2009), with an annual transport volume of about 20,000 containers. There are four major technical components of the concept:

- The InnovaTrain solution relies initially on 7.45m swap bodies that are used in continental road/rail traffic. Refrigerated units allow for the carriage of perishables. But also other types of transport units of similar length, for all other kinds of general cargo, can be provided.
- On rail, the transport units are carried by container wagons. Each of the wagons can accommodate four of the transport units. The wagons are permanently coupled in a fixed composition with a loco at one end and a driving trailer at the other, in order to avoid shunting.
- With the help of hybrid power, the train can either run on the electrical main track at speeds of up to 120 km/h, or drive into a private railway siding or in a loading track of an intermodal terminal by using its diesel power.
- Intermodal load transfer can be done using conventional vertical (lift on/lift-off) and/or horizontal transhipment technology. Horizontal transhipment allows load transfer to take place at every cargo station or private railway siding on an asphalted surface.

The InnovaTrain solution fully meets the expectations of the SPECTRUM project, because weaknesses of conventional rail freight transport of LDHV goods can be overcome. A high average speed of about 80km/h, the omission of shunting activities, and little time spent on railway sidings and in transhipment reduce lead times as well as inventory costs, and increase operational productivity.

Scheduling on regional and suburban rail networks enables frequent departures; short stop-and-go operation at intermediate sidings along the travel line enables the use of hourly slots. Flexible routing and more options for locations of rail-road cargo handling ease supply chain event management, and there is less risk of delays and breakdowns because there are less interdependencies than in complex bundling networks.

Moreover, increased productivity in railway operation, reduced pre- and post-haulage as well as low-cost handling makes short trains economically viable even on short distances. To sum up, the InnovaTrain concept is competitive with road transport with regard to time, price, and quality.

This concept requires an easy transfer capability to move swap bodies between the truck and the train.

There are no modifications to the wagons to be made beside an simple on-top intermediate frame which can be transferred to any intermodal wagon with 20' pins. .

Notably, it should not be forgotten that the success of the hybrid cargo-shuttle train system requires only simple infrastructure consisting of a rail siding and a parallel loading lane long inough to accommodate the train.

In this respect, for its clients, the InnovaTrain solution acts as a one-stop shop for the development of the train service and the underlying logistical concept, for the provision of the technical components, and for consulting around financing the transport system, as well as for developing the supporting ICT. It is a commendable development using a mix of existing tried technology (locomotive, driving trailer) and this has allowed the concept to be deployed initially on a national basis.

4.5.2 Results

The case study "InnovaTrain" shows that it is possible to carry LDHV goods by rail in a cost-efficient manner. The case reveals that the transport service offered in this case is able to compete with road transport, especially with regard to transport quality (transit time, reliability). This can be seen in the overview given below. The whole concept could be regarded as the blueprint for the development of innovative rail freight services in the context of the SPECTRUM project.

Table 4.1: Comparison of cost and time

Criterion	InnovaTrain	Road transport	Remarks
Transport costs	€ 356.32	€ 441.60	Road: 1.20EUR/km, 368km total distance
Transit time	8 h 51	5 h 25	Road: 356km on motorways, 12km other

Success factors are the space accessibility and frequent availability of the service offer, a high flexibility concerning bookings (1 h cut-off time), plus a centralised management and co-ordination of the transport service, which is either marketed to freight forwarding companies or directly sold to shippers. A close co-ordination with shippers and with shippers and logistics associations is also of importance.

Finally, the success of this case is not only based upon a technical solution. It is rather the result of the method of a transport chain: Instead of focusing on purely carriage by rail, InnovaTrain created a transport concept from door to door where rail provides the backbone over the longest possible stretch of the route.

Nonetheless, there are some requirements for a successful implementation of the InnovaTrain concept. One important aspect is railway infrastructure. Rail lines should allow for a speed of at least 80km/h. Furthermore, the rail lines should be electrified for the purpose of high acceleration, at least until a location very close to the point of load transfer.

These requirements are to be fulfilled when transferring the concept to other European countries. The case study participants see a high potential for this transport system, in particular in rural areas in Germany, in Spain, or in Sweden, where the feasibility of liner trains carrying LDHV goods was proven.

For SPECTRUM, the InnovaTrain solution is considered a good practise case to be followed by others. The overall economic case for the widespread adoption of this technology outside its home domain remains under scrutiny.

5 The logistic requirements and SPECTRUM's role in improving logistics concepts

5.1 INTRODUCTION

The new technology and service concepts developed in SPECTRUM must improve the production of rail transport services in ways that rail can enter market segments in which it could not compete using orthodox technology, systems and business management, or that rail can improve its competitive position in existing markets in which it already has a share.

Many factors determine the competiveness of (improved) railway services and therefore its chances of obtaining a position in the market. One factor is the technical capabilities of the train. Of importance are, for example, the way the train will be integrated in the logistic system (business case), and how the train will be commercialised (business model).

The technological innovation of SPECTRUM, concerning improved acceleration and higher commercial speed, can clearly reduce lead times of the railway transport leg, but benefits are likely to spread to the other parameters of the logistic chain as well, while the impact on the overall cost of transport service production may be variable.

In this chapter, the potential contribution of the SPECTRUM-design to the rail freight market is explored. The chapter describes the logistic requirements and it explains what their implications to transport service production are, and how the SPECTRUM-design could possibly improve the role of railways in better meeting them. The focus in chapter 6 is on quality parameters. Subsequent chapters 7 and 8 will describe the costing methodology used in the business economic model and apply the model for cost assessments in different market segments.

Logistics requirements comprise quality parameters of the services, next to costs and prices. Whereas costs and prices are quantified by definition, precise specification of the quality parameters, however, is rarely done and often subject to different interpretations and semantics.

There are many quality parameters in logistic requirements and often these are correlated. The first step in synthesising the market opportunities of SPECTRUM has been to create a common understanding of the logistic requirements. This section investigates the quality parameters that are referred to in the SPECTRUM project plan. These are:

- "Punctuality", which is the first of the reliability parameters and concerns the capability of meeting with agreed time schedules.
- The reliability parameter "safety" concerns the capability of transporting without damaging cargo.
- The reliability parameter "safety and controlling of cargo condition", which concerns the ability of keeping control of cargo during transport and e.g. having the possibility of intervening.
- "Security" which is an indicator of the level of protection against intentional mistreatments.
- "Speed", or its reverse parameter "lead time", to be measured between the moments that cargo is handed to and received back from the transport process.
- "Frequency" of the transport service.
- "Service availability" which reflects the extent to which clients can continuously rely on the provision of a service.
- "Flexibility" which is the capability of responding to unforeseen deviations, either in demand or supply side, from planned execution of tasks.
- The requirement of "Tracking and Tracing" which could be seen as a means of controlling but also as an additional service of visibility and transparency of the transport process by which all players in the chain can anticipate.

The evaluation of each of these logistics requirements is structured in the following pages. The evaluation of each of the logistic requirements consists of five steps:

- Definition of the requirement,
- Interpretation,
- Remarks concerning the assessment of the requirement,
- Potential improvements and benefits which can be expected from a SPECTRUM-train,
- Remarks concerning the implementation, for example conditions of success.

The assessment of logistic requirements and of their realisation needs to consider the prevailing conditions in the market. In practice, logistic requirements are correlated with possibilities. For example, a certain lead-time will only be required if it is realistic to expect that it will be met. Users of transport services on well developed corridors will have higher expectations of transport service availability and reliability than those on corridors with poor infrastructure and few service providers.

Therefore, it seems more realistic to assess required performance indicators (e.g. rate of punctuality) against those of existing transport services by road or conventional rail or intermodal transport. In the long run, acceptance of improvements of the transport system, like higher-speed rail services, is likely to influence future requirements of users of transport services.

5.2 RELIABILITY / PUNCTUALITY

a. Definition:

Punctuality is the capability to meet with scheduled timing of services, implying that delays need to be prevented and need to be minimised in extent if they occur.

b. Interpretation:

If a transport operation is on the critical path of the logistic chain, a delay will have immediate implications, e.g.:

- Lower product availability in distribution of final products with short yield times (perishables, marketing actions) which reduces sales
- Lower product value if it concerns perishable products
- Delaying the production process if it concerns intermediate products
- The need for contingency measures for undisturbed proceeding of subsequent steps
- The need for rescheduling successive handlings

Some deviation from schedule – time or frequency - may be tolerated in logistic chains which have buffers incorporated such as on cross-docking points, in intermodal terminals or in warehousing. These can be buffers in time as well as (intermediate) stocks.

Ex-ante quantification of the requirement is complex. Service contracts may concern overall operations (like the complete transport service package in European distribution), they may focus on development (improvement compared to previous year) and they may or may not make exceptions for unforeseen circumstances, etc.

c. Assessment:

Punctuality is what all clients require and demand on an increasing basis , but nowhere in the transport market can a guarantee be given of 100% punctuality. In other words, some level of “unreliability” is inherent to any transport service.

The assessment of punctuality could be based on experience in current rail freight and road freight transport segments and involve:

- The identification of the frequency and cause of attributable delays;
- The extent of delays if they occur;
- Identification of the reality of the delay: a train arriving late at a terminal which is not open for road freight collections has no serious impact on the shipper/receiver.
- Identification of risks and their consequences, e.g. rail slot allocation rules or road congestion.
- Identification of methods to recover from disruption and to advise all the necessary parties (shippers/ receivers/hauliers/terminals of any planned recovery plan including revised ETA. Shippers should not be left in the dark on this sort of issue.

Segmentation is appropriate, like between short- and long-distance, urban and non-urban, regions, product value or between other product characteristics.

For the ex-ante assessment of the SPECTRUM-train, punctuality of rail passenger trains could be taken as proxy.

d. Benefits:

If the logistic system is untouched, SPECTRUM’s characteristics will enable

- An increase of time buffers. This contributes to an improved door-to-door reliability.
- Catching up with schedule if delays occur during rail transport process.
- Better allocation of rail slots after any disorder in the railway network. This takes the assumption that SPECTRUM rail freight concepts will be accepted by Infrastructure Management into a category with better priority rules and that disruption response mechanisms are properly and fully exercised by the infrastructure manager to bring situations back to normality as quickly as possible.

SPECTRUM’s characteristics may bring about adjustments in the logistics system, which may outbalance performance on punctuality to some extent, for example:

- If higher speed is fully converted into lower lead times. The subsequent steps in the chain will have an earlier start and that way for example the area to be served within 48 hours will be enlarged.
- if better punctuality is fully converted into a reduction of stocks, by which the reliability of the logistics system as a whole will be unaffected.
- If routinely reliable smaller deliveries/collections are made inventories could be reduced and may align much more with production requirements compared to fewer big train movements which may imply short term storage and multiple handling.
- Shorter trains may be able to access load/discharge points that longer trains cannot.

e. Implementation:

The assumption is that SPECTRUM's promise that speed and acceleration characteristics will be significantly improved towards passenger train standards will be met.

These features need to be demonstrated in the design and development of the train concept and acknowledged by the infrastructure managers and certification institutes.

Infrastructure managers (IM) should accept it as special category of freight transport with higher priority in slot allocation (in the initial scheduling as well as when solving disrupted train schedules), for example same priority as intercity passenger trains. The IM will need to recognise the new fast freight trains as just another fast train irrespective of whether it is a passenger or freight operation.

5.3 RELIABILITY / SAFETY

a. Definition:

Safety is the capability to forward cargo without damaging cargo or assets in the logistic process. Safe systems avoid the occurrence of damages and minimise the extent of damage if incidents occur.

b. Interpretation:

Damages can be caused by:

- Poor packaging or lashing;
- Incidents in transhipment handlings;
- Instability and turbulence during transport, e.g. due to poor quality of infrastructure or acceleration and deceleration of the vehicles;
- Incidents in the transport services (traffic safety).
- Malicious acts of damage

Compliance of equipment with technical regulation, working with qualified staff and following safety procedures are the baseline of safety. The need for additional safety measures correlates with the value and with vulnerability of the cargo.

c. Assessment:

Logistics and transport service operators can take measures to improve safety, but cannot fully guarantee safety. Ex-ante assessment of the occurrence of damage is difficult because of behavioural component and of unpredictable causes of accidents. The extent of the damage differs between commodity types (value, danger) and depends on the severity of the incident. Assessment of the transport system could be based on experience in current rail freight segments (conventional and intermodal) and in road transport and involve:

- Frequency of occurrence of damage;
- Extent of these damages;
- Identification of risks.

Possible sources:

- Insurance data;
- Large players in the logistic service markets that administrate systematically.

Traffic safety can be assessed by performance indicators e.g. by comparing accident rate and consequence), but may be a limited contributor to overall safety. Performance rates of passenger transport could serve as proxy for occurrence of accidents of SPECTRUM train.

d. Benefits:

Benefits of SPECTRUM compared to current rail depend on:

- The extent to which SPECTRUM in its operations is better capable of absorbing the impact of unstable or poorly maintained infrastructure or other external conditions;
- The extent to which incidents at higher speed cause more damage;
- Whether it is likely that the number of incidents is reduced by SPECTRUM's operation.

Intermodal chains, in comparison to road, have the extra handling (terminal or station) as an additional source of risk but this can be mitigated.

Certain commodities may require packaging devices / procedures for the rail operation and/or for transhipment.

e. Implementation:

The SPECTRUM design may need to include extra measures that protect against vibrations of railway wagons, acceleration forces or forces during transhipment. Ideally, SPECTRUM should guarantee that vehicle the expected vibrations will not more than in road transport.

Safety of cargo can be improved by its packaging and lashing into the loading unit (or truck or wagon). Extra measurers may be needed if (vertical) transhipment is involved and/or if rail legs are involved and/or if it concerns sensitive cargo.

Important is to acknowledge that safety is to an important extent determined by a behavioural component (the way cargo and assets are treated) and depends on consistently following procedures.

5.4 RELIABILITY / SAFETY –CONTROLLING CARGO CONDITION

a. Definition:

This is a requirement for special cargo that is on top of cargo safety parameters discussed above. It entails the capability to keeping the condition of cargo under control. It could concern control of:

- Temperature (frozen, refrigerated, heated)
- Humidity
- Light / darkness
- Gas pressures or concentration

b. Interpretation:

Deviation from pre-set conditions runs the risk of severely reducing the value of the cargo or possibly creating a hazard on the railway and surrounding environment. Controlling the cargo condition implies the ability to:

- Create and maintain correct conditions for the cargo category;
- The monitoring of the status of the conditions and/or the cargo during the transport process;
- Intervene if deviations occur.

The requirement's implications are:

- To the construction of the loading unit (or wagon or truck) and to any associated equipment and energy supply that must maintain the condition;
- To have monitoring equipment installed and working with high reliability (which also may require energy supply);
- To ways of correcting deviations by automatic / remote control of equipment.

A back-up system, which is at least procedural and could involve preparedness for human "on the spot" intervention will improve confidence to the system.

c. Assessment:

Assessment of remote controlling of cargo flows is an assessment of technology and process:

- Are all elements needed to comply with the requirements installed?
- Which are risks of failure of either of the elements?
- Is the back-up system adequate and workable?

Reference is what is currently accomplished in conditioned road transport chains as a minimum.

d. Benefits:

Benefits are the reduced costs of damage. Important variables are the product value and the volume of traffic that is attracted.

Certain conditioned transport is already moving by train and can do so with lower risk of failures of the system. Most benefit is to be expected from cargo attracted from its current road-based solutions, which can be realised if solutions for the special products are convincing and sustained.

e. Implementation:

Conditioning of cargo itself is mostly proven technology, but the novelty is in the remote controlling of conditioned cargo in railway and intermodal and the accomplishing of a minimum risk of failure during the transport process. This capability is widespread in the road freight sector so technology transfer from one modal sector to another might accelerate the adoption of this approach.

Simulations or tests will be required for proving that equipment does not fail, power supply is continuous, data transfer between train and control centre on/off board runs well. Suppliers' guarantees and warranties will need to be assessed.

This should include e.g. resilience against heavy weather conditions, power failure in the railway net, tunnels, triggers in the event of loss of power to alert the monitoring parties.

The system will provide more confidence if contingency measures (e.g. how to organise manual intervention) are well developed. E.g. in ultimate circumstance cargo needs to be removed to other transport units (trucks). This has implications for interoperability between rail and (e.g. refrigerated) road transport.

5.5 SECURITY

a. Definition:

Secure transport chains are protected against intentional mistreatment (theft and robbery, malicious damage and vandalism, terrorism, trafficking and smuggling).

b. Interpretation:

Prevention from access to cargo or the loading and/or transport unit is the most basic security measure. This is partly done by physical measures (fencing, construction of the equipment, locks). Monitoring and alarm systems as well as effective subsequent policing will further hinder mistreatment.

Specific arrangements are in place for passing through ports and border crossings, requiring compliance with legally defined procedures. Operators and authorities can take further measures on spots in the transport chain where trucks or wagons are stationary, like truck and wagon parking areas, equipment storage areas, marshalling yards, terminals and transhipment yards. The monitoring of the dwell time of any equipment should offer a basis for the interrogation of cargo modules for security intrusions. Automated activation even when cargo modules are not moving would give a measure of continuous monitoring.

c. Assessment:

Quantitative assessment of security levels is complicated, because it requires data about incidents that are low in number and rarely accessible to the public.

A qualitative approach of identifying risks within the logistic chain and measures to prevent is e.g. done in ISPS-assessments in ports. It involves assessment of:

- Opportunities given to abusers of the logistic chain and
- Measures to prevent abuse or mitigate risks.
- The involvement of police and the ability of other security agencies to intervene

Differential analysis would compare risks in SPECTRUM train and transhipment with conventional intermodal train and/or road transport.

d. Benefits:

The security benefits of SPECTRUM – if any - most likely are to be expected from the uninterrupted operations. Compared to current rail freight operations, the SPECTRUM wagon set will spend less time on sidetracks or marshalling yards so less opportunity is given to enter them. Also the train in manned by the driver throughout its operation and transhipment of the loading unit occurs immediately after the arrival.

e. Implementation:

Higher value commodities – typical to SPECTRUM's target market, require convincing security measures throughout the logistic chain.

Security imposes requirements to strengthen the design parameters for the construction of the ILU[8] or wagon and to credible locking and sealing devices including e-seals. Monitoring (tracking and tracing) of movements may be preventive and can support the process of retrieval or policing if events occur.

Additional requirements may be needed for restoring or backing up transport of specific equipment like engines in temperature-controlled transport in case events occur. These sort of scenarios need to be identified.

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[8] ILU – Intermodal Loading Unit

5.6 FREQUENCY

a. Definition:

Number of departures and arrivals should be such that services can be incorporated in the logistic chain and align with the requirements of the shipper/receiver.

b. Interpretation:

Frequency should be taken together with timing. In many segments extra departures / arrivals on weekend days, departures during morning hours or arrivals in the evenings are of no relevance (except that they add capacity to a service) unless linked into a responsive logistics model that can accommodate such time windows.

Frequency and timing reflect the usefulness of the transport service to the client. More frequent but smaller trains may be of significant value in achieving this objective. The risk of delayed or disrupted deliveries is higher in this context.

Too low frequency will implicate to clients that either:

- Lead times for part of their cargo will be longer and have inventory implications;
- An alternative solution is required on non-departure days. In this situation frequency is an issue of service availability. Defaulting to truck is a serious competitive threat.

c. Assessment:

Frequency is a service parameter that may be publicly available. It is most often expressed in terms of number of departures per hour/day/week. More frequent than daily could be relevant for short distance movements.

Alternative routings may be provided through various hubs in a rail or intermodal network, which implies an increased service spread and network resilience. This requires that the trains are able to operate fully over the networks and that the vehicles and cargo modules are compliant with the prevailing loading gauges and kinematic envelopes.

d. Benefits:

Increased frequency makes it more attractive to clients to use the railway solution. Existing clients may be induced to use the service more intensively and the number of clients could increase.

Increased frequency implies increased carrying capacity (more equipment) or deployment of shorter trains or both, with impacts on the utilisation and cost structure of the train service.

e. Implementation:

Demand constraints may hold back an increase of frequency or otherwise entail lower utilisation of trains and therefore higher costs per unit. The ramping up of new service concepts and technologies and the linkage of these to existing logistics networks and systems will need to be a key part of any introductory process. This assumes the service providers can increase frequency and deploy more rail vehicle/module assets in response to increased transport demand.

5.7 SERVICE AVAILABILITY

a. Definition:

The extent to which the rail services are guaranteed and continuous.

b. Interpretation:

Non-availability can be scheduled:

- Demand pattern: in case the main flow consists of seasonal products only, services may be suspended or reduced in frequency outside of peak the season. This implies possible limited or non-availability for remaining cargo.
- Possible allocation of rail slots to passenger traffic in seasons/daily cycles of passenger peak demand. Mitigated by the use of off peak train paths and the use of any spare passenger quality train paths.
- Possible allocation staff and locomotives to passenger traffic in seasons of passenger peak demand, possibly mitigated by the use of leased in equipment and train crews from other railway domains. Freight only train operators should be more immune to this sort of possibility. The more the Spectrum trains operate to passenger train levels of performance crew familiarity and experience in operations should be less of an issue.
- Seasonal capacity constraints because of infrastructure quality (frost season) or access due to repair and maintenance works mitigated by advanced notice of any planned infrastructure works.

Service availability could also be seen in relation to client's complete logistics portfolio: does it pay to shift to a solution that is e.g. only servicing one specific destination? Non-availability can also be unplanned and therefore temporary:

- Blockades on the routes due to weather conditions or physical causes
- Unexpected capacity shortage e.g. due to equipment failures or illness of staff, strikes.

c. Assessment:

Non-availability due to predictable seasonal patterns is likely to be in accordance with service schedules. Otherwise it concerns a "risk of non-availability". Then data may be used from:

- Infrastructure Managers who have recorded availability of infrastructure slots;
- Operators or their clients who may have historic figures about suspended services and attributable causes.

d. Benefits:

Improving the availability of services implies that:

- Utilisation of the assets in operation increases;
- Utilisation of client's assets that are specific to the cargo flow, like handling platforms or loading units improves;
- Fewer temporary contingency measures are needed.

A position of frequent poorly explained or advised non-availability can significantly bring down attractiveness of the transport solution.

e. Implementation:

Non-availability can be avoided:

- If the equipment can endure difficult infrastructural conditions (such as snow, frost, flooding or leaves) by better design and maintenance
- If repair and maintenance are short, infrequent and without need of taking equipment out of service. This could be achieved by dynamic maintenance regimes built around condition monitoring and the undertaking of minor maintenance during cargo loading/discharge operations.
- If the execution of the transport service has a high priority in comparison to other transport services by the operator.

5.8 SPEED / LEAD TIME

a. Definition:

Speed can be door-to-door, terminal-to-terminal, etc. The revenue speed (total distance/ total time) is what is relevant to users. Transport lead-time is the inverse variable of speed. Lead-time, like speed, can be door-to-door, terminal-to-terminal, etc.

b. Interpretation:

For shippers the door-to-door time is what is most relevant. The perceived lead-time is between collection and delivery of the cargo. There is added value to client if higher speed compresses client's production or distribution process. Practice may be however that, for example, time gains result in earlier delivery but are outside the client's business hours. In this case there is no perceived improvement of lead-time.

For logistics companies transport time of each of the legs in the logistic chain will influence the planning and deployment of their assets. Compression of transport operations can improve the equipment rotation (and therefore reduce costs and increase profits by driving up utilisation) well above accepted levels.

c. Assessment:

- Compare door-to-door times by road and by conventional rail / intermodal. This will need to identify where routine delays are incurred and need to be attributed. Rail is often blamed as the cause of delay when in reality delay is induced by the shipper, receiver, pre and end haulage and terminals.
- Compare service parameters of intermodal / rail services.
- Investigate differences of technical speed and revenue speed.

d. Benefits:

To shippers higher speed is likely to create benefits of shorter lead times if it concerns:

- Time sensitive final goods in distribution (product availability in sales); this could also include small lot logistics such as mail and parcels.
- Movement of final goods in replenishment of (regional) warehouses (less final product in stock);
- Movement of intermediate goods on critical path of production (compression of production line);
- High-value goods (less product in stock, i.e. less costs of capital).

The potential benefits to players in the logistic chain from improved equipment rotation allowing other additional work to be undertaken by the same assets to secure much higher productivity

e. Implementation:

The benefits can be yielded if the increases of speed can actually be transferred into shorter lead times. There should be no limitation from rigidities of the logistic system such as:

- Opening hours of terminals (24/7);
- Business hours of logistic companies (24/7), the dispatcher of recipient (24/7);
- Slot availability of infrastructure and of terminals (24/7 and wholly flexible to spot or very short term requirements;
- Execution of procedures at border crossings;
- Regulatory constraints in night distribution and the weekend driving ban for trucks. This may be the most controversial in relation to the levels of noise and traffic generation surrounding a terminal involving train movements, cargo operations, containers being stacked or grounded and truck movements in/out of the terminal. The ban may limit the 24/7 feasibility.

5.9 TRACKING AND TRACING

a. Definition:

The capability of following the position of the cargo (or loading of transport unit).

b. Interpretation:

Information about position may be required on the level of transport unit (train / wagon or truck), ILU, or pallet or package). Next to position data it may involve information about the ILU and cargo condition. Communication requirement may be continuous or discontinuous. The latter could be e.g. only when cargo is handed from one to a next carrier in the logistic chain. Communication may be limited to (a selection of) contracting parties in the logistic chain or open to a wider audience. The reasons behind the requirements may be:

- Logistics optimisation (real time planning and scheduling);

- Registration (working time administration, monitoring service quality);
- Security and condition monitoring(e.g. traceability in food chain or pharmaceutics);
- Customer service (ETA of parcels in E-commerce);
- Liability (supporting evidence in case of mal-performance, loss or damage).

c. Assessment:

Possibility of T&T-functions can be assessed from technical viewpoint. Are there restrictions in use and/or weaknesses in the system?

d. Benefits:

Benefits of T&T will be limited if its use is constrained to phases of the logistic chain or if the system is subject to failures/disturbances. Additional benefits on this quality criterion are not to be expected from SPECTRUM in comparison to T&T-systems elsewhere in the transport system.

e. Implementation:

Overall, T&T has become a common feature in transport chains, but there is variety in to what is required with respect to level of detail of information and density of the communication. SPECTRUM should allow for state of the art T&T-services. Equipment should be free of disturbances (such as weather conditions or tunnels) and have continuous power feed. The design of the communication and software for registration purposes are non-specific and therefore not part of the scope of SPECTRUM.

5.10 FLEXIBILITY

a. Definition:

The capability of responding to unforeseen deviations from planned execution of tasks.

b. Interpretation:

The deviations can be in demand, for example:

- Cargo is not available for transport at the agreed;
- There is an unexpected short-term peak/dip in demand;
- Cargo is not available in a good condition (badly packed, incomplete documents)

The deviations can be in supply, for example:

- Problems in the infrastructure (ice and snow, repair, accidents, terminal congestion)
- Failure of equipment (locomotive, wagon, ILU, truck, transhipment)

c. Assessment:

There is no quantitative indicator of flexibility. An assessment should focus on the availability of alternatives when needed:

- Spare capacity, ideally without intervention but just by increased equipment utilisation or otherwise by adding or replacing wagons, staff, etc.;
- High frequency services, so cargo can be assigned to next service without compromising too much on lead time;
- Rescheduling of handlings (terminal, transport) so delays can be absorbed;
- Routing alternatives with transport services as well as with infrastructure;
- Alternative transport mode (road) as the default.

Good interventionist management and monitoring will improve the operation of alternatives and moderate its additional costs.

d. Benefits:

SPECTRUM, as compared to conventional rail is likely to have better access to rerouting options on the rail network and may have higher priority. SPECTRUM train may also be better capable of catching up with delays that can be considered as an unofficial time buffer. Disadvantage of any special equipment associated with a new train or service concept is that it potentially holds back exchange of equipment between services, particularly in the initial stage after introduction.

e. Implementation:

Flexibility within the “system of SPECTRUM-rail services” will be higher when there is spare capacity and when services are high frequency. Also exchangeability of equipment between different operations improves flexibility, which can be achieved by calling at corresponding terminals where wagons can be shunted between trains or wagon/train sets can be manipulated. Such conditions can be created when the market has matured and when the demand for SPECTRUM-services allows for such a system. Flexibility can be created in the transport operations by inserting buffers to allow for delayed or faulty cargo delivery. Flexible routing will be easier if IM have accepted higher priority for SPECTRUM-train operation in their slot allocation rules. There must be a contingency plan when equipment fails, for example:

- It must be easy to isolate a wagon from the train set.
- It must be easy to move a train with a crippled vehicle to a point where this can be examined, detached or decisions made about continuing a transit until the cargo delivery is completed.
- The remaining formation is not compromised adversely and the shipper/receiver/terminal is automatically advised of the delay and response measures.
- For short self-propelled trains the ability to continue to move under reduced power is a major advantage compared with a locomotive hauled train.

It must be easy to have the cargo removed to another transport unit (truck or train). This has particularly implications for specialized transport (e.g. refrigerated).

6 Transport demand analysis

6.1 INTRODUCTION

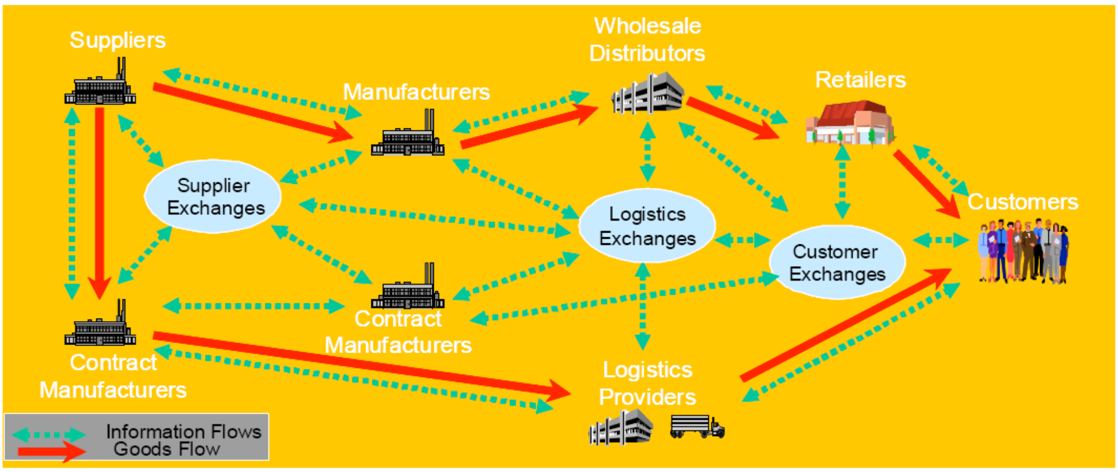
The second part of the top-down approach is the transport demand analysis. The main objective of the transport demand analysis is to estimate the potential demand for LDHV goods in Europe (EU-27 and Switzerland). This has been done using freight transport statistics and existing macro models.

The transport demand analysis was focused especially on road transport. This is the sector that currently transports the majority of the LDHV goods and where shifts to rail transport could take place. The chosen time horizon for the transport demand forecast is 10-20 years: 2020 for the medium-term forecasts and 2030 for the long-term forecasts.

6.2 METHODOLOGY

A model is a representation of reality (see Figure 6.1). For this project, the EU ETISplus and iTREN tool has been used to estimate the current and expected transport flow of LDHV goods. This section explains in more details how this has been achieved.

Figure 6.1: Modelled representation of the supply chain



(Source: RETRACK Deliverable 1.4 Market requirements)

6.2.1 Methodology for estimating the current transport demand

Choosing and obtaining data from the base year is the starting point for estimating the current and expected transport demand. The freight flow data comes from the EU ETISplus project[9]. It provides an O/D (Origin/Destination) cargo transport matrix for road and rail for the year 2005. The ETISplus matrix describes the generation and attraction of physical flows of goods between countries and geo-clusters given the economical and institutional determinants of the base year (i.e. the year 2005). To obtain more recent information, the data was adjusted to the levels of year 2009, based on freight flow developments observed between 2005 and 2009 according to EUROSTAT statistics. Therefore, the year 2009 will be the new base year used for the calculations. The data has been analysed in terms of freight volumes (tonnes/TEU) by transport mode and geographical scope.

The second step is to select the LDHV goods from the freight flow data of 2009. The LDHV goods have been selected from the freight flow data of 2009 based on their density (kg/m3) and their value (Euro/kg).

This data was derived from the most recent Intra- and Extra EU trade information and from a study performed for the EC on Longer Heavy Vehicles[10]. The selected LDHV goods fall under different subcategories (i.e. NST3 commodity types) of the following main NST/R classes:

- 0: Agricultural products (e.g. fruits and vegetables);
- 1: Foodstuffs (e.g. alcoholic and non-alcoholic beverages, meat/fish, dairy products);
- 5: Metals (e.g. tubes, metal alloys and castings);
- 8: Chemicals (e.g. plastic materials and medicinal and pharmaceutical products);
- 9: Other type of products (e.g. appliances, clothing, machinery, furniture and other manufactured articles).

6.2.2 Methodology for the medium and long-term forecasts

Based on the transport estimates from the year 2009, forecasts have been made for the medium (2020) and long term (2030) using the Integrated Scenario developed by the EU project iTREN-2030[11]. iTREN-2030 combines four existing assessment tools to develop its scenarios:

- TRANS-TOOLS – for transport networks;
- TREMOVE – looking at the environmental effects of the transport sector;
- POLES – simulating long-term energy scenarios for different parts of the world;
- ASTRA –forecasting the long-term consequences of EU transport policies.

The iTREN-2030 project has developed different scenarios, including the Integrated Scenario, based on a number of key assumptions regarding:

- The development of the global economy and EU economy.
- Depletion of resources of raw materials, world market prices for resources.
- Demographic, social, technological and cultural developments.
- Economic and transport policy environment in the EU.

The Integrated Scenario (INT) is driven by changing framework conditions, a few breaks-in-trend as well as by energy and transport policies until 2030. This scenario is supplied with very detailed quantified indicators by Member State and EU region for energy, transport, vehicle fleets, environment and economic development until 2030 (see Annex).

The iTREN-2030 Integrated Scenario also takes the impacts of the financial and economic crisis of 2008/2009 into account, describing a world shaped by the crisis, but which is also gradually recovering from it.

Transport policy is leaving its traditional paths and instead is being driven by newly emerging issues, i.e. climate policy and growing GHG mitigation requirements for the transport sector, demand- and supply-driven fossil fuel scarcity and new propulsion technologies, leading to the application of a diversity of fuels and engine technologies in the transport sector.

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[9] See for more information: http://www.etisplus.eu.

[10] Source: EC study on Longer Heavy Vehicles

[11] For more information on iTREN, see: http://ec.europa.eu/research/fp6/ssp/itren_2030_en.htm

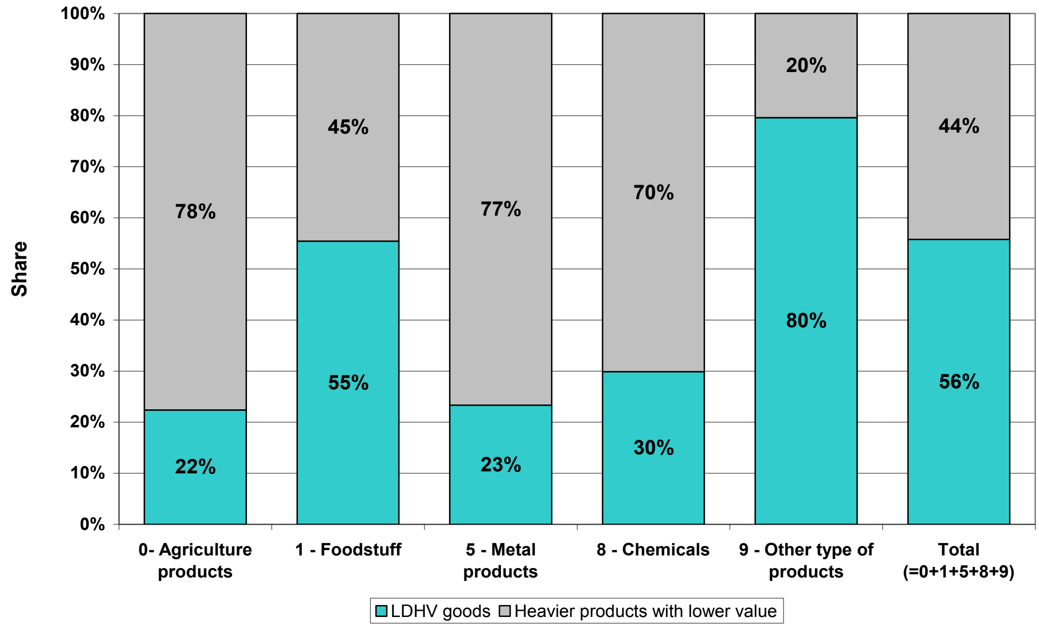
However, behavioural change in the scenario remains limited to adopting new engine technologies, without changing urban settlement structures, travelling behaviour or mobility concepts. A list of the transport and energy policies incorporated in the iTREN integrated scenario is also presented in Annex.

6.3 TRANSPORT DEMAND FOR LDHV GOODS IN 2009

6.3.1 Road transport demand for LDHV goods in 2009

In 2009 a total of approximately 15 billion originating tonnes were transported by road in the EU-27 countries and Switzerland. Around 46% of all road transport concerns the main NST/R categories relevant for this study (i.e. NST/R levels 0, 1, 5, 8 and 9). Figure 6.2 presents the share of transported LDHV goods per selected main NST/R category and as an average of these 5 NST/R groups. The average share of LDHV goods within the total tonnage of the selected groups is approximately 56%. Most of the LDHV goods fall under the category 'other type of products' followed by 'foodstuffs'. These are generally goods closer to the end consumers.

Figure 6.2: Share of LDHV goods compared to the total tonnage of the selected main NST/R categories (based on estimated tonnage transported by road in 2009)



The most important countries/regions where the selected goods are being transported by road are given in Table 6.1. It shows a specialty pattern of specific industries found in each country. For example, for metal products, amongst others the automotive industries in Italy. Also for agricultural products, the agricultural sector in France. France is one of the world's leading producers and exporters of agricultural products and the leading agricultural power in the EU, accounting for about one-third of all agricultural land within the EU.

Table 6.1: Most important countries/regions where transport of selected goods takes place (based on transported tonnage by road in 2009)

Selected LDHV goods per NST/R category	Most important countries/regions where transport of selected goods takes place
0: Agricultural products	France, Finland, Sweden, Poland and Spain
1: Foodstuffs	Spain, France, Poland, UK and Germany
5: Metals	(Northern) Italy, Spain and Germany (around the Ruhr area)
8: Chemicals	The Netherlands, Germany, Poland and Italy
9: Other type of products	UK, the Netherlands, France and Italy

Table 6.2 presents the share of selected LDHV goods by distance class. Around 37% of the total LDHV goods transported in EU-27 and Switzerland are transported by road over a distance of 300 km or more. Modal shift could already be feasible at distances below 200 km or longer. This implies that if pre- and end-haulage is needed on one or both sides, the total distance could be 200 km or more. For example, a rail transport study performed by Panteia/NEA in 2011 compared the costs for rail transportation with road haulage between Coevorden and different national and international locations.

For the route Coevorden-Rotterdam (around 200km), rail transport was found to be financially attractive at distances of 0 to 90 km between the terminal and the clients (pre- and end-haulage)[12]. In the study "Towards a new strategy for policy on inland waterway transport (IWT) in The Netherlands" (Policy Research Corporation & NEA, Dutch Ministry of Transport and Public Works, 2006) it was concluded that modal shift between dry-dry locations on both sides of the chain pre- and end-haulage was only feasible at distances of 200 km or more.

Another study by Policy Research Corporation from 2006 also showed that in cases where pre- end haulage can be avoided, IWT can be competitive on shorter distances (with door-to-door transport on distances of even 20 to 40 km onwards)[13]. IWT has similar characteristics as rail transport, namely transport it is dependent on the available fixed infrastructure (rail tracks and terminals) and in most cases some pre- and end-haulage is needed.

The share of LDHV goods transported over distances of 200 km or longer is about 49%.

The five national and international road transport relations over distances of 200 km or longer that show the greatest demand are presented in Table 6.3. On national level these are located within Greece, Spain and Sweden. The most important type of LDHV good transported are "other type of products" (NSTR/9). On international transport relations these are between Spain and France, Belgium and Luxembourg and The Netherlands and France. Again, the most important type of LDHV good transported fall in the category "Other type of products".

The table below presents the ten most important types of LDHV goods transported in EU 27 and Switzerland. Most of these goods fall under NSTR/9 (other type of products). The table also shows an important aspect regarding the transport by road of LDHV goods. Most of the top 10 products are transported within national borders (83%).

[12] Source: Dryport Emmen-Coevorden, Panteia/NEA, 2011.

[13] Source: Marktonderzoek binnenvaart, Policy Research Corporation, 2006.

Table 6.2: Share of distance classes (in km) per type of LDHV goods (based on estimated tonnage transported by road in 2009)

Selected LDHV goods per NST/R category	<50	50-100	100-150	150-200	200-300	300-400	400-500	>500	Total
0: Agricultural prod.	11%	26%	11%	7%	12%	9%	7%	17%	100%
1: Foodstuffs	15%	22%	9%	7%	12%	10%	8%	18%	100%
5: Metals	16%	21%	9%	7%	12%	10%	7%	20%	100%
8: Chemicals	30%	24%	9%	7%	10%	7%	4%	9%	100%
9: Other type of prod.	15%	21%	8%	7%	12%	10%	8%	20%	100%
Total LDHV goods	**15%**	**21%**	**9%**	**7%**	**12%**	**10%**	**8%**	**19%**	**100%**

Figure 6.3 presents a map with the total LDHV goods transported by road in 2009 per NUTS2 region in EU-27 and Switzerland. The figure also presents the rail transport network in Europe (i.e. the green lines). As expected, the largest volumes transported by road are seen in industrial regions.

Figure 6.3: Total LDHV goods (in tonnage) transported in 2009 by road in EU 27+Switzerland (NUTS2 level)

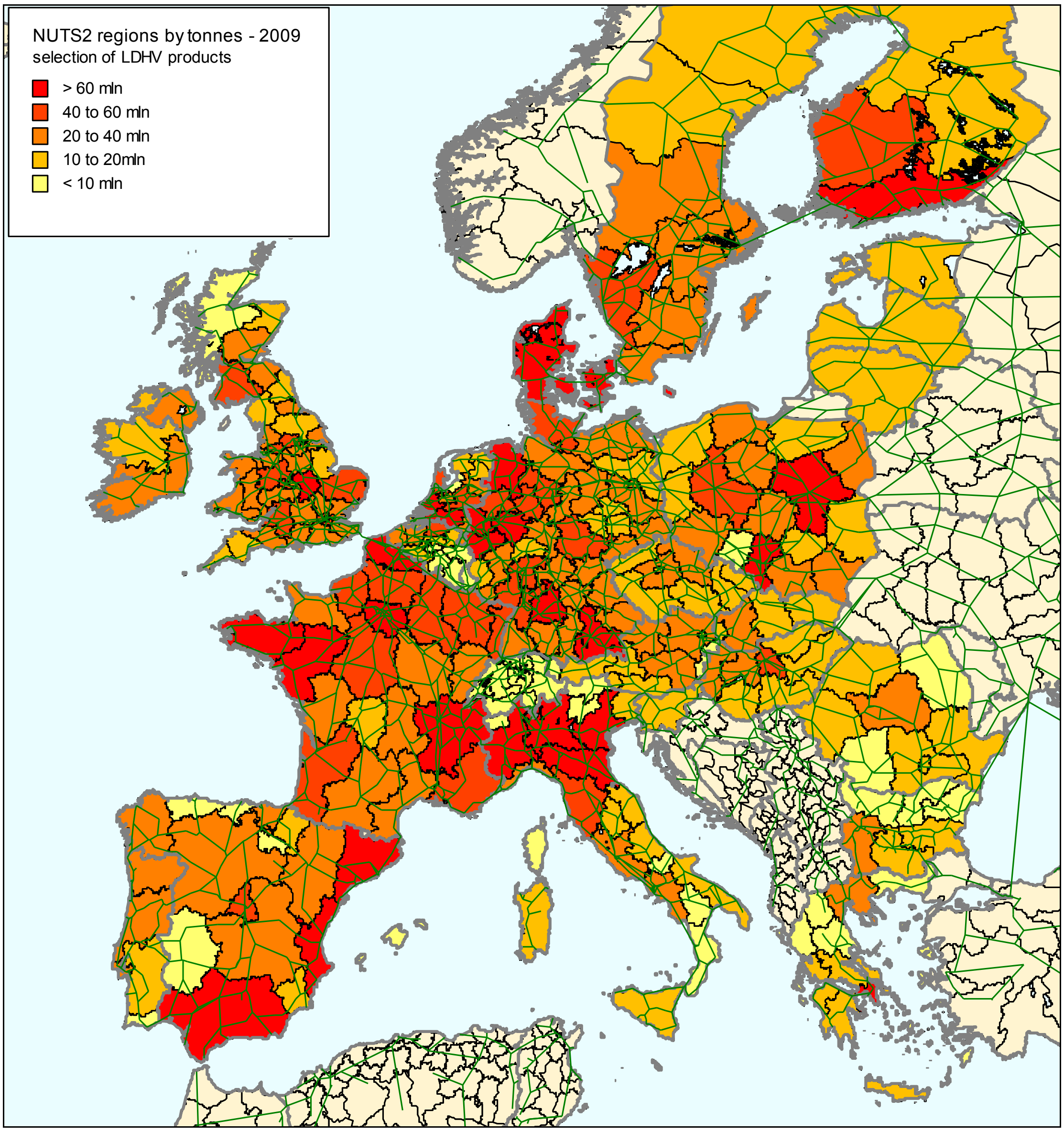


Figure 6.4 to Figure 6.8 present different maps of LDHV goods *per NST/R category* transported by road in 2009 per NUTS2 region in EU-27 and Switzerland. It also shows per map, a selection of the top 30 locations (based on the total tonnage transported per NUTS3 region).

Figure 6.4: Agricultural LDHV products transported in 2009 by road in EU 27+Switzerland (NUTS2 level) and selection of the top 30 locations where these products are being generated/attracted (NUTS3 level)

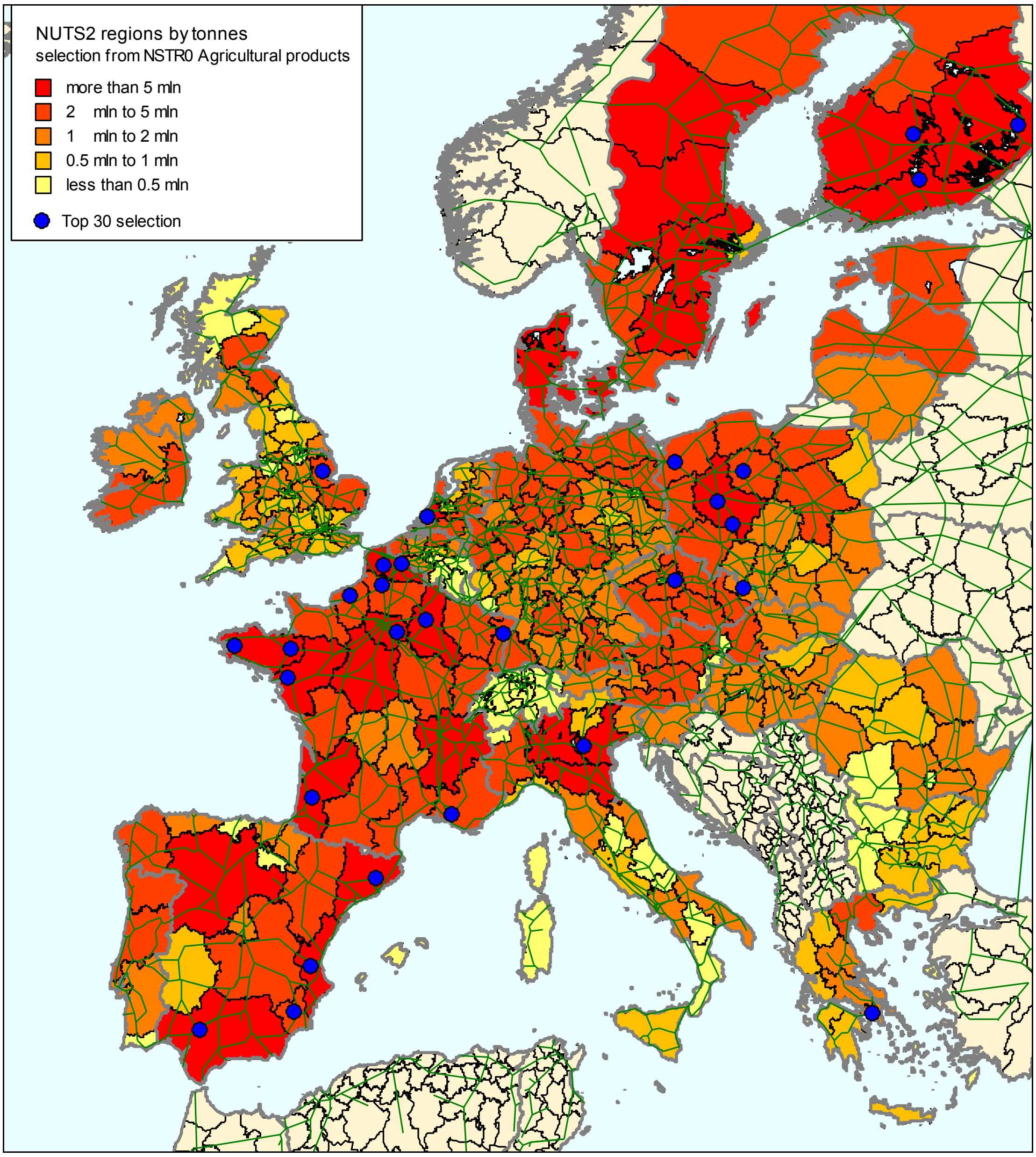


Figure 6.5: LDHV foodstuffs transported in 2009 by road in EU 27+Switzerland (NUTS2 level) and selection of the top 30 locations where these products are being generated/attracted (NUTS3 level)

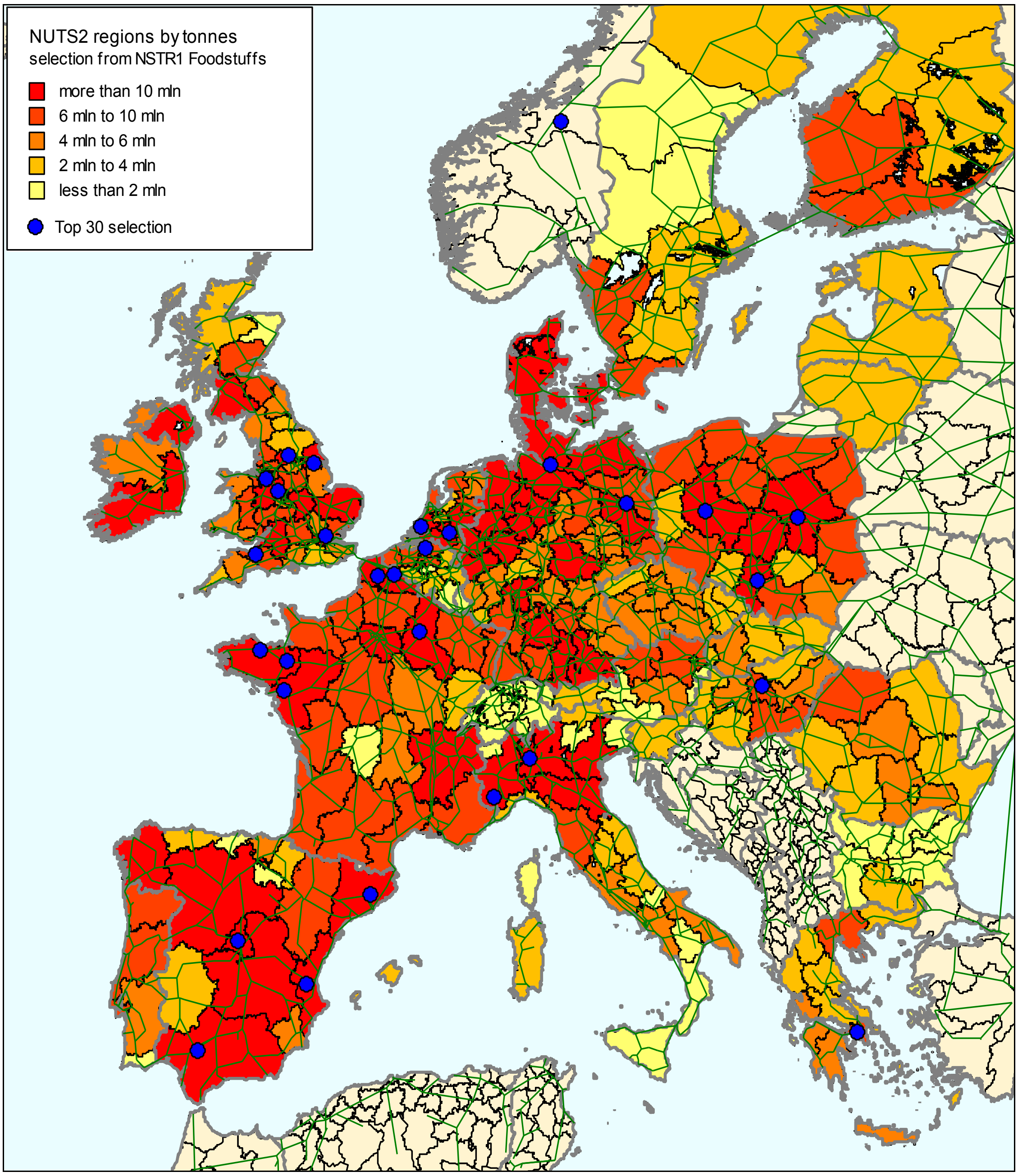


Figure 6.6: Metal LDHV products transported in 2009 by road in EU 27+Switzerland (NUTS2 level) and selection of the top 30 locations where these products are being generated/attracted (NUTS3 level)

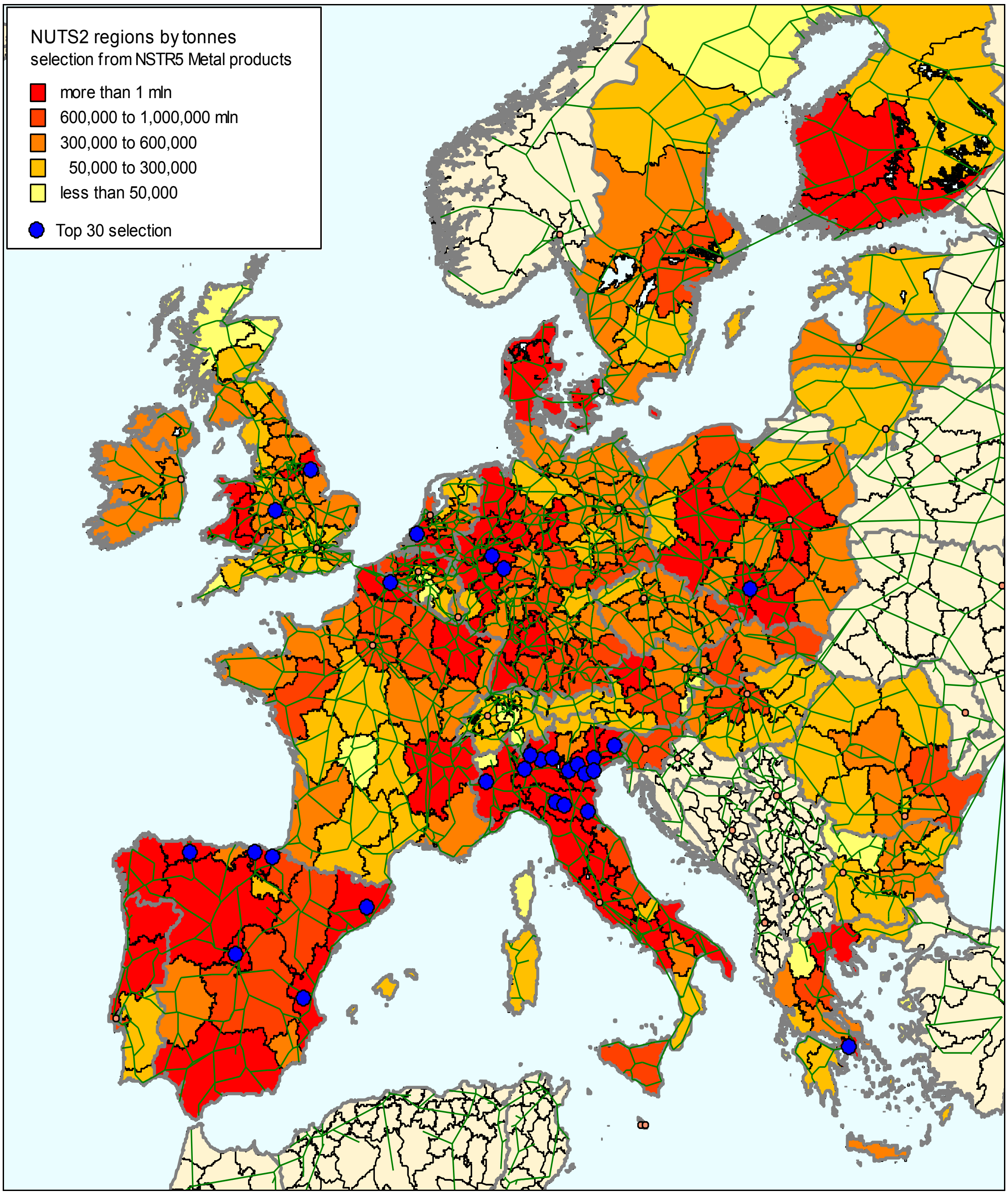


Figure 6.7: LDHV chemicals transported in 2009 by road in EU 27+Switzerland (NUTS2 level) and selection of the top 30 locations where these products are being generated/attracted (NUTS3 level)

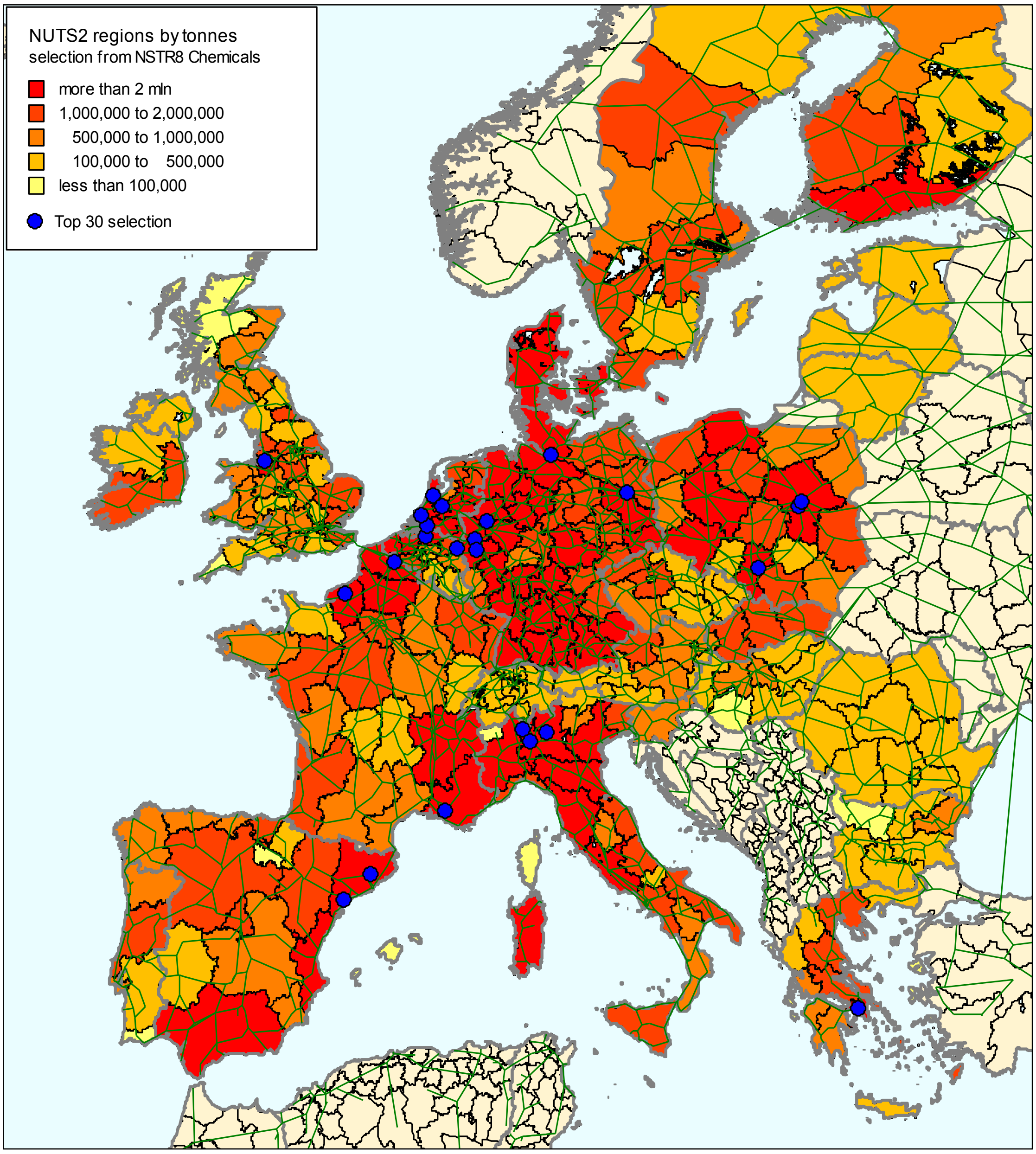


Figure 6.8: LDHV other type of products transported in 2009 by road in EU 27+Switzerland (NUTS2 level) and selection of the top 30 locations where these products are being generated/attracted (NUTS3 level)

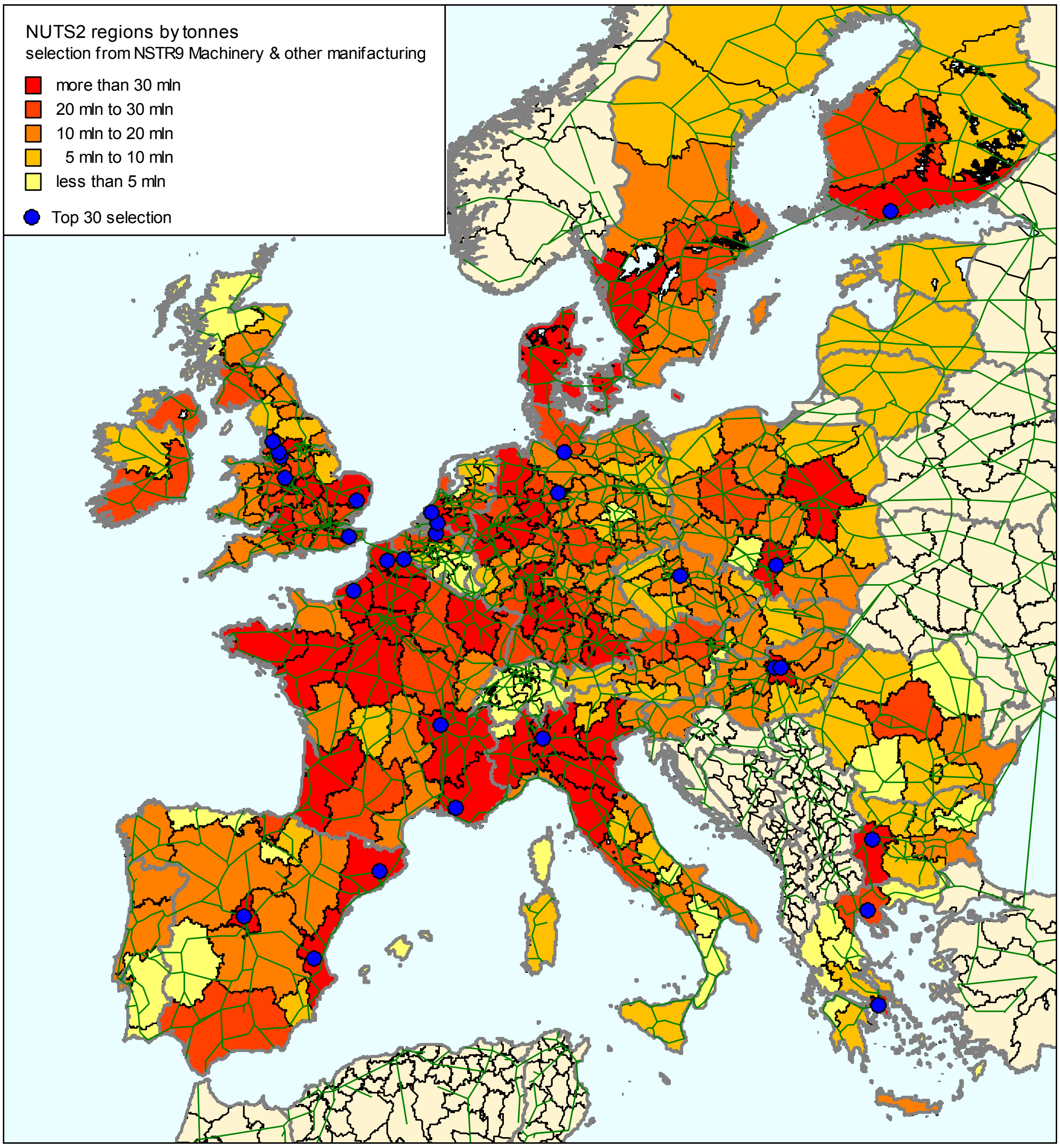


Table 6.3: Largest national and international relations (NUTS 3 level), based on transported tonnage by road over distances ≥ 200 km in 2009)

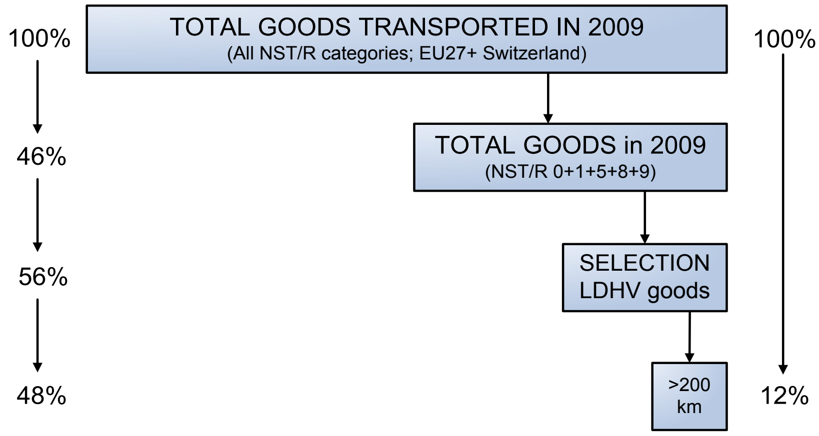
	Top-5 national and international relations (NUTS 3 level)	Total tonnage transported (over distances ≥200km)	Top-3 type of goods transported (NST/1 level)	Share of total tonnage on transport relation	Average distance (in km)
National	Attiki - Kentriki Makedonia (Greece)	4,064,537	Other type of products (9)	78.9%	503
			Foodstuffs (1)	13.5%	
			Metal products (5)	4.2%	
	Cataluña - Community of Madrid (Spain)	3,049,617	Other type of products (9)	76.6%	585
			Foodstuffs (1)	17.5%	
			Metal products (5)	3.7%	
	Cataluña - Community of Valencia (Spain)	2,503,490	Other type of products (9)	68.9%	400
			Foodstuffs (1)	21.7%	
			Agriculture products (0)	4.2%	
	Övre Norrland - Övre Norrland (Sweden)	2,252,106	Other type of products (9)	50.4%	292
			Agriculture products (0)	34.3%	
			Foodstuffs (1)	10.0%	
	Community of Valencia - Community of Valencia (Spain)	2,160,218	Other type of products (9)	61.1%	223
			Foodstuffs (1)	27.8%	
			Agriculture products (0)	6.9%	
International	Cataluña (Spain) - Provence-Alpes-Côte d'Azur (France)	627,072	Other type of products (9)	71.7%	450
			Chemical products (8)	14.3%	
			Foodstuffs (1)	9.2%	
	Cataluña (Spain) - Rhône-Alpes (Rhone, France)	346,421	Other type of products (9)	78.9%	645
			Foodstuffs (1)	8.1%	
			Chemical products (8)	5.5%	
	Cataluña (Spain)- Rhône-Alpes (Isere, France)	293,235	Other type of products (9)	80.0%	602
			Foodstuffs (1)	7.6%	
			Chemical products (8)	7.2%	
	Provence of Antwerp (Belgium) – Grand-Duché (Luxembourg)	280,877	Other type of products (9)	69.5%	238
			Foodstuffs (1)	14.8%	
			Metal products (5)	6.0%	
	South Holland (Rotterdam) - Nord-Pas-de-Calais (France)	271,301	Other type of products (9)	67.3%	218
			Foodstuffs (1)	13.4%	
			Chemical products (8)	9.2%	

Table 6.4: Most important type of products transported nationally and internationally in EU 27 + CH (based on transported tonnage by road over distances ≥ 200 km in 2009)

Types of products transported in EU 27 + CH	**National transport by road over distances ≥200km (in million tonnes)**	**International transport by road over distances ≥200km (in million tonnes)**	**Total million tonnes transported by road over distances ≥200km**
Paper and paperboard (unworked)	195	39	234
Other manufactured goods (not classified according to kind)	170	34	203
Non-electrical machinery, apparatus and appliances, engines, etc.	139	28	167
Wood and cork manufactures (excluding furniture)	99	20	119
Non-alcoholic beverages	89	11	99
Electrical machinery, apparatus and appliances, engines, etc.	74	15	88
Other manufactured articles	71	14	85
Paper and paperboard manufactures	57	11	69
Furniture (new)	43	8	51
Plastic materials (unworked)	31	17	48
Total (share of total)	**969 (83.2%)**	**195 (16.8%)**	**1164 (100%)**

Figure 6.9 summarizes the results presented above. It indicates the potential market for LDHV goods, that are currently being transported by road over distances of 200 km or greater and that have the potential to be shifted to rail transport. The potential LDHV market in EU-27 and Switzerland was about 12% in 2009. This is almost 1.9 billion tonnes.

Figure 6.9: Potential market of LDHV goods (based on estimated tonnage transported by road in 2009)



6.3.2 Rail transport demand for LDHV goods in 2009

In 2009 a total of approximately 1.07 billion tonnes was transported by rail in the EU-27 countries and Switzerland. It should be mentioned that 2009 was the first year where the economic and financial crisis had full impact on transport volumes. In 2008 where the last quarter of the year was hampered by the crisis, volumes reached a maximum of nearly 1.3 billion tonnes. It should also be noted that only transport within the EU27 and Switzerland is considered, thus rail transport to non-EU members (except for Switzerland) has been excluded from the analysis. Domestic and international rail transport within these countries is included. At present, LDHV goods on rail are predominantly transported in containers and swap bodies. But also transports in Boxcars (type "Habinns" and equivalent).

In general, the share of LDHV goods in rail transport is found under NST/R 9. The exact volume of LDHV goods transported by rail is difficult to estimate, as railway information is relatively scarce due to confidentiality concerns. In addition, the commodity classification for the NST/R 9 'other type of products' is a mix of container transport where it is unknown what commodity is transported in the containers and genuine 'finished products' such as car transport.

The share of LDHV is estimated to be around 5% of the total rail transport and in general is found mainly under NST/R 9. For example, the value of the goods on container trains transporting only high value goods can amount to €200,000 per container or more. Examples of these are the Samsung trains between Rotterdam and Bratislava with TVs, or John Deere machinery and spare parts between Bremerhaven and Forst (in Germany). All other NST/R categories are assigned as non-LDHV goods.

Table 6.5 presents the main NST/R categories for rail transport within the EU27 and Switzerland. It can be observed that NST/R 2, 3, 4, 6 and 7 together have a share of 69%. The main NST/R commodities 0, 1, 5, 8 and 9 which have been selected for road transport, have are share of 31%. The total volume under NST/R 9 category is almost 54.2 million tonnes. Most of these goods can be considered LDHV goods. However, to a lesser extent, there are also LDHV goods transported under the other NST/R commodities (0, 1, 5, 8).

The overall level of LDHV in rail transport is estimated at 5%, which is approximately 53.9 million tonnes. The Annex provides more information for rail freight transport between the countries and the share of the commodities within each country.

Table 6.5: Rail transport in 2009 by NST/R in 1000 tonnes within EU+CH

NST/R1 code	Transported volume (in 1000t)	Share (in %)
0	102,380	9.5%
1	36,507	3.4%
2	116,123	10.8%
3	355,768	33.0%
4	124,043	11.5%
5	61,365	5.7%
6	140,956	13.1%
7	10,282	1.0%
8	39,884	3.7%
9	54,165	5.0%
Total	**1,078,228**	**100.0%**

(Source: NEA, ETISPlus)

6.4 MEDIUM-TERM (2020) AND LONG-TERM (2030) FORECASTS OF LDHV GOODS

6.4.1 Road transport demand for LDHV goods in 2020 and 2030

The medium and long-term forecasts of the LDHV goods transported by road are presented in Table 6.6. The LDHV goods transported by road are expected to grow by 23% in 2020 and by 53% in 2030 compared to 2009. This is a growth of about 2% per year on average. The transport by road of metal products and other type of products are expected to have the highest increase.

Table 6.6: Medium and long-term forecast of transport demand of LDHV goods by road (based on estimated tonnages and including all distance classes)

Selected LDHV goods per NST/R category	In million tonnes			Index (2009=100)		
	2009	2020	2030	2009	2020	2030
0: Agricultural products	262	311	374	100.0	118.9	142.9
1: Foodstuffs	882	1,056	1,283	100.0	119.7	145.4
5: Metals	106	133	167	100.0	125.4	157.1
8: Chemicals	201	234	276	100.0	116.6	137.6
9: Other type of products	2,394	2,994	3,784	100.0	125.1	158.0
Total LDHV goods	**3,846**	**4,729**	**5,884**	**100.0**	**123.0**	**153.0**

Figure 6.10 and Figure 6.11 present geographical maps with the expected medium and long-term developments of LDHV goods transported by road in 2020 and 2030. Although growth is expected in all countries, the strongest increase is expected in the Eastern-European countries (e.g. Poland, Czech Republic, Hungary and Romania), Spain and also in the area between the UK and France (i.e. London and Northern France).

The Annex presents different maps with the expected development of the LDHV goods transported by road in 2020 and 2030 *per NST/R class.* The top 30 locations are also given in the maps. In general, one can conclude that the countries that are already important in specific market segments will keep growing and continue to be among the top 30 locations.

However, the growth is not expected to be as strong as in Eastern Europe. For the transport of other type of products (NSTR9), besides the forecasted increase in the Eastern European countries, also in Northern Europe (e.g. Sweden and Latvia) a strong increase is expected. The only market segment where the Eastern European countries (except Poland) are not expected to transport large quantities by road in the medium and long-term is the transport of LDHV chemicals.

6.4.2 Rail transport demand for LDHV goods in 2020 and 2030

In 2020 the total volume of rail freight transport in EU27 and Switzerland is estimated to increase to 1.4 billion tonnes. Relative to 2009, this is a growth of 29% of total rail freight transport. Given the crisis, it is anticipated that rail volumes will see a moderate increase in 2010 and 2011.

From 2020 towards 2030, the volume transported by rail is expected to increase to 1.5 billion tonnes, which means additional growth of 7%. It is expected that with the structural changes in the economy and demography, the transport of bulk commodities will decrease. The share of NST/R 9 in total rail transport will increase to a maximum of 7.3% in 2030 based on existing technology, operational and commercial models. The Annex provides more detailed figures similar to 2009 for 2020, in which the distribution per country and per NST/R are detailed.

Table 6.7: Volume of total rail transport volume with EU27+EU in 2009, 2020 and 2030 (in 1000 tonnes), including the share of NST/R 9

	2009	%	2020	%	2030	%
Total	1,078,228	100.0%	1,390,426	100.0%	1,487,756	100.0%
Index Total	100		128.95		137.98	
NST/R 9	54,165	5.0%	75,361	5.4%	108,897	7.3%
Index NST/R 9	100		140.1		200.9	

(Source: Panteia/NEA)

The figures presented in Table 6.7, reflect in the period from 2009 towards 2020 the effect of the crisis that started in the end of 2008 and has continued for rail transport. The expected transport volumes for 2012 do not match the pre-crisis levels. The positive aspect of the increasing share of NST/R 9 is that the service requirements for the transport of these goods are to some extend similar to that of the LDHV goods transported by road and that potentially could be shifted to rail.

Forwarders, in the road and/or rail sector, are facing similar challenges in the market. This is what is observed in the pilots of Spectrum, and could work out positively for the rail markets. It does pre-suppose some profound changes to the current technical, operational and business models within the rail freight sector. More of the same is not a recipe for growth in the demanding LDHV segment of the market.

Figure 6.10: Forecast for 2020 of the total LDHV goods (in tonnage) transported by road in EU 27+Switzerland (NUTS2 level)

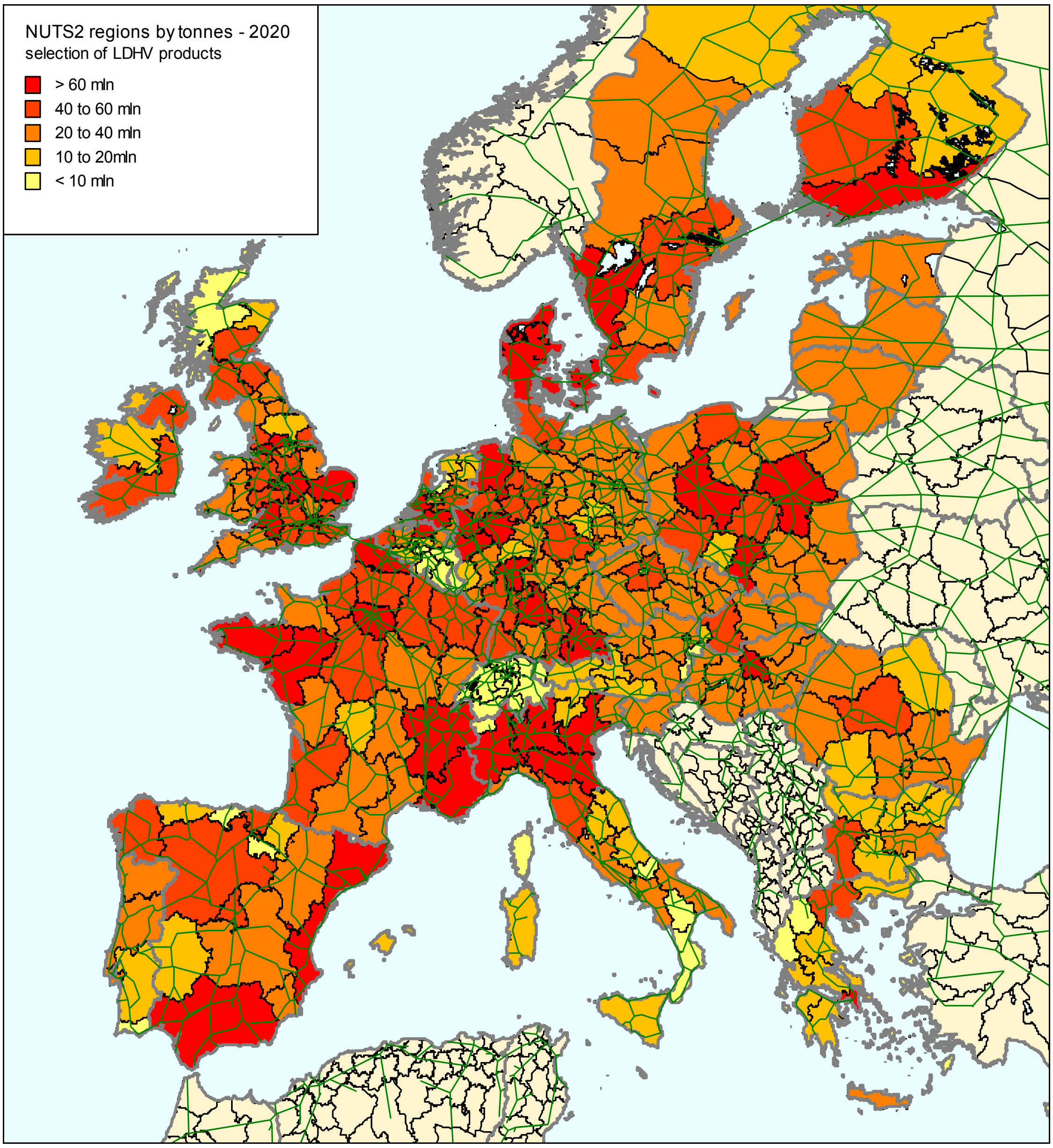
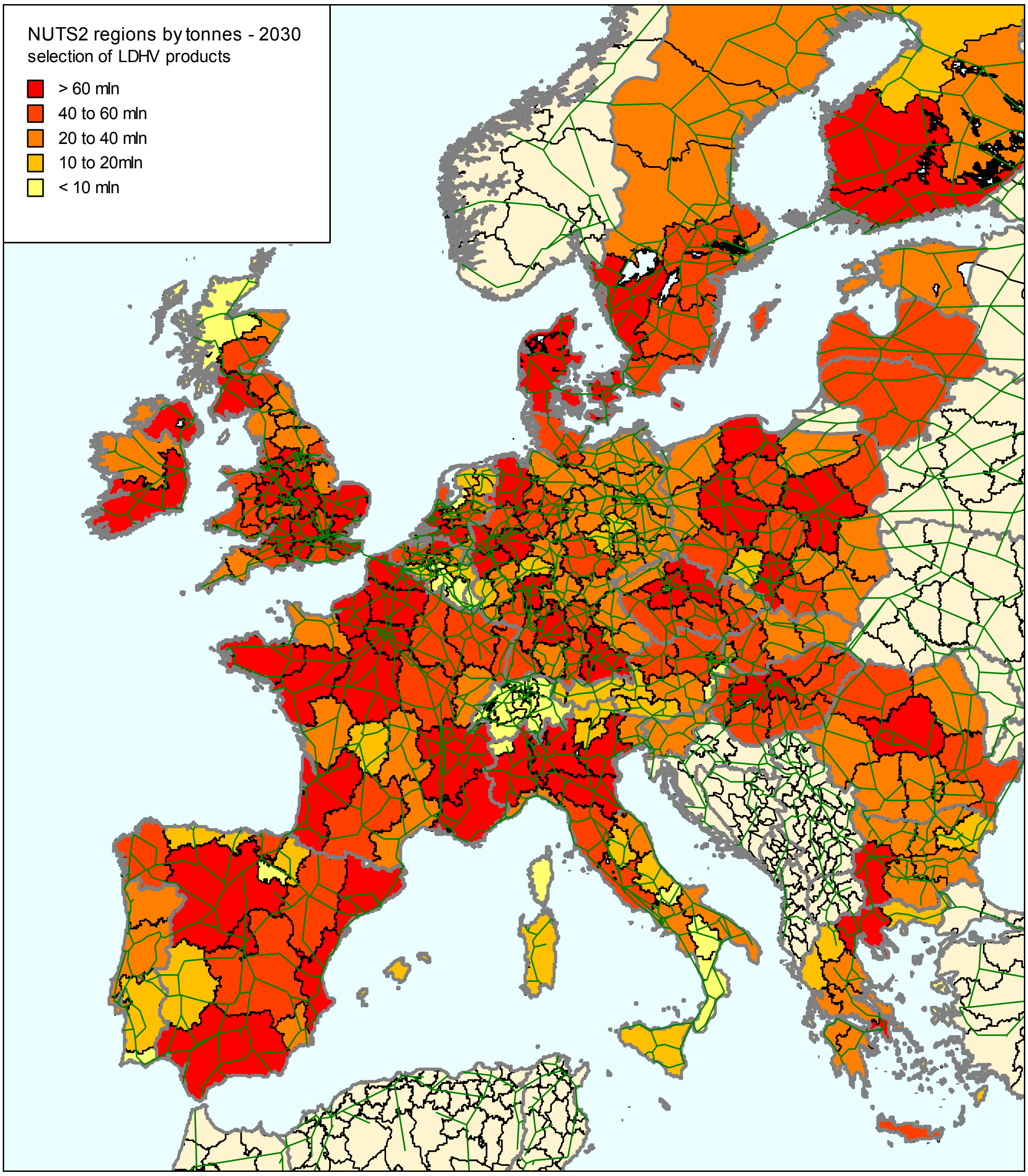


Figure 6.11: Forecast for 2030 of the total LDHV goods (in tonnage) transported by road in EU 27+Switzerland (NUTS2 level)



6.5 CONCLUSIONS

The selected LDHV market in EU-27 and Switzerland was about 12% of the total freight transported in 2009. This is almost 1.9 billion tonnes of goods currently transported by road over distances of 200 km or more.

A forecast for the years 2020 and 2030 indicates that the market for LDHV commodities (currently assigned to road in unchanged market conditions) will grow by 23% respectively 53%.

However, not all these goods will or will be shifted to rail since this also depends on the improved market positioning and actual market uptake. The 12% of selected freight flows therefore can be further refined to come closer to a realistic market potential for rail. This market potential will be further determined in WP 4.

7 Market analysis for service operation and corridor definition

7.1 INTRODUCTION

In this chapter the market for a SPECTRUM service is analysed from different perspectives for the target market:

- Transport activity of individual regions.
- Relative performance of OD relations.
- A specific case study on the transportation between EU and Turkey.
- Conditions in urban areas and examples of operations.

Based on the insights obtained from this analysis the corridors are defined to be further investigated in this study. In the following the results of this process are described.

7.2 ACTIVITY PER REGION

Using the results presented previously, it is possible to select a group of countries that is very active for the transportation of the selected commodities, The most active countries are Sweden, Spain, Netherlands, Latvia, UK, Romania, Germany and Italy. In the following table an example is given on how these countries could be combined into corridors, indicating the main type of products expected to be transported in the long-term. The term corridor is introduced, as a corridor relates and bundles different origin destinations on the corridor. A certain balance in flows allows commercial and viable railway services. In all presented corridors NST/R9 “other type of goods/containers” flows are present, this allows the combination with present and any proposed rail services of containers.

Table 7.1: Possible corridors for LDHV goods based on activity per region

Potential corridors	Route	Main type of goods transported
LDHV Corridor W1	Between Sweden and Spain	• Agricultural products • Foodstuffs
LDHV Corridor W2	Between the Netherlands and Latvia	• Chemicals • Other type of goods
LDHV Corridor W3	Between the UK and Romania	• Foodstuff • Other type of goods
LDHV Corridor W4	Between Germany and Italy	• Metals • Chemicals • Other type of goods

7.3 RELATIVE PERFORMANCE OF OD RELATIONS

7.3.1 Methodology

Based on the transport demand analysis, the 50 relations with the greatest transport demand by road have been identified for international (top 20), national (top 20) and seaport-hinterland (top 10) traffic at different distance categories. The most important type of goods transported on these traffic relations has also been given. Although this is a limited subset of all flows considered it provides insight in where the potential for rail can be found.

It is also important to examine for each of these traffic relations whether the high transport demand by road is related to lack or no availability of rail infrastructure or appropriate services that can support the requirements of the shipper/receiver. This has been verified first by using a rail transport OD-matrix. For relations with limited to no rail traffic at all, an additional analysis has been performed. These relations and the possible explanation behind the low transport demand by rail have also been presented using footnotes.

In addition to this analysis estimations have been made on the port-related traffic when the origin/destination is located at a port area. The estimation is based on a study performed by NEA on ports and their hinterland connections within TEN-T14. For regions (NUTS 2 level) with more than one port, the share of the largest port will be presented. An important aspect to take into account is that these shares are related to general port-related goods and do not represent only LDHV goods.

7.3.2 Top 20 international road transport relations

The top 20 international road transport relations are presented in Table 7.2 and Table 7.3. The first table presents the 10 greatest transport demand by road over distances between 400 and 700 km (see Table 7.2). Most of these relations are linked with France or Spain. The three greatest transport relations are between France and Spain. Table 7.3 presents the top 10 international traffic relations by road over distances longer than 700 km. Once more, most of these relations are linked with France and Spain. The three greatest transport relations are between Italy and France, Italy and Spain and France and Spain. The most important type of LDHV goods transported are “other type of products” (NSTR 9).

[14] Source: NEA et al, 2010. Ports and their hinterland connections within TEN-T, European Commission (DG-MOVE).

Table 7.2: Top 10 international traffic relations (NUTS 2 level), based on estimated transported LDHV tonnage by road over distances between 400-700 km in 2009

Relation	Tonnage transported by road	Top-3 type of goods transported (NST/1 level) and share of total tonnage	Average distance (in km)	Estimated share of port-related traffic
Rhône-Alpes (France) – Cataluña (Spain)	1,230,355	Other type of products: 74% Foodstuffs: 12% Chemicals: 6%	627	14% around port area near Barcelona
Provence-Alpes-Côte d'Azur (France) – Cataluña (Spain)	1,081,943	Other type of products: 70% Chemicals: 12% Foodstuffs: 12%	459	35% around port area near Marseilles and 14% around port area near Barcelona
Aquitaine (France) – Cataluña (Spain)[15]	741,541	Other type of products: 60% Foodstuffs: 19% Chemicals: 12%	448	14% around port area near Bordeaux and 14% around port area near Barcelona
Lombardia (Italy) – Rhône-Alpes (France)	562,328	Other type of products: 82% Metal products: 9% Foodstuffs: 4%	418	
Lombardia (Italy) – Alsace (France)	550,337	Other type of products: 79% Foodstuffs: 8% Chemicals: 5%	427	
Nord - Pas-de-Calais (France) – Arnsberg (Germany)	460,924	Other type of products: 70% Metal products: 15% Foodstuffs: 10%	406	36% around port area near Dunkirk
Centre (Portugal) – Community of Madrid (Spain)	428,250	Other type of products: 69% Foodstuffs: 14% Metal products: 6%	480	11% around port area near Aveiro
North (Portugal) – Community of Madrid (Spain)	413,769	Other type of products: 76% Foodstuffs: 13% Metal products: 5%	511	16% around port area near Oporto
Pays de la Loire (France) – Pais Vasco (Spain)[16]	337,572	Other type of products: 79% Metal products: 12% Foodstuffs: 7%	639	35% around port area near Nantes and 43% around port area near Bilbao
Lisboa (Portugal) – Andalucia (Spain)	333,566	Other type of products: 57% Foodstuffs: 18% Chemicals: 10%	416	17% around port area near Lisbon and 17% around port area near Algeciras

[15] Low transport demand by rail. Possible explanation: track gauge problem between Spain and France.
[16] Low transport demand by rail. Possible explanation: use of short-sea shipping for this relation.

Table 7.3: Top 10 international traffic relations (NUTS 2 level), based on estimated transported LDHV tonnage by road over distances longer than 700 km in 2009

Relation	Tonnage transported by road	Top-3 type of goods transported (NST/1 level) and share of total tonnage	Average distance (in km)	Estimated share of port-related traffic
Lombardia (Italy) – Nord - Pas-de- Calais (France)	357,153	Other type of products: 65%	1052	36% around port area near Dunkirk
		Foodstuffs: 17%		
		Chemical products: 7%		
Lombardia (Italy) – Cataluña (Spain)[17]	341,854	Other type of products: 79%	941	14% around port area near Barcelona
		Chemical products: 8%		
		Foodstuffs: 8%		
Île de France (France) – Cataluña (Spain)[18]	288,903	Other type of products: 74%	937	14% around port area near Barcelona
		Foodstuffs: 14%		
		Agriculture products: 7%		
Île de France (France) Pais Vasco (Spain)[19]	259,801	Other type of products: 90%	877	43% around port area near Bilbao
		Foodstuffs: 4%		
		Metal products: 3%		
Franche-Comté (France) – Cataluña (Spain)[20]	251,840	Other type of products: 84%	870	14% around port area near Barcelona
		Foodstuffs: 9%		
		Agriculture products: 3%		
Lombardia (Italy) – Île de France (France)	248,620	Other type of products: 86%	842	
		Foodstuffs: 7%		
		Metal products: 3%		
Nord - Pas-de-Calais (France) – Cataluña (Spain)	245,849	Other type of products: 49%	1150	36% around port area near Dunkirk and 14% around port area near Barcelona
		Foodstuffs: 28%		
		Agriculture products: 15%		
Etelä-Suomi (Finland) – Estonia (Estonia)[21]	224,292	Other type of products: 75%	747	11% around port area near Helsinki and 64% around port area near Tallinn
		Foodstuffs: 16%		
		Agriculture products: 4%		
Centre (France) – Cataluña (Spain)	189,251	Other type of products: 74%	792	14% around port area near Barcelona
		Foodstuffs: 15%		
		Agriculture products: 5%		
Lombardia (Italy) –	187,960	Other type of products: 81%	1319	22% around port area near

[17] Low transport demand by rail. Possible explanation: use of short-sea shipping (part of the trip) for this relation.

[18] Low transport demand by rail. Possible explanation: track gauge problem between Spain and France.

[19] Low transport demand by rail. Possible explanation: track gauge problem between Spain and France and/or use of short-sea shipping (part of the trip) for this relation.

[20] Low transport demand by rail. Possible explanation: track gauge problem between Spain and France.

[21] No transport demand by rail. Explanation: no rail infrastructure available.

Community of Valencia (Spain)[22]		Foodstuffs: 9% Metal products: 4%		Valencia

[22] Low transport demand by rail. Possible explanation: use of short-sea shipping (part of the trip) for this relation.

7.3.3 Top 10 national road transport relations

The top 20 national road transport relations are presented in Table 7.4 and Table 7.5. presents the 10 greatest national transport demand by road over distances between 200 and 400 km. Most of these relations are within Italy, Poland and Finland. The top 10 national traffic relations by road over distances between 400-700 km are presented in Table 7.5. Most of these relations are within France, Italy and Spain. The most important type of LDHV goods transported are “other type of products” (NSTR/9), followed by ‘’foodstuffs’’ (NSTR/1).

Table 7.4: Top 10 national traffic relations (NUTS 2 level), based on estimated transported LDHV tonnage by road over distances between 200-400 km in 2009

Relation	Tonnage transported by road	Top-3 type of goods transported (NST/1 level) and share of total tonnage	Average distance (in km)	Estimated share of port-related traffic
Emilia-Romagna – Lombardia (Italy)	10,695,762	Other type of products: 55% Foodstuffs: 19% Metal products: 13%	214	53% around port area near Ravenna
Slaskie – Mazowieckie (Poland)	8,409,592	Other type of products: 63% Foodstuffs: 25% Chemical products: 6%	302	
Toscana – Lombardia (Italy)	7,998,774	Other type of products: 71% Foodstuffs: 14% Metal products: 6%	330	54% around port area near Livorno
Länsi-Suomi – Etelä-Suomi (Finland)	7,994,750	Other type of products: 69% Foodstuffs: 14% Agriculture products: 12%	280	26% around port area near Rauma and 11% around port area near Helsinki
Veneto – Lombardia (Italy)	7,219,432	Other type of products: 52% Foodstuffs: 20% Metal products: 13%	219	25% around port area near Venice
Wielkopolskie – Mazowieckie (Poland)	6,983,275	Other type of products: 47% Foodstuffs: 37% Agriculture products: 9%	315	
Wielkopolskie – Slaskie (Poland)	6,110,025	Other type of products: 65% Foodstuffs: 23% Agriculture products: 5%	318	
Övre Norrland – Övre Norrland (Sweden)[23]	4,709,136	Other type of products: 41% Agriculture products: 38%	280	37% around port area near Lulea

[23] The tonnage carried by road on this relation is transport within the same NUTS 2 region.

		Foodstuffs: 18%		
Emilia-Romagna – Piemonte (Italy)	4,698,203	Other type of products: 52%	305	53% around port area near Ravenna
		Foodstuffs: 25%		
		Metal products: 10%		
Pomorskie – Mazowieckie (Poland)	4,474,336	Other type of products: 51%	364	41% around port area near Gdansk
		Foodstuffs: 34%		
		Chemical products: 7%		

Table 7.5: Top 10 national traffic relations (NUTS 2 level), based on estimated transported LDHV tonnage by road over distances between 400-700 km in 2009

Relation	Tonnage transported by road	Top-3 type of goods transported (NST/1 level) and share of total tonnage	Average distance (in km)	Estimated share of port-related traffic
Rhône-Alpes – Île de France (France)	5,549,871	Other type of products: 85% Foodstuffs: 10% Agriculture products: 3%	519	
Lazio – Lombardia (Italy)	5,488,423	Other type of products: 73% Foodstuffs: 16% Metal products: 6%	602	23% around port area near Fiumicino
Attiki – Kentriki Makedonia (Greece)	5,126,544	Other type of products: 77% Foodstuffs: 14% Agriculture products: 5%	508	14% around port area near Megara and 18% around port area near Thessaloniki
Etelä-Suomi – Itä- Suomi (Finland)	4,810,805	Other type of products: 54% Agriculture products: 28% Foodstuffs: 15%	401	11% around port area near Helsinki and 9% around port area near Varkaus
Community of Valencia – Cataluña (Spain)	4,728,230	Other type of products: 64% Foodstuffs: 24% Agriculture products: 5%	403	22% around port area near Valencia and 14% around port area near Barcelona
Cataluña – Comunidad de Madrid (Spain)	4,267,237	Other type of products: 72% Foodstuffs: 22% Metal products: 3%	591	14% around port area near Barcelona
Andalucia – Castilla y León (Spain)	4,236,965	Other type of products: 44% Foodstuffs: 40% Agriculture products: 12%	674	17% around port area near Algeciras
Pomorskie – Slaskie (Poland)	4,115,522	Other type of products: 72% Foodstuffs: 18% Metal products: 5%	547	41% around port area near Gdansk
Cataluña – Castilla y León (Spain)	4,112,755	Other type of products: 56% Foodstuffs: 31% Agriculture products: 9%	642	14% around port area near Barcelona
Campania – Emilia-Romagna (Italy)	3,474,257	Other type of products: 64% Foodstuffs: 21% Metal products: 9%	622	42% around port area near Naples and 53% around port area near Ravenna

7.3.4 Top 10 seaport-hinterland road transport relations

The top 10 seaport-hinterland road transport relations over distances below 200 km are presented in. This does not include goods transported within the same NUTS 2 region. The top three seaport-hinterland road transport relations are linked with the area around the port of Rotterdam, in which approximately 69% of the goods transported are port-related traffic. The most important type of LDHV goods transported are "other type of products" (NSTR/9), followed by ''foodstuffs'' (NSTR/1).

Table 7.6: Top 10 seaport-hinterland traffic relations (NUTS 2 level), based on estimated transported LDHV tonnage by road in 2009, over distances below 200 km and which are not transported within the same NUTS 2 region

Relation	Tonnage transported by road	Top-3 type of goods transported (NST/1 level) and share of total tonnage	Average distance (in km)	Estimated share of port-related traffic
North-Brabant – South-Holland (Netherlands)	8,420,233	Other type of products: 63% Foodstuffs: 20% Chemical products: 10%	82	69% around port area near Rotterdam
South-Holland – North-Holland (Netherlands)	4,958,221	Other type of products: 62% Foodstuffs: 18% Chemical products: 11%	82	69% around port area near Rotterdam and 47% around port area near Amsterdam
South -Holland – Gelderland (Netherlands)	4,809,963	Other type of products: 62% Foodstuffs: 24% Chemical products: 8%	104	69% around port area near Rotterdam
Emilia-Romagna – Veneto (Italy)	4,715,153	Other type of products: 50% Foodstuffs: 22% Agriculture products: 12%	178	53% around port area near Ravenna and 25% around port area near Venice
Nord - Pas-de-Calais – Picardie (France)	4,363,555	Other type of products: 66% Foodstuffs: 20% Agriculture products: 10%	130	36% around port area near Dunkirk
Toscana – Emilia-Romagna (Italy)	4,191,113	Other type of products: 67% Foodstuffs: 15% Chemical products: 8%	189	54% around port area near Livorno and 53% around port area near Ravenna
Schleswig-Holstein – Hamburg (Germany)	3,933,747	Other type of products: 60% Foodstuffs: 25% Chemical products: 10%	56	57% around port area near Lubeck and 52% around port area near Hamburg
Centre – North (Portugal)	3,808,093	Other type of products: 48% Foodstuffs: 32% Agriculture products: 12%	151	11% around port area near Aveiro and 16% around port area near Oporto
Bretagne – Pays de la Loire (France)	3,756,677	Other type of products: 47% Foodstuffs: 41% Agriculture products: 9%	150	10% around port area near Lorient and 35% around port area near Nantes
Province East-Vlaanderen – Province Antwerpen (Belgium)	3,526,622	Other type of products: 62% Foodstuffs: 22% Chemical products: 9%	65	33% around port area near Ghent and 58% around port area near Antwerp

7.3.5 BOTTLENECKS AND OPPORTUNITIES TOP RELATIONS

The traffic relations that have been identified previously have been grouped to distinguish between international and domestic freight and between several distance classes. For each of the segments the relations have been determined with the highest freight volume of LDHV goods for road transport:

- A top 20 of international freight transport >700km
- A top 20 of international freight transport 400km - 700km
- A top 20 of domestic freight transport 400km - 700km
- A top 20 of domestic freight transport 200km - 400km
- A top 10 of (domestic) sea port related freight transport

In this section this selection is analysed in order to identify corridors that can be used as reference in the SPECTRUM study. Further these identified corridors then are compared with the Commission plans for the TEN-T core network development and initiatives such as the ERTMS corridor development.

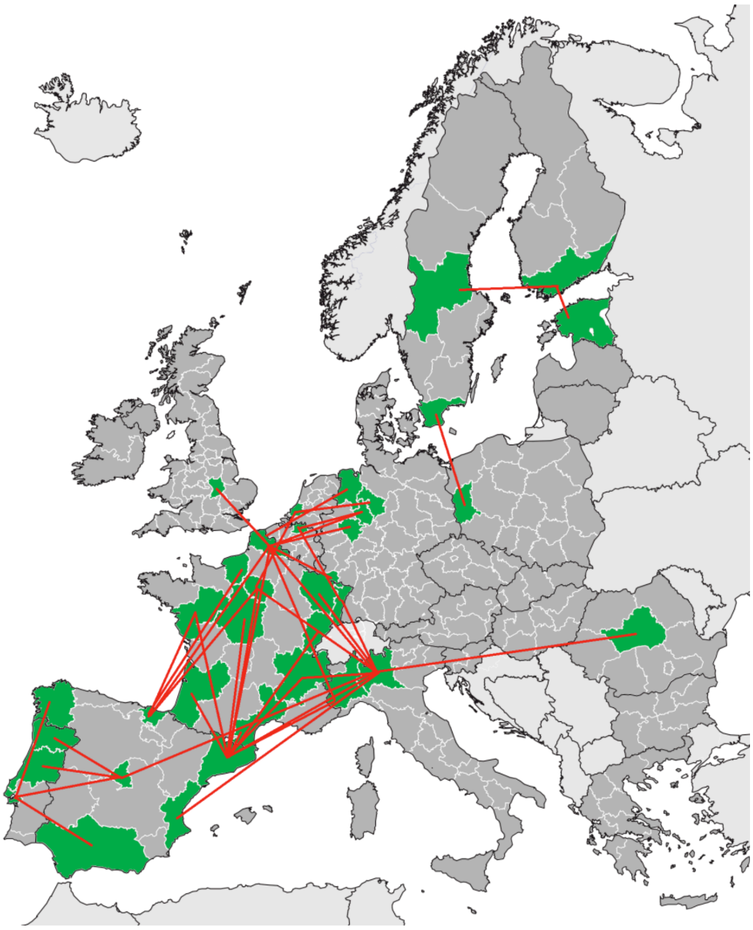
In this analysis specific focus is given on the international relations given their different nature in the context of this study. For domestic relations the technical conditions are relatively uniform for the whole network and organisationally it is also easier since it requires less cooperation. On the other hand the distance is generally smaller for domestic relations which has a negative influence on the competition with road transport using conventional methods, systems and technology sets. For international relations in more cases the distance is favourable for rail but there are more technical and organisational barriers. In this analysis we try to identify reasons why there are relatively high volumes of road transport on the identified international corridors. This provides useful empirical input for the discussion on the requirements.

Major Corridors based on top relations

Figure 7.1 shows the distribution of the regions throughout Europe and which regions are connected to each other. From this map the following corridors are identified based on the top relations:

- Ferry connections in Scandinavia
- Transalpine corridors in relation with Lombardia (Italy)
- Corridor between Centru Romania and Lombardia Italy
- Corridors between Spain and France
- Corridors between Spain and Portugal
- Corridor between Northwest France and Northwest Germany

Figure 7.1: Top 40 international relations



These corridors based on top relations are interesting since it shows where there is a lot of road transport which means there might be a current competitive weakness for rail. By analysing these corridors insight can be obtained on where improvements might be needed to be able to compete with road transport.

An analysis has been made to analyse whether there are differences in corridors in case the ranking is not made on basis of the weight of the selected flows but on the value of it. It was concluded after the analysis that the resulting corridors are not significantly different than the corridors based on the weight.

Analysis of corridors based on top relations

As mentioned the corridors based on top relations are interesting cases that can be used to identify potential improvements for rail to be able to compete with road transport. For each of the identified corridors a brief discussion is taken up to discuss the main reasons for the high road transport volumes.

Ferry connections in Scandinavia

Large volumes of freight is transported by road between:

- Lubuski Poland and Sydsverige Sweden.
- Norra Mellansverige Sweden and Etelä-Suomi Finland.
- Etelä-Suomi Finland and Estonia.

On these relations also small amounts of rail transport are registered although they are very limited. What is immediately clear is that all these relations require a ferry service. The specific regions with high road volumes are also situated at the port regions on both sides. This suggests that the pre and end haulage on either side is relatively small which is not favourable for rail transport. So in this case the total length of the relation is not the most influential factor. The use of either driver accompanied ferry services or ferry services which move only the loaded trailers has the advantage of available tractor units and drivers and allows road freight services to be short, medium or long haul sector operations to or from the ports served. Rail does not have this universal competence or equipment availability.

What can be said about these corridors is that the road ferries are more frequently available and also serve different ports. So the rail transport service on these types of relations requires a good coordination with the ferry services. Increasing of the rail services cannot be done without increasing the ferry services for instance or the adoption of an inter-modal option with containers carried by sea on short sea purpose built ships operating between terminals or being placed on trailers for the short sea passage.

Transalpine corridors in relation with Lombardia (Italy)

The high concentration of road transport of the selected commodities in this region can, besides the large economic activity of this region, be attributed in part to the logistical consequences of the high tunnel costs for trucks that cross the Alps but may also reflect traffic which is mandated to move by road. This generates a lot of bundling/consolidation activities in this region in order to perform the Transalpine part as efficiently as possible. From the figures in Table 7.1 and Table 7.3 it can also be seen that besides high road volumes there are also high rail volumes on these transalpine relations. In Northern Italy a lot of consolidation of cargo takes place at the various terminals which are situated there. Freight from Italy as well as from other regions is repacked in order to make optimal use of the capacity of the trucks or is transhipped on trains. Lombardia is connected to the TEN-T rail network and it is also part of several ERTMS corridors. This provides opportunity to optimise the situation even further. On this corridor we do not identify a specific bottleneck. On the contrary it could be regarded as a state of the art upper limit for the modal share for rail for the LDHV goods. New infrastructure may open opportunities to add to rail's hare in this sort of traffic together with new train and cargo module designs and innovative cargo transfer equipment.

Corridor between Centru Romania and Lombardia Italy

About 165.000 tonnes of LDHV goods are being transported between Lombardia and Centru by road, annually. In the TEN-T map it can be seen that although these regions are connected by the core network there is quite a significant part of the track that has to be upgraded. Further they are connected by an ERTMS corridor D which implies a further future improvement. At this moment however the service level is low and minimal infrastructure requirements are not met to make rail competitive with road for the LDHV commodities.

Corridors between Spain and France

There is a lot of freight being transported between northern regions in Spain and French regions. The most important barrier for rail transport between Spain and France is the different gauge of the tracks. This requires special trains that can adapt to the different tracks or changing trains at the border which takes additional handling time. This delay has a negative impact on the competitive position of rail compared to road. New technology to allow rapid bogie changes in each direction should open up rail's capacity and capability.

Corridors between Spain and Portugal

Between Spain and Portugal different corridors can be identified with high volumes of road transport. First if we look at the TEN-T rail core network we can see that there is no connection planned on the TEN-T between North West Spain and Portugal and between Southern Spain and Portugal. On these relations we find high volumes of road freight for LDHV goods and it is clear that this is due the absence of a proper rail connection and a competent competitive rail freight service offer. Further there is a high speed connection planned between Madrid and Portugal but currently the service level is low.

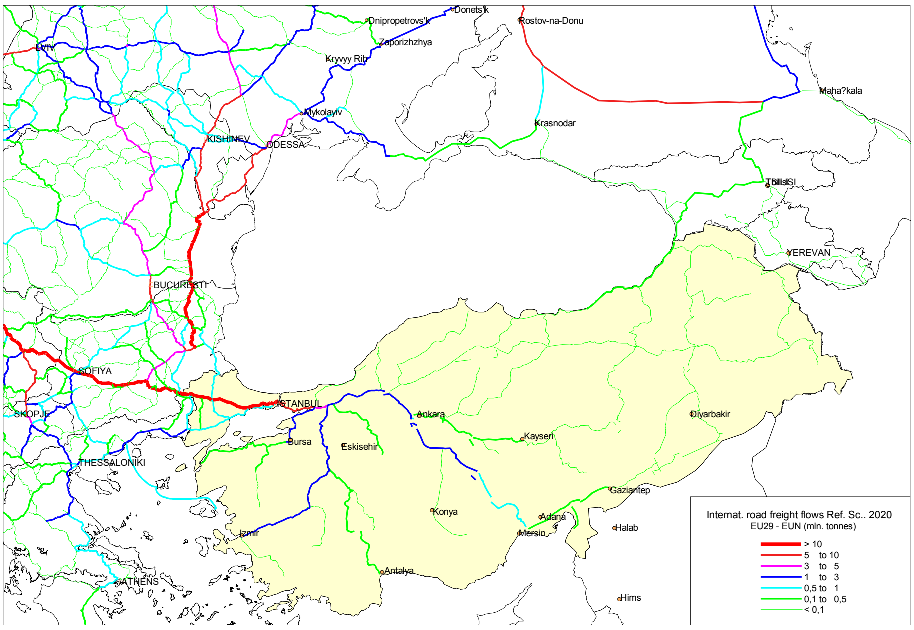
Corridor between Northwest France and Northwest Germany

Between Nord Pas de Calais and North-western German regions there are several relations with high volumes of road transport of LDHV goods. Here the main reason is that the relative time it takes by rail is longer since the international rail services between France and Germany go primarily through the French-German border and do not cross third countries. This means a significant detour in this case. On the relations in consideration the shortest route would pass through Belgium and The Netherlands but this would require cooperation with two additional countries and would introduce the planning systems of two additional countries with a higher risk of disruptions. In this case the organisational aspects should be regarded as the principle bottlenecks. This could however be minimised with already available international train path planning and operational co-ordination. The relative responsiveness, cost competitiveness and quality of service issue may also be significant. Road freight currently has a time/speed advantage on point to point flows and this is made more so in the case of perishable or condition controlled traffic.

7.4 TRANSPORT DEMAND ANALYSIS BETWEEN EU AND TURKEY

The transport demand analysis between EU and Turkey has been included as an additional analysis. Turkey is rapidly developing its industry and international trade. The road transport from Turkey is entering the EU in dense flows. Due to the geographical characteristics of Turkey most flows have to pass or originate from Istanbul. In the figure here below this can be seen.

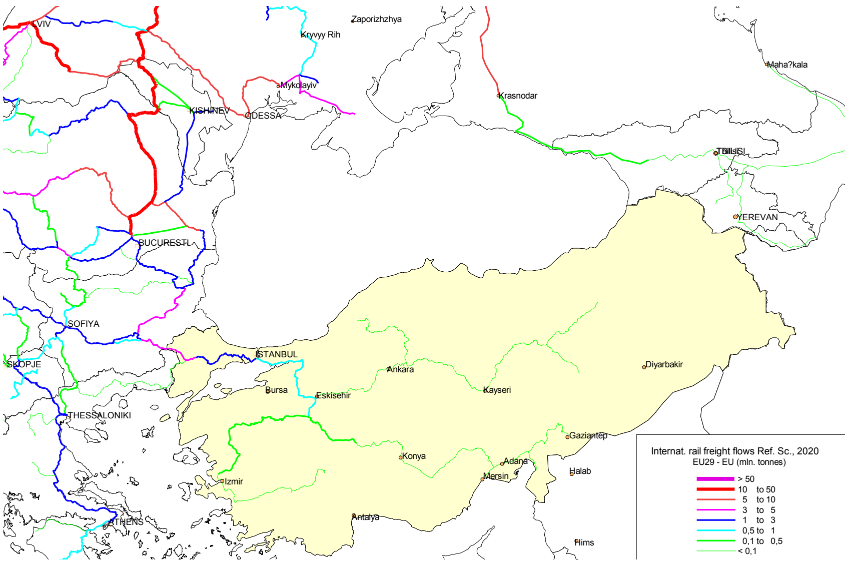
Figure 7.2: International Road freight flows in 2020 reference scenario between EU29 and EUN



(Source: TINA Turkey, European Commission)

Although rail transport is not very well developed in Turkey in terms of freight volumes (see Figure 7.3) this connection with dense road flows provides from this point of view promising opportunities for a new rail services.

Figure 7.3: International Rail freight flows between EU29 and EUN, 2020 reference scenario, Source: Tina Turkey, European Commission



(Source: TINA Turkey, European Commission)

Transport demand for LDHV goods in 2010

The data used in the following analysis is presented in tonnes transported by road for the year 2010. For this part of the project, the Extra-EU trade dataset of EUROSTAT has been used. The chosen time horizon for the transport demand forecast is 20 years, namely for the year 2030. The table below shows the freight flow by road in 2010 between Turkey and several EU countries. Almost 6.5 million tonnes of LDHV goods have been transported in 2010 by road between Turkey and these European countries. This is around 65% of the total goods transported by road. These goods are mainly transported between Turkey and the following three countries: Germany, Bulgaria and Romania. In the coming 20 years, this volume is expected to grow strongly (around + 400%).

Table 7.4: Total tonnage transported (x 1000 tonnes) by road between EU countries and Turkey in 2010

Country	LDHV goods	Other type of goods	Total tonnage
Austria	403	81	484
Belgium	345	186	531
Bulgaria	703	851	1,554
Czech Republic	145	69	214
Denmark	57	15	72
Estonia	4	2	6
Finland	32	9	41
France	493	299	792
Germany	1,657	819	2,476
Greece	233	95	328
Hungary	153	101	254
Ireland	3	1	4
Italy	322	152	473
Latvia	8	4	12
Lithuania	11	4	14
Luxembourg	15	18	33
Netherlands	325	159	484
Poland	427	110	537
Portugal	7	14	21
Romania	722	379	1,101
Slovakia	102	44	146
Slovenia	65	36	101
Spain	141	62	203
Sweden	71	33	104
United Kingdom	5	1	5
Total	**6,448**	**3,543**	**9,991**

Figure 7.4 presents the direction of these freight flows by road graphically. Figure 7.5 presents the share of the main NST/R categories selected in this study, compared to the total LDHV goods transported by road between EU and Turkey in 2010 (i.e. the almost 6,5 million tonnes). Most of the LDHV goods fall under the category ‘other type of products’, followed by ‘chemicals’ and ‘agriculture products’.

Figure 7.4: Total LDHV goods (in tonnage) transported in 2010 by road between various EU countries and Turkey

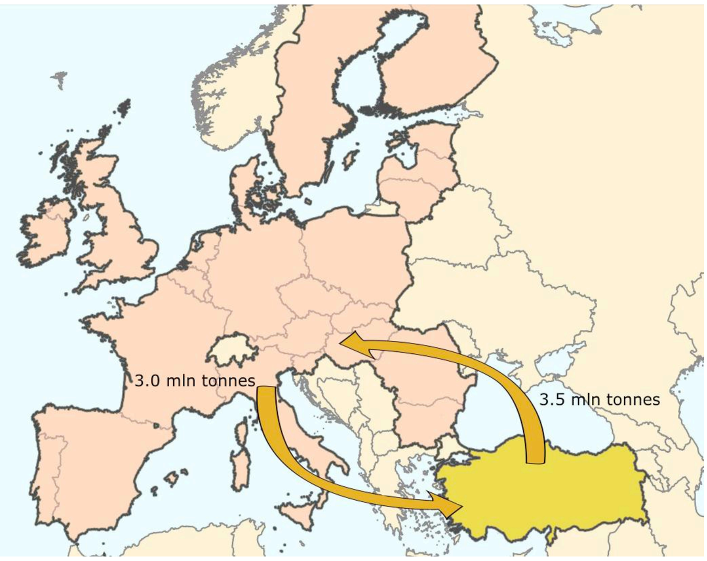
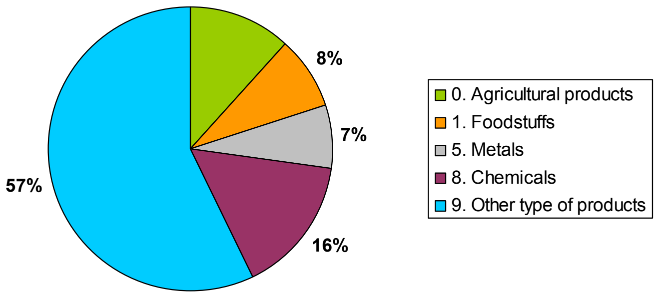


Figure 7.5: Share (in %) of the selected main NST/R categories compared to the total LDHV goods transported by road between EU and Turkey in 2010



Opportunities for a service related to Turkey

As can be seen in Table 7.4 there are large flows going to North West Europe. The flow to Germany is largest but also the flows to for instance Austria, Belgium and the Netherlands are significant. The distance between these counties is large which is beneficial for rail transport. A possibility would be to combine these flows to bridge a large distance up a hub in to for instance Budapest. From there they could be regrouped to go to destinations in for instance Austria, Germany, Belgium and the Netherlands. A hub at this location would also make it possible to combine these flows with flows to Italy and France.

New rail freight services in the RETRACK-project have participated in traffic beyond its nominal end point (Constanza) with commodities such as car parts forming a part of this traffic. If a routinely reliable, fast and cost competitive service such as RETRACK can make inroads into traffic to/from Turkey currently using conventional rail technology and systems then more highly developed rail concepts should be much more able to make a significant impact on modal shift.

7.5 SPECTRUM SERVICE AT THE EDGE OR WITHIN THE URBAN AREA

There are many stakeholder groups involved in freight transport in urban areas: customers, local government, transport companies or logistic service providers, terminal operators, train operators, inhabitants and retailers; each with their own interests: social, environment, political, cultural, economic and physical ones.[24] In addition to this, the interaction between the different stakeholders makes urban freight transport very complex.

In and around urban areas the majority of freight is now transported by road. Road transport is a flexible and reliable way to transport freight, and also generates low direct costs. However, the increase in road transport has led to, inter alia, congestion problems and air pollution as well as noise and safety issues. Rail freight transport at the edge or within urban areas is seen as a possible solution to these increasingly pressing problems.

As discussed previously, the potential of a SPECTRUM service depends on several factors, such as the location and size of intermodal rail terminals, transport volumes, total transport costs and current rail infrastructure capacity. To be able to introduce SPECTRUM services at the edge or within urban areas one must overcome even more obstacles, on top of the ones previously mentioned.

Currently, the biggest weakness of urban rail transport is that it does not have door-to-door capabilities, has higher total costs and has limited service availability. Last mile issues could be addressed by inter-modal solutions such as bi-modal trailers, trailers moved on rail wagons, containers and swap bodies. Even though rail is an energy efficient way to transport goods, fuel and energy is currently only a relatively small but vital share of total cost. Energy and fuel prices are expected to continue rising and are to make up a larger portion of total cost and should favour rail in this context. Road transport has an absolute dependency on liquid hydrocarbon fuel and this is a major weakness that will not be resolved or redeemed quickly. It implies major technical, operational and commercial changes for the road based components of the logistic sector.

One of the issues of rail freight transport is that it has to compete with passenger rail services. The SPECTRUM train must have about the same speed, acceleration and deceleration as passenger trains so that it can operate optimally in combination with passenger trains without inflicting delay on other traffic and consuming excessive train paths. Currently, passenger trains have priority over cargo trains. So train service interruptions, such as track work or unplanned delays on the network, can cause delays in freight transported by rail. As a consequence, freight trains could have longer travelling time, become less reliable and generate higher costs. This may be less of a concern where overnight and off peak train paths are able to be exploited and where new types of train technology may be able to exploit passenger quality train paths.

Rail freight transport using the present technical, commercial and operational model has limited physical flexibility. To have freight transported to urban areas by rail, additional rail network connections between terminals and the railway network are needed. Whether this is possible depends on the availability of affordable land in urban areas. The last few years developments in city planning, zoning and rebuilding has reduced operational and commercial options that used to be open to rail. These problems may be offset by the use of different terminal concepts (small/austere/active only when needed) and train formations which can much more readily penetrate the urban areas.

To be able to use rail as a transport mode, agreements must be made beforehand to obtain access to (a part of) the rail network. These can be on the schedules, routes, and guidelines and procedures of the rail network operator. So, especially compared to road freight transport, rail freight transport can be perceived as being very inflexible. They cannot always use another route and this can be a function of the loading gauge on the routes and diversionary routes available. It is possible to make last minute changes using very short term planning methods. Rail is a planned environment with the control of train movements being much more of a planned series of routines and systems. There is a need for much more responsive train path planning methodology and systems to open up options in real time.

Another potential bottleneck for rail freight transport is the traffic generated by rail-linked terminals in and around urban areas. To make rail freight transport more cost effective using existing technology and operating methods, freight is, at present transported by large volumes. The intermittent and periodic arrival of large bulks cause peaks in road transport in and around urban areas, which can in turn lead to traffic congestion and environmental concerns. In addition to traffic problems, shippers and receivers prefer a

[24] Source: Egger S., 2006. Determining a Sustainable City Model, Environmental Modelling & Software, Vol. 21 No. 9, pp. 1235-1246.

continuous method of supply and despatch. Hence, large trains do not fit the high value time sensitive spectrum of the market's requirements. Small trains that run frequently may be more applicable.

This means that the SPECTRUM service in and around urban areas must:

- Be able to operate and run optimally in combination with passenger trains (same acceleration, speed and deceleration) and use available passenger quality train paths
- Have a rail network infrastructure connecting the terminals to the railway network or proximity to low cost terminals and facilities
- Have the ability to load and discharge within the urban areas at low cost with very short final delivery journeys
- Have small trains that run frequently and with unfailing reliability
- Generate much lower
- Costs, be much more productive and be capable of providing additional services such as high speed delivery
- Be fully competitive in terms of service and products with road freight
- Deploy a full panoply of technical options including trailers, containers, pallets, swap bodies moved quickly and cost effectively on/off trains

For the SPECTRUM service concept the routine occurrence of huge congestion problems in road transport with lots of lost time to ensure deliveries in tight time windows set by shippers and receivers, low efficiency and high cost endows a major advantage to rail. Furthermore rising and unstable fuel prices and labour costs make rail freight transport potentially more cost-attractive. If there are strict environmental requirements, for example on air and noise emissions in and around urban areas then rail freight transport may also become more attractive. Public authorities might elect to support these initiatives and subsidies and help reduce the total cost including the external cost burdens. Rail has as a minimum to match and outperform the cost and service profile of high standard road freight operations on a fully commercial basis and not rely on subsidies to ensure success.

Three case studies are briefly presented here as an example of urban rail freight transport: the Monoprix rail and CargoSprinter. The Monoprix rail is a successful experiment and is still in operation. The CargoSprinter did not operate for long and was terminated after one year of operations. The third one is the UK developed TRUCKTRAIN®.

7.5.1 Case 1: Monoprix rail

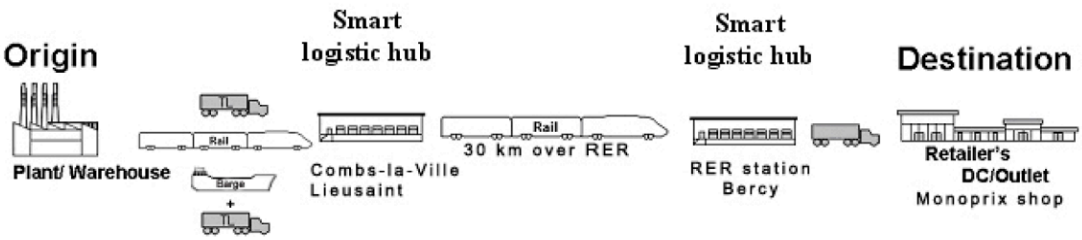
Monoprix is a large French retail chain (a subsidiary of both Galeries Lafayette group and Casino), that started using rail transport for urban freight distribution since December 2007. The initiative was launched by local governments and the French railway infrastructure manager (RFF). In this research they looked at potential experiments for regional rail transport, and Monoprix participated and implemented this innovative concept.

In the old scheme trucks have to travel from a terminal 35 kilometres south of Paris to deliver the Monoprix supermarkets in Paris. In the new concept the goods are transported 30 kilometres from the terminal in Combs-la-Ville/Lieusaint to the city-located warehouse Bercy. Figure 7.7 depicts the Monoprix supply chain concept. From the warehouse in Bercy, more than 80 shops in Paris are delivered by natural gas powered vehicles.

Figure 7.6: The Monoprix rail and the natural gas powered vehicles

(Source: French Institute of science and technology for transport, development and networks, IFFSTAR)

Figure 7.7: Monoprix supply chain concept[25]



(Source: French Institute of science and technology for transport, development and networks, IFFSTAR)

Monoprix decided to supply only some of its products by train, namely non-alcoholic beverages and heavy-weighted Fast Moving Consumer Goods (FMCG). The reason for this is that these FMCG take up a lot of storage space and are heavy. The remaining goods are supplied by trucks. The total amount of goods that are transported using this concept comes up to 30% of the total supply (120,000 tonnes or 210,000 pallets a year) and reduces about 337 tonnes (this seems to be a small saving relative to the goods volume being moved)of CO2 a year. Samada, a logistical subsidiary of Monoprix, controls 100% of the supply chain. Since the flows of goods are big enough, it is not advantageous to combine transport activities with other suppliers.

The motivation of this initiative comes from the growing road congestion problems in and around Paris. About 9% to 15% of the total traffic within Paris can be attributed to freight vehicles, whereas the occupation or road-lane capacity of freight vehicles is about 25%. Furthermore, the occupation of road lanes by freight vehicles reaches even 62% in the historical city centre. Longer stops and double parking problems create more problems on the road network. This leads to for example more accidents involving freight vehicles. About 40% of the total greenhouse gases from transport operations in France come from city logistics. Aside from air pollution, increases in freight traffic also leads to increases in noise emissions.

The concept of replacing trucks with trains in part of the supply chain deals with most of the problems mentioned on freight traffic in the Paris region. Firstly, because 12,000 trucks did not enter the Paris city centre, 70,000(?) litres of fuel was saved, resulting in a decline of 340,000 tonnes of CO2 and 25(?) tonnes of NOx. Secondly, the amount of vehicle-kilometres is reduced, lowering traffic congestions on the road network surrounding Paris. Compared to the former supply chain organisation, road congestion now hardly influences the supply chain. Thirdly, the liquid gas powered engines are equipped with noise reduction technology. And lastly, due to Paris' limitations, trucks are less than 29 m² on ground which has a positive effect on safety and vehicle handling problems in the narrow streets of Paris. On the other hand, having smaller vehicles means more round trips.

However, there is one drawback, namely the additional costs this new scheme creates. The cost per pallet in the old scheme is €13.25, while in the new scheme it is €17.61. Monoprix expects that in the future the

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[25] Source: Deketele L., Coelho P., Grosso M., Lynce A-R., 2008. Moving From 80% Road To 80% Non Road - Modal Shift In A Fast Moving Consumer Goods Supply Chain, TransportNET project.

modes will be effectively charged for the externalities they create. In addition to this and higher fuel prices, they expect that in the future this new scheme will become more profitable than the old one.[26]

Currently, Monoprix uses the train to transport goods on a daily basis to Paris and wants to extend this experiment to its suburban stores. In the Bercy terminal Monoprix only uses 3,700 m² of 10,000 m², so one option is increasing their activity in the Bercy terminal.[27]

7.5.2 Case 2: CargoSprinter

The CargoSprinter was designed by Windhoff, a German manufacturing company, in the mid-1990s in association with freight operators DB Cargo and Fraport. A design was also produced by TALBOT to perform the same sort of duties. The principal differences were in the configuration of the un-powered inner wagons. The CargoSprinters are relatively short trains, 5 units, with a conductor's cabin on both sides, and can carry around 10 TEU. The CargoSprinter units are designed so that they can easily be connected to each other. The intermediate units are unpowered, whereas the end unit of each group of units are powered by small diesel motors and can also carry up to two 20 ft. containers. The main goal of the CargoSprinter is to provide freight transport between smaller container terminals and to compete with highway trucks but they could be deployed on a mix of short, medium and long haul traffic applications.

Figure 7.8: CargoSprinter

(Source: Windhoff, www.windhoff.com)

The CargoSprinter has a modest acceleration and deceleration speed, and can run in between the passenger trains but is limited in its top speed to ~100kph. . The CargoSprinter concept is interesting for inter urban transport on the passenger transport lines but is not powerful enough in the versions produced to accelerate at speeds that would allow it to integrate with dense streams of fast moving passenger traffic ,It could potentially operate over freight transport lines and work with freight train quality train paths over mixed traffic routes One of the drawbacks of CargoSprinter is that it comes, as with all prototypes, with high investment costs. Also, high operational costs follow from, among other things, the low loading capacity of the CargoSprinter and the ability to spread the associated costs. Note that these CargoSprinters are quite small and were not in the trial aplications able to be use intensively in 24/7 operations.

Unfortunately, after the experiment the CargoSprinters are rarely used, not for technical but economic and political reasons by the sponsoring party. Only a few of these trains were produced. Windhoff reconstructed the CargoSprinters into infrastructure and service trains, named Multi-Purpose Vehicles (MPV). Examples of MPVs are the Railtrack in the United Kingdom, used for track maintenance and specialised overhead electrification train, and the maintenance of high speed lanes in the Netherlands. Two MPV sets were used as a proof of concept trial under the EC sponsored IRIS project to move containers between Southampton and London (Barking) and Birmingham. The low power, low acceleration and low adhesion limits of the trains were recognised as major weaknesses of this technical concept. The overall concept of fast, self propelled, b-directional high productivity trains remains valid and the IRIS trials pointed in the direction of the need for something fundamentally much more powerful and capable

Even though the CargoSprinter trains are rarely used, the concept itself is very interesting. CargoSprinter trains were (planned to be) sold to Germany, Australia and the Netherlands.

[26] Source: Maes J., Vanelslander T., 2009. The use of rail transport as part of the supply chain in an urban logistics context, Conference proceedings van Metrans 2009, Long Beach, USA.

[27] Source: SUGAR, Sustainable Urban Goods Logistics Achieved by Regional and Local Policies, 2011. City Logistics Best Practices: A Handbook for Authorities, Bologna, Ital0079.

Germany

In Germany between 1997 and 1999, two CargoSprinter trains ran between the intermodal rail terminal Rail AirCargo Station at Frankfurt Airport, Hamburg, Osnabrück and Hanover. This is equivalent to 5000 lorry loads per year. Initially this experiment was very successful with high reliability and the service was fully utilised. Due to work on the connecting railway track in the second year of operations, the CargoSprinter service was stopped. As a result, the CargoSprinter service was terminated.

Australia

CRT Group, an intermodal transport company in Australia, introduced the first CargoSprinter to Australia in 2002. The CargoSprinter trains in Australia had similar technical characteristics as the ones in Germany. The Queensland Rail bought CRT Group, however the CargoSprinter is kept by a separate private company of the CRT's director Colin Rees and is currently continuing the development of a more powerful version of the CargoSprinter.

The Netherlands

Shortlines, a Dutch rail freight operator, announced in 2000 that they want to invest 5DM million in CargoSprinter trains with Windoff. The CargoSprinter train was planned to run between Eindhoven and Rotterdam for Phillips. However the deal was cancelled because of high costs and time issues relating to the installation of ATB safety systems on the trains.

The UK

The Cargo Sprinter was used in a further set of trials supported by the SRA. These trials were a little different to those undertaken under the IRIS operations. The same fundamental weaknesses (low speed, poor acceleration, low adhesion and a cargo deck height on the power cars limiting the type of containers able to be deployed) were evident. There was no follow up to the trials or commercial service development. Other projects using short fast formation concepts remain in development.

7.5.3 Case 3: TRUCKTRAIN®

The TruckTrain® project is an independent innovative rail freight system including innovative fast, self propelled short formation bi-directional trains focused on inter-modal and palletised traffic opportunities over short, medium and long hauls. The core TruckTrain has power on every vehicle (diesel electric) and power on every axle. The trains are designed to compete with the quality end of the road freight spectrum. Other technical derivatives of the core concept have been developed to accommodate high cube containers and high volume logistics traffic with options on loading and cargo restraint technology. Radical derivatives using bi-modal trailers in short push-pull formations have been developed. All of these exploit the capability of the rail system to use high installed power to achieve rapid acceleration (and commensurate braking) thereby allowing the trains to operate in fast moving streams of passenger traffic.

The trains are able to operate deep within urban areas and minimise the "last mile" issue. The bi-modal trailer derivative (TracTruc®) is able to offload/load the trailers without any external lifting equipment. This potentially allows participating in traffic where it is unable to participate at present, particularly for traffic mandated to be moved in tri-axle trailers.

The trains are designed for very intensive service applications with minimal down time for fuelling and servicing .High annual mileage targets (150000miles 240000km per annum have been set and this has dictated much of the design and equipment specification, Both of these functions are designed to be undertaken during cargo loading. The trains will incorporate on-board systems for technical and cargo condition monitoring to support intense traffic applications and drive asset management in a very robust way. The trains are designed to be worked intensively and be able to operate freely over the rail networks where they are deployed. Multi-voltage capability and the option of bi-modal power for off line activity are feasible.

The TruckTrain® concept has sired a number of related systems initia)tives designed to maximise the use of train capacity and ensure high levels of asset management/utilization. The Freight Arranger® project (http://freightarranger.co.uk/) is designed to allow shippers to more readily enquire as to available services, schedules, capacity and pricing as well as linking in road pre and end haulage. Systems for crew management and allocation to ensure trains are not delayed awaiting competent and available crew for train operations. In addition systems for the deletion of the requirement for driver route knowledge using external systems to advise the train and driver (in that sequence) of signal location and signal aspect, speed limits, point location etc are in development. This will endow the new trains with much more flexibility and match road freight in terms of an ability to "roam" on the rail network in complete safety.

Figure 7.9: Artist's impression of TRUCKTRAIN®

(Source: TRUCKTRAIN®)

The TruckTrain has been developed with a UK focus but is fully transferrable as a concept into other railwy domains and potential applications. It acts as a catalyst for some profound changes in the organization, operation and commercial positioning of rail by exploiting technologies and systems in a new combination.

7.6 CORRIDORS SUGGESTED TO BE STUDIED IN THE SPECTRUM STUDY

Based on the different analysis in this chapter different elements come forward that serve as inputs for the design of a future SPECTRUM train network and the corridors to be analysed in this study. In addition we also take into account other relevant aspects. The following are important inputs:

- Active regions in Sweden, Spain, Netherlands, Latvia, UK, Romania, Germany and Italy can potentially be grouped into corridors and a network.
- Based on OD ranking of top relations (in weight and value) intense flows between Spain, France and Italy, and also between Italy, Germany and Austria, and in addition on Scandinavian routes are identified.
- There are dense flows between west and northwest EU and Turkey which follow for a long stretch the same route. Inclusion of a hub in Budapest could be an option.
- The RNE network should be taken into account.
- Existing corridor initiatives should be taken into account such as the RETRACK corridor.

For the analysis in WP2 the following corridors are suggested:

- Corridor 1: Spain (Valencia-Barcelona) - France - Germany - Scandinavia. Possibly this corridor should be regarded as two separate corridors.
- Corridor 2: Spain (Valencia-Barcelona) - Lombardy (possibly also linking up to ferries in Italian ports) - Austria - Budapest.
- Corridor 3: Belgium-Netherlands ports (possibly also toward the tunnel at Calais) - Germany - Central Eastern Europe (split to Warsaw and Budapest).

8 The operational and technical requirements

The operation of the SPECTRUM concept on the existing European railway network with its known specifications, limitations and constraints imposes some operational requirements on the concept. This results mainly out of the problems of international operations and of the mixed operation of passenger and freight trains on a densely used network. The necessary changes on the rolling stock are also an important issue. On the other hand the SPECTRUM concept differs from the existing rail freight solutions in Europe. Therefore there is also a need for some change of the existing infrastructure and the existing operational regulations. The detailed requirements for the concept depend on the exact use of the train, which types of good to be transported, which countries to be served, which lines to be used and conditions the goods have to be kept in and the configuration of the train/trains.

8.1 International operations

As identified, the most important corridors of LDHV goods transported by road are national ones. The identified international corridors mainly involve only two or three countries. This means there is no obligation for the SPECTRUM rail freight concept to navigate across European borders. Although domestic applications of the SPECTRUM concept have a large potential and are operationally easier than international ones, it is anticipated that cross-border running will also be key to the long term future of the SPECTRUM concept. As part of D1.1 (logistics and market requirements) it was identified that the production of goods in China is shifting toward the west of the country whereas European manufacturing moves eastwards. This may also have an influence on the freight flows and transportation of goods throughout Europe. With this in mind the requirements for border crossings and interoperability need to be defined.

8.1.1 Requirements for border crossings

Border crossings are the trouble spots of international rail freight in Europe, although the situation is improving. Large improvements for international rail freight in Europe could therefore arise from improved border crossings. Much experience on problems at border crossings has been gained from the EU funded project – RETRACK, which was part funded through the FP6 framework. The RETRACK project applied an innovative open rail freight service concept to the movement of rail freight across Europe. This is being achieved through the design, development and implementation of a commercial trans-European rail freight service along the rail corridor between Rotterdam (Netherlands) and Constanta (Romania) on the Black Sea. The project has secured modal shift of cargo from road to rail and created an effective and scalable rail freight corridor between high demand regions in Western Europe and new high growth regions in Central and Eastern Europe.

As well as the RETRACK project, EU funded projects SUSTRAIL and e-Freight provide also relevant information for SPECTRUM. SUSTRAIL is particularly relevant because it has many synergies with the SPECTRUM project. SUSTRAIL aims to “Design a freight vehicle & track system for higher delivered tonnage at reduced cost”. e-Freight aims to develop and demonstrate innovative e-freight capabilities to assist transport users, transport service providers, transport infrastructure providers and transport regulators.

In the following sections the requirements for the SPECTRUM-concept resulting from the experiences gained in the EU-funded projects RETRACK, SUSTRAIL and e-freight are discussed. The requirements result from the typically existing border crossing problems and can be classified into three categories.

1. Organisational requirements

In the different projects experiences on typical organisational problems at border crossings could be gained:

- Issues may arise when organising a train path across international borders. To avoid problems national infrastructure companies usually work together on a bi-lateral basis to plan the train path. For the example in the RETRACK project the train the path was identified, discussed and settled at an international level by the relevant European infrastructure companies. A new pan European agency for the design and response to international train path requests has been developed to facilitate the process particularly for new market entrants. The RETRACK operators were normally able to secure train paths routinely on a spot basis.
- As the dedicated RETRACK route is a main traffic route, trains can and did experience traffic congestion particularly at border points and high train activity areas around major conurbations and industrial zones. This is an issue to consider when planning the SPECTRUM route/s. In reality this has not been a major issue as the train operators have been able to operate closely with national infrastructure operators to overcome any planning issues and in transit problems.
- An example from the SUSTRAIL project indicates border crossing to be costly to the operator due to time consuming organisational issues between Bulgaria and Turkey. The section of the route between Jabalkovo and Kapikule demonstrates a significantly higher total cost and operational cost than other sections along the route. This is largely due to freight trains experiencing significant delay at Svilengrad station, which is the last station before the border with Turkey.
- Research carried out during the RETRACK project suggests there are bilateral issues to be solved between NL, DE, AU, HU and RO as some countries along the route have agreements in place for border crossing. The main problems are that of the Austro-Hungarian border crossing points. Alternative route options have been used to minimise the impact of these issues.

These problems can only be solved on an organisational level of the involved infrastructure managers and railway undertakings. Therefore no specific requirements for a SPECTRUM-train result from this issue.

2. Information problems

Cargo Documentation

International waybill regulations are responsible amongst other things for border crossing routines, freight calculation and the simplification of the international railway business within Europe. For the international transport of goods CIM waybills are necessary otherwise a special detailed contract will be needed.

- Traditionally B/L's are issued in 3 originals (the 1st being accomplished the others stand void) and N copies.
- A system of "holder" name-place + a unique conversion key forwarded by the previous holder to the next solves the problem of uniqueness, if there is one.
- The last holder, by using the conversion key will enter the data of the beneficiary and rightfully release the cargo, if required, against payment.

Several projects (RETRACK, e-Freight) are working towards a cargo waybill with electronic data on an internet platform with adequate safeguards for access and security. Advantages of this may include increased speed of production of cargo documentation which will impact on speed at border crossing and accuracy of data entry which can be used for marketing purposes, although there is a risk that a mix of CIM and electronic waybill may confuse shippers and carriers during any transition. A SPECTRUM-train needs to be adapted for the future electronic waybill system from the outset..

Border points provide an issue for safety and security, there is a risk of delay and train vulnerability is exposed on a routine basis due to hazardous cargo being governed by international protocols and international standards. This is something to consider when choosing cargo for the Spectrum concept with the corresponding need for interventionist management to minimise any risk at this point.

Delay information

Delays of incoming trains at border stations are a critical issue. The information on the delay and the new estimated time of arrival at the border station is often not transmitted and the arrival at the border station is not preannounced to the neighbouring infrastructure manager. Within one country the infrastructure manager can find a solution for the run of the delayed train up to the border. If the neighbouring infrastructure manager is not informed about the delay of the train or the information is not sufficient than the neighbouring infrastructure manager often can't find an appropriate solution for the delayed train in short term. In general there are two possibilities for such a train:

- The train may continue without a slot. In this case the train run can potentially be interrupted because other trains, running on time, will have a higher priority. The arrival time at the destination is made uncertain as a consequence.
- The train may have to wait for the next available slot. This can cause loss of time at the border station. The arrival time at the final destination will be much later than in the original timetable.

In any case the reliability of the train suffers and the actual arrival time at the final destination will be much later than in the original timetable. The shippers may not know when their cargo will arrive. This is a systemic weakness within the present rail service offer. Other systems are being developed to mitigate this weakness by allowing shippers, forwarders and cargo interests to interrogate the relevant train tracking systems and either identify or trigger a response from the train operator on any revised ETA.

The information of a neighbouring railway undertaking about the delayed arrival of a train is also often insufficient. In border stations a railway undertaking may let the train drivers and locomotives wait only a defined time, e.g. one hour, for a delayed train of a neighbouring railway undertaking. After this time locomotive and driver may be redeployed for other services. If the railway undertaking is not informed correctly about the delay of a train it may take a sub-optimal decision.

A solution for these problems would be a positioning system for the train to identify the current position of the train and calculate its ETA. This positioning system should be open for the information of different stakeholders (railway undertakings, infrastructure managers, shippers, and receivers) on the actual position of the train. To avoid the described problems a SPECTRUM-train should be equipped with such an open positioning system.

3. Technical requirements

The specifications for freight trains are different in different European countries, mainly because the standards for railway infrastructure differ within Europe. The RETRACK-project identified the following main issues:

- Different maximum train length;
- Different maximum weight of trains (depending on topographical and technical issues);
- Different possible maximum loading gauges along the corridor. This can pose a potential problem in the event of diversions being required;
- Different axle loads;
- Different signalling systems and different voltages are important issues. It may require at least one loco change in transit or the use of multi-system locos. Speed limits and heavy re-construction activities due to bad track conditions may also be mentioned.

These issues should be addressed during the development of SPECTRUM-concept. The specific individual requirements of the countries to be served should be met by the SPECTRUM-train.

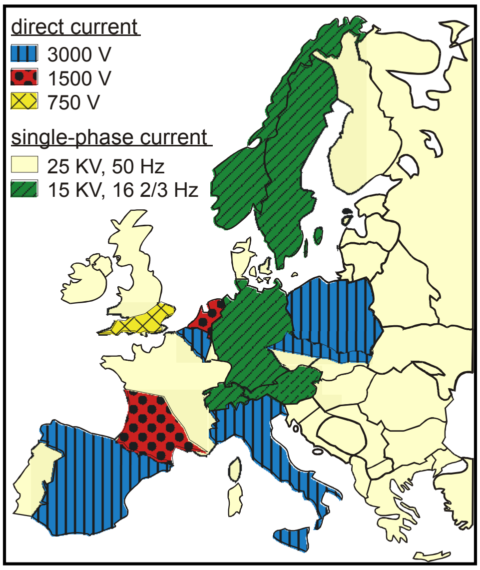
8.1.2 Requirements for interoperability

To operate seamlessly across-borders a SPECTRUM train has to be interoperable in the countries involved. Generally interoperability causes higher costs the more countries are involved. Therefore it is necessary to analyse the necessary level of interoperability.

Voltage and train control systems

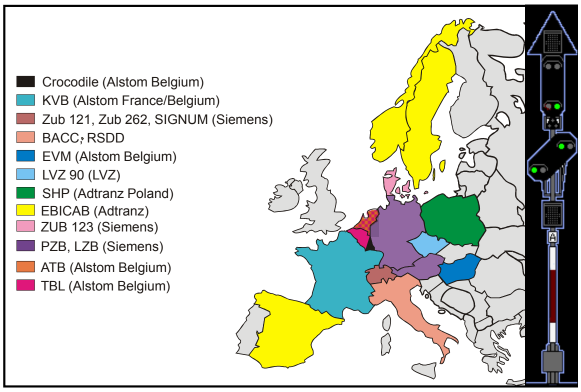
In European railway there are many different voltages and train control systems. Therefore a train running in more than one country faces problems. Figure 8-1 gives an overview on the different voltage systems in Europe and Figure 8-2 shows the different train control systems.

Figure 8.1: Different voltage systems in Europe



(Source: Railistics)

Figure 8.2: Different train control systems in Europe



(Source: Railistics)

Locomotive-hauled trains either need a change of locomotives at the border or a multi-system locomotive. The change of locomotives at border stations causes various problems and extends the running time. Multi-system locomotives are generally more complex and more expensive. It may also not viable to use locomotives for all existing voltage and train control systems in Europe, so a choice has to be made in which countries the locomotive is to be used.

As example the costs of a single-system locomotive and a multi-system locomotive of the same type are given in Table 8.1 and Table 8.2. The example deals with the important European rail freight corridor Netherlands-Germany-Switzerland-Italy (e.g. Case study FloraHolland). In this example the purchasing price for the multi-system locomotive is about one third higher than for a single system locomotive. The total costs per hour (including other costs not related to the purchasing price and the possible business hours) are about 20% higher. The more different voltage and train control systems are installed in the locomotive the higher the purchase price and the costs per hour are. The need for high and near constant in traffic service to offset this cost is an imperative.

Table 8.1: Costs of single system locomotive

Costs Single System			
Purchase price			3.000.000,00 €
Depreciation	25 years	4% p.a.	120.000,00 €
Interest		5% p.a.	75.000,00 €
Insurance	Private RU	2,00% p.a.	60.000,00 €
Maintenance			150.000,00 €
Total costs per year private RU			405.000,00 €
Total costs per hour Private RU			**155,77 €**

Table 8.2: Costs of multi system locomotive

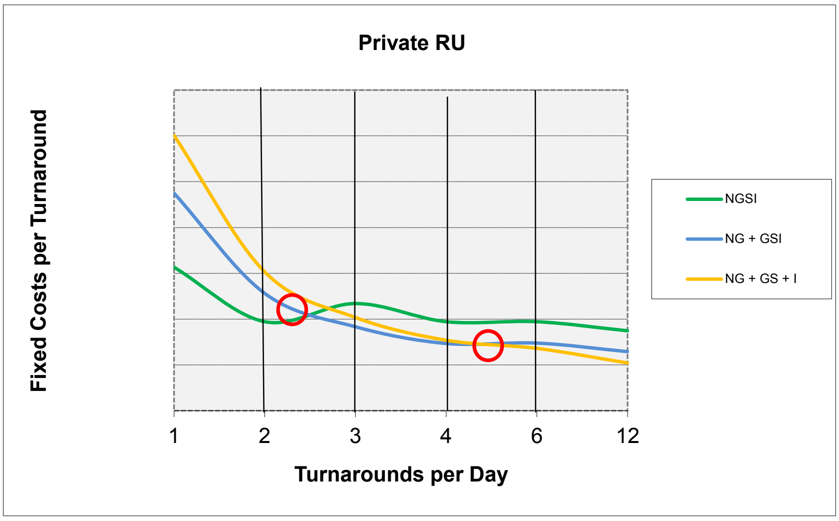
Costs Multi-System (3 systems)			
Purchase price			4.500.000,00 €
Depreciation	25 years	4% p.a.	180.000,00 €
Interest		5% p.a.	112.500,00 €
Insurance	Private RU	2,00% p.a.	90.000,00 €
Maintenance			155.000,00 €
Total costs per year Private RU			537.500,00 €
Total costs per hour Private RU			**206,73 €**

It may be possible that the multi-voltage loco can offset the higher cost by more intensive service application. The use of a multi system locomotive can be more expensive than the use of several single system locomotives. This depends on the turnarounds and applications per day. If several turnarounds per day on a corridor are possible single system locomotives can be used more efficiently. The additional costs of the use of more locomotives and the locomotive change at border stations are getting less important against the lower costs per business hour of single system locomotives. The example shown in Figure 8.3 shows for the corridor Netherlands-Italy via Germany and Switzerland a cost comparison for the following cases

- Multi system locomotive for all countries (NGSI).
- One multi system locomotive for the Netherlands and Germany (NG); one for Germany, Switzerland and Italy (GSI).
- One locomotive for the Netherlands and Germany (NG); one for Germany and Switzerland (GS) and for Italy (I).

This example shows that beginning with three turnarounds per day the costs for the use of individual locomotives for different countries are getting lower than the costs for a multi system locomotive for all countries.

Figure 8.3: Cost comparison for single and multi-system locomotives



For normal Locomotive-hauled trains only the locomotive needs to be interoperable with respect to voltage and train control system. This is different for train-sets with their own (electric) propulsion system. In that case the whole train set needs to be interoperable to cross a border. The same would be true for wagons in locomotive hauled trains having their own access to the catenary for energy supply (e.g. for temperature control).

The requirements for a SPECTRUM-train regarding voltage and train-control depend therefore on the actual train-concept. The concept should be in general adaptable for all common voltage and train-control systems so that the train has the possibility to operate in all European countries. It may be that SPECTRUM trains could be constructively confined to single voltage/signal system domains or deliberately constrained onto routes requiring only one change of systems. The rapidly decreasing cost and size of electronic equipment may make concerns over the complexity and cost of full multi-voltage capability less worrisome.

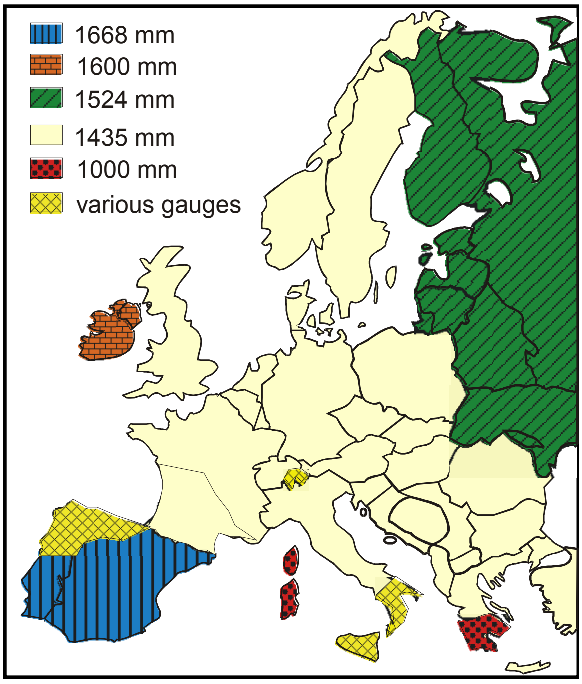
Other forms of interoperability

Other problems for international trains in Europe concern the gauge and the loading gauges. In Europe there is a standard gauge of 1435 mm. But in several countries there are different gauges:

- 1668 mm on the Iberian Peninsula
- 1600 mm in Ireland (not relevant)
- 1520/1524 mm in Finland, the Baltic countries and the CIS countries
- 1000 mm, 750 mm and other gauges are common for secondary lines in different European countries (e.g. Switzerland, Spain, Italy and Greece)(not relevant)

Figure 8.4 shows the different gauges in Europe.

Figure 8.4: Different gauges in Europe



Source: Railistics

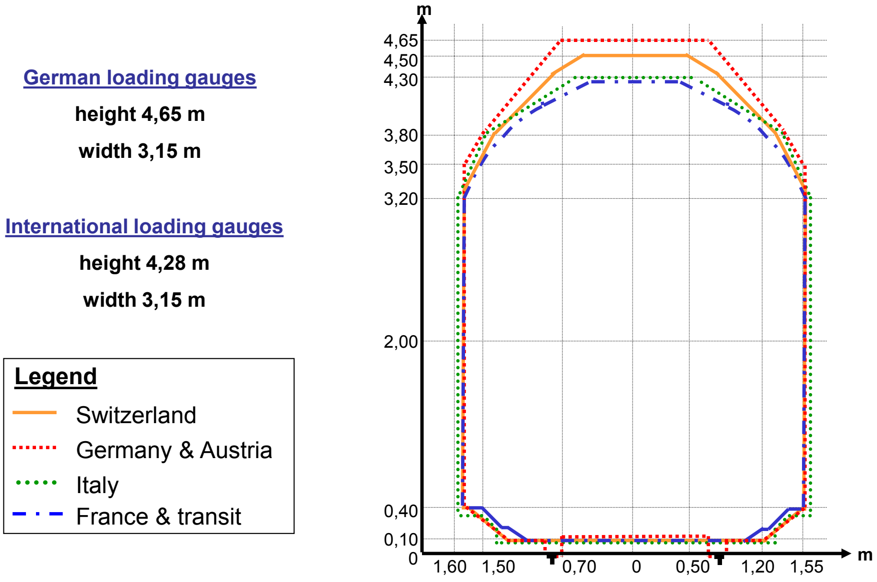
For trains connecting countries with different gauges generally there are two possibilities:

- One is the transhipment of cargo at the border. This is especially true for trains with containers or other intermodal loading units.
- The other possibility is to switch the gauge of the wagons. Therefore the wagons need special bogies and there is a need for special equipment at the border crossing. Because of the additional costs this is only used for special wagons dedicated to cross-border services.

The possible loading gauges also differ widely throughout Europe. Nearly every country has its own loading gauge, but there are also variances within one country. For example, the loading gauges of Germany, Austria, Switzerland, Italy and France are given in Figure 8-5. There is a European standard loading gauge as minimum requirement. Great Britain has on most lines a loading gauge which is much smaller than this European standard gauge.

Wagons running in international service are normally designed for the European standard gauge. For services to and from Britain there are special wagons in use. In intermodal traffic the requirements for the wagon depend also on the loading unit to be carried (e.g. standard container vs. high-cube container).

Figure 8.5: Loading gauges in several European countries



The SPECTRUM-train should be developed for standard gauge (1435 mm). Specific versions for other European gauges could be developed out of this version. Regarding the loading gauge the SPECTRUM-concept should be adapted to the minimum European standard with the maximum coverage.

ETCS

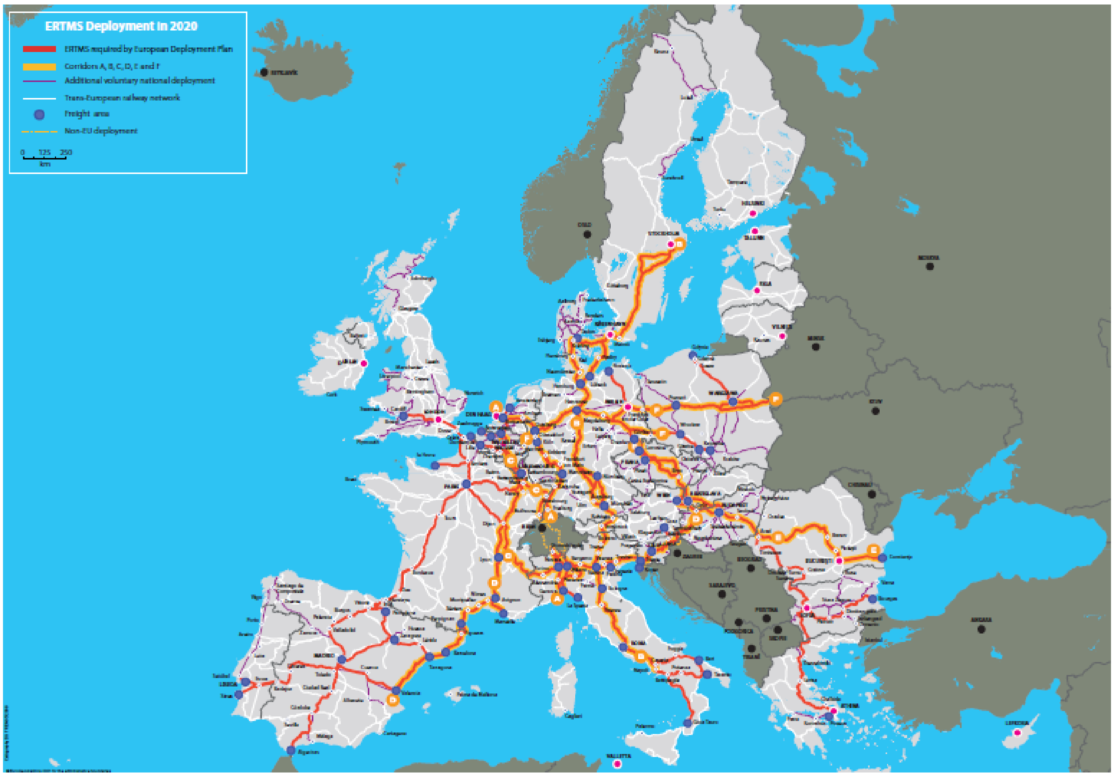
In the long run the national train control systems within the EU may be replaced by the European Train Control System ETCS. Therefore problems resulting from different train control systems will vanish. But the actual deployment plan for ETCS envisages for 2020 the deployment of ETCS on only a few of the major railway corridors. Most railway lines throughout Europe will remain equipped with the national train control systems. Therefore it remains necessary to cope with different train control systems at least in short and medium term. For example the national deployment plan of Poland envisages that until 2023 only about 5000 km of the national railway network of about 19.000 km will be equipped with ETCS. By the end of 2012 only about 1200 km on two corridors shall be equipped with ETCS[28]. On the 1520 mm railway networks of the Baltic countries no deployment of ETCS is planned[29]. Even in Denmark where all railway lines shall be equipped with ETCS Level 2, the commercial operation on the first two early deployment lines will not start until 2017 and 2018[30]. Figure 8-6 shows the planned deployment of ERTMS/ETCS in the EU 2020. But in some countries delays are to be expected.

[28] Polish National European Rail Traffic Management System Deployment Plan, Warsaw, 2007.

[29] e.g European Rail Traffic Management System (ERTMS), National Implementation Plan Latvia, 2007.

[30] Trafikstyrelsen (editor), Dansk ERTMS Implementeringsplan 2009, Copenhague, 2009.

Figure 8.6: European Deployment Plan for ERTMS



(source: European Commission, DG Mobility and Transport)

The requirements for the SPECTRUM concept resulting from interoperability depend on the corridor to be used and the type of goods to be transported. As an example the previously identified corridor Netherlands-Latvia is analysed. According to the logistics and market analysis the main type of goods transported are "chemicals" and "other type of goods". Therefore it is expected that a LDHV-train on this corridor might consist of intermodal wagons carrying different types of loading units, special vans and tank wagons. It cannot be excluded that temperature control of some types of goods is necessary also on this corridor.

The requirements resulting from interoperability on a corridor are mainly influenced by the countries served. In this case these are: the Netherlands, Germany, Poland, Lithuania and Latvia. All countries have different voltages and train control systems. In Lithuania and Latvia the main lines crossing the country are not electrified. They also have a different track gauge. These characteristics are displayed in Table 8.3. In addition in the Baltic countries a different coupling system is used.

Table 8.3: Characteristics of different countries

Country	Power system	Train control system	Gauge
Netherlands	1,5 kV DC	ATB EG/ATB NG	1435 mm
Germany	15 kV 16,7 Hz AC	PZB/LZB	1435 mm
Poland	3 kV DC	SHP	1435 mm
Lithuania	Diesel	ALSN	1520 mm
Latvia	Diesel	ALSN	1520 mm

It does not seem realistic to have one train running on the whole corridor without change of configuration. The biggest problem is the gauge change at the Polish/Lithuanian border. The locomotive needs to be changed there anyway (a hybrid multi-system locomotive for two gauges seems not realistic). The gauge change of wagons is possible, but special bogies are necessary. Therefore the costs (purchasing and maintenance) for those wagons are considerably higher than for standard wagons. For intermodal wagons these extra costs can be avoided with a terminal at the border where the loading units are switched from standard gauge wagons to broad gauge wagons. An option could be to transport all goods to Lithuania and Latvia only in intermodal loading units. So a change of gauge for wagons can be totally avoided.

The energy supply of the wagons needs to be independent from the catenary and the type of locomotive used (diesel or electro, voltage system of locomotive). As loading gauge the European loading gauge should be taken. This loading gauge should be guaranteed in the Netherlands, Germany and Poland. In Lithuania and Latvia a special loading gauge for broad gauge railways is applied. This is broader than the European one so there shouldn't be any problems.

Previously the most important relations (national and international) are defined. The most important international relations are between regions in France and in Spain, Therefore this relation is also analysed here. The most important characteristics of these countries are given in the following table.

Table 8.4: Characteristics of different countries

Country	Power system	Train control system	Gauge
France	1,5 kV DC and 25 kV 50 Hz AC	Crocodile/KVB/TVM	1435 mm
Spain	3kV DC	ASFA	1668 mm (1435 on some lines)

Again the gauge change at the border is the biggest problem. The effects are the same as described above. A particularity here is that the High-Speed lines in Spain are generally built with 1435 mm gauge (as in France and the rest of Europe). Since 2010 there exists also one connection of both networks in 1435 mm from France to Barcelona. Despite some organisational problems this connection can also be used by freight trains. On relations from France to Catalonia region a gauge-change is therefore not anymore necessary.

Another particularity is that within France different voltage systems are used. France has a DC system mainly used in the south and an AC system used mainly in the north and on High-Speed-lines (including the 1435 mm-connection to Spain). Therefore locomotives used in cross-border services on the standard gauge line might need to be three-system locomotives.

8.2 OPERATIONAL REQUIREMENTS

The SPECTRUM train should fit in better in the existing passenger train operations. Therefore a SPECTRUM train needs to have some extent the characteristics of passenger trains. The simple transfer of the characteristics of a modern passenger train regarding vehicle dynamics, maximum speed, power etc., arguably makes a freight train quite expensive but the system benefits of uniform train performance profiles will outweigh the more expensive build costs. Therefore it seems necessary to analyse to which extent a SPECTRUM train should have the characteristics of a passenger train to fit in passenger operations.

Freight trains often don't have stopovers on the line for commercial reasons (loading and unloading) whereas local and regional passenger trains stop regularly for entry and exit of passengers. Therefore freight trains do not need the same specifications as passenger trains for mixed operations with local and regional passenger trains. Due to less stops on the line the maximum speed of a freight train could be lower than that of local and regional passenger trains to reach the end of line within the same time, which is the most relevant criterion for a good integration of freight trains into passenger operations. The acceleration and deceleration capability of freight trains has to improve to fit better into existing passenger operations, but due to less stops of freight trains it does not necessarily have to have exactly the same acceleration and deceleration capabilities of modern passenger trains for local and regional service but should be close to this performance to minimise the risk of imposed delays.

The situation is different for the integration of freight trains into operation of long-distance passenger operations with very few stops. In that case the maximum speed of freight trains needs to be similar to that of the passenger trains. The same is true for acceleration and deceleration performance to minimise the impact of delay on other trains and the ability to exploit passenger train infrastructure.

8.2.1 Methodology of operational study

For this analysis a division of rail operations into three categories seems to be appropriate. These categories are:

- High Speed lines
- Commuter rail systems in larger conurbations
- Conventional long distance lines

For each of these categories an analysis with different scenarios was carried out to define the necessary characteristics of a SPECTRUM train. The analysis was carried out with the help of an IT-tool for timetable construction and analysis (FBS). For each category a sample line with typical characteristics for this type of line was created. The details of these sample lines are shown in the following table.

Table 8.5: Characteristics of different rail operations categories

	High Speed Line	Conventional Long Distance Line	Commuter Rail Line
Length (km)	100	90	50
Number of tracks	2	2	2
Maximum speed (km/h)	250	160	120
Train paths per hour and direction, passenger	4	4	8
Distance between stations (km)	20	15	5
Length of block section (km)	5	3	2
Gradient (‰)	6	6	6

For each category different scenarios were carried out. In these scenarios different operational conditions and different train configurations of a sample SPECTRUM train are analysed. The basic characteristics of the SPECTRUM train are the same for all categories:

- Length: 389 m
- Load: 960 tons
- Payload: 520 tons
- Electric Locomotive(s): German class 146.1
- Wagons: 26 Hbilss 307-160 covered wagons with sliding doors

Regarding the maximum speed three cases are analysed in all scenarios:

- 160 km/h
- 140 km/h
- 120 km/h

For the category Commuter Rail Line the maximum speed of the line is 120 km/h. Therefore only one case was considered. To examine differences in accelerations and power for every scenario a case with one locomotive (German class 146.1, power 5.6 MW, average acceleration approximately 0.1 m/s2) and a second case with locomotives (German class 146.1 2 times 5.6 MW, average acceleration approximately 0.5 m/s2) was considered for every speed case. The different scenarios are shown in the following table.

Table 8.6: Scenarios of operational study

Category	Scenario	Description	Locomotive case (Freight train)	Speed case (Freight train)
1: High Speed Line	1.1	4 High Speed trains per hour stop at every intermediate station	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
	1.2	4 High Speed trains per hour don't stop at intermediate stations	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
2: Conventional Long Distance Line	2.1	4 Intercity trains per hour stop at every intermediate station	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
	2.2	4 Intercity trains per hour call intermediate stations alternatingly	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
	2.3	4 Intercity trains per hour don't stop at intermediate stations	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
	2.4	2 Intercity trains per hour, calling every station, 2 per hour don't stop	A: one Locomotive	120 km/h
				140 km/h
				160 km/h
			B: two locomotives	120 km/h
				140 km/h
				160 km/h
3: Commuter Rail Line	3.1	8 Commuter trains per hour, calling every station	A: one Locomotive	120 km/h
			B: two locomotives	120 km/h
	3.2	4 commuter trains per hour, calling every station, 2 Regional trains per hour calling selected station	A: one Locomotive	120 km/h
			B: two locomotives	120 km/h

For the passenger trains standard rolling stock of the respective train categories were chosen:

- High Speed trains: 1 EMU (German class 403)
- Intercity trains: 1 locomotive (German class 101) and 10 coaches (1 dining car, 2 first class, 7 second class coaches)
- Regional Trains:1 EMU (German class 428)
- Commuter trains:1 EMU (German class 423)

For each case a freight train was inserted in the timetable between two consecutive passenger trains. The passenger trains were generally assumed to have higher priority. In the case of a potential conflict the departure times of freight trains were adjusted or freight trains have to wait for overtaking.

The aim of the study was to find a configuration of a SPECTRUM train with respect to maximum speed, power and acceleration which can smoothly fit in the existing passenger timetable. This means preferably no overtaking by passenger train and no loss of capacity by too a big difference in travel time on the line.

The results of the study are given in timetable diagrams. These diagrams indicate all trains on time and path of all train movements on the railway line. For better readability only one direction is indicated. All lines have two tracks and it is assumed that each track is reserved for one direction.

All cases are compared in a matrix. In this matrix all cases posing no (or only minor ones) operational problems (such as loss of capacity or lengthening of travel times) are shown in green, those posing smaller problems in yellow and bigger problems in red.

8.2.2 Results

As a first result of the study it can be said that the power of one locomotive (cases A) is not sufficient to bring a train of the assumed weight to a speed of 160 km/h on a line with a gradient of 6 ‰. The maximum possible is about 140 km/h Therefore for all cases with one locomotive there is no big difference between a maximum speed of 160 km/h and 140 km/h. With two locomotives (cases B) in contrast a maximum speed of 160 km/h can be reached without any problems but at a much higher line haul cost (energy used, track access charges etc) which may make this option non-competitive.

Category 1: High speed line

Result of scenario 1.1 is that both in locomotive cases A and B a freight train with 140 km/h as well as with 160 km/h can fit in the passenger operations. Because of the absence of stops with the freight train a lower maximum speed compared to the one of high speed trains can be accepted.

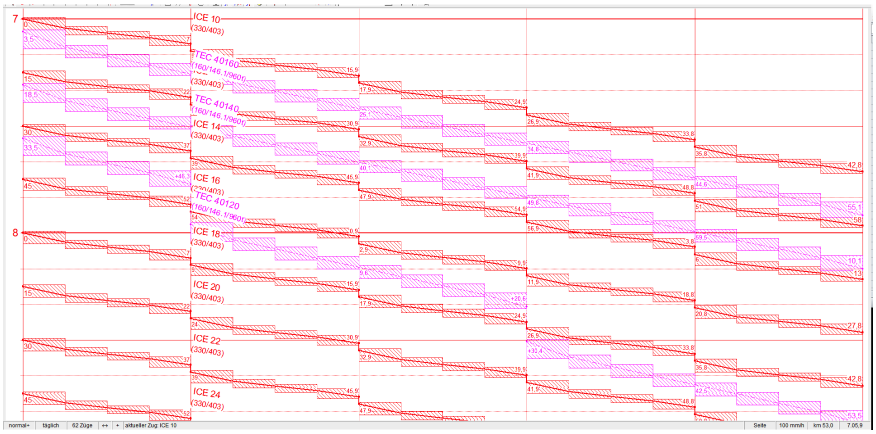
The overall travel time on the line is quite similar. The high speed trains need 42.8 Minutes for the whole line with 4 stops, a freight train needs in case A (one locomotive) 51.6 minutes. This is about the maximum possible time between two following passenger trains. This can become a problem even in the event of very small operational disruptions and should therefore be avoided.

In case B (two locomotives) the overall travel time of a freight train is 46 minutes (140 km/h) and 41.1 Minutes (160 km/h). This leaves an acceptable buffer time between the freight train and the passenger trains. The travel time of the train with 160 km/h is even lower than for the high speed trains, because of the absence of stops for the freight train.

The speed case 120 km/h poses in both locomotive cases a problem. The freight train is too slow to fit in the passenger operations. Freight trains therefore have to be overtaken by passenger trains once (case B) or even twice (case A). This leads to a further extension of the travel times of freight trains and has negative impacts on the capacity of the line.

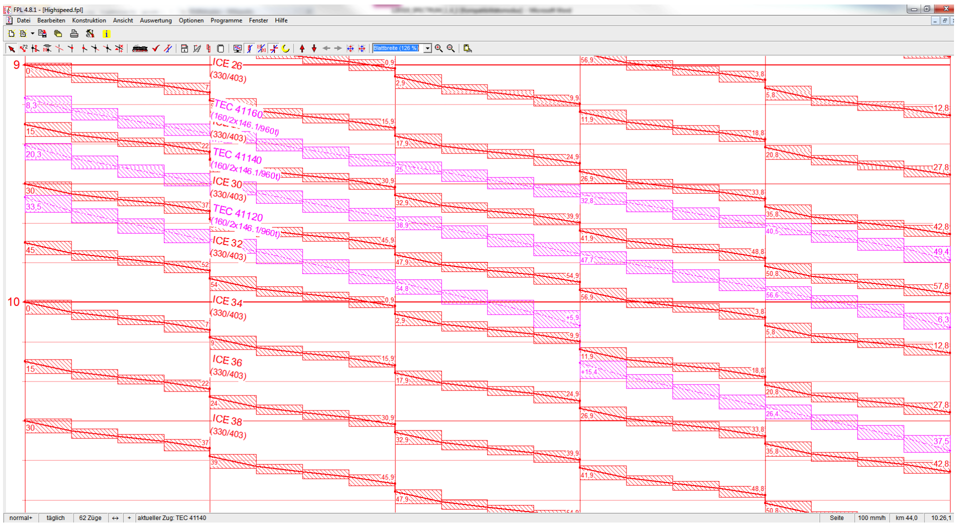
The timetable diagram of scenario 1 case A is shown in the following figures. The high speed trains are labelled ICE and shown in red colour and the freight trains TEC (purple). The maximum speed of the freight trains is given by the last three number of the TEC trains (e.g. 40160 means 160 km/h maximum speed). It is clearly visible that the freight trains with 140 and 160 km/h (40140 and 40160) maximum speed scrape through between two high speed trains whereas the freight train with a maximum speed of 120 km/h (40120) has to be overtaken twice by high speed trains.

Figure 8.7: Timetable diagram of scenario 1.1 A



For comparison also the timetable diagram of scenario 1.1 B is given in the following figure. The labels and numbers of trains have the same meaning as in the diagram of scenario 1.1 B. The additional buffer time between the freight trains and passenger trains can be seen.

Figure 8.8: Timetable diagram of scenario 1.1 B

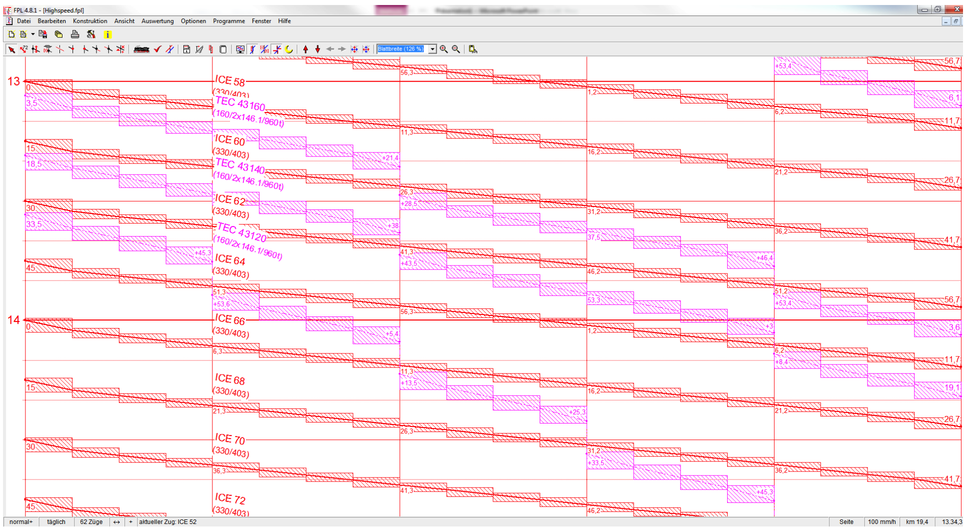


In scenario 1.2 every freight train has to be overtaken by high speed trains in every station. This means a noteworthy lengthening of travel time for the freight trains and has a negative impact on the line capacity. The speed difference between high speed trains and freight trains becomes more important in this scenario because both types of train don't stop on the line.

Figure 8.9: Timetable diagram of scenario 1.2 A

In scenario 1.2 B the negative impact is smaller, but the freight trains with 140 and 160 km/h still has to be overtaken twice (compared to four times in scenario 1.2 A). The freight train with 120 km/h has still to be overtaken four times by passenger trains.

Figure 8.10: Timetable diagram of scenario 1.2 B

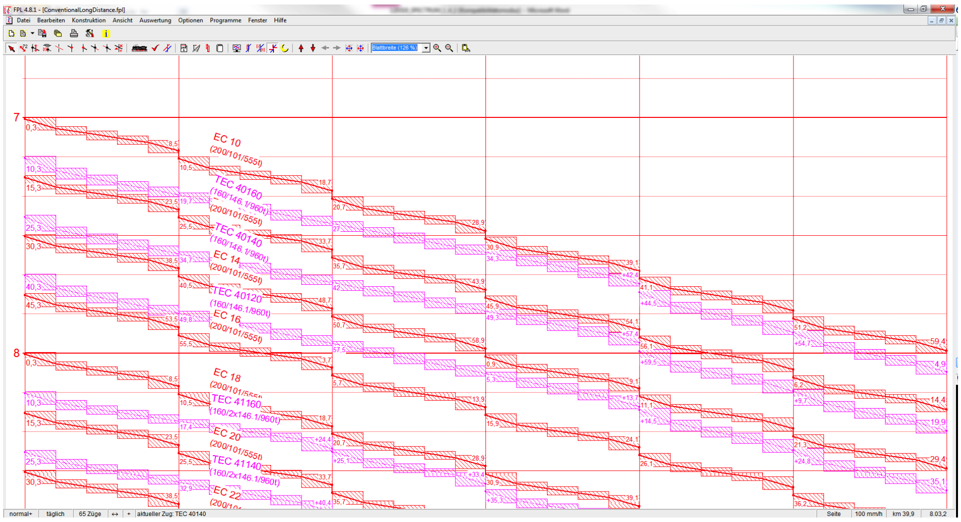


To operate within a High Speed line environment freight trains need much more installed power (7.8kw/tonne gross) to be able to operate without imposing significant delays on very high speed services. The use of two locomotives imposes much higher costs (capital cost elements plus higher energy consumption and track attrition (locomotives are the highest cause of track wear and this increases with weight and speed). There may be penalties imposed on freight trains which do create delays for following high speed passenger trains. This may be obviated if the freight operations are constrained to night time periods when passenger services are limited. The operation of very fast loco hauled trains in push pull mode may be a possibility but the high cost of locomotives needs to be addressed. Integral power in short train formations which can be linked in multiple to accommodate varying commercial and operational positions may be better placed to operate in a fast train scenario.

<u>Category 2: Conventional long distance line</u>

Scenario 2.1 shows that the freight trains fit in smoothly in the passenger operations for all locomotives cases A and B and all speed cases (120 km/h, 140 km/h and 160 km/h). Because the freight trains don't stop at the intermediate stations the travel time of the freight trains is lower than for the intercity trains even for a lower maximum speed. The intercity trains with 5 intermediate stops take 59.1 minutes for the whole line whereas the freight trains have travel times between 53.4 and 54.8 minutes. The timetable diagram of scenario 2.1 A is given in the following figure.

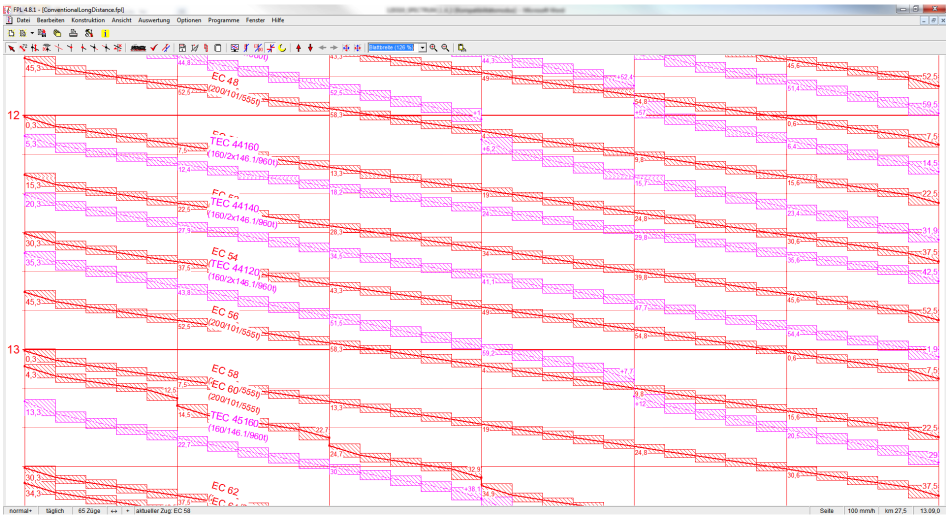
Figure 8.11: Timetable diagram of scenario 2.1 A



In Scenario 2.2 the intercity trains have alternating stops at the intermediate stations. Two trains per hour call at the stations number 1, 3 and 5 and 2 trains per hour stop stations number 2 and 4. The travel time of the intercity trains therefore shortens to 50.4 minutes (three stops) and 48.5 minutes (two stops). The gaps between the intercity trains are therefore different between a three-stop and a twos-stop train than between a two-stop and a three-stop train. The freight trains fit in all gaps in any case.

This is different in scenario 2.3 A and 2.3 B. In these scenarios the intercity trains don't stop at all on the line. The travel time therefore drops to 37.2 minutes. In locomotive case A (one locomotive) all freight trains have to be overtaken once. In locomotive case B only trains with 120 km/h maximum speed have to be overtaken by intercity trains. The travel time of freight trains with two locomotives and 160 km/h also drops to 37.2 minutes because they are not hindered any more by slower intercity trains. This is shown in the following figure of scenario 2.3 B

Figure 8.12: Timetable diagram of scenario 2.3 B

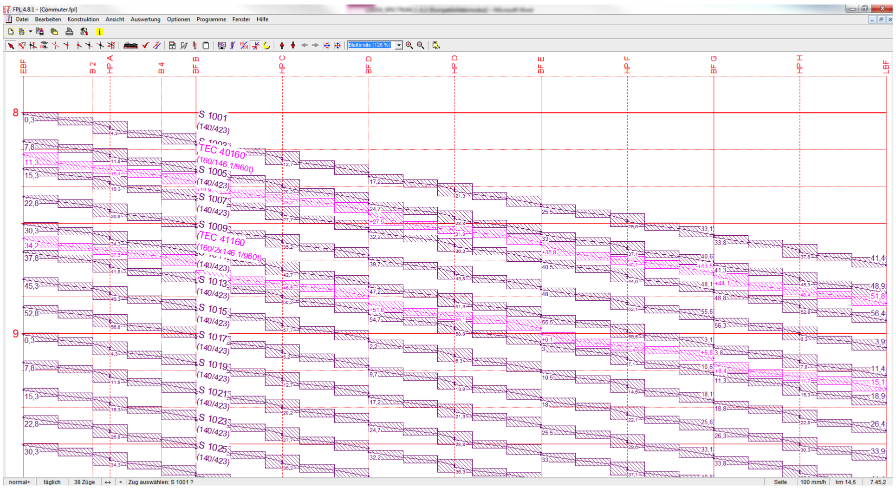


In scenario 2.4 A and 2.4 B again every freight train has to be overtaken once by a passenger train. This is partially due to the different travel times of intercity trains. This different travel times between non-stopping trains and the trains stopping at every station lead to a loss of capacity on the line so freight trains have to wait for the following free slot. This reinforces the case for more installed power and the case for integral power in short train formations able to be coupled as required.

Category 3: Commuter rail line

The commuter rail line has only an assumed maximum speed of 120 km/h. Therefore only the speed case 120 km/h is considered for both locomotive cases. Both locomotive cases fit in the very dense commuter line timetable in scenario 3.1, but the non-stopping freight trains are hindered by the commuter trains calling every station to some extent. There is not much buffer time and therefore a considerable risk in case of operational disruptions. The following figure shows the timetable diagram of scenario 3.1 A (train TEC 40160) and 3.1 B (TEC 41160). The commuter trains are shown in dark blue and labelled S.

Figure 8.13: Timetable diagram of scenario 3.1 A and B



In Scenario 3.2 the passenger timetable is less dense but because of the different travel times of regional trains and commuter trains more complex. The overall capacity of the line is lower because of these different travel times. There is only the possibility to have 2 slots per hour for freight trains between two commuter trains. There is no possibility to fit in a freight train between a commuter train and a regional train. This is not caused by the freight train but the passenger trains and therefore the two different locomotive cases have no impact on this. In the following figure the timetable diagram of scenarios 3.2 A (TEC 42160) and B (TEC 43160) are given. Commuter trains are labelled S (dark blue) and regional trains RE (green).

Figure 8.14: Timetable diagram of scenario 3.2 A and B

This suggests that Spectrum trains may need to operate outside the commuter peak in major conurbations and exploit the quieter traffic periods Later morning to mid-afternoon and overnight.

Comparison and conclusion

The different cases are compared for all scenarios in a matrix indicating scenarios causing no operational difficulties or problems in green colour, those posing smaller problems/difficulties in yellow and those with severe difficulties in red colour.

Table 8.7: Comparison of different cases

Scenario	Case A			Case B		
	120	140	160	120	140	160
1.1						
1.2						
2.1						
2.2						
2.3						
2.4						
3.1						
3.2						

Results of the operational study are:

- 120 km/h is too low as maximum speed for a freight train to fit in smoothly in passenger operation except for commuter lines where maximum speed is generally not higher than 120 km/h.
- In most cases 140 km/h is sufficient, but the ability to achieve 160 km/h might be better depending on the actual requirements.
- Most problematic is the mixed operation with high speed trains.
- Mixed operation of passenger trains with different travel times can pose problems for the integration of freight trains into passenger operations.
- Power and acceleration of one standard locomotive might not be sufficient for operation of freight trains on a level comparable to passenger transport. This does of course mean higher costs.

This study was done with simplified sample lines. A more detailed study should be done when more is known on the concrete use of the SPECTRUM train.

8.3 TECHNICAL REQUIREMENTS ROLLING STOCK

Out of the previous analysis of the operational requirements for a SPECTRUM train some conclusions for the technical requirements of the rolling stock can be drawn. This covers mainly:

- The ability to run with 140 km/h or 160 km/h fully loaded.
- The necessary power and acceleration/braking to keep up with passenger operations.

Other technical requirements derive from the market requirements and regulations. These are for example:

- Low noise operation, especially in urban areas.
- Flexible train configurations.
- Possibility for energy supply in train (temperature control) either supplied on train or possibly from external power or onboard power generation I(diesel electric power packs).

Another very important point is that SPECTRUM wagon needs to be in accordance with the TSIs. All new built freight wagons that are going to run on European rail needs to be certified according to TSI rule WAG 2006/861/EC and 2009/107/EC.

This specification is only valid for wagons up to 120km/h. There need to be a very special approval procedure for wagons that are going to run at 140-160km/h, which has not been done yet. All the wagons that today are running in service at these speeds are certified before the need for TSI approval. To offset the higher speed there will be a need to reduce the tare weight of the wagon.

Different subsystems of a SPECTRUM train are concerned by these requirements. Here the running gear and the traction and energy supply are given as the most important examples.

Running gear

The running gear is to be designed for either 120km/h or 160km/h for a fully loaded train. The bogie for 120km/h is a standard system running on most freight wagons today and have gone through the TSI approval certification. The bogie for 160km/h is not a standard system and has today not gone through the TSI certification. This means that if SPECTRUM decides to go ahead with a train for 160km/h it will either mean a lengthy process for the TSI certification or we will maybe not even get the approval. There are existing LTF bogies in service with low track force characteristics which it may be possible to modify exchanging weight for speed. The noise emission is very important which means that we also need to look into Low Noise Bogies.

Since we are aiming for LHDV-goods it could be possible that the requirement on the load is low enough so that we can use single axle system instead of bogies. For a wagon that runs 160km/h there is a need for a disc brake system compared to a conventional shoe brake systems used in most freight wagons and if the wagon is very light in empty load it also need to be equipped with a WSP system. If the wagons are running more than 200.000 km per year it could be an advantage from a maintenance perspective that also the 120km/h wagon is equipped with disc brakes. There is likely to be a limited future for clasp brakes operating within the speed distance envelopes envisaged for Spectrum. The disadvantage for a disc brake system is that in short term it is more expensive but it could be that for higher mileage the LCC cost would be lower.

Traction/energy supply

As the operational study showed, the conventional configuration of freight trains in Europe with one conventional locomotive will not be sufficient for a SPECTRUM train regarding traction power and acceleration. Possible solutions could be:

- The construction of new, more powerful locomotive.
- The use of second locomotive (as in the operational study).
- The use of a train set with own propulsion. This train set can be with traction units (similar to locomotives) at each end or with distributed power within the train set.

The use of short train sets (about 200 to 400 m length, similar to the ones used by Innovatrain) would also allow for flexibility in train configuration. Trains could share paths on a part of their journey and split up to reach separate destinations.

The energy supply for temperature control of containers on the train is also closely linked with the traction of the train. In a fixed train set with traction units the energy supply of the wagons could be done directly by the traction units. Therefore no own energy supply of the wagons (e.g. diesel engines, etc.) is needed.

With regard to train configuration and possible energy supply within the train, the coupling system should also be considered in the further analysis but should be fully automatic and include the linkage of train control equipment and the braking systems together with any security, communications and condition monitoring links.

8.4 ADAPTATIONS ON EXISTING INFRASTRUCTURE

It will not be possible to induce big changes in the existing infrastructure for the SPECTRUM concept. Therefore only small adaptations seem to be feasible. Adaptations seem especially possible in (intermodal) terminals and their access from the mainline. The previous analyses showed that in some countries and regions the terminal network might need to be extended or revised to cover a substantial part of the county. Therefore also possibly new built terminals should fulfil the requirements of SPECTRUM concept.

A SPECTRUM train shall have at least some characteristics of passenger trains and therefore is faster than a conventional freight train on the line. The reduction of transport time, achieved on the main line, should not be lost again in accessing the terminal or in the terminal itself. The option for (intermodal) line trains should be preserved in SPECTRUM project.

Another option for a SPECTRUM train is to have a mixed train for combined transport and conventional rail transport in vans or tank wagons. Loading and unloading facilities for these types of wagons should also be provided in the same terminal as for combined transport.

It is therefore necessary to have:

- A fast access of trains to the terminal.
- A fast (railway) operation within the terminal.
- A fast handling of loading units within the terminal.
- The possibility for handling of goods in vans and tank wagons.

In the following conventional layouts of intermodal terminals are examined with regard to these items.

8.4.1 Conventional terminal layouts

In Europe there are three main types of intermodal rail terminals today. These are:

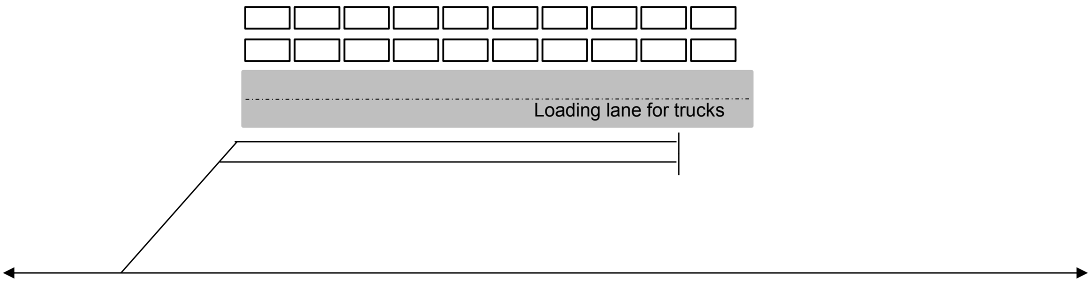
- Small terminals with one or two tracks (with some of less than train length) and a reach stacker for handling.
- Medium terminal with one module of 3-4 tracks (train length) and 2 gantry cranes.
- Large terminals with two or more modules.

Besides these standard types a large variety of special terminals and mixed forms exist. Often the terminals of a smaller type are planned for an extension to a larger type, e.g. in a first step one module is planned and second one is foreseen for the future.

Small terminals

Small terminals are a cheap solution for low demand and intermittent. The investment is low and there is low required space. Because of the handling with reach stackers no electric traction within the terminal is possible. Ground works need to be substantial to accommodate the weight of the reach stacker and a full loaded container with weight focused on the front wheel sets of the reach stacker. A (diesel) shunting locomotive has to be used unless a bi-modal loco is used to get the train in and out of the terminal. The tracks are often shorter than train length. This can cause additional shunting effort for trains that need to be sectioned. A typical layout is shown in the following figure. Generally this type of terminal is only suitable for combined transport.

Figure 8.15: Typical layout of a small terminal



An example for a small low cost terminal is this simulation of a planned terminal. The handling of load units in a terminal of this type is generally slow, but can be increased to a certain extent by the use of several reach stackers.

Figure 8.16: Planned small terminal in France

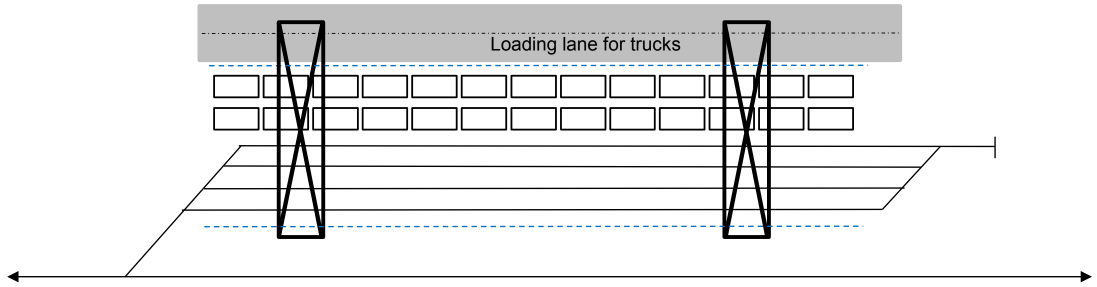
(Source: Railistics)

More austere simple terminals deep within urban areas could be considered as a means of fully exploiting rail's advantages. Small terminals that are only active when cargo is scheduled to move through are feasible and could be considered as incremental capability alongside existing active or redundant railway land where road access is also feasible. The rail configuration is made simple (single track only) if the train is able to operate in a bi-directional way (push pull loco hauled or integral power). There may be redundant railway land that actually increases in value once it is able to be served by modern trains. The ability to get trains into new logistics parks using push pull or integrally powered trains offers the possibility of much simpler track configurations and therefore capital/development and infrastructure costs plus the greater use of space for storage etc.

Medium sized terminals

Medium sized terminals with one module have generally tracks with train length and cause therefore lower shunting effort. Electric traction within the terminal is also impossible unless a bi-modal loco is used. The following figure gives an example for a typical layout of a medium sized terminal. This type of terminal is usually used only for intermodal loading units.

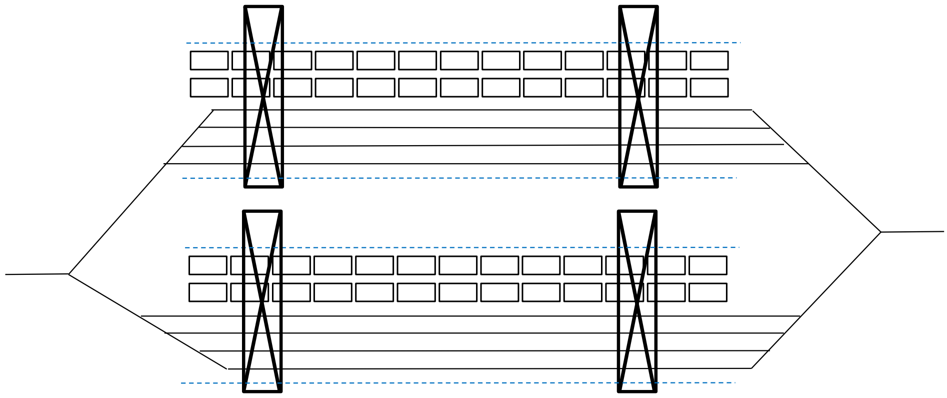
Figure 8.17: Typical layout of a medium terminal



Large terminals

Large terminals are generally situated in large centres with high demand for combined transport or intended as hub terminals with train/train-handling. These terminals do have tracks with train length and therefore cause no additional shunting effort. A direct access with electric locomotives is again impossible because the handling with cranes does not allow overhead wires or a bi-modal loco is used. These terminals are generally also dedicated for combined transport.

Figure 8.18: Typical layout of a large (hub) terminal



8.4.2 Evaluation of conventional terminal layouts

The results of the evaluation of the conventional terminal layouts carried out in the section above are shown in the matrix below. It has to be kept in mind that this is a short evaluation of conventional standard layouts. Individual terminals can be optimised and therefore no conclusion on individual terminals can be done by this evaluation. Green colour in the matrix means there are no or only minor problems to be expected for a SPECTRUM train, yellow means there are problems to be expected and red means severe problems are to be expected.

Table 8.8: Evaluation of conventional terminal layouts

Criteria	Terminal type		
	Small terminal	Medium terminal	Large terminals
Access to terminal			
Railway operations in terminal			
Handling rate			
Non ILU			

For all types of conventional terminal layouts there are problems to be expected. Therefore optimisations and adaptations for the SPECTRUM concept are necessary. These adaptations cover all evaluated criteria, but the main items are the fast access and rapid cargo handling.

8.4.3 Possible adaptations of Terminals

One main problem identified in the above sections is that there is no possibility for a direct access to the terminal with electric locomotives unless it has a small diesel bi-modal capability which is developed by locomotive producers at the moment. Every train has to be shunted into the terminal by diesel power. The direct access with electric locomotives would be more time efficient and save the extra costs of a shunting locomotive.

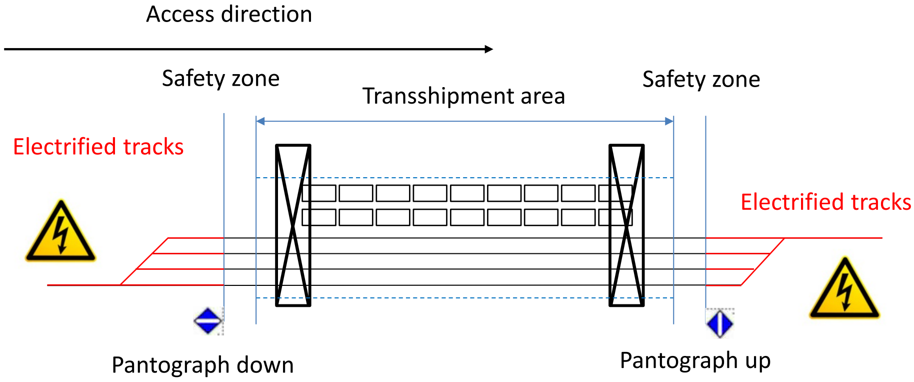
1. Terminal access with momentum

A possible solution for this is the access to the terminal with momentum. The tracks are electrified up to the actual transhipment area. The train enters the terminal with the electric locomotive. The pantograph is lowered before the terminal and the train continues with momentum into the terminal. If the terminal is connected to the rail network at both ends the train can leave the terminal again with the power of the electric locomotive at the head of the train back under the electrified power lines.

This technique is used for example in the KTL terminal in Ludwigshafen, Germany. The principle is illustrated in the figure below. To make full use of this adaption the terminal needs rail access from both sides. If this is not feasible then external shunting or bi-modal operations are required together with an escape line for the locomotive. This could be hybrid power, so diesel power for terminal loading track.

The access with momentum requires terminals with rail access from both sides which is very rare in Europe (e.g. Munich, Cologne and Hamburg Billwerder in Germany). Access with momentum to a dead-end track which is installed in the vast majority of intermodal terminals throughout Europe. Secondly there it is often required to get a general allowance to make use of train momentum operation.

Figure 8.19: Principle of a terminal with momentum access



2. Hybrid power

The locomotive industry is developing various concepts of hybrid power. The most common concept is an auxiliary diesel power in addition to the main electric power for the main line operation. The auxiliary diesel power is capable to shunt the train composition into the terminal loading track without uncoupling the main line and coupling the shunting locomotive. If the train composition is fixed and has a driving trailer on the opposite end of the train (see Cargo-Pendelzug from RailCare/Innovatrain) the access to and exit from the terminal is even more cost and time efficient due to simplified operation procedures.

3. Innovative handling technologies

Another possibility is to use innovative handling technologies. Conventional handling technologies like cranes and reach stackers are based on vertical transhipment of the loading units. In that case a catenary can't be installed inside the terminal, because the crane/reach stacker grabs the loading unit from directly above and lifts it for transhipment. Some experimental equipment able to reach containers using a slewed gantry have been developed but not found widespread adoption.

New innovative technologies like Metrocargo or the Innovatrain container mover are based on the horizontal transhipment of loading units. The transhipment equipment grabs the loading unit from the side and lifts it only very little. It is therefore no problem to install a catenary above the transhipment track. Trains with electric locomotives can enter and leave the terminal without restrictions. The access to the terminal is accelerated and no shunting locomotives are needed. The demonstrator of the Metrocargo concept is shown in the following figure. With transhipment technologies like this it may also be possible to accelerate the handling itself compared to normal terminals.

Horizontal transfer equipment has still to make a significant breakthrough in terms of extent in terms of routine operational use. Previous projects (INHOTRA) were able to identify 72 potential technical options but few have found commercial application. Loading cycle times have not matched the use of reach stackers and gantry equipment.

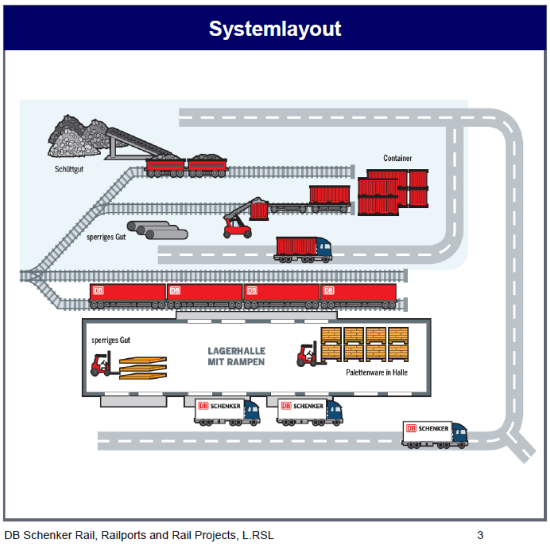
Figure 8.20: Metrocargo demonstrator

(Source: Metrocargo)

<u>4. Mix combined transport with other types of rail transport</u>

To mix combined transport with other types of rail transport (e.g. vans and tank wagons) there could be loading and unloading facilities for several types of cargo concentrated in one area where adequate space is available and the concentration of functions does not create its own internal friction or impose major functional problems such as long internal transits. One example for such a solution are the railports of DB Schenker active in several European countries. Railports combine loading facilities of different types, e.g. for containers, bulk cargo, and general cargo with storage areas. An exemplar layout of a DB Railport is given in the following figure. The railports require shunting and splitting of trains and therefore not capable for the SPECTRUM train.

Figure 8.21: DB Railport system layout



(Source: DB Schenker)

The following ready-to-use transhipment technologies, beside the most common portal crane and reach stacker, could be applied to the following size of terminal. It has to be taken into account that the layout of a specific terminal can limit the usability of a specific technology if not a complete new infrastructure is required. The column “adaptations” state to which component of the transport system (terminal infrastructure, load units, wagon, truck, handling procedure) adaptations have to be made so the handling technology can work.

Table 8.9: Evaluation of conventional terminal layouts

		terminal size			
technology	**load unit**	**small**	**medium**	**large**	**adaptation**
Modalohr	semi-trailer		X	X	Terminal, wagon
CargoBeamer	semi-trailer		X	X	Terminal, wagon
Sidellifter (Hammar)	Container	X	X		truck
Mobiler (Bermüller)	swap body	X			load units, truck
ACTS	Roll-off container	X			wagon
RTS (Hungary)	container	X	X	X	terminal
ISU (RCA)	semi-trailer	X	X		handling
Mega Hub (Noell, Krupp)	container, swap body			X	terminal
Metrocargo	container		X	X	terminal
Containermover Innovatrain	swap body, container	X	X		truck (wagon)
Megaswing (Kockums)	semi-trailer	X	X		wagon
Light combi (Sweden)	swap-body C	X			handling
A – IUT (RCA)	container, swap body		X		terminal handling
RoRo Rail (Kockums)	Swap body C	X	X		wagon

8.5 ADAPTIONS OF EXISTING OPERATIONAL REGULATIONS

At the moment freight trains are often considered as low-priority in the operational regulations. In some countries specific regulations exist to prevent freight trains from using capacity on lines densely used by commuter trains in peak times or regional trains. An example is the Italian national rail network operated by the national infrastructure manager RFI. The network statement of RFI[31] contains special priority rules for congested infrastructure. Congested infrastructure covers many sections in the Milan region and other Italian economic centres.

In peak times (defined as 6 am to 9am and 5 pm to 7 pm) passenger trains running according to service contracts with central or regional governments (meaning mainly commuter trains and other regional and even long distance trains) have priority and therefore making it impossible to run freight trains during this time of day on many important sections of the Italian network. Freight trains have only priority on congested lines if they are international services during night time (between 10 pm and 6 am).

Similar regulations exist also in other European countries. In some other countries there are problems for operating freight trains during peak hours also on lines densely used by passenger trains.

The characteristics of a SPECTRUM train will be very different from those of a conventional freight train and will be closer to those of a passenger train. Therefore the operational regulations especially access regulation and priority rules will have to be adapted to guarantee that SPECTRUM trains can make use of their advantages.

[31] Rete Ferroviaria Italiana: Network Statement December 2011 edition, section 4.4.3.2 December 9 2011,

8.6 CONCLUSIONS ON OPERATIONAL AND TECHNICAL REQUIREMENTS

8.6.1 Border Crossings

The concrete requirements for a SPECTRUM train depend on the actual use of the train. To avoid information problems the SPECTRUM train should be suitable for a cargo waybill with electronic data and should provide the possibility for a positioning system. This positioning system should be open for the information of different stakeholders (railway undertakings, infrastructure managers, shippers/receivers, cargo interests) on the actual position of the train. The technical problems are mainly caused by the railway infrastructure in the different countries concerned. A SPECTRUM train will need to be e adapted to the railway infrastructure in the countries served.

8.6.2 Interoperability

The actual requirements for a SPECTRUM-train resulting from interoperability depend on the countries to be served and the type of goods to be transported (and therefore the type of wagon/rail vehicle to be used). The costs of interoperability are generally getting higher the more countries are served. Therefore it seems not viable to develop a train suitable for all systems. The SPECTRUM train should in its first iteration be in its general design adaptable to most European countries (at least the ones with standard gauge). The specific adaption should be made only for the country or countries to be served in operation. The need therefore is for some form of modular design concept of the vehicle and its integral support systems

8.6.3 Operational Study

The consequences for a SPECTRUM train resulting from the operational study are several minimum requirements:

- Maximum speed of at least 140 km/h.
- Locomotive power of more than 5 MW (for a gross train with about 1000 tons weight).
- Acceleration of about 0.5 m/s^2.
- High braking capability based on a mix of disc and electric brakes (rheostatic/regenerative)

8.6.4 Rolling Stock

The rolling stock needs to fulfil the logistical and operational requirements stated above. Especially the running gear with axles, bogies, braking system, etc and the traction system need to be adapted. In addition to that the rolling stock needs to be in accordance with the TSI. Because of the many necessary changes this means the possibility of a long approval process. Where appropriate existing certificated technology which can match the performance requirements set for Spectrum might be incorporated into the design.

8.6.5 Rail Terminals

The most important issue for rail terminals is the fast access to the terminals with short transhipment times to guarantee that the time gained through faster operation on the tracks is not lost again in terminals. Therefore several options for optimisation of terminals are possible including access with momentum, diesel auxiliary power or horizontal transhipment.

8.6.6 Operational Regulations

In operational regulations freight trains often have low priority because they are slower and have a lower acceleration and deceleration performance than most passenger trains. A SPECTRUM train will have a least some characteristics of a passenger train.

Therefore many operational regulations need to be changed to prioritize trains not because of the type of train (passenger or freight) but because of the characteristics of the train (such as maximum speed and acceleration).

8.7 INTERMODAL TERMINAL NETWORK

As far as the terminal infrastructure is concerned, one research question was:

What is the ideal structure of a terminal network in terms of accessibility and density?

Terms and definitions

A terminal network is a freight transport service network that is used by different modal channels. There are normally regular transport services connecting the terminals, where the freight is transferred between the transport services. Terminals represent access points to a range of transport service networks (where freight can enter and leave a freight transport network or can be transferred between freight transport links).

The density of a terminal network means the number of terminals within a defined area and their distribution across the area. A too low density of a rail terminal network is regarded as an important competitive disadvantage of the rail sector for the transport of LDHV. With the help of a dense terminal network, transport volume can be attracted from a larger number of regions because prohibitively costly pre- and post-haulage distances are reduced. Apart from the influence of this density on the geographical performance of a terminal network, the density of a terminal network influences its connective (frequency of services using individual, terminals linked) and capacitive performance (quantitative and qualitative throughput).

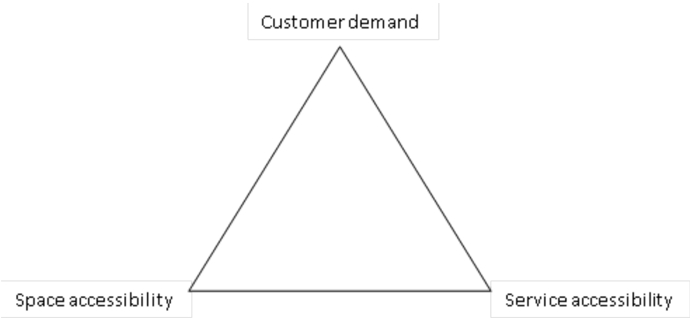
This number and spatial distribution of the terminals is also referred to as 'space accessibility' of the network. If there are a lot of (intermodal) rail terminals along the railway network, space accessibility will be considered as high. In major urban areas there may be several competing or complementary terminals of similar or differing capacity and capability that may all service traffic from individual shippers, forwarders, transport operators and shipping lines at varying levels or for specific commercial and operational reasons

There is another dimension of accessibility of a network: 'service accessibility' of a network reflects the possibilities to use a transport network regarding time. This involves the departure time (end of loading), the frequency of departures from a terminal and the number of direct and indirect connections to a destination terminal. 'Service accessibility' of a network is important for opening up of the LDHV market segment, as a higher number of transport routes served between the terminals and a higher transport frequency makes transport services more attractive to the specific potential users. The service accessibility has to be fully in line with or better than the requirements of the customer, otherwise the competing services of other transport modes will be chosen.

The two dimensions of accessibility (space accessibility and service accessibility) are linked: 32 The frequency of services provided by the transport operator depends upon the amount of cargo that can be attracted from the users of the transport service, and this is determined by a combination of space accessibility and routinely good service times. The service which can be made available is very much dependent on the space availability of the terminal network and its ability to manage this with widely varying traffic activity on an hourly, daily, weekly and monthly basis. However the best available space accessibility management will not help if the service availability is not sufficient regarding the customers´ requirements. See Figure 8.22.

[32] Besides, there is the physical accessibility of the (intermodal) terminals from the road and railway network by the different transport vehicles. This has already been addressed in the previous subsections.

Figure 8.22: The magic triangle for terminal networks - Interrelationships between space accessibility, service accessibility and customer demand.



It should not be forgotten that there is also a link between the service accessibility and the performance of terminals: Services also rely on the quality of a terminal (a high frequency service cannot be provided through terminals with limited capabilities).

Determinants and decision variables regarding the design of terminal networks

The design of (intermodal) terminal networks is determined by cost and quality aspects: First of all, economies in transport and transhipment production have to be considered. A high transport volume on a certain transport link reduces unit transport costs (economies of scale). And a high terminal throughput reduces the amount of handling costs per unit incurred.[33] A challenge here is that terminal operations are characterised by peaks when trains arrive and depart, and these times are more expensive. Using average costs for units handled in a certain period of time underestimates the cost of peak time units and overestimates the cost of off-time units. For a strategic purpose, such as the terminal network planning, an average cost per loading unit handled, maybe per type of terminal (small/medium-sized/large), should be sufficient.[34]

Second, given a certain frequency of service and a certain network volume (transport volume carried in the network in a certain period of time), when having a routing via intermediate transhipment points such as hubs there is always the trade-off between longer transport routes and transit times plus additional handling costs and the economies resulting from bundling/consolidation effects on the legs of the transport chain on the other (the latter is achieved by a consolidation of cargo).

Networks with a routing via intermediate transhipment points also offer the chance to achieve economies of scope (operational synergies) by improving the geographical allocation of transport assets such as rolling stock and intermodal loading units (fewer empty trips and equipment re-positioning). Intermediate points also offer the possibility to include buffers in the supply chain so the risk of complete interruption of the supply chain can be reduced and reaction time on such events can be shorter (no need to build up a complete new alternative supply/transport chain).

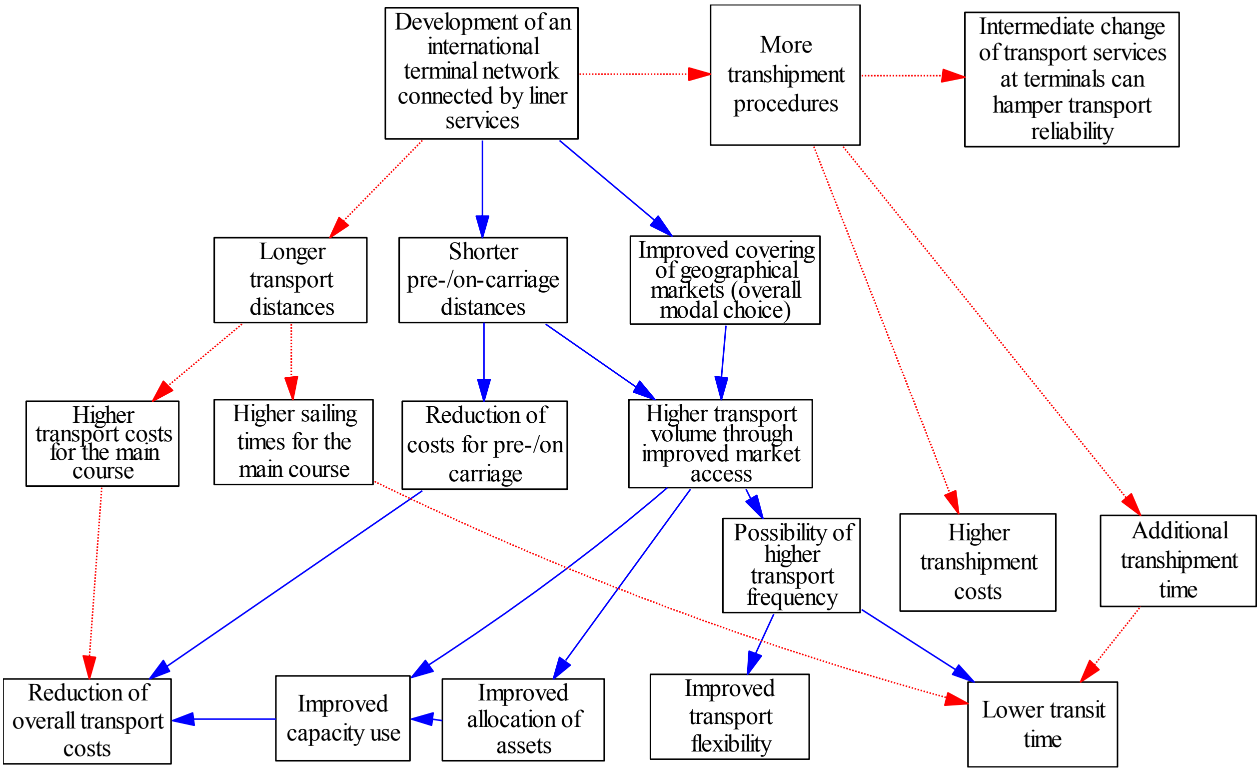
On the other hand, transport reliability is easier to achieve when having direct links between terminals instead of intermediate transhipments, due to a reduced risk of delays and missed onward connections. See figure. Again, buffers considered at intermediate terminals can help to overcome this risk of delays, so that transport reliability is even higher regarding the complete transport chain.

If a terminal network is developed on an international level (e.g. across Europe) the potential network volume will be higher.

Figure 8.23: Effects of the development of a terminal network connected by frequent liner

[33] This also depends on the performance of the terminal regarding resources and time needed per handling of a unit. There are physical boundaries, but also the efficient planning of the terminal operation has an influence.

[34] See Flodén, J. (2007) Modelling Intermodal Freight Transport – The Potential of Combined Transport in Sweden, BAS Publishing, Göteborg, pp. 143-146



(Source: Platz, T.E. (2009) The Efficient Integration of Inland Shipping into Continental Intermodal Transport Chains, TRAIL Thesis Series nr. T2009/7, the Netherlands TRAIL Research School, Delft, p. 132)

When designing a network the following primary decision variables have to be incorporated into the network design:[35]

- The number and the potential location of the terminals.
- The service =density between the terminals.
- The capacity of the terminals and services.
- Inventory positions.
- The routing of the shipments.

Singling out e.g. terminal capacity, this is dependent upon cargo handling technology deployed and the area of the terminal. The number and location of the terminals determines their catchment area, and the catchment area determines the potential freight flow between two terminals, which has an impact on the type of service and rolling stock used. This means that there are various interrelationships between decision variables on the design of a transport and terminal network (cf. warehouse location allocation problem). Models for designing a network incorporating these decision variables exist (since ca. 1990). An example for this is the RESPONSE model (see Chapter 9). For a more complex system analysis, simulation techniques should be used carried out with the aim of generating feasible local system optima (e.g. the EMOLITE[36] decision support system developed in a FP4 project).

The HIT-Model[37] developed at Göteborg University relies on terminal locations as input data and can be used once the locations of the intermodal terminals (=space accessibility) are given, to determine time accessibility of the network. As an output, O/D (origin/destination) flows between rail terminals are shown, including train departure and arrival times respecting specified delivery time windows. But research revealed that after a review of models aiming at an optimal configuration of the service network there is still no clear

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[35] See Groothedde, B. (2005) Collaborative Logistics and Transportation Networks – A Modeling Approach to Hub Network Design, TRAIL Thesis Series Volume T2005/15, The Netherlands TRAIL Research School, Delft, p. 58

[36] EMOLITE = Evaluation Model for the Optimal Location of Intermodal Terminals in Europe

[37] HIT-Model = Heuristics Intermodal Transport Model. It formed the basis for FP6 project MINT – model and decision support system for evaluation of intermodal terminal networks.

indication whether a few large terminals or many small terminals are more efficient.[38] This is a pragmatic position and reflects a mix of historic commercial, technical and other inputs.

Current design of (intermodal) rail terminal networks

There are currently many intermodal rail terminals in Europe. These are not equally distributed in space. Many of them are concentrated along certain transport corridors (e.g. along the Rhine) or in certain regions notably in agglomeration areas (e.g. around Milan). A database including the location of terminals is maintained by UIRR (http://www.uirr.com) and currently contains more than 350 terminals which are spread over 20 countries.

The available intermodal rail terminals have different functions. Some of them represent begin/end (BE) terminals for container hinterland traffic for seaports (e.g. Frankfurt-Ost, Regensburg). Then, seaport rail terminals (e.g. in Hamburg) could serve as 'nodes' in the network: B/E terminals in the hinterland can be linked via seaports.

The current connections of such B/E inland terminals via seaports are often indicated by intermodal route planning tools (such as BE Logic). But this link via seaports is not favourable for SPECTRUM trains. SPECTRUM trains demand fast operation at reasonable costs. On the one hand, the geographical location of the seaports on the coast may lead to long deviations and higher transport costs. On the other hand, the longer distances caused by the trip to the seaport and back inland may increase transit times. Practically, the longer transit times are also caused by hinterland transport services that are not co-ordinated regarding the timetables. SPECTRUM trains require fast access and fast railway operations in the terminal to guarantee that the time gained through faster operation on the tracks is not lost in terminals (see 8.4.2 'Evaluation of conventional terminal layouts'). Rail terminals in the seaport do often not fulfil these criteria, as they are accessible via the port´s railway only.

Moreover, in the case of liner train operation, short transit times are required for the intermediate terminals. Otherwise, door-to-door transit times for shipments continuing their trip to other terminals will increase and eventually become non-competitive. In case of the seaports, only a limited share of the loading units is assumed to continue its journey back inland. Shunting or intermediate storage operations cause additional costs and increase lead times as well.

Many other intermodal rail terminals serve as BE terminals for national or cross-border continental intermodal transport services. These may be linked to other terminals of that type via hubs.

A hub is a central point for collection, sorting and distribution for a particular region or area, embedded in a means of transport network and spokes. A hub and spoke system is a network consisting of one or more central transhipment point(s) and several radial spokes. Either, shipments originate at (or are destined for) the hub, or the hub is used for intermediate transhipment, so there is only an indirect connection between two terminals. In a rail-based hub and spoke network, either shuttle trains commute along the spokes, and all cargo is being transferred at the hub, or (groups of) wagons are exchanged at the hub. The advantages of a hub and spoke network as against networks consisting of only direct links between nodes are a higher frequency of transport services per transport connection (given a certain transport demand and network volume), an increase in the number of available transport connections, and economies of scale in transport operation.[39] Another advantage of a hub and spoke system is the stochastic smoothing (same expectation for transport demand at a smaller deviance), reducing peaks in demand and increasing average capacity use. Hub and spoke networks are suitable to attract cargo from areas with small, dispersed freight flows. Ideally, synchronisation of batch-wise departures and arrivals in the hub would have to be achieved. This implies a bundling in time at the extreme points of the spokes which may not align with shipper's imperatives and schedules.

Gateway terminals link domestic and international intermodal transport networks. Their purpose is to bundle transport volume in order to achieve economies of scale and to make the supply of services more attractive. On the other hand, routing shipments via gateways may increase transport distances and transit times. This underpins the need for suitable handling equipment and standardized loading units to reach a high degree of automation. Aside from this, availability of actual information on cargo is important to reduce transit times and to avoid delays (this is important for hubs, too).

[38] See Bontekoning, Y.M. (2006) Hub exchange operations in intermodal hub-and-spoke networks, TRAIL Thesis Series Volume T2006/1, The Netherlands TRAIL Research School, Delft, pp. 29-30

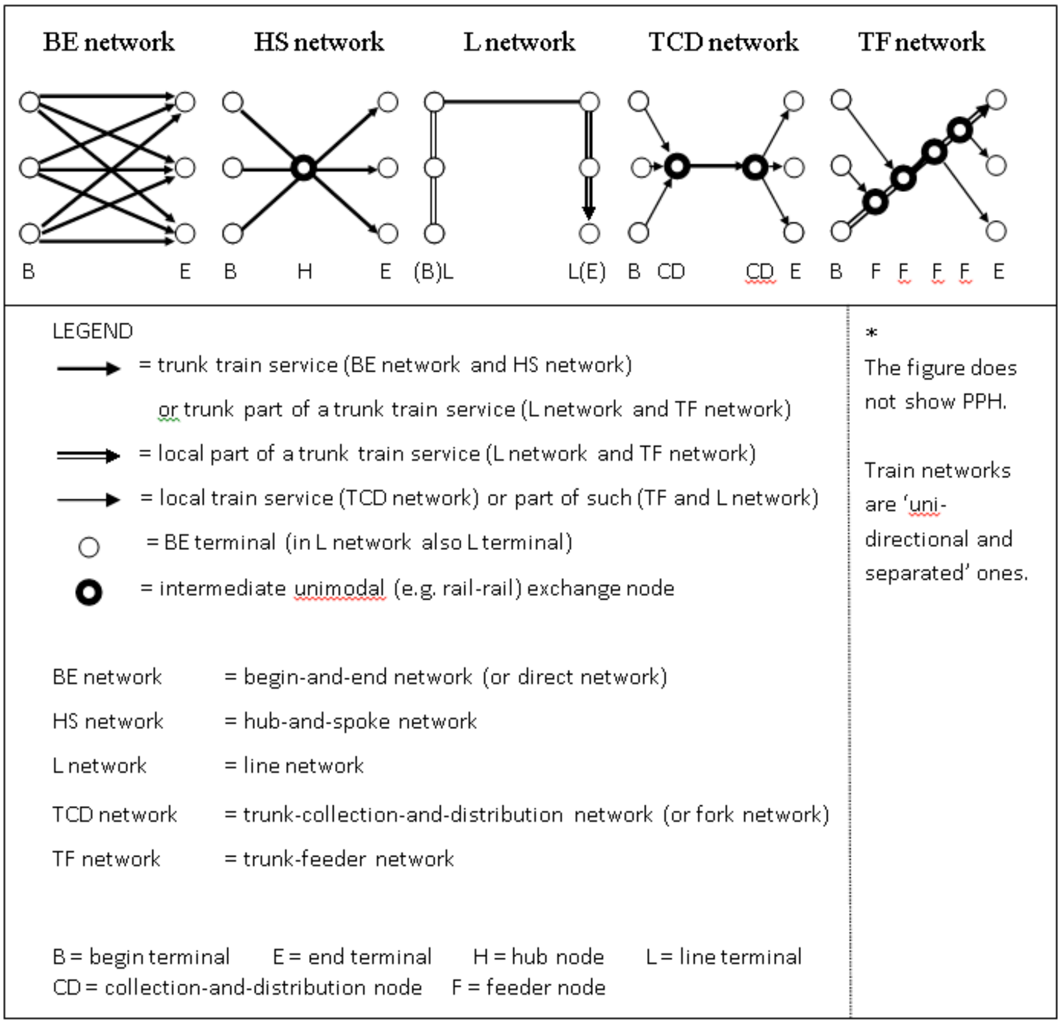
[39] See Bontekoning, Y.M. (2006) Hub exchange operations in intermodal hub-and-spoke networks, TRAIL Thesis Series Volume T2006/1, The Netherlands TRAIL Research School, Delft, p. 187

Suitable design of a terminal network for SPECTRUM

According to Kreutzberger, the following structure of bundling networks can be distinguished (see figure):

- Direct bundling networks (=BE networks).
- Hub-and-spoke networks (= HS networks).
- Line networks (= L networks).
- Trunk-collection-and-distribution networks (= TCD networks).
- Trunk-feeder networks (= TF networks).

Figure 8.24: Basic bundling types in transport networks



(Source: Kreutzberger, E.D., 2008, The Innovation of Intermodal Rail Freight Bundling Networks. Concepts, Developments, Performances, TRAIL Thesis Series Volume T2008/16, The Netherlands TRAIL Research School, Delft, p. 70) Note: PPH = Pre-/Post-haulage)

There is no best bundling type in general, but only one in the context of a certain network transport volume that can be achieved and logistical requirements of the transport service users (i.e. shippers, freight forwarding companies). The potential network transport volume and the logistical requirements of the transport users depend on the spatial economic structure. Thus, the spatial economic structure is decisive for the choice of the appropriate bundling system and transport and terminal network. The question is whether the amount of cargo originating in or destined for an area focuses on certain locations where the economic activity is massed-together, or whether the region shows a more polycentric structure. At the other extreme the opportunistic development of terminals based on available land/site characteristics and links to at least two modes of transport has been a characteristic of terminal development without much by way of market analysis and transport planning.

BE networks are currently preferred by intermodal transport operators such as Kombiverkehr or HUPAC to connect transport relations with a high O/D volume. In their networks, they almost solely rely on direct bundling. There is a focus on cargo with high volume provided by big industry plants, notably the chemical or automotive industry, as well as hinterland connections for containers with terminals in big ports and industrial centres. What could be regarded as problematic when launching new connections for LDHV goods as in SPECTRUM is that most of these flows will be too small to fill a direct train that can be operated in an economically viable manner at a (presumably high) frequency of service as demanded by the transport service users. Most intermodal rail terminals in Europe are laid out for such direct bundling networks (meaning that there are only a few that are suitable for rail-rail intermodal transfer as necessary for the other terminal network types). Experts advise to let direct trains operate if flows are sufficiently large.[40] The problem with this is that large trains are not appropriate in terms of size, flexibility, availability and cost profile for lower and intermittent volume traffic. The rail freight operator's focus solely on big trains is a limitation on their ability to service this, admittedly more difficult market sector but one which, in aggregate, is larger than the one being served by the BE model.

L networks, TCD networks and TF networks are regarded as suitable for freight corridors or areas with small network volumes.[41] For example, the train system of the Innovatrain case operates in a line network and fulfills the demands of the transport service clients while being operated efficiently. In essence, an L network can be easily created by including an intermediate stop for a direct train where either wagons can be added or additional load can be loaded. L networks can also be operated using circular train services. This was for instance proposed for national rail distribution in the Netherlands[42] and Germany. Moreover, given a certain transport network volume and (minimum) train length, a higher frequency of departure can be offered compared to BE networks and HS networks.

Hub-and-spoke bundling has also been taken into consideration for SPECTRUM. HS networks are rather suitable for medium network transport volumes (requiring longer trains). They offer good space accessibility (with short pre- and post-haulage distances). A prerequisite is that the hubs can perform transhipment at low cost. This means that the transhipment should take place with a high degree of automation. For instance, this is subject to hold for the planned mega-hub in Lehrte near Hannover. Another prerequisite is that the routing via the hub does not increase transport distances and transit times too much if the hub is efficient. Concerning this routing via the hub, it should be considered that research revealed that the cost advantage of achieving an increased load factor will never be overcompensated by the costs of detours.[43] A corridor-neutral hub (e.g. the former Intercontainer hubs in Metz or Herne or IFB´s Mainhub Antwerp) allows organising more trainloads than corridor-specific hubs which are located along certain corridors (e.g. the current intermodal hubs Duisburg and Cologne).[44]

Regarding the additional handling of cargo/loading units at intermediate nodes, the L network is superior to the other networks. In this regard, a HS network is also preferable as against TCD and TF networks.

Example: EU-Turkey freight transport corridor

As potential for SPECTRUM is seen for the corridor between the West and the Northwest of the EU and Turkey, there are different options for a terminal network allowing for efficient operation:[45]

- Hub and spoke network
  - the hub being located in Nuremberg, 4 spokes to and from Istanbul, Rotterdam, Italy, Sweden
  - the hub being located in Vienna, 4 spokes to and from Istanbul, Rotterdam, Poland and Spain
- Line network
  - Istanbul-Sofia-Belgrade-Budapest-Vienna-Linz-Regensburg-Nuremberg-Frankfurt/M.-Duisburg- Rotterdam
  - Istanbul-Sofia-Belgrade-Ljublijana-Salzburg-Munich-Mannheuim-Mainz-Cologne-Rotterdam
- Trunk-feeder network: trunk lines as in the line network, with local feeder trains to/from Thessaloniki, Bucharest, Warsaw-Bratislava, Prague, Ploce, Koper/Trieste, Verona, Leipzig, Hannover, Basel, Metz, Antwerp

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40 See Kreutzberger (2012) Twin hub Intermodal rail freight Twin hub Network North West Europe, presentation at Retrack Final conference 11 + 12 June 2012 Budapest, p. 6

41 See Kreutzberger, E., R. van Duin and M. Zhang (2006) Transportbundeling, TRANSUMO – Europese Netwerken KP 3, Concept rapportage, p. 22

42 See RUPS/NEA (2001) Raildistributie getoetst (RaGe) – Eindrapport - Management Sammenvatting, Schiedam

43 See Kreutzberger, E. (2008) The Innovation of Intermodal Rail Freight Bundling Networks in Europe. Concepts, Developments, Performances, TRAIL Thesis Series Volume T2008/16, The Netherlands TRAIL Research School, Delft, p. 259

44 See Kreutzberger, E., R. Konings and C. Witteveen (2010) Modelling the bundling of intermodal rail flows from/to seaports, WCTR paper, pp. 7-8

45 See Kreutzberger, E., R. van Duin and M. Zhang (2006) Transportbundeling, TRANSUMO – Europese Netwerken KP 3, Concept rapportage, pp. 39-53

- Trunk-collection-and-distribution network: Trunk line between Sofia an Duisburg, feeder connection between
    - Sofia and Thessaloniki
    - Sofia and Bucharest
    - Duisburg/Cologne and e.g. Antwerp, Zeebrugge, Flushing

New terminals

For SPECTRUM, it should also be considered whether there is the potential to implement additional terminals in order to reach and cover areas that have not been served well. It was already referred to the identification and re-commissioning of old and disused rail head facilities. Horizontal transhipment technology or solutions for load transfer under the catenary may be options to implement terminals requiring low investment short-term where needed. The alternative of truck mounted cranes able to lit containers on/off trains and also to trucks (Containerlift) might be considered.

9 Competitive position of the future developed spectrum design – cost assessment by the micro business-economic model

In Chapter 9, the potential impact of the rail logistic concept to be designed in SPECTRUM on the competitiveness of rail is assessed. This chapter first describes the methodology applied for this assessment and then applies this methodology in a business economic calculation model.

The business economic model is designed to investigate different business cases, representing different segments of the market in which a positive contribution by SPECTRUM is anticipated. These cases assume an operational structure and assume characteristics of the assets used and apply business economic data concerning costs.

For the SPECTRUM concept to obtain a position in the transport market, the innovation will need to improve quality parameters (punctuality, safety, flexibility, product and service) and reduce costs. The micro-business economic model developed focuses on costs. It compares costs of the SPECTRUM services with its alternatives that use existing technology.

These alternatives are either uni-modal road transport, intermodal transport or conventional rail transport. The exercise is an initial assessment of commercial viability and it serves to identify potential market segments, to which the introduction of SPECTRUM concept can produce promising benefits. The final assessment will be performed at a later stage in WP4 "Synthesis and Evaluation".

The micro- business economic model uses a bottom up approach for assessing the costs of transport services. The model comprises evaluation of business cases and will:

- Describe the characteristics of the current transport services. If the services are currently non-existent, then it describes the characteristics of virtual services assuming realistic service production parameters. The need for assets in transport service production will be derived from transport service parameters;
- Then apply cost-values per hour of using these assets, and so calculate transport costs when using existing technology. The cost-values have been collected from market research and monitoring systems that partners in the SPECTRUM consortium have conducted;
- Describe how the new SPECTRUM concept could possibly affect the key parameters of the service;
- Calculate operating costs of the rail services using the SPECTRUM concept, using preliminary business economic data about costs;
- Compare the transport costs between the competing road transport and the conventional rail or intermodal services (real or virtual).

To carry out these steps, principles from the RESPONSE-model have been applied. The RESPONSE-model is a TNO tool, which has been successfully applied to many different cases concerning road and railway transport; but it can also be employed in inland shipping, or air freight networks. By showing influences between costs and service levels, the model searches for opportunities to reduce costs and optimise the transport networks for the logistics service providers.

For SPECTRUM, elements of the RESPONSE-model are used for estimating and comparing both transport costs and lead time for road transport and rail transport enhanced by the SPECTRUM-concept. In particular, a spread sheet model is developed based on the model to incorporate a higher level of detail of the input data in a more transparent manner.

9.1 SPECTRUM SERVICE PARAMETERS AND COSTS

SPECTRUM service parameters have both a technological and logistics component. At this stage SPECTRUM design parameters are not yet defined. For that reason rudimentary assumptions are applied by estimating additional construction costs and additional costs of operations in comparison to current railway assets. In summary, these assumptions are:

- 30% reduction of maintenance costs of wagons in comparison to current practice.
- 30% increase of procurement price of wagons in comparison to current practice.
- Lifespan equal to existing wagons (25 years) in spite of more intensive use of the SPECTRUM-wagons.

- Wagons compatible to mega-size intermodal loading units and the metric volume (m3) of covered wagons will be 20% more than currently in use.
- Refrigerated cargo will be facilitated with small diesel units, as is current practice with reefers. In a later stage electric powered systems may be envisaged.
- Maximum train weight will be 1500 gross tonnes (this rules out two axle wagons) including the locomotive if this configuration is considered that is sufficient for serving the low-density goods.
- The higher acceleration and speed of the SPECTRUM train will affect energy consumption. This assumption will need re-visiting in a later stage. The increased performance comes at a cost in energy consumption
- It cannot be told with certainty how the infrastructure managers will charge the use of their networks for the innovative rail service. Different assumptions may apply: charges as in freight transport, express service premiums, or charges in accordance with passenger transport services.

Justification of these assumptions is given in the Annex.

The logistics parameters of SPECTRUM are determined on a case by case basis. They will consider SPECTRUM's potential for offering services in schedules similar to passenger services and, accordingly, average speeds of SPECTRUM will be set at much higher levels than current freight services.

The assumption therefore will be that service parameters will not be set back by a lower priority infrastructure managers could assign to freight in comparison to passenger transport.

9.2 UNI-MODAL ROAD TRANSPORT SERVICE PARAMETERS AND COSTS

The parameters of road transport services in the business economic model assume realistic values of lead times and average speeds and take account of restrictions from legislation on driving and resting time. For equal comparison to its competing modes, time parameters when loading and unloading with clients will be the same as the road operation.

Also other parameters like equipment utilisation, which may be lower in transport segments and corridors where transport demand is unbalanced, will be aligned with those applied in cost assessments of competing transport modes.

The costs of road transport have a variable and fixed costs component. The variable, distance-related, component is mainly fuel costs and also includes a distance-related part of repair and maintenance costs.

All other costs involved (labour, depreciation, interests, insurance, management and other business costs) are considered as fixed in the annual accounts of transport operators and are converted into fixed, time related, costs per business hour of the truck.

All costs are different between e.g. conventional and refrigerated transport. The cost parameters are based on values derived from NEA (2011)[46]

[46] NEA (2011), Kostencalculaties in het beroepsgoederenvervoer over de weg 2011

9.3 INTERMODAL TRANSPORT SERVICE PARAMETERS AND COSTS

The parameters of intermodal transport services are derived from service schedules in the current market. These service schedules indicate so-called cut-off times in terminals, which is the latest moment that intermodal loading units (ILU) can be delivered at the terminal for departure, and delivery times, which is the earliest moment that the ILU can be collected from the terminal after arrival.

The door-to-door time will probably but not entirely have to involve the road legs at both ends. These will be estimated on the bases of parameters of distance and road vehicle rotations in these operations. For services that do not yet exist, e.g. short distance intermodal services, realistic assumptions on speed will be used for defining virtual service parameters.

The cost of intermodal transport is an adding-together of the costs borne by all chain elements:

- Pre- and end haulage to and from the intermodal terminal by road transport.
- Transhipment handlings in the terminal.
- Rail operations, which also involve charges for rail infrastructure use and for rail services like shunting.
- The use of loading units.
- Management, chain integration and other business costs.

9.3.1 Pre-and end-haulage costs

Pre- and end-haulage is a critical phase of transport in an intermodal chain, characterised by the low and inefficient use of vehicle and driver. Truck circulation in these operations would involve at least:

- Waiting time and procedures at the terminal gate. Time needed for administrative procedures at the terminal gate in many cases has been minimised, for example due to pre-announcements and pre-arrival data exchange. Waiting times may occur due to terminal congestion: the number of trucks that can be handled simultaneously on the terminal premises is limited and many terminal operators face the problem that truck arrivals are concentrated around peak hours. Incentives to flatten the peak may be an inducement to spread the load away from the peak times. Better information on train arrival times and train loading positions may assist in better terminal planning and operation particularly in the event of delay or disruption which may not always be attributable to the train segment of the inter-modal chain
- Terminal dwell time. This is the time needed for taking the ILU off the truck and for loading a subsequent ILU and the time the truck needs for moving between unloading and loading positions and waiting time for terminal equipment to prepare to serve the truck. Dwell time depends on terminal layout and deployment of handling equipment.
- Movement between terminal and client (carrying ILU), which depends on distance and traffic conditions.
- Time needed for ILU delivery/pick-up with the client. This could consist of just (de)coupling of truck and semi-trailer but may also involve the actual (un)loading of the ILU, waiting times for handling, etc.
- Subsequent movements. Ideally this would be between this client and the terminal, carrying a subsequent loaded ILU or the empty ILU for its return trip. Very often though, next loads need to be collected with other clients and often ILU for this purpose need to be collected from a depot (transport company's premises). The impact of shipping line restitution positions needs to be accommodated.

In practice, trucks (and drivers) active in pre- and end-haulage are rarely producing more than 2 round trips per day and effectively rarely cover more than 300 km distance. In dedicated intense flows between one terminal and one client this transport can be better organised and the number of round trips may be higher.

The inefficiencies result from – from trucker's viewpoint - demand side constraints. Their trip scheduling has to consider train schedules and client's schedules causing that demand of their services is concentrated in early morning and late afternoon hours. Truck operators may further have to face waiting times with clients due to time windows for delivery / collection, which all together are likely to result in excessive idle times of trucks.

Also, in comparison to long-distance uni-modal road transport, pre- and end-haulage operations are likely to have a large share of empty runs. Overall, transport is unbalanced, which on local level is augmented however because of the uneven timing of services. E.g. ILU arrive by train early in the morning and client may have ILU ready for departure only after 3 p.m., due to which trucks may have no direct commercial employment.

The business economic model will assume truck rotations in pre- and end-haulage case-wise, considering specifics of supply chains. The impact on costs will result accordingly.

9.3.2 Transhipment costs

The costs of transhipment are considered as given and transhipment tariffs are taken into the calculation. The tariffs (and underlying costs) depend, for example, on the function of the terminal in the intermodal chain. They will be on the higher end if terminals are equipped for high volumes and high efficiency of transhipment to and from rail. On the lower end are small-scale terminals with simple reach-stacker operations. The tariffs that will be considered are:

- €45 for transhipment per ILU in advanced continental terminal (more than 2 tracks, mixed operation of reach-stackers and portal cranes; often two handlings per transhipment).
- €40 per ILU for transhipment between seaport stack and hinterland modes (ship to shore is outside our scope).
- €20 per ILU in small-scale terminals (1 or 2 tracks, reach-stacker operation).
- €15 per ILU with horizontal transhipment with Innovatrain container mover.
- €50 per hour for loading/unloading of covered wagons by fork-lifters.

Horizontal transhipment (as demonstrated by InnovaTrain) is considered to be part of the rail as well as the pre- and end haulage leg. The costs involved concern those resulting from additional investments and maintenance to wagons and to trucks for their respective extra attributes needed for horizontal the transhipment.

9.3.3 Rail operating costs

The costs of rail transport service production has “fixed” and “variable” components. The latter are those that vary with distance, mainly being those of energy consumption. Fixed costs are those costs that are borne by railway undertakings even if trains are not moving. These costs consist of costs related to the capital (interest, depreciation, insurance), costs of drivers and other labour and business costs.

The attribution of these “annual fixed costs” to transport services is done by dividing annual costs by the number of round trips per year or by assessing the share of total annual business hours in which the asset or driver is deployed costs in this service.

The subsequent step is to derive the costs per ILU or e.g. per pallet from rail transport service costs by assuming a level of utilisation (number of ILU per year per rail service).

When scheduling rail service production, many restrictions need to be considered and therefore may not be as predictable as for example road transport service production. The most relevant constraints are briefly explained:

- The service characteristics of rail freight services are the result of a slot allocation procedure in which operators have to accept a certain level of constraint due to their lower priority than passenger transport. The resulting freight transport schedules can be such that movements are constrained on rail links with scarce capacity.
- Routing and timing of services may be such that these congested links and hours are circumvented.
- The services are made to measure clients’ needs. There is a current tendency of early evening departures and early morning arrivals following the business rhythm of dispatch and receipt of many companies. Night departures or arrivals may be of no added value to some clients, because of their own business hours and limited terminal operations overnight.
- As a consequence of this pattern, the wagon sets may need to remain in terminal premises during full day times, which would be much longer than needed for mere transhipment unless alternative profitable work can be found for these resources. Alternatively, in order to create space inside of the terminal, the wagon sets may be pulled to nearby yards and then returned. This low level of productivity needs to be addressed. The cost of the wagons/vehicles idling for a large part of the day should be minimised and incremental work found for expensive mobile assets. This predetermines the requirement for a wholly different approach to train planning and asset management. The new trains should have the capability to be planned 2-3 days in advance with their work and route schedules well developed and assigned
- Rail operations will involve technical checks (brakes) at terminals and border crossings and may require interruptions for the changing of drivers. The same applies to road operations however, but to a lesser degree.
- Longer distance services often include long time buffers, during which train sets are parked on the route, e.g. near or in marshalling yards or terminals or near border crossings). In such situations railway operators are likely to decide to decouple locomotive operations from wagon set movements. Wagon

assets need to be owned and not treated as a “dumb” asset. Much greater intervention and direction is needed to drive up productivity.

All these aspects together imply that gross service speed (distance divided between the time lag between departure and arrival) tend at present, to be low in comparison to maximum technical capabilities. In today’s intermodal transport market the more “efficient services” would have gross speeds from terminal to terminal of around 60km/hour, while gross service speeds below 30 km/hour are no exception.

With so many variables it is not as predictable as in road how rail transport services are produced, e.g. the number of hours that a locomotive and wagon set are coupled, the number of hours that the train is moving, the exact route, etc. The information exists at a diffuse level. The railways have failed to consolidate and exploit this information for commercial gain.

The calculations in the business economic model will make the assumption that in intermodal chains, wagons are 100% dedicated for use in the specific service. This is in accordance with prevailing practices in shuttle services and close to block train production models. It would not be in accordance with single wagonload production, which however is rare in intermodal transport segment.

The consequence of this rule is that the fixed cost component of the wagon set in one single trip can simply be calculated by dividing its annual fixed costs by the number of single trips per year. Variable, distance related, costs of wagons would include maintenance costs.

The model will assume that locomotives are dedicated to the intermodal service (and to the wagon sets) only if schedules are tight. In this situation, wagons are moving fairly continuously and terminal dwell times are very short. Then the alternating of locomotives would not pay. Locomotives are routinely assigned and re-assigned so this position is not as clear cut as indicated.

For less efficient services (i.e. with low gross service speeds) the business economic will assume that locomotives have operations that are separate from the wagon sets. Then, rules will be applied for estimating the number of hours that locomotives are available for the service.

This number will be less than the gross service time, but always would need to include the time needed for locomotives to approach terminals, border crossings, side tracks, yards or any other intermediate stops where the locomotives are changed.

When locomotives are isolated from wagon sets in the costs calculations their costs will be derived from operation parameters of the fleet of locomotives in total. It will for example consider average annual number of assigned productive business hours of locomotives as denominator in cost calculations. KPIs need to be developed to substantiate this for existing and new operations.

Variable costs of locomotives are related to energy consumption and energy unit costs. Part of the maintenance cost is also related to the use of the locomotive, however these will be treated as fixed costs in the business economic model.

The locomotives considered are electric powered locomotives that are common in current practice. The selected locomotive type will have sufficient power installed for effectively operating the total train weight of the heaviest train in consideration (for which in the LD-commodity market 1500 tons would be a fair estimate assuming maximum train length). For cost calculations in international services there will be a case-wise decision whether to deploy multi-current locomotives or to change locomotives at the border. The former has higher capital costs, while the latter will involve operational costs related to the positioning of subsequent locomotives.

The costs of train drivers will depend on the number of hours that locomotives are in use for the service. Data about annual gross labour costs of train drivers (i.e. year salary) will be divided by the average number of hours that drivers are effectively in service.

The characteristics of the wagon set depend on the segments the train is operating in. In continental intermodal transport they would need to carry European dimension containers (45’ hi cubes, swap-bodies or semi-trailers, made for easy transfer between wagon and road on both ends. Port related services need to carry ISO-containers.

For the segments of intra-company transport and urban deliveries covered wagons may be used. The number of wagons that assumed used will be close to the maximum allowable train length in long-distance movements where traffic justifies this formation length. For shorter distances, shorter trains will be considered, so allowing for faster equipment rotation. The wagon set characteristics and configurations are summarised in the next table.

Table 9.1: Wagon set characteristics and configurations

Segment	ILU	Wagon	Wagon set
Intermodal & continental	Swap body or "continental container" – mega size	Flat wagon (SGGMRSS 90)	1 w = 29.59m=2 s-b 18 w = 533 m = 36 s-b
Intermodal & continental	Semi trailer – mega size	Pocket wagon (SDGGMRSS-L)	1 w = 34.20m=2 s-tr 16 w = 548 m = 32 s-tr
Intermodal & port hinterland	Maritime ISO-container (20 ft or 40 ft)	Flat wagon (SGGMRSS 80)	1 w=26,70m = 4 TEU 20 w=554 m = 80 TEU
Intermodal & continental	Refrigerated swap-bodies	Flat wagon (SGGMRSS 90)	1 w = 29.59m=2 s-b 18 w = 533 m = 36 s-b

9.3.4 Costs of infrastructure use

Infrastructure charges differ widely between stretches in Europe for example because of differences in maintenance that needs to be applied on the network which will be reflected in the costs that need to be recovered through charges. Infrastructure managers may also diversify tariffs between categories of users and possibly between priorities ("express") or timing ("peak hours"). The calculations will as much as possible use real tariffs as published in network statements.

9.3.5 Infrastructure and rail operations related costs

Case-wise it will be decided whether such costs will occur and will be taken into account in the cost calculations. One can think of shunting services when locomotive and wagon sets are decoupled and coupling and use of an extra engine in transalpine traverses. The basis for the calculations will need to be explicit in their assumptions for this category of costs.

9.3.6 Loading unit costs

Loading unit costs are relevant to intermodal transport chains. These costs involve the attribution of the annual fixed costs of capital, maintenance and insurance to the rotation of ILU in the intermodal transport chain. This rotation of ILU would be at its fastest if the ILU taken into one direction will be transported back by train on the same round trip. Very often however, ILU will be dropped with clients where they are (un-)loaded when it suits the clients, which would most likely postpone their return trips. For refrigerated cargo ILU costs also time related energy costs for the time that the reefer unit is loaded need to be included. The position on the restitution of maritime containers and the shipping line's focus on getting kit back to major ports or inland terminals need to be recognised in this.

Table 9.2: Costs per day of ILU

Semi-trailer (mega-size)	€ 30
ILU swap body (mega-size)	€ 10
ILU ISO 40ft container	€ 15
ILU-ISO 20ft container	€ 10
Reefer 45ft	€ 35

9.3.7 Management and other business costs

Management and other business costs are the costs involved in constituting framework conditions for a good execution of the tasks. A distinction can be made between management of the transport chain and business management. Chain management concerns management needed for the execution of the transport services, for example costs of booking and other client contacts and costs of an organisational back-up in case certain actions are needed. These are activities such as planning, steering, monitoring, communicating, administration and contingencies.

Business management involves the functioning of all entities active in the chain and contains a wide range of activities, e.g. acquisition and contracting, procurement of assets and human resources development. Both cost categories are difficult to quantify, even more so are principles of fair attribution of the costs involved to trip level. The model will assume a cost-plus approach with percentages that may vary between cases in accordance with their complexity.

9.3.8 The factor of asset utilisation

Most of the cost elements of railway transport service production have a “fixed” nature: they do not change materially when use of the service changes. A consequence is that utilisation of the service is a very important determinant of the transport costs per ILU. Economies of scale will only apply if the train is actually being well utilised, for example costs per ILU of trains which are 60% occupied is about 50% higher than of trains with 90% occupation.

The business economic model assumes, in accordance with prevailing practice, that the service is in place throughout the year. During this time, the occupation rate of trains may be varying between peak and off-peak seasons. The model assumes one average occupation rate, which is defined as the number of ILU transported in one year divided by the annual ILU-capacity of the train.

Certain segments, e.g. urban deliveries, are characterised by cargo flows into one direction and empty hauls in the opposite direction, which then will result in a maximum utilisation of 50% unless clever triangulation can be achieved. Intermodal transport may involve carriage of empty ILU, which is considered as a load to the rail haulage and therefore does not affect the utilisation rate.

9.4 RAIL AND MULTIMODAL TRANSPORT SERVICE PARAMETERS AND COSTS

Other segments in which SPECTRUM could potentially obtain a position are:

- Connecting rail sidings, most commonly intra-company transport forwarding (semi-) manufactured products in the production and distribution channels of supply chains, e.g. meant for routine replenishment of stocks.
- Deliveries to highly urbanised areas.

The annual volumes that would be required for maintaining a regular dedicated transport service between rail sidings means that such services are not now widely available. What used to be common practice up to the 1970's today, if still on rail, is more often being served in single wagon production systems or by intermodal transport services. The business economic model will test competitiveness of transport services that use shorter trains composed of covered wagons as well as of flat wagons carrying swap bodies and containers.

Deliveries to urbanised areas are currently dominated by road transport. With increasing pressure from traffic congestion and quality of life requirements there may be opportunities for rail, however this would require more than just opening of the urban railway infrastructure network for freight. It would have to involve a restructuring of urban freight solutions by channelling goods through (rail-sided) urban distribution centres.

The business economic model will assume such DC's to be available and will test competitiveness of SPECTRUM services with short train lengths for covered wagons and for swap bodies and containers. The wagon sets under investigations are summaries in table 7.3.

Table 9.3: Wagon sets under investigation

Segment	ILU	Wagon	Wagon set
Intra-company, conventional	n.a	Covered wagon (HBBINS)	1 w= 15.50m 20w=310m
Intra-company, intermodal loading units	Swap body C-class Swap body A-class	Flat wagon (SDGMRSS 104 or 90)	1 w = 33.48 = 4 s-b 16 w = 538 m = 64 s-b
Urban delivery, conventional	n.a.	Covered wagon (HBBINSS)	1 w= 15.50m 10w=155m
Urban delivery, intermodal loading units	Swap body C-class Swap body A-class	Flat wagon (SGGMRSS 104)	1 w = 33.48 = 4 s-b 10 w = 335 m = 40 s-b

10 Preliminary assessment of the cost competitiveness of the SPECTRUM concept

The ex-ante quantitative assessment is conducted on the SPECTRUM design using the micro economic business model. The objective is to identify possible market segments for the rail freight solution to be designed in SPECTRUM; assess the likely commercial viability of the solution as well as its potential impacts on the competitiveness of rail in the market. In total, twelve business cases are investigated. The selection of business cases is such that all targeted market segments are envisaged. The first nine business cases and the corresponding market segments are presented below.

Table 10.1: Selected business cases

Segments	Short distance 150 km - 400 km	Medium distance 400 km - 700 km	Long distance > 700 km
Continental, domestic, ILU	X	X	
Continental, international, ILU		X	X
Seaport related, domestic, maritime container	X (<= 200 km)		
Refrigerated, international, ILU		X	X
Intra-company, both ILU and covered wagon	X	X	
Urban supply, ILU	X (<= 150 km)		

Three business cases are selected from the previously described case studies:

- The P&G case study: movements Amiens – Mechelen – Euskirchen;
- The GreenRail/Floraholland case study: movements Rotterdam – Busto Asizio; and
- The InnovaTrain case study: connecting urban areas of Geneva, Härkingen and St-Gallen.

The following sections present the results of the preliminary assessment based on each of these business cases.

10.1 ASSESSMENT OF LONG-DISTANCE CONTINENTAL INTERNATIONAL INTERMODAL RAIL SERVICES

The assessment of long-distance continental international transport takes the relation between the regions of Antwerp and Milan as the example. The service parameters are mostly derived from the service from the rail operator HUPAC: departure on day A in the evening, arrival on day B in the evening between terminal in Antwerp and terminal in Busto-Arsizio. Both terminals are located on RailNetEurope's (RNE) rail corridor – Corridor 02 (Antwerp/Rottedam – Köln – Basel – Milan/Genova). The two terminals serve strong economic regions and the latter is also an important gateway to the Italian transport network.

The rail distance between terminals is 1087 km. The distance for uni-modal road transport is 933 km. On such long distance, intermodal rail transport today already has a strong competitive position as compared to road transport. The door-to-door costs of intermodal transport on this relation tend to be lower than uni-modal road transport. Much depends on the characteristics of the pre- and end-haulage (which in both urbanised areas may be of low efficiency).

The scale economics of railways however are likely to outweigh them. The summarising table 8.1 presents the costs of rail and transhipment together per swap body and per semi-trailer[47]. They are about €890 less than of road for the former and €717 for the latter, per direction. On this relation, costs include infrastructure charges of rail and road tolls, which are relatively high for road and rail.

Table 10.2: Cost comparison Antwerp-Busto Arsizio

	Swap body	Semi-trailer	Truck (trailer + semi-trailer)
Terminal to terminal at current situation (transhipment included)	€ 693	€ 868	
Terminal to terminal under SPECTRUM scenario (transhipment included)	€ 560	€ 684	
Pre- and end-haulage	P.M.[48]	P.M.	
Door-to-door			€ 1585

The introduction of the technology to be developed in SPECTRUM would further reduce intermodal costs, because of a better utilisation of the railway assets. In this example:

- The rotation of the wagon sets would improve, and 2 instead of 4 wagon sets would be needed.
- With this faster rotation, it pays to dedicate locomotives to this service, which implies an overall better utilisation of the locomotives: their annual number of business hours will be higher than the rolling stock's averages. The calculations are based on 2 locomotives dedicated to the service.

Next to cost advantages, quality characteristics are also affected under the SPECTRUM scenario:

- Punctuality is likely to improve, because of a fixed coupling of wagon sets and locomotive that reduces risks of disruptions in the chain. It would be possible to have an ambitious service schedule that would still allow for some buffer to cope with delays in rail operations. (e.g. cut-off time at departure day on day A at 5pm and loading unit available at end terminal on day B at 07am).
- Lead-time is drastically improved. With evening departures (on day A), ILU can be collected early next morning (on day B) and then delivered with clients on the same day (day B). Current intermodal rail service would have deliveries with clients on day C, while uni-modal road transport – with single driver – could be expected to reach clients only in the afternoon of day B
- Security will be improved, because train movements are not broken and wagons don't need to be marshalled.
- Frequency would not necessarily be affected, but could be increased at relatively low costs. By using the locomotive more intensively and deploying a 3rd wagon set, 2 departures per day could be realised.

[47] It was decided that the calculation of the pre- and end-haulage costs is not to be included in the preliminary assessment phase because it would involve assumptions such as the distance and travel time between clients and terminals; the volume to be carried by trucks; how many roundtrips a truck would make per day; how many of those trucks carry a loading unit and probably more, etc. These concrete parameters need to be derived from specific companies in the LDHV market. Without such references making assumptions on these parameters would be random, and consequently it would bias the results of the cost comparison as well as the overall conclusion.

[48] P.M. = Pro memorie. for future reference

- Such increased frequency would imply additional capacity and so contributes to improved flexibility.

10.2 ASSESSMENT OF MEDIUM-DISTANCE CONTINENTAL INTERNATIONAL INTERMODAL RAIL SERVICES

The assessment of medium-distance continental international transport takes the relation between the regions of Mid-Germany and Northern Italy as the example. The service parameters are derived from Kombiverkehr-service between terminals in Nurnberg and Verona, which are both the gateway terminals to the respective national networks and both are part of RNE corridor 04 (Hamburg/Bremerhaven – München - Verona).

The distance between the two terminals is about 517 km. In current practice the connecting service may be viable because of its position in the European intermodal transport network. This would imply that a large share of demand originates from rail-rail–transhipments on either sides of the terminal, rather than from rail-road transhipments.

For rail-road transport, at both side there is often the need for pre- and end-haulage over distance of over 150 km in order to reach the economic centres (i.e. Mannheim/Frankfurt and Milano). The distance for road-only transport between Nurnberg area and Verona area is about 600 km. On this relation, intermodal rail transport has relatively a strong position compared to road only transport to an important extent due to the infrastructure charging policies in the Alp-transit traffic. As can be seen in the summarising table 8.2, the costs of rail transport and transhipment together per swap body are about €570 less than of road per direction or €490 per semi-trailer.

Table 10.3: Cost comparison Nürnberg-Verona

	Swap body	Semi-trailer	Truck (trailer + semi-trailer)
Terminal to terminal at current situation (transhipment included)	€433	€515	
Terminal to terminal under SPECTRUM scenario (transhipment included)	€377	€449	
Pre- and end-haulage	P.M.	P.M.	
Door-to-door			€ 1004

After the introduction of the technology to be developed in SPECTRUM, the locomotives will remain undedicated to the service. Current as well as future situations will involve locomotive changes after arrival in the terminals, however none at intermediate stages.

With the speed increase under the SPECTRUM scenario, the operator could decide on rotating only one wagon set. This would provide the costs values as indicated in the table.

To achieve this however, it would have negative consequences to the timing of services, which most likely would be perceived as disadvantageous by clients. When two wagon sets are kept in operation, as is practice in the current situation, costs of SPECTRUM would be slightly less than the current costs. In such situation, its positive impacts would be on quality parameters:

- Punctuality will improve whereas SPECTRUM-design allows for a bank of time that can be used as buffers in schedules.
- Lead time is improved in a way that ILU which are dispatched early evening will be available earliest in the morning, whereas current schedules require afternoon dispatch for late morning arrival.
- It would be possible to have such more ambitious service schedule (e.g. cut-off time at departure day on day A at 9pm and loading unit available at end terminal on day B at 6am) instead of today's schedule (e.g. cut-off time on day A at 17pm and loading unit available at end terminal on day B 0am) and still allow for some buffer to cope with the occurrence of delays in rail operations.

10.3 ASSESSMENT OF MEDIUM-DISTANCE CONTINENTAL DOMESTIC INTERMODAL RAIL TRANSPORT

The assessment of medium-distance continental domestic transport takes the relation between the regions of Hamburg and Stuttgart as the example. The service parameters are derived from Kombiverkehr-service: departure on day A at terminal Hamburg Billwerder and arrival on day C at terminal Kornwestheim with the distance of 699 km from each other. On this relation, there is often the need for pre- and end haulage over distances of over 100 km.

The distance of road-only transport between the areas is also about 700 km. This distance is considered by many in the market as “break-even-distance”, beneath which road transport would appear to be the preferred alternative with lowest current prevailing input costs.

Next to the standard intermodal service, Kombiverkehr offers an “express service”, the service parameters of which are however not publically specified. Our analysis will then assume for this express service the departure to be on day A, arrival on day B, with an average travel speed of 65 km/hr by rail from terminal to terminal.

That Kombiverkehr-service has the A-C schedule implies a rather slow service speed and the subsequent relatively low efficiency. Opting for this service schedule may be due to constrained infrastructure capacity on the route.

The cost evaluation shows that SPECTRUM-design could reduce one-way transport costs by €107 for mega-size swap-bodies and €155 for semi-trailers.

In comparison to a more efficient service – titled “express service” - with net average speed of 65km/hr, the savings appear to be marginal.

The express service equipped with the future SPECTRUM technology has locomotives dedicated to the service. Current as well as future situations will involve locomotive changes after arrival in the terminals, however none at intermediate stages. The service under the SPECTRUM scenario will run with one locomotive and two wagon sets. With advanced technology and higher speed, the operator could decide on rotating only one wagon set and one locomotive.

The need for time for terminal operations and some buffer time in the schedule would require deployment of shorter wagon formations. Such short train operation would involve higher costs than a more relaxed operation with two full length wagon sets, as can be seen in Table 10.4.

Table 10.4: Cost comparison Hamburg-Kornwestheim

	Swap body	**Semi-trailer**	**Truck (trailer + semi-trailer)**
Terminal to terminal at current situation	€ 521	€ 644	
Terminal to terminal at current situation: The express service	€ 418	€ 495	
Terminal to terminal under SPECTRUM scenario	€ 386	€ 458	
Terminal to terminal under SPECTRUM scenario: Short train	€ 460	€ 563	
Pre- and end-haulage	P.M.	P.M.	
Door-to-door			€1089

Practice in Germany is such that services which would be granted with higher priority would be subject to 65% higher infrastructure charges. These are not taken into account in the table. They would increase the costs by €38 per swap body and €43 per semi-trailer for a one-way trip in a full-length train.

SPECTRUM will have positive impacts on the following service quality parameters:

- Punctuality, which will improve because of coupling of wagon sets and locomotives is not interrupted and because of the possibility to insert time buffers in schedules.
- Lead time is drastically improved in comparison to current schedules, but would even improve “express service” and allow for combining early evening dispatches with early morning arrivals.

10.4 ASSESSMENT OF SHORT-DISTANCE CONTINENTAL DOMESTIC INTERMODAL RAIL TRANSPORT

The service parameters for short-distance continental domestic transport are virtual. The distance is assumed to be 400 km for both intermodal rail and road only transport. At the moment continental services on such difference are not economically viable because on such distances road transport is preferred. The reason that this segment is included in our analysis is because it is the ambition of Europe to shift cargo from road to rail on distances above 300 km (EC, 2011)[49]

The evaluation in this segment would involve improvement of a virtual service over 400 km with net rail speeds of 50 km/hour in an already efficient rotation, i.e. one round trip per day of one locomotive and one wagon set. The cost comparison assumes values of infrastructure charging in Germany for rail as well as road.

The introduction of the SPECTRUM-design while maintaining the frequency of one per day will only bring about marginal net cost savings due to the reduction of driver's labour time. A doubling of the frequency to two departures per day would require a second wagon set and a second locomotive. With two locomotives and two wagon sets it would also be possible to provide a frequency of 3 departures per day, so also saving on equipment costs.

Table 10.5: Cost comparison virtual service over 400 km distance

	Swap body	Semi-trailer	Truck (trailer + semi-trailer)
Terminal to terminal at current situation	€ 305	€ 356	
Terminal to terminal under SPECTRUM scenario	€ 296	€ 343	
Terminal to terminal under SPECTRUM scenario: high frequent	€ 282	€ 324	
Pre- and end-haulage	P.M.	P.M.	
Door-to-door			€ 621

Table 10.5 shows that the cost reductions under SPECTRUM scenario are not impressive. They would even be offset if higher "express" infrastructure charges for rail would be applied. The consequence of this observation is that only the quality improvements of such operations would be beneficial to this segment. Impacts could be expected on:

- Punctuality. The operations of the intermodal transport solution with current technology would be in a tight schedule, prone to disruptions and delay. SPECTRUM will solve this. The simulated circulation of three trips per day however, could in practice be as tight.
- Frequency. A high frequent solution would improve the attractiveness on because of the merits
- Flexibility. A higher frequency will also increase flexibility, because it gives the possibility of ILU to be rescheduled between services without affecting service levels to clients. (Rescheduling opportunities would also benefit occupation rates of the train, and so reduce costs.) These are key quality and service issues that rail needs to address despite the small apparent commercial advantage identified. The higher utilization and productivity of the SPECTRUM concept needs to be fully exploited even in this type of application to really make an impact.

10.5 ASSESSMENT OF SHORT-DISTANCE SEAPORT RELATED HINTERLAND SERVICES

Transport services of maritime containers between terminals in seaports and in their hinterlands comprise a large share of all intermodal transport services in Europe. Railway services have been alternative to road and barge services as competing mode. Increasingly railway services have become a means of port authorities and terminal operators to solving congestion problems in their areas.

Terminal operators prefer large-scale operations above the fragmented handling of trucks and port authorities combat to defend accessibility of the port region and many take measures to contain local

[49] EC, 2011: WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system/* COM/2011/0144 final page9

pollution caused by road traffic. This has led to the development of concepts in which inland terminals are extended gates of the seaport, linked with seaports by frequent rail shuttles and fast terminal handling on both ends.

The business economic model has evaluated two virtual cases:

- The inland terminal is on 120 km distance from the port and currently linked by a highly efficient service with frequency of 3 times per day. This service operates in a fairly tight schedule with 1 locomotive and 1 wagon set. With the technology to be designed in SPECTRUM, the production of the 1 locomotive and 1 wagon set is assumed to be increased to 4 services per day. This is however a demanding requirement that has implications for the planning of train paths, crews, maintenance of the rail assets and high levels of precision and reliability in the terminals.
- The inland terminal is on 200 km distance from the port and currently linked by a service of a frequency of 2 times per day, with 1 locomotive and 1 wagon set With the technology in SPECTRUM, the production of the 1 locomotive and 1 wagon set is assumed to be increased to 3 services per day. This is an equally demanding requirement.

For infrastructure charges, values of the Dutch railway network are used.

Table 10.6: Cost comparison between current technology and the technology to be designed in SPECTRUM on virtual port hinterland services over short distances 120 km and 200 km

	120 km	200 km
Current situation	€ 19.36 / TEU	€ 30,46 / TEU
SPECTRUM scenario	€ 17.15 / TEU	€ 26,27 / TEU
Savings per TEU	€ 2.21 (11.4%)	€ 3.79 (12.4%)
Annual savings per train set	€ 132,668	€ 226,806

Table 10.6 shows that in terms of absolute costs per ILU or per TEU and of cost reductions, values will seem unimpressive. Nevertheless, since it concerns intensive transport operations with high annual volumes, investing in SPECTRUM technology would have high annual savings, as shown in the last row of the table.

10.6 ASSESSMENT OF INTERMODAL SERVICES FOR REFRIGERATED CARGO

Refrigerated transport on the train today is using diesel powered reefer units on flat intermodal wagons. The fuel consumption of reefers depends on the characteristics of the reefer body, the cooling system, as well as the outside temperatures. In the GreenRail demonstration project, diesel fuel consumption of the reefer container was about 3 litres per hour.

This does not add to the costs of physical transport, rather implies a limit to the range of the reefer which is limited by the size of the diesel tank. Refilling of the reefer tanks, when done in terminals, adds to labour costs. But refilling of the reefer tanks when the units reside on a wagon platform would be more complicated to organise. Reefer management with condition monitoring would be able to minimise the number of instances when reefer re-fuelling away from terminals is required.

The SPECTRUM design can either hold to the existing reefer technology, or develop a solution for electric power supply to wagons, allowing for carriage of electric or diesel-electric reefers.

Electric power supply would minimise the risks of (diesel-electric) reefer tanks running empty (particularly on long distance) and therefore create confidence to potential clients of rail. It would require additional engineering measures for drawing power from the locomotive, which would increase the capital costs of the wagons but presumably only to a marginal degree.

The business economic model evaluates the potential impacts of the SPECTRUM-design with diesel reefer units on the same intermodal transport relations as were evaluated for conventional swap bodies in the previous sections.

The use of reefers implies extra costs compared to conventional cargo because of the higher ILU-procurement costs, routine maintenance and because of its fuel consumption. These are the costs that have to be borne if a presence in the reefer market is proposed. The road transport alternative has similar extra costs: more capital costs of truck construction or of the semi-trailer and extra fuel for the refrigerating.

The table below shows how the concept to be developed SPECTRUM could improve the competitive position of intermodal rail transport in comparison to road transport. Additional costs, not included in the calculations in the table, will emerge in the intermodal transport chain if door-to-door lead times soar, for example if the loaded reefer is stalled at terminal's premises.

Fuel consumption will continue and refilling of the tank may be required. This could be offset by the use of condition monitoring and the more intensive monitoring and management of the high value reefer assets to minimise this sort of situation.

Table 10.7: Cost comparison between current technology, the SPECTRUM scenario, and road transport for refrigerated cargo

	terminal to terminal, current technology	terminal to terminal, under SPECTRUM scenario	Road transport
Long distance international Example: Antwerp-Milano (1000 km)	€908	€690	€1697
Medium distance international Example: Nurnberg-Verona (600 km)	€519	€434	€899
Medium distance domestic Example: Hamburg-Stuttgart (700km)	€690	€453	€1173
Medium distance domestic Example: Hamburg-Stuttgart, (700km), Express service	€472	€453	€1173
Short distance domestic Example: within Germany (400 km)	€443	€344	€669
Short distance domestic Example: within Germany (400 km), 3 departures / day	€443	€329	€669

The introduction of SPECTRUM will improve the service quality parameters, which are particularly important in this segment of perishable goods:

- Lead times will be reduced, on medium and longer distances by one day. This is not only positive for the longer span that fresh goods can be sold to the market in the destination region, but the faster delivery may also avoid decrease of the value of the perishables, when marketed.
- Safety (avoidance of damage to cargo) will also be improved because reefers will be less prone to running empty and/or other disturbances.
- Punctuality will improve if new services involve larger buffers in time.
- Security will improve because intermediate stops are less in number and in duration. The train's may obtain higher priority status and/or it will have a lower claim on rail infrastructure capacity and therefore higher likelihood that it can be fit in between passenger train schedules.

The issue of controlling the condition of cargo is yet insufficiently managed with the technology under investigation. All loading units may be equipped with devices of monitoring position, temperature and humidity inside the reefer. However the implementation of intervention measures like filling of reefer tanks, when the values of these parameters (e.g. temperature, humidity level) are adverse, is not foreseen during rail operations.

This is a major product and service deficiency within the rail sector that needs to be addressed as much as any technical measures. Train crews should have the responsibility for operational intervention and communication in the event of technical and service disruptions on the same lines as truck drivers and their responsibility for the cargo in transit. In road transport, the driver could take care of this. Rail should emulate this example.

10.7 ASSESSMENT OF RAIL SERVICES FOR INTRA-COMPANY TRANSPORT

Train schedules for intra-company transport are the result of negotiations between the railway undertaking and the client to whom the service is dedicated (shipper and/or logistics service operator). They are not always readily and publically available.

In the business economic model, the impact of the SPECTRUM-design on current performance is tested on a number of virtual cases:

- Short distance (300 km) transport between rail-sidings with conventional railway wagons (or covered wagons);
- Medium distance (600 km) transport between rail-sidings with conventional railway wagons (or covered wagons);
- Short distance (300 km) transport between rail-sidings, using ILU;
- Medium distance (600 km) transport between rail-sidings, using ILU.

All cases consider trains of medium lengths as well as short lengths. The covered wagons in use are designed for efficient carriage of low-density cargo. These are light weight, 2-axled and 15-meters each. There are 20 wagons in a medium length train and 12 wagons in a short train.

The intermodal wagons will carry A-class (mega-sized) swap bodies or short C-class swap bodies in sets of 12 and 8 wagons respectively. This would correspond with a daily capacity of 24 and 16 truckloads. The service to be designed in SPECTRUM is assumed to double rail speed from 46km/hour to 92 km/hour.

A characteristic of this segment is that all transport is in high quantities, originating from one point and destined for one single other point. Cargo flows in the intra-company transport are considered to be into one direction and, with dedicated wagons and/or ILU, therefore utilisation rates are considered to be low: 80% when loaded, meaning an average of 40% in round trips.

Since loading and unloading is done on the rail-sidings or platforms on the premises of shipper's or logistics service providers, any transhipment costs are not taken into the comparison. (This loading and unloading would also need to be applied to road transport.)

Road transport in this comparison may have the advantage, since it is likely to be more successful for road than rail in collecting return cargo from other clients in the vicinity of the destination unless other cargo can be secured to rail for return using brokerage options.

Table 10.8: Costs (€) per ton payload[50] in rail production with current technology and SPECTRUM and by road over short and medium distances

Short-distance = 300 km	Covered wagons	A-class swap bodies	C-class swap bodies
Current situation, train with medium length	€20.3	€21.1	€20.3
Current situation, train with short length	€31.7	€29.8	€28.6
SPECTRUM scenario, train with medium length	€17.4	€18.1	€17.4
SPECTRUM scenario, train with short length	€26.6	€25.1	€24.1
Road transport	€22.5	€22.5	€22.5
Medium-distance = 600 km	Covered wagons	A-class Swap bodies	C-class Swap bodies
Current situation, train with medium length	€35.3	€36.2	€34.7
Current situation, train with short length	€54.6	€51.0	€48.9
SPECTRUM scenario, train with medium length	€27.9	€28.9	€27.8
SPECTRUM scenario, train with short length	€44.0	€41.3	€39.5
Road transport	€45.4	€45.4	€45.4

The differences in costs between the three different types of loading types (covered wagon, C-class and A-class swap bodies) appear to be small, with slight advantage to the C-class bodies.

The comparisons in the table show how SPECTRUM will decrease rail operation costs. The costs decreases are around 15% over the 300 km distance and around 20% in 600 km distance. Particularly in the longer distance SPECTRUM would significantly decrease costs further below those of road transport operations.

SPECTRUM advantages could offset by rail infrastructure charging policies. The values in the table assume that infrastructure charges between current technology and SPECTRUM are the same. The Infrastructure Manager could apply an “express” surcharge, which in Germany currently is 65%. Applying this surcharge would offset all of SPECTRUM’s cost savings over 300 km and most of the savings over 600 km. Whether this surcharge would be applied needs to be investigated to minimise uncertainty on this point.

Advantages with respect to service quality parameters may be expected concerning punctuality and compression of lead times, particularly the longer distance. The quality improvements between conventional and SPECTRUM technology on other aspects do not appear to be of key importance.

This may present an opportunity to enhance the service and product quality aspects and encourage shippers to use the service on these measures as well as any operational and commercial grounds.

10.8 Assessment of Intermodal Rail Services for Urban Supply

Rail freight services that constitute a structural and significant part of urban distribution system do not exist. The SPECTRUM design could contribute to establish this, and could so help to relieve the road network in urban areas. The business economic calculation considers 2 terminals – or rather rail-sided cross-docks, one in the urban territory and one on 150 km distance. Both terminals are dedicated for this task only and use

[50] Payload is derived from the cubic volumes of the ILU or transport assets and considers the maximum weight / per m3 of 230 kg, which SPECTRUM assumes.

reach-stackers and/or fork-lifters for transhipment between warehouse or road and rail, at the costs of €20 per ILU per transhipment. The ILU's used are C-class swap bodies (up to 7.82 meters length) that are most suited to be moved within the urban area with light trucks.

Table 10.9: Costs (€) of rail production with current technology and SPECTRUM in urban supply.

Distance = 150 km	C-class swap bodies	Savings SPECTRUM
Current situation, train with medium length	€175	
Current situation, train with short length	€216	
SPECTRUM scenario, train with medium length	€164	-6.6%
SPECTRUM scenario, train with short length	€197	-8.9%

A comparison to road transport is complex. Often it will concern less-than-truckload cargo and it would require much insight in how destinations are spread over the urban areas and how well accessible these areas are, apart from many constraints in delivery times that may exist.

If assumed that a light truck (8 tons of cargo) will be loaded in the warehouse at 150 km distance and that the truck can reach the client from there in three hours, its costs would be about €350. This includes loading time at the warehouse, but does not include unloading with the client. Utilisation would be 50% (half of km is empty run), as is assumed for rail in this segment.

The table shows that rail could be part of a competitive solution; however end-haulage into the urban area would become a very critical element. An additional advantage of using ILU rather than trucks may be in the cargo handling operations in the warehouse.

The table also shows that it is probably not the SPECTRUM-design that will make a difference in costs since its savings is less than 10%. The calculation assumes common rail freight infrastructure charges and "express surcharges" would make SPECTRUM end up potentially more costly than conventional freight trains.

In this segment cargo is very critical and time sensitive. SPECTRUM is likely to contribute to lead time compression and punctuality improvement, assuming that its features will make that rail will fit better in the dense passenger rail traffic than conventional trains.

The use of rail for supplying terminals deep within the urban areas will eliminate road traffic in areas where that is most needed. The analysis in the business economic model based on internal business costs and performance criteria does not consider such external effects.

In the future urban authorities may want to reconfigure urban logistics for example by a certain level of co-funding and through public service contracts, in which rail-based urban delivery services will be defined in concession agreements with companies in the logistics industry. Under such concession a rail service into the urban area may be further extended by a capillary network of urban supply.

The use of even shorter trains and of intermediate technology like bi-modal trailers, which can operate on road as well as on (urban) rail infrastructure, could be part of such extension of services.

10.8.1 Assessment of intermodal rail services based on the case studies in Task 1.2

Three case studies addressed in WP1 Task 1.2 focus on intermodal transport solutions in different segments of the market. In this section, preliminary assessment is made based on these case studies to assess whether and how concepts to be developed within SPECTRUM would affect the costs of these services. These services are:

- The intermodal service on the route Amiens – Mechelen – Euskirchen, developed to serve transport demand of Procter and Gamble;
- The intermodal service between Rotterdam RSC and Busto Arsizio, used by Flora Holland in the GreenRail demonstration project;

- The intermodal services by Innovatrain, connecting urban areas of Geneva, Härkingen and St-Gallen.

The fourth case study in Task 1.2, which investigates a high-speed rail service concept, CAREX, linking Amsterdam and London via the Channel Tunnel, will not be assessed in this section. This is because the CAREX-service will use the high-speed network. Such services are not available at the moment, and no data on routes over suitable rail infrastructure is available.

10.8.2 SPECTRUM to connect Dourges – Mechelen – Duisburg[51]

We assume that the SPECTRUM-concept applied in this case will increase average travel speeds between the terminals from 60 km/hour to 92 km/hour. The values of other service parameters (mainly terminal dwell times), characteristics of pre- and end-haulage and e.g. assumed utilisation are the same as in the case study in Task1.2.

The assessment using the business economic model shows that the SPECTRUM concept would lead to different round-trip costs of the train service than those in the case study. In particular, round-trip costs in the SPECTRUM scenario, comprising traction, drivers and infrastructure charges, appeared to be about 33% lower.

The assessment of impacts on costs is therefore derived from a marginal analysis, resulting in:

- € 27,724 per year increase in wagon costs (€ 34,655 if 80% of cargo is on the train);
- € 54,235 per year reduction in locomotive costs;
- Equal infrastructure charges.

With the assumption that rail management costs would be attributed in accordance with €31,813 the fixed costs of rail production (i.e. excluding the variable energy costs) the annual saving would be about €32,000 (or €24,000 if 80% of the cargo is moved by train) per year.

This would be a saving on rail production of about €5 per loading unit per direction and therefore can be neglected. With an “express surcharge” to infrastructure use of 65%, these costs would increase by 182,500 per year, leading to an increase of €20 per loading unit.

10.8.3 SPECTRUM to connect Rotterdam RSC and Busto Arsizio

We assume that the concept to be developed in SPECTRUM applied in this case will increase average net travel speeds between the terminals from 47 km/hour to 92 km/hour. Assumptions of the other parameters as inputs for the business economic model are based on the cost parameters provided in the case study.

The increase in speed will enable the intermodal operations with 2 locomotives and 2 wagon sets, instead of 3 of each in the current situation. This will decrease rail operation costs by 15%, or €80 per loading unit per direction.

Additional savings can be expected from lower rental costs of the loading unit and from lower diesel consumption of these loading units, in total comprising a significant amount of €64 per loading unit per round-trip.

Total savings therefore would be €224 per ILU per round-trip. If infrastructure charges would be subject to 65% “express surcharges”, these savings would be reduced by (2x€78=) €156 to €68 per ILU per round trip.

10.8.4 SPECTRUM to connect Geneve-Härkingen-St Gallen

The assessment of the round-trip costs under the SPECTRUM scenario is about equal to those assessed in the case study, despite the difference in the technology – the model assumes TRAXX-locomotives with 7 wagons for 4 C-class swap bodies.

The innovative technology to be developed in SPECTRUM is assumed to increase the average speed from 72.3 km/hour to 92 km/hour. Savings in locomotive and driver costs are partly offset by the extra investment costs of the wagons.

Estimated net impact of SPECTRUM on costs would be only €7 per ILU per direction. With express surcharge, the cost increase would be €31 per ILU.

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[51] This is the rail-leg on route Amiens – Mechelen - Euskirchen

10.8.5 Conclusion on case comparisons

As can be seen, in all 3 case studies the replacing of current rolling stock by the SPECTRUM-design set would reduce the rail transport operating costs. The reduction is slight (less than 5%) for the P&G case and for Innovatrain, which can be explained by the fact that current technology is already being efficiently deployed.

The 15% savings in the rail costs of the long-distance intermodal service of FloraHolland are more impressive, and this transport has additional cost savings due to shorter fuelling times of the reefers.

A critical assumption in these assessments is that rail infrastructure charges remain unchanged. Express surcharges would offset cost advantages,

For each of the three case studies, and particularly the case of FloraHolland, the benefits of SPECTRUM-design should be expected to originate from the improved service quality parameters, mainly punctuality and lead time.

11 SWOT analysis

A SWOT analysis is a widely utilised strategy and planning tool to help companies evaluate a business proposition or an existing business activity in a particular market or operating environment and to develop strategies to deal with likely changes in the future. The following table presents a SWOT analysis of the SPECTRUM rail concept based on the key findings of the project so far.

Strengths	**Weaknesses**
• Rail freight transport energy efficient and environmentally friendly. • Rail freight transport is safe and secure. • Rail operates within a controlled and planned environment • Traditional rail freight can already be cost-effective over medium and large distances over 300km. • Considerable recent investments have been made in rail infrastructure and equipment eliminating bottlenecks and missing links in the network. • Rail transport can achieve higher terminal-to-terminal average operational speed compared to road transport on well-developed connections. • Rail has strong green credentials in terms of energy, noise impact and land use	• Rail freight operations are dependent on the availability and quality of the rail infrastructure. • Mixing passenger and traditional freight rail operations reduce the capacity of the infrastructure due to differences in performance capabilities. • Congestion on the line infrastructure and terminals impair the possibility to run more trains or reroute, and limit the flexibility to use alternative train paths. • Rail freight is often given a lower priority to passenger services in allocation of infrastructure capacity. • Additional costs and longer lead times caused by necessary transhipment, terminal operations and pre- and end haulage reduce the competitive position of rail freight compared to road transport, especially on short and medium distances. • The competitive advantage of higher terminal-to-terminal speeds compared to road transport is often lost when door-to-door transport time is taken into account. • Low average geographical coverage of intermodal rail terminals given the total LDHV goods transported in some countries (e.g. France). • There is a lack of standardisation of European rail systems (e.g. track and loading gauges, train control systems and voltage systems). • Rail freight is hampered by limited physical flexibility, using current rail systems and planning methods. • There is no neutral open mechanism to facilitate the bundling of goods, especially given the characteristics of the companies in the LDHV market (frequent shipments with small volumes). • The possibility of transport of refrigerated goods, track and tracing and remote condition monitoring for HV sensitive goods is currently very limited on rail in Europe

Opportunities	Threats
• The share of LDHV goods in Europe is around 12% of all road transport (>200 km) and is expected to grow at an above average rate in the coming 10 to 20 years. • A larger potential market for LDHV goods could be achieved (<200 km) using the right combination of technologies, asset management and responsiveness. • The largest LDHV freight flows are domestic, eliminating the need for cross-border interoperability. • Opportunities in the transport of containers, pallets and temperature controlled goods, now dominated by road transport with a more competitive rail offering such as of small, reliable, fast and frequent trains. These should link with higher-volume freight trains under development. • Lower total transport costs using new technology and more intensive asset utilisation. • Additional loading and unloading locations (e.g. rail sidings) using innovative, fast and low-cost transhipment systems. • Opportunities would rise with efficient urban-interurban interfaces in place due to increasing urbanisation, which means that a larger share of transport activities will take place in urban areas. • The increasing and unstable fuel prices, the external costs of road transport (e.g. congestion and environmental impacts) and the trend towards additional charges, restrictions and requirements for road transportation will favour alternative transport modes. • Developing the railway sector a core strategy of the EU. Planned government funding for rail upgrades on certain corridors will have a positive impact for SPECTRUM. • The production of goods in China is shifting towards the west of China and will most likely also deliver to the EU. This could have a positive impact on the freight flows and transportation of goods by rail between China and Europe.	• The current rail infrastructure and systems will not be able to cope with the potential shift of LDHV goods. • Increasing rail network congestion, as a result of growth in both passenger and freight services. • Lack of terminals near the origins and/or destinations, which could make the pre- and end haulage costs too high. • Absence at present of rail freight services that can compete in the LDHV market. • High barriers to be interoperable between different countries (e.g. gauge, voltage, train control and signalling system), making it difficult to be economically feasible, and other border crossing problems (e.g. cargo documentation and announcements of delays). • Lack of consistency in government policies, access/operational requirements and priority rules; and the time needed to adapt these. • New rail infrastructure and systems usually require large investments with a long lead time. This could go beyond the means of many rail transport companies. • The financial and economic crisis may affect the willingness of companies to invest in SPECTRUM rail freight concepts. • The environmental advantages of rail could be overshadowed by technological improvements in the road transport sector. • Not being able to fulfil the evolving logical and technical requirements of the various companies and for the different cargo types. • Interaction with passenger trains operating at different speeds and with different travel times, could affect the possibility to fit a SPECTRUM rail concept in the timetable and the reliability of the service. • Possible failings in the intermodal chain, integration of pre- and end haulage and terminal delays. • Non-availability, due to work on railway tracks, infrastructure or equipment problems, weather conditions and strikes. • Unable to cope with limited or additional cargo due to flexible order patterns and seasonality. • With regard to urban areas: reduced operational options due to limited and affordable land and possible congestion and environmental concerns due to the arrival of additional trucks.

12 Concluding remarks

12.1 Business Cases: where and what can SPECTRUM contribute and how to proceed?

The contribution the SPECTRUM rail offering will have to meet the diverse logistics requirements of the shippers involved. It is the challenge of the transport and logistics service providers to incorporate the SPECTRUM offering in their service portfolio in a way that benefits to their clients can be maximised, while additional costs can be minimised. The role of the SPECTRUM offering therefore depends on the characteristics of the markets that it will serve. The shippers require developments in the service quality concerning the following aspects:

- Higher reliability (punctuality): in the supply chains supplying high value goods, requires that the reduction of stocks is of vital importance.
- Shorter transit time: for example the value of perishable products of decreases the longer time it takes for delivery, longer shelf life of certain products has a value to be tapped.
- Lower total costs: however this applies mostly to goods having relatively lower value or freight flows which are not on the critical path of production or distribution.
- Improved flexibility: this becomes important when for example the volume of goods to be transported highly fluctuate.
- Better safety and security measures: for example for high-value products that are vulnerable to damages and products that need to be kept under constant temperature control and security monitoring.
- Greater sustainability: this is of importance for clients who have committed to reducing carbon footprint and air pollution; the use of electric traction is a major commercial strength.
- Improved supply chain control and visibility: for example clients who have short planning horizons will depend much on real time scheduling of their services.
- Greater availability (24/7) and responsiveness to cargo enquiries governed by short term and spot transport requirements.

The SPECTRUM rail offering could be operated by a group of logistics service providers who cooperate with one another. These service providers could involve any organisational entity along the supply chain spectrum from the asset bounded railway undertakings to the asset free 4PL. These service providers need to identify collectively what the preferences of shippers are, how to determine and adapt their service parameters to the requirements of the shippers, and how the SPECTRUM service concept can best be incorporated in their overall service portfolios.

For the appreciation of the new SPECTRUM technology and service concept, it is important that the expected impact of the SPECTRUM rail offering will be well demonstrated. This is even more so when its introduction would requires investments or the unit costs of the service operation would increase. This needs to be offset by much higher sustained productivity, better service quality, and reliability enhancements in order to encourage its use.

The benefits of using the SPECTRUM rail offering will potentially be most evident if it is introduced in an operation, which has initially been dedicated to one client using rail sidings on its premises. This could encapsulate inter-modal and wagon based traffic/commodities. Then the role of the SPECTRUM rail offering can be to respond directly to the shipper's needs and will be agreed jointly between the shipper and the logistics operators involved.

Given the economy of scale which is required for financially viable operations of the SPECTRUM services, such dedicated services can only be expected within supply chains with high value transport demand over distance. The automotive industry, foodstuffs and small lot logistics could be examples to be explored and developed as demonstration options. In other supply chains the SPECTRUM service concept will then be open to many clients between whom the benefits and risks will be shared. Each player will value the impact in his own way. Rail could provide a very valuable component in global container logistics if services to/from major ports were improved and the commercial reach of rail was enhanced. However, immediately after its introduction SPECTRUM will improve supply chains because:

- SPECTRUM provides a solution for a market that is not offered by rail freight.
- It can serve as catalyst that can trigger improvements of services in a wider network.
- It can contribute to reducing the high European rail freight total transport costs in some niche applications.
- It provides an improved logistic solution to local agents who are accountable for logistics performance in regions of Europe on behalf of the global shippers or logistics service providers.

Important aspects that determine the magnitude of the benefits of SPECTRUM concept are:

- The amount of cargo involved.
- How critical the improvement is; e.g. in urban delivery or delivery to retail DC's it concerns the final phase of the distribution chain, therefore with limited possibility of rectifying underperformance.
- How it can contribute to the service levels of clients; e.g. by expanding the area that can be served within 24 hours or 48 hours and also competing over lower threshold distances.

The assessment by the business economic model has explored impacts of SPECTRUM in different segments and different circumstances. The primary exercise was to envisage how improvements would impact one particular service.

The services enhanced by the SPECTRUM-design applied in seaport related hinterland services for example concern increasing productivity by providing fast, frequent and continuous services on corridors with high transport volumes. The current services are already very efficient, but because of the high volumes, applying the technology to be developed in SPECTRUM would still be likely to be attractive as an investment option. It should allow rail to develop a more extensive commercial and operational "reach" and to compete for traffic which conventional trains are not well equipped to serve.

In some other segments, the contribution of the SPECTRUM design will be mainly on service quality. Medium-distance intermodal transport services will come within range of competitiveness to road, because services enhanced by the SPECTRUM design can improve the current weaknesses on that distance – lead times and punctuality, and produce cost savings on the railway leg. The ability to service lower and intermittent traffic flows not well suited to orthodox train operations and commercial parameters would be a significant advantage.

Such advantages can be further accumulated in networks which are connected with the services enhanced by SPECTRUM, e.g. in intermodal gateways and hubs, or in multi-tiered networks of large logistics service providers or of European Distribution systems.

The cost competitiveness of the SPECTRUM design assumes a certain level of utilisation of all railway assets, and services can only be sustained if these levels are routinely realized. The implication of this is that there may be the need of a certain minimum volume (base load of filled ILU) that will be captured by the SPECTRUM service.

The freight traffic database, which is a result of task 1.1, can provide insight in such flows and it is possible to examine whether the transport volumes that could be attracted by a service applying the SPECTRUM design will be the sufficient base load for such service.

12.2 Key messages

Given the extensive, in-depth analyses of the Spectrum rail offering in this document, a set of key messages are formulated.

Market scoping

The market potential for the SPECTRUM rail freight concepts is focused on time-sensitive, low-density and high-value goods (time sensitive LDHV goods) that are currently transported by road on distances over 200km. On the European level this amounts to 1.9 billion tons of freight per annum, which represents about 12% of all road transport in Europe. Within this 1.9 billion tons of freight flows, 1.6 billion tons are of domestic transport (84%) and 0.3 billion tons are of cross-border intra-European transport (16%). It also shows that the largest domestic flows are up to ten times larger than the largest cross-border flows. If the market potential is analysed under a less ambitious target, where road freight is studied on distance over 300km (as stated in the 2011 EU White Paper on transport), the potential for the SPECTRUM rail offering would then become 9% of all road transport in Europe in tonnage.

The freight flows of the time sensitive LDHV goods will form the market base and are expected to grow at an above average rate in the coming decades, especially in comparison with the traditional rail markets of high-volume, low-value commodities. Besides, in geographical terms, some shifts in freight patterns are expected due to the relocation of production to different areas (e.g. Eastern Europe and Western China), and increasing goods demand due to economic development in regions that are catching up to the more developed regions in western Europe. In addition, due to increasing urbanisation, a larger share of transport activities will take place in major towns and agglomerations. Furthermore, that some of the very large freight flows are carried out by road rather than by rail can be explained by geographical conditions such as mountainous areas with limited rail infrastructure, access and service provision, cross-border interoperability issues, cheaper road service and the weakness of the competing rail product and service offers.

It should be noted that a significant share of the freight flows is featured by a diffuse pattern of flows that cannot fill up trains in the traditional rail offerings. Market consultation, case studies and projects running in parallel to SPECTRUM (such as the FP7-project CO3) show that even very large shippers together do not have sufficient consolidated volumes to fill up a train that can be operated economically viable. In fact, the pre-eminence of SME-sized companies, considered to be the backbone of Europe's economy today, limits the potential for the use of the traditional rail freight services available. The model commonly preferred by the rail operators, which is an operation using longer and heavier trains, fulfils their aspirations to spread the costs of cargo transport over the maximum weight or volume, but is in direct contrast with the evolving needs of the shippers who prefer regular, flexible, and reliable shipments. The road operators have been able to fulfil such needs of the shippers at the expense of the market share of the rail sector in this type of market segment.

Part of the time sensitive LDHV cargo flows requires reliable condition control throughout the entire supply chain at a service level that is not routinely available in the present rail freight market. Many existing train services do not have any refrigeration power and as such this type of traffic is dominated by road transport. Quantification of these specific flows is only partially possible since transport statistics do not contain information about conditioning requirements.

The real potential for the SPECTRUM rail freight concepts, analysed by the economic business modelling turns out to be only a fraction of the aforementioned freight flows 1.9 billion tons. This is due to (1) logistical characteristics of the cargo flows related to supply chain structures, (2) accesses to the railway infrastructure, (3) constraints concerning rail traffic management, (4) market acceptance and recognition of the new service concepts.

The logistical characteristics are related to the supply chain structures established by the shippers, such as shipment sizes and delivery requirements (i.e. just-in-time systems). These characteristics pose challenges to the exploitation of the market potential. It further underlines the point made earlier about the diverging perceptions of the stakeholders, in particular the rail service providers, the shippers, and the wider cargo interest groups and the retention of a constrained supply side position by the rail freight sector.

The rail freight infrastructure characteristics refer to the restrictions concerning the ability to operate train services on different rail infrastructure across the countries (i.e. interoperability issues) and the priority rules for path allocation set by the individual infrastructure managers (e.g. i.e. priority often given to passenger trains).

The current traffic management system sets constraints on the actual rail services in terms of reliability, availability, schedules, speed, flexibility, and tracking & tracing possibilities. The overall rail transit speed can be increased if utilisation of the line capacity is maximised, and this further reduces the impact on the highly variable transit speeds.

In short, in order to practically penetrate this specific time sensitive LDHV goods market, rail freight services will need to adapt its business-, operational-, commercial- and technical models on aspects of infrastructure (i.e. both terminals and major routes) and rolling stock, to be capable of effectively competing in a market that is dominated by road transport.

Business perspective

The business perspective of the SPECTRUM rail freight concepts is determined by how well the rail freight sector will exploit the potential. Based on the analyses, SPECTRUM is looking at the following business options:

(1) Train services that are short-distance, fast, reliable, frequent and flexible operating for example but not exclusively on hub-and-spoke networks. It may be that the flexibility of the train leads to the creation of new operating concepts responding much more to spot and short term traffic and this then has implications for train planning, commercial management, asset management and crew competence and availability to service such a dynamic option. Train services with multiple stops (liner trains) operating on longer routes are also possible.

(2) Train services that provide constant, reliable temperature control possibilities on a range of service models.

(3) Train services that are connected with urban rail networks and possibly with urban consolidation centres/logistics parks and austere terminals deep within urban areas but designed to allow rail to deliver/collect within very short range of the shipper/receiver. The use of alternative mobile lifting equipment deployed only when traffic is planned may be a further level of refinement. .

It is also possible to make combinations, where necessary, of some of the or all of the options into a whole new model of rail freight business operations , capable of competing with road transport in terms of service and product competitiveness. These models should, however, avoid as much as possible competition with existing rail operations. They extend the commercial and operational “reach” of rail. In such a way the SPECTRUM rail freight concepts will play a complementary role, providing credible alternatives and solutions next to the needed concentration/critical mass ” approach applied in other rail areas where the focuses is on the higher capacity trains on trunk lines.

The SPECTRUM concepts will provide the rail freight sector with solutions that can significantly contribute to enhancing the competitiveness of rail. Preliminary assessments of the external effects (quantified impacts of, for instance, emissions and congestion) conducted using the macro economic business model indicate that substantial economic benefits can be achieved through an increasing use of rail transport, whilst reducing the environmental and social impacts associated with road transport.

Potential barriers

The freight flows patterns are diffuse and shipment sizes are too small for conventional rail freight operators. This can be overcome with a more rational and innovative approach for example to shorter trains of differing capability and capacity designed specifically to be used for low and intermittent traffic much as the road sector is able to do. The requirements for transporting various cargo types within the time sensitive LDHV category differ, but they could be accommodated in a carefully designed innovative rail concept that is capable of exploiting the economy of scale and economy of scope nature attribute to the rail sector. Smaller more intensively used trains could potentially unlock markets where rail is unable to compete at present.

Service levels of current rail freight offerings are considered insufficient by many potential clients in terms of reliability, transit time, and overall quality of services. This can be mitigated by for example the adoption of much more intensive systems of asset management, constant supervision of real time performance and intervention to minimise the impact of disruption. It could also help operational planning to make much better use of the rolling stocks.

The density of the terminal network and capacities, and the service levels of individual terminals are insufficient. Alternative austere low cost designs that can use redundant sites or that can be used to develop cost effective rail access to existing road only logistics terminals could reduce the impact of this constraint.

Proposed implementation of new innovative technologies in rail transport confronts high barriers due to stringent TSI-regulations, complex and lengthy certification processes, together with high insurance and financial requirements.

Requirements, and technological & organisational solutions for SPECTRUM

There is a need for improvements in rail terminals in terms of network density, terminal capacities and performance levels. The high costs associated with orthodox infrastructure investments help justify the preference for smaller-scale, lower-cost solutions including emergent horizontal transhipment technology. However, investment partners and funding institutions willing to embrace these solutions and bring them into reality can only be convinced by an overall logistic concept.

Considering higher costs associated with the adoption of some of the solutions envisaged for the SPECTRUM rail freight concepts, improved asset management (efficiency gains) and uses of technologies which can enhance interoperability (e.g. multi-voltage locomotives/trains, hyrbid power trains) are essential to retain competitiveness and connection to the market. Increased acceleration, braking, line speed and decreased terminal handling time contribute significantly to achieving this.

Effective bundling of cargo flows of multiple shippers supported by tracking & tracing facilities is essential. The availability of cloud based train-slot planning systems could help maximise “train fill”. Personnel (e.g. driver) allocation could help ensure the train assets are fully exploited. Development of driver training simulation systems and in-cab driver location/signalling information to remove arcane “route knowledge” requirements is a further possibility to be developed to liberate the deployment of new train technologies and match the flexibility of road freight.

“Multi-stop trains” pose requirements in terms of transport service management, terminal network densities and performance (acceleration, braking and line speed). In addition, optimisation of network capacity is needed to enables SPECTRUM rail freight concepts to mix with passenger trains more effectively, especially in urbanised areas. This implies a different, more interventionist, responsive and “hands on” management approach to the planning and operation of train services and manipulation of the infrastructure to allow the new train technology to be fully exploited.

Whilst diesel-fuelled cooling units are successfully applied in small-scale transport chains, there is a perceived need for the development of electrically powered solutions that can operate throughout Europe. More clarity is needed in the future on the real market potential for these solutions however.

SPECTRUM’s competitive position – cost assessment by the business-economic model

For the SPECTRUM offering to obtain a credible and accepted position in the transport market, the innovation will need to improve quality parameters (e.g. reliability, safety, flexibility) and/or reduce costs. SPECTRUM’s business economic model focuses on costs. It compares operational costs of the SPECTRUM services with its alternatives that use existing technologies. These alternatives are either uni-modal road transport, intermodal transport or conventional rail transport. This is a preliminary assessment of the commercial viability of the SPECTRUM services and it serves to identify market segments, to which the introduction of SPECTRUM can produce promising benefits.

Potential Impact

The contribution of the SPECTRUM rail offering will depend on the characteristics of the markets. It will have to meet the diverse logistics requirements of the shippers involved..The focus will be paid primarily on reliability, punctuality, transit time, costs, conditioning measures, service availability and service flexibility. This will be assessed in WP4 in the macro business model (see D1.3.1, a separate document).

The expected impacts of the SPECTRUM rail offering should be well demonstrated. This will justify the potential extra investments and higher operational costs derived from the new technologies and logistics concept employed in the service offering.

Benefits will be most evident if the SPECTRUM service is introduced for an operation dedicated to one client and using rail sidings/terminal equipment on his premises, or if the service is applied on supply chains with high freight demand over distance (e.g. the automotive industry).

The benefits will be less evident when impact is measured on a supply chain on a global scale. Last but not least, it is the challenge of the transport and logistics service providers to incorporate the SPECTRUM offering in their service portfolio in a way that benefits to their clients can be maximised while additional costs can be minimised.

It is expected that the freight flows will generally grow at an above average rate in the coming decades. Specifically, the potential is about 1.9 billion tons, which is 12% of the freight flows. Under a less ambitious target where road freight flows are studied at a distance of over 300 kilometres (as referred to in the DG MOVE White Paper), the market potential is about 1.4 billion tons, which is 9% of the total road freight flows.

Utilising SPECTRUM to convert a part of this traffic to rail would save 37 million tonnes of carbon, or 5.32 billions euros annually. Let us assume that SPECTRUM could over a ten year period help shift 10% of traffic to rail, and a linear build up, then from market take up, SPECTRUM could save 2.9billion euros of external costs ten years and 20 million tonnes of carbon by securing a 10% market share of time sensitive low density high value goods.

	Cost savings vs Road (millions of euros)	
	Rail	Rail
Externality	Diesel	Electric
air polution	-635	2,880
climate change	768	935
noise	19	167
accidents	38	118
congestion	1,227	1,227
Environmental(1+2+3)	152	3,982
Socio-Economic (4+5)	1,265	1,345
Total	1,417	5,328

Carbon Emissions			
Mode of Transport	Type	gram CO2 per net tonne km	Total CO2
Road Freight	HGV (average)	124.7	4.7386E+13
Rail Freight	Diesel/Electric	28.5	1.083E+13
		Saving (grams)	36,556,000,000,000
		Saving (tonnes)	36556000
		Saving (m tonnes)	37

CO2 Values adapted from AEA, 2010 study - see Aditjandra et al (2012)- Investigating freight corridors towards low carbon economy.

Workpackage 4 will elaborate impacts further and with greater nuance.

Conclusion

We conclude that the SPECTRUM concept has a huge demand to satisfy, and this demand is in alignment with the broad concept of a freight train that performs similarly to a passenger train offering faster, more reliable and flexible railfreight services.

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ANNEX I: ITREN 2030 key indicators and assumptions

Key indicators of the iTren 2030 scenario

Indicator	Absolute values		Aver.% change per year
	2005	2030	
Population total (1,000 persons)	488,594	494,331	0.0
GDP (billion euros 2005)	10,573	15,772	1.6
Oil price (euro 2005 per bbl)	44	90	2.9
Freight transport activity (billion tkms)	6,875	10,193	1.6
Road	*2,073*	*3,056*	*1.6*
Rail	*447*	*798*	*2.3*
Inland navigation	*192*	*335*	*2.2*
Maritime	*4,162*	*6,004*	*1.5*
Passenger transport activity (billion pkms)	6,457	7,873	0.8
Car	*4,665*	*5,633*	*0.8*
Bus	*615*	*585*	*-0.2*
Rail	*477*	*695*	*1.5*
Air	*442*	*628*	*1.4*
Slow	*259*	*333*	*1.0*
Gross Inland Energy Consumption (ktoe per year)	1,821,472	2,149,186	0.7
Oil	*669,119*	*646,031*	*-0.1*
Gas	*442,979*	*551031*	*0.9*
Coal, Nuclear	*582,937*	*641,535*	*0.4*
Renewables	*126, 437*	*310,589*	*3.7*
Share of renewables in final energy demand	8.3%	16.1%	2.7
Share of bio-fuels in transport demand	1.0%	9.9%	9.6
Car fleet size (1,000 vehicles)	211,062	294,212	1.3
Gasoline	*149,304*	*148,788*	*0.0*
Diesel	*57,588*	*135,371*	*3.5*
LPG/CNG	*3,229*	*2,016*	*-1.9*
Innovative	*941*	*8,037*	*9.0*
CO2 Transport emissions (million tonnes)	1,268	1,485	0.6

Source: iTREN-2030

Overview of transport and energy policies in the iTren integrated scenario

Measure	Type	Start year	Description
Road user charge trucks	P	2020	Implementation of Greening Transport Package using the cost values identified by the IMPACT Handbook on external cost of transport (about 7 to 10 €ct/vhc-km)
Road user charge cars	P	2025	Implementation of Greening Transport Package transferring the cost values identified by the IMPACT Handbook to car transport (about 2.5 €ct/vhc-km)
City tolls	P	2025	Implementation for metropolitan areas in EU27 only at the level of about 35.7 €ct/vhc-km during peak-period
Fuel tax harmonisation	P	2020	Following EC directive 2003/96/EC tax levels of 35.9 €ct/l gasoline and 41 €ct/l diesel introduced
Air transport into EU-ETS	P	2012	Inclusion of all air transport within or leaving the EU27 into EU-ETS with reduction targets of -3% in 2012 and -5% after 2012 compared to average of 2004 to 2006
Road transport into EU-ETS (upstream)	P	2020	Inclusion of road transport into EU-ETS by upstream approach (CO_2 price in 2020 about 28 $€_{2005}$ per tonne CO_2)
Railway liberalisation	P	2010	Implementation of 3rd railway package reducing passenger rail cost by -2%
CO2 limits cars	P	2015, 2020	Regulation setting CO_2 limits for average new car fleet with a limit value of 130 g CO_2/km in 2015, 105 g CO_2/km in 2020
CO2 limits LDVs	P	2015, 2020	Regulation setting CO2 limits for average new LDV fleet with a limit value of 175 g CO2/km in 2016 and 135 g CO2/km in 2020
Binding use of low resistance tyres HDV	P	2012	The binding use of low resistance tyres for trucks will reduce energy consumption by -3.5%
Battery electric cars	TA	2012	Breakthrough of battery technology and market diffusion of electric city cars after 2012
Battery electric LDVs	TA	2015	Breakthrough of battery technology and market diffusion of electric LDVs for urban deliveries after 2015
Hydrogen fuel cell cars	TA	2025	R&D support and support for market introduction will lead to market diffusion after 2025
Car efficiency labelling	P	2009	Effective labelling of cars according to their energy/CO2 efficiency affecting choices of car buyers to reduce CO2 emissions by -3.5%
Driver education for drivers of HDV	TA	2010	Driver education can reduce energy demand by -20%. It is assumed that due to changing framework conditions -10% is achieved by ambitious education programmes of companies
Increased implementation of CNG fuelling stations	TA	2010	The requirements of climate policy and price differentials increase attractiveness of CNG generating incentives to implement more CNG fuelling stations
GHG reduction target for the EU for 2020	P	2012	Agreement of binding reduction target of GHG emissions of EU27 of -20% until 2020 against 1990. Extension of EU-ETS with certificate price of 28 $€_{2005}$ per tonne of CO2 in 2020
Renewable energy target	O	2008	Harmonized renewable energy support premiums across the EU to reach 20% renewable energy by 2020
Energy efficiency action plan	P	2008	Increase of energy efficiency by 1% annually
Support for CCS	P	2010	Support of R&D and demonstration sites for CCS such that around 2030 first large-scale plants can be built

Source: iTREN-2030. P = policy, O = objective without specifying implementation, TA = trend adaptation

ANNEX II: Rail OD Matrix 2009

Origin Destination matrix rail transport 2009 in 1000 tonnes in EU27 + Switzerland an by NST/R

		02 Destination_N1																									
		AT	BE	BG	CH	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK	Total
01	AT	28531	340	41	664	658	5140	23	0	38	1	261	374	1974	0	4750	4	22	7	140	300	0	229	138	1667	183	73	45558
Origin_N1	BE	549	15484	2	620	60	3508	19	0	603	3	4964	0	81	0	2729	0	1167	0	764	100	0	1	199	13	2	321	31189
	BG	3	84	13736	1	4	7	0	0	2	0	0	266	5	0	77	0	0	0	0	4	0	203	0	5	2	0	14399
	CH	489	247	6	11255	4	939	6	0	0	0	152	0	7	0	646	0	27	0	208	8	0	0	0	7	5	24	14030
	CZ	7865	483	36	43	36859	7498	24	0	9	1	82	6	2466	0	523	3	0	0	1142	5367	0	188	36	822	6376	0	69829
	DE	7183	1667	34	3963	4935	210722	618	0	1394	66	3859	131	2252	0	8798	26	1160	0	2800	5028	4	61	1510	326	609	205	257351
	DK	13	1	0	22	7	272	477	0	0	4	24	2	1	0	99	0	0	0	3	1	0	0	119	1	0	0	1046
	EE	0	0	0	0	0	0	0	23156	0	0	0	0	0	0	0	99	0	455	0	3	0	0	0	0	0	0	23713
	ES	21	330	0	2	4	1008	7	0	17797	0	355	0	20	0	11	0	8	0	18	9	220	0	0	2	32	43	19887
	FI	12	0	1	9	1	51	5	0	0	21360	1	0	0	0	26	1	0	1	0	0	0	0	477	0	0	13	21958
	FR	331	7395	0	1143	52	3643	90	0	1706	11	62827	1	37	0	7475	0	522	0	639	149	1	10	403	62	12	404	86913
	GR	3	0	112	0	0	62	0	0	0	0	0	630	209	0	3	0	0	0	0	2	0	5	0	3	1	0	1030
	HU	2357	36	39	24	626	1374	8	24	15	0	25	265	11169	0	623	30	9	3	25	240	0	990	9	758	451	0	19100
	IE	0	0	0	0	0	0	0	0	0	0	0	0	0	631	0	0	0	0	0	0	0	0	0	0	0	0	631
	IT	1904	1766	20	183	94	5560	147	0	28	41	1651	32	234	0	23940	0	25	0	303	246	0	55	150	97	26	225	36727
	LT	0	0	0	0	19	34	0	402	0	0	0	0	25	0	0	12932	0	1385	0	693	0	3	0	0	1	0	15494
	LU	19	633	0	31	7	283	44	0	3	14	158	0	5	0	173	0	1485	0	32	14	0	2	35	1	1	0	2940
	LV	0	0	0	0	0	0	0	97	0	0	0	0	10	0	0	337	0	1299	0	366	0	1	0	0	0	0	2110
	NL	387	771	0	477	489	11960	17	0	0	4	852	0	108	0	703	0	0	0	4796	246	0	4	73	5	158	0	21050
	PL	2626	95	40	59	7381	11134	23	23	0	1	265	0	667	0	302	75	3	11	95	71577	0	281	150	134	1250	0	96192
	PT	0	0	0	0	0	5	0	0	297	0	0	0	0	0	0	0	0	0	0	0	8443	0	0	0	0	0	8745
	RO	80	1	368	2	11	2	0	0	0	0	3	9	580	0	55	1	0	0	0	21	0	44942	0	14	10	0	46099
	SE	219	181	3	0	15	1844	214	0	0	195	176	0	0	0	232	0	3	0	33	57	0	0	34833	4	0	0	38009
	SI	3325	0	8	1	63	54	7	0	0	1	22	48	415	0	367	1	0	0	0	117	0	6	4	3301	183	0	7923
	SK	2207	11	19	13	10216	1304	8	10	24	0	13	8	878	0	138	5	0	0	8	1600	0	255	0	201	4886	0	21804
	UK	5	108	1	1	0	46	0	0	64	0	452	0	0	0	219	0	0	0	26	0	0	0	0	0	0	173573	174495
Total		58129	29633	14466	18513	61505	266450	1737	23712	21980	21702	76142	1772	21143	631	51889	13514	4431	3161	11032	86148	8668	47236	38136	7423	14188	174881	1078222

		NSTR1 code										
		0	1	2	3	4	5	6	7	8	9	Total
01	AT	4382	888	1444	18324	6973	2703	8242	134	879	1590	45559
Origin_N1	BE	2305	1063	3422	8134	2448	3593	3798	460	2275	3691	31189
	BG	94	129	3655	1151	3088	1955	2693	378	1059	197	14399
	CH	2230	703	303	3018	1471	1886	1456	46	1562	1355	14030
	CZ	9081	2993	7500	21696	6730	4067	10855	680	2927	3302	69831
	DE	17937	6148	16506	117601	40202	11405	31228	1858	7322	7146	257353
	DK	128	113	58	270	64	62	214	11	57	68	1045
	EE	3100	1069	1892	7650	2278	1422	3899	244	1032	1127	23713
	ES	2302	840	1406	5670	1698	1396	2896	179	821	2679	19887
	FI	6853	687	1310	4408	1435	998	3927	216	1064	1059	21957
	FR	9663	4213	5569	26118	13702	6469	11207	585	3237	6148	86911
	GR	199	32	31	483	79	104	68	3	15	19	1033
	HU	2483	876	1444	6886	1885	975	2536	161	803	1051	19100
	IE	46	25	178	136	101	21	61	4	37	22	631
	IT	3520	1724	2357	12058	4320	2853	5356	213	1484	2843	36728
	LT	556	146	866	11191	1527	89	559	325	61	174	15494
	LU	250	85	184	641	496	761	319	19	84	100	2939
	LV	251	86	187	756	185	121	322	20	83	100	2111
	NL	1877	1099	1796	4837	1974	1195	1791	204	1458	4821	21052
	PL	9176	3475	24506	24632	9729	4988	11883	1011	3192	3603	96195
	PT	668	236	1031	4148	902	296	960	50	214	239	8744
	RO	2047	1034	17217	9281	2406	2018	4205	1543	1891	4458	46100
	SE	94	129	129	129	129	129	129	129	129	129	38009
	SI	643	210	1894	2825	866	295	662	48	192	286	7921
	SK	2569	861	1495	8152	2044	1455	3147	195	835	1050	21803
	UK	19926	7644	19743	55573	17311	10109	28543	1566	7171	6908	174494
Total		102380	36507	116123	355768	124043	61365	140956	10282	39884	54165	1078228

ANNEX III: Rail OD Matrix 2020

Origin Destination matrix rail transport 2020 in 1000 tonnes in EU27 + Switzerland an by NST/R

		02 Destination_N1												
		AT	BE	BG	CH	CZ	DE	DK	EE	ES	FI	FR	GR	HU
01 Origin_N1	AT	36528	463	56	879	1161	7424	27	0	47	2	209	408	3110
	BE	648	17985	2	792	101	4619	22	0	507	5	4780	0	115
	BG	3	98	19490	2	7	11	0	0	3	0	0	341	9
	CH	487	288	9	12718	6	1259	7	0	0	0	114	0	9
	CZ	10119	516	58	59	55158	10507	28	0	6	2	83	6	3703
	DE	9628	1642	50	5536	7513	235648	723	0	1264	71	2851	116	3541
	DK	15	1	0	26	8	318	558	0	0	5	28	2	1
	EE	0	0	0	0	0	0	0	32874	0	1	0	0	0
	ES	29	443	0	2	8	1555	8	0	19577	0	338	0	33
	FI	17	0	0	12	2	63	6	0	0	26489	1	0	1
	FR	419	9761	0	1535	87	5178	105	0	1594	14	73671	1	49
	GR	6	0	188	0	1	127	0	0	0	0	0	360	364
	HU	3366	48	50	31	1123	1576	9	33	15	0	25	258	16243
	IE	0	0	0	0	0	0	0	0	0	0	0	0	0
	IT	2166	1759	18	199	145	6551	172	0	26	46	1196	28	333
	LT	0	0	0	0	39	47	0	669	0	0	0	0	48
	LU	21	809	0	31	10	340	51	0	2	15	134	0	7
	LV	0	0	0	0	0	0	0	206	0	1	0	0	18
	NL	565	875	0	522	721	13877	20	0	0	4	656	0	138
	PL	4262	113	67	91	13806	16983	27	38	0	2	169	1	1383
	PT	0	0	0	0	0	9	0	0	563	0	0	0	0
	RO	136	2	678	3	24	4	0	0	1	0	6	14	1150
	SE	296	271	4	0	28	2500	250	0	0	316	177	0	1
	SI	6363	1	12	1	133	110	8	0	0	1	21	64	774
	SK	3204	17	25	24	18799	1930	9	17	31	0	15	8	1718
	UK	7	114	1	1	1	59	0	0	59	0	380	0	0
Total		78285	35206	20708	22464	98881	310695	2032	33837	23695	26974	84854	1607	32748

		02 Destination_N1														
		IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK	Total
01 Origin_N1	AT	0	5193	6	21	9	173	489	0	400	228	2712	234	71	598
	BE	0	2690	0	1448	0	981	193	0	2	295	19	4	294	355
	BG	0	48	0	0	0	0	8	0	407	0	10	4	0	204
	CH	0	693	0	33	0	282	12	0	0	0	10	7	27	159
	CZ	0	789	5	0	0	1497	10963	0	323	63	1229	11656	0	1067
	DE	0	8021	35	1546	0	3392	9446	4	117	1944	473	934	210	2947
	DK	0	116	0	0	0	4	1	0	0	139	1	0	0	12
	EE	0	0	153	0	748	0	8	0	0	0	0	0	0	337
	ES	0	13	0	9	0	21	16	361	0	0	4	56	45	225
	FI	0	33	2	0	1	0	0	0	0	723	0	0	13	273
	FR	0	8250	0	747	0	802	249	1	14	645	78	21	397	1036
	GR	0	4	0	0	0	0	5	0	9	0	6	2	0	10
	HU	0	825	50	20	3	40	474	0	1995	16	1009	802	0	280
	IE	818	0	0	0	0	0	0	0	0	0	0	0	0	8
	IT	0	26500	0	28	0	344	410	0	81	220	126	33	193	405
	LT	0	0	21383	0	1810	0	1083	0	6	0	0	3	0	250
	LU	0	201	1	1859	0	36	24	0	3	39	1	2	0	35
	LV	0	0	693	0	2244	0	572	0	2	0	0	0	0	37
	NL	0	388	0	0	0	5250	414	0	6	107	9	213	0	237
	PL	0	361	145	5	17	116	93511	0	656	270	207	2504	0	1347
	PT	0	0	0	0	0	0	0	19223	0	0	0	0	0	197
	RO	0	95	2	1	0	0	52	0	76711	0	33	27	0	789
	SE	0	317	0	4	0	48	106	0	0	40058	7	0	0	443
	SI	0	553	2	0	0	0	293	0	14	6	4523	424	0	133
	SK	0	180	10	0	0	9	3316	0	447	0	313	7062	0	371
	UK	0	175	0	0	0	32	0	0	0	0	0	0	212975	2138
Total		818	55445	22487	5721	4832	13027	121645	19589	81193	44753	10770	23988	214225	13904

		NSTR1 code									
		0	1	2	3	4	5	6	7	8	9
01 Origin_N1	AT	5203	1214	1657	25138	9607	3499	10327	156	1162	1888
	BE	2696	1256	4164	9484	2828	4009	4131	461	2625	3848
	BG	142	189	4995	1881	4187	2653	4053	506	1530	303
	CH	2361	932	261	2967	1913	2356	1868	44	1858	1400
	CZ	14545	5123	10120	32848	11401	6513	15617	982	4482	5149
	DE	21176	6991	20998	133438	43526	13716	35542	1573	8633	9131
	DK	150	132	68	316	75	73	250	13	67	80
	EE	4247	1708	2480	10890	2583	2298	5906	328	1648	1696
	ES	2583	1052	2035	6005	2545	1676	2865	328	1059	2370
	FI	7956	944	1752	5916	1666	1227	4993	254	1318	1330
	FR	11473	4893	6430	32475	15541	8222	12767	559	3994	7264
	GR	308	42	29	350	66	172	58	4	22	19
	HU	3779	1388	2288	9140	2738	1482	3883	294	1260	1761
	IE	63	32	204	187	131	29	91	5	48	29
	IT	3619	1999	3008	13233	4649	3752	5384	242	1768	2920
	LT	923	276	1638	17692	2335	176	1062	531	128	327
	LU	294	91	203	825	616	905	385	18	88	110
	LV	413	172	384	1178	351	229	629	34	155	190
	NL	2358	1267	2788	4458	2408	1613	1815	155	1672	5209
	PL	14016	5750	28672	34720	14631	7698	17740	1297	4851	5360
	PT	1380	565	1915	9434	2236	705	2458	108	474	522
	RO	3522	1674	28214	16489	3606	3605	8159	2544	3324	7802
	SE	6921	2060	3085	9766	3771	3848	5766	338	3597	5232
	SI	1403	336	2775	4977	1342	461	1102	88	289	530
	SK	4454	1834	2584	12140	4131	2783	5276	334	1572	2026
	UK	23434	9705	26131	66574	20017	12832	35396	1756	9091	8866
Total		139419	51624	158877	462521	158900	86532	187524	12952	56715	75361

ANNEX IV: Case Study Guidance

Work package 1 (WP1) of the Spectrum project aims to define the market opportunities for low density, high value (LDHV) goods to be served by new, innovative rail concepts. Task 1.2 within WP1 will build upon a global trend and demand analysis (task 1.1) with the examination of four case studies, identified as:

- P&G: Transport of various low density high value goods over distance and into urban conurbations
- FloraHolland: Transport of temperature controlled flowers and plants representing 60% of the horticultural market
- Innovatrain: Transport of intermodal goods using rail in innovative and competitive services
- London Carex: Addressable rail freight market between London and Amsterdam, Paris, Liege and Lyon. Case study to be examined by Panteia/NEA and NewRail in a joint venture as a substitute for the Kriotrans case study

Case studies will inform the business economic model on a micro level therefore specific micro level data is required. However; analysis of case studies should begin with a broad approach, gathering information about the company before refining the analysis ultimately with the examination of a specific route.

When examining case studies partners should aim to ascertain (with a view to the Spectrum project addressing) the barriers preventing their case study from currently operating a particular rail freight route in the high value low density goods market. Partners should seek to identify the cause of these barriers and most importantly what measures are required to overcome them - new technologies for example.

In order that consistency and continuity of case studies is maintained, and that data obtained feeds effortlessly into task 1.3 (Synthesis of market opportunities) the following guidance should be adopted.

Company information

Company information may be acquired through a broad literature review but is required to set the scene before the analysis is refined to focus on operational and specific route information.

Company information aims to assist in determining the markets in which the case study company is currently operating. If the company do not nor have no plans to operate within the HVLD goods market, they should not be considered an acceptable case study.

Information should include but is not limited to; who are they, what do they do, where are they based, where do they operate and what services do they offer?

Analysis should go on to explore the company's potential to operate (if not already doing so) in the market of low density, high value goods – key to the Spectrum project. What would they do differently, where would they operate and what services would they offer?

Operational Information

The exploration of operational information aims to address the question; how does the company currently conduct its freight and logistics? Partners should identify how case studies would conduct their operations in the HVLD market. How many vehicles, how many containers are in operation? Number of distribution centres?

Although cost information is highly sensitive and often difficult to obtain, partners should endeavour to obtain as much operational cost information as possible. Ideally this will include total transport costs through the collation of costs associated with transport, inventory and warehouse carrying.

Operational information should also identify the types of technologies currently being used and what technologies would assist in accessing the HVLD market.

This should include the container types, the method of temperature control if applicable, power generation, tracking of goods/containers and any special handling requirements. An acceptable rate of failure should also be determined.

Key routes

Continuing to narrow the focus, analysis should examine the key route in which HVLD goods are transported. Key routes should be those transporting the highest volume of HVLD goods and should show genuine innovation and / or a new approach to logistics and freight transportation. The route should detail the countries and regions that the route takes with a view to identifying the rail standards used – track gauge and power supply for example. It is desirable that a cost tariff also be calculated for transporting goods along the chosen key route, this will be expressed in Euros per kilometre (€/km).

Units of measurement

To ensure consistency when exploring potential new routes a set of standard units of measurement should be implemented. The units of measurement should be the same as those reported in the Eurostat database.

- The volume of rail freight traffic is measured in tonnes (mass);
- The performance of rail freight traffic is measured in tonne- kilometres;
- Containers are measured in twenty-foot equivalent units (TEU) as detailed below:

Length	Width	Height	Volume	TEU
20ft (6.1m)	8ft (2.4m)	8.5ft (2.6m)	1,360 cu ft ($39m^3$)	1
40 ft (12 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	2,720 cu ft (77 m^3)	2
45 ft (14 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,060 cu ft (87 m^3)	2
48 ft (15 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,264 cu ft (92.4 m^3)	2.4
53 ft (16 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,604 cu ft (102.1 m^3)	2.65

- Rail freight traffic flows on the network are measured in number of trains;
- Air freight traffic flows on the network are measured in number of aircraft;
- The volume of goods transported by air freight is measured in tonnes;
- Vehicle speed is measured in km/h;
- Temperature parameters should be measured in degrees Celsius;
- All monetary values should be expressed in Euros (€).

Summary and case study considerations

- Analysis should begin with a broad approach and general collation of company information.
- Case studies should specifically address the markets of high value, low density goods.
- Case studies should show an innovative approach to the transportation of goods or the development of a new service.
- The approach to case studies should take a more focused approach by examining the operational requirements of the company.
- Key routes should be investigated as part of the analysis seeking to develop a cost factor for the process of transportation along the route.
- Each case study conducted should not require more than 1 man month of work and be completed by September 2011.

ANNEX V: City Logistics and Rail Freight

This Annex provides background material aimed at non-experts in urban freight to better understand the possibilities of linked rail freight with city logistics, one of the potential market areas for a SPECTRUM rail freight concept. According to OECD (1996), city logistics is defined as “measures for maximising the loading factor of vehicles and at minimising the number of vehicles per km, aiming at making goods distribution in the cities more environmentally sustainable". Urban freight transport is complex and heterogeneous. There is a reason for this: urban freight is determined by the urban economy, and there is a great number of different economic sectors in a city, from industry to services, private and public, from major conglomerates to informal retail and manufacturing. This diversity is what makes cities so unique and valuable, a place where thousands of activities converge – but in a limited and constrained environment.

Urban freight transport is the result of logistic decisions, which seek to move goods efficiently within a production and distribution system. A city is provisioned by hundreds of supply chains, one for each economic sector. All these supply chains are the result of logistic decisions, which are in turn based on the demands of the production and distribution sectors, themselves dependent on the behaviour of economic agents such as households and firms. Each activity (commercial, service, industrial, administrative etc.) taking place in an urban environment can be associated with a specific freight generation profile, which is constant from one city to another.

A general assessment of the goods demand of large cities can be given, at least as a representative situation of urban freight supply and demand in developed countries (Macharis, Melo, 2011). A city generates about:

- 1 delivery or pick- up per job per week
- 300 to 400 truck trips per 1000 people per day
- 30 to 50 tons of goods per person per year.

Urban freight represents 10–15 percent of vehicle equivalent miles travelled on city streets and 2–5 percent of the employed urban workforce (LET, 2000). A total of 3–5 percent of urban land is devoted to freight transport and logistics. A city not only receives goods, but also ships them: 20–25 percent of truck- km in urban areas are outgoing freight, 40–50 percent are incoming freight, and the rest both originates from and is delivered within the city (LET, 2000). Transport companies providing urban freight services are generally very small. In Europe, 85 percent of short- distance truck companies have fewer than five employees. In Italy, the ‘padroncini’ (small individual entrepreneurs, usually owning one truck) carry 80 percent of all consignments delivered in urban areas.

One of the main factors of the big environmental impact of goods distribution in urban areas is the vehicle age. In Dublin in 2004, a fourth of all vehicles were manufactured in or before 1994. Only 15 percent of vehicles were new (one year or less). In the Milan region, 40 percent of circulating trucks are more than ten years old. The renewal of the freight fleet is generally slower than for non- urban road freight traffic because urban freight involves numerous competing small operators that cut costs as much as possible. Another important issue is road safety. Trucks participate in a small share of the accidents in cities, but the accidents involving them are serious. On London’s roads in 2005, about 14 percent of all collisions involving goods vehicles result in serious or fatal injuries, which is higher than the figure for other road users (BESTUFS, 2006)

City logistics practices have developed in the recent years in very different ways throughout EU cities. Different measures were put into force to reach the "city logistics goals" defined above, with different level of integration between "single measures" (Infrastructure, technology & equipment, restrictions & incentives, Logistics & transport organisation, accompanying measures, etc.) and "multiple measures": a coherent and shared combination of more "single measures", implemented simultaneously by the Public Administration or equivalent local Government or by a public or private promoter (Dasburg, N., Schoemaker, J, 2009).

Italy is a peculiar case in city logistics (Vaghi C., Percoco M., 2011), both in terms of policies and business models. Many cases have been developed as "second movers" after the first European city logistics stream, mainly based on cooperative and voluntary schemes between operators, spread in the Nineties. In Italy the majority of medium sized cities have issued "ZTL" (Limited Traffic Zones), where the access is limited for most pollutant freight vehicles, and the loading/unloading of goods is restricted in daily "time-windows". Some Municipalities are issuing (Ecocity, 2011) exemptions from ZTL valid for vehicles with higher load factors. Although this possibility is under discussion according to the National Road Traffic Act, the trend is set and may lead to a diffusion of more favourable traffic conditions to vehicles which demonstrate to be more efficient in terms of goods volume transported.

Italy is a peculiar case also for the diffusion of UCCs (Urban Consolidation Centers), as the real triggering factor of making a city logistics trial successful is the opportunity of cross-docking goods in a peri-urban platform. Three "UCC-based" business models can be recognised in Italy:

- "Padua model", in which the main public and private stakeholders (e.g. the Municipality, the Provincial Administration, the local Chamber of Commerce on one side, Associations of couriers and transport operators, on the other side) agree – through the signature of a Framework Agreement – on regulations (implicitly accepted by all stakeholders while signing the F.A.), and reciprocal supply of specific assets, including the availability of the UCC-platform. The UCC is provided and managed by a in-house logistic operator ;
- "Venezia-Mestre model", in which the UCC-based logistic concept is the same as in "Padua model", but the UCC and last-mile transport service manager is selected through a public tender. The service manager is endowed by its own UDC, and vehicles are owned (or granted) by the Municipality
- "Vicenza model", in which the UCC-based logistic concept is entirely managed by a NewCo, created as a public-private partnership between the Municipality and private stakeholders.

The installation of urban consolidation centres can be attributed to legal requirements to restrict general vehicle access e.g. to historic centres. The CIVITAS VIVALDI project developed and implemented a successful scheme in an urban distribution centre in Bristol. The scheme started from the business model approach providing added value towards the supply chain partners.

Alternative consolidation concepts have been developed and tested at a market level. Bordeaux implemented a publicly-operated consolidation centre. The Belgian company Kiala is an example for using convenience stores as urban consolidation centres The UK retailer Waitrose together with the transport operator OCADO implemented an urban consolidation scheme based on small containers. Presently the CITYLOG project is to develop and test a modular box, called BENTOBOX in urban delivery structures. The UK company Office Depot has successfully trialled a small consolidation centre near the City of London and it makes its deliveries with a 100% clean vehicle fleet, based on battery electric vans and electrically assisted cycle freight. It is fair to say that few urban consolidation centres outside of controlled spaces have proven to be successful, usually failing to develop viable market models.

The practice of issuing cooperative freight systems was very popular at the beginning of "city logistics stream" in the Nineties (see Basel, Freiburg cases, among others). Nowadays some cases of certification schemes created by the Municipality are active. Certification confers privileges on an operator, such as extended delivery hours or the use of designated loading/unloading facilities. It may also provide operators with a competitive advantage when bidding for contracts, as clients are increasingly committed to selecting bidders that off er the best environmental guarantees. A recent example of such an initiative is the FORS (Freight Operator Recognition Scheme) in London. FORS provides a performance benchmark for the trucking industry (Transport for London, 2007) by certifying operators that comply with a list of efficiency, safety and environmental impact criteria.

More cooperation between middle-small size delivery companies The trend described above for city logistics demonstrate a general trend towards a higher cooperation between SMEs in logistics, both in the inbound flow (raw material procurement for a group of SMEs), and in the distribution. The cooperation is evident in some peculiar cases of transport procurement brokerage, development of common logistic platforms, and agreements for transport capacity sharing.

The main barriers towards cooperation among small and medium logistic providers are cultural and report mainly to the (small and medium sized) shippers' willingness to protect sensitive data and attitudes on their managed business, although paying higher prices for transport and logistic services. However, it is a matter of fact that SMEs can hardly access optimized transport solutions because of small volumes and low frequency of their transports, and then of limited contractual power against carriers and logistic operators. This is particularly true where the strong prevalence of small companies and their habit to trade with partners in other countries result in hindering the cooperation.

The transport demand fragmentation is usually a reality in supply chains and industrial branches where (either in a region or in a corridor) the logistic chain is not "dominated" by few big logistic providers, or few big industries, that are capable to bundle transport demand, while imposing logistic procedures and quality standards to their customers and suppliers. Several EU-funded projects (e.g. CASTLE, KASSETTS) have tried to developed cooperative schemes between SMEs in logistics, in order to overcome the scattered demand of transport services in different contexts and reach a high saturation of trucks. KASSETTS is a peculiar case of project, aiming at developing a multi-regional ICT tool for transport demand brokerage. The project aimed at reaching two main goals: (i) finding a sufficiently large number of collaborating companies located in the same territory to aggregate their payloads, and (ii) combining these with the payloads of companies in other territories to complete routes and avoid empty trucks. According to the project documents, the analysis of KASSETTS applications have shown cost saving over 20% by user SMEs, 30% less kilometers run by vehicles and number of transport routes reduced by 37%.

More electric freight vehicles

There are a few number of fully electric trucks available today. They are normally used in specific applications for very limited range, e.g. ports. Renault Trucks has full electric version of its Maxity model that is a light urban truck. Innovative vehicle technologies are a key factor to reach a low impact city logistics. From the environmental point of view, pollutant emissions can be zeroed through electrical vehicles. This kind of propulsion can also improve the overall quality of life by reducing the noise emissions related to the engine. The introduction of an electric-based powertrain on the logistics vehicles will require some adaptations to the traditional mission management services. Especially if the batteries will not have a high capacity, the delivery route planning shall take into account this relevant constraint.

At the vehicle side, the on board telematic system shall ensure a full vehicle monitoring not only for the delivery tracing, but especially to adapt the mission to the energy consumption. Therefore, the back office (logistics management system) shall be made aware of the remaining capacity, so that it can carefully decide if a given vehicle can extend its route and include a new pick up destination. This information can be needed also for a specific routing, for example to inform the driver about possible recharging points in the city.

Commercial vehicles such as buses and distribution trucks usually use diesel engines as main propulsion where the electric engine is used to break energy and peak power support allowing downsizing of the combustion engine.

In this heavily subsidised market, hybrid buses have been introduced in small volumes at very high price levels. The technology chosen such as e.g. the Allison E-drive system is in EC terminology a first generation hybrid system with associated cost disadvantages.

Several manufacturers will launch first generation hybrid truck 2011-2012, but from a financial standpoint these trucks are not viable. DAF has built a new generation hybrid distribution truck that is doing field tests now to generate information on the market capabilities of this new hybrid concept. The expectations are targeted at 30% for the increase of the fuel economy. Compared to standard diesel trucks the weight increase is 250 kg for the total system of which 100 kg for the lithium-ion battery package. IVECO-Altra has shown up to 18% fuel economy improvement with a parallel hybrid IVECO daily minibus compared to the conventional driveline with automated manual transmission.

Volvo vehicles with a parallel coaxial electrical machine have demonstrated potential fuel consumption reduction of more than 20% for some city drive cycles. For distribution trucks with interurban drive cycles, fuel consumption reduction is in the range of 10-15%. Current cost level represents a major obstacle for a wide market introduction especially on the distribution truck market that is more price sensitive and exhibits less fuel consumption reduction potential than the city bus market. The current bus demonstrator has a steel-based body in white with a weight of approximately 12 ton for an empty vehicle. A fully loaded vehicle has a total weight of around 18 ton.

These types of system represent second-generation hybrid parallel technology where the electrification of auxiliaries has not been fully developed. The diffusion of electric trucks still has to be subsidised for representing an effective alternative to diesel. Even in public city logistics schemes, the diffusion of electric trucks is not as high. In Italy, on 10 city logistics active trials, 32 vehicles are "officially" deployed, 12 of which are electric powered (Bologna, 2010 and Vaghi, 2008). However, those figures are rapidly increasing, in line with the growth of the active systems. Some failures in the use of electric trucks use in city logistics exist, due to the high cost and the relatively scarce diffusion of skilled maintenance personnel, which hinder the reliability of the vehicle[52]. EU-funded projects such as SMARTFUSION will reach the goal set by the EC towards a wide spreading of electric trucks in urban distribution. The project goal is to integrate different aspects of electric and hybrid propulsion, together with elements of tracking, IT devices for assistance to drivers and route planning, all in order to make the diffusion of electric trucks more attractive to users. In the current FP7 call, the EC is pursuing the goal by funding projects for the demonstration of electric trucks in real life conditions.

[52] The deployment of a full electric truck was terminated even in the most successful city logistics case in Italy, Cityporto Padova.

ANNEX VI: Summary of the steps in the business economic costs assessment

Step 1, Description of how the new technology affects key parameters of the service. The step will translate service parameters (origin, destination, timing of arrival and departure) into production parameters:

- Assets used:
  - Locomotive(s) type(s),
  - Type of wagon and number of wagons;
  - If intermodal: type of intermodal loading unit;
- Staff deployment: driver hours;
- Route / distances over rail and road.

For example the composition of wagon sets is likely to differ between intermodal services and urban deliveries. The line of reasoning of step1 will be worked out for each individual case.

Step 2 is the calculation of SPECTRUM's operating costs. It uses the production parameters of the rail service step1 as input as well as cost parameters:

- Fixed costs/hr of locomotive(s)
- Energy consumption of locomotives and its costs/km
- Other variable costs of locomotives (maintenance)
- Costs/day of wagons (variable share of maintenance costs will be included)
- Labour costs of the driver per productive hour (distinction between countries is optional)

The model will use assumptions about the procurement costs of SPECTRUM's wagons, their lifespan, maintenance costs and energy consumption. Since the design phase is yet to be started these variables will be derived from estimates of how the design will differ from wagons in current practice that SPECTRUM aims to improve (flat wagons, pocket wagons, covered wagons).

If the SPECTRUM-design also involves covered wagons which are temperature controlled (in contrast to flat wagons or pocket wagons carrying temperature controlled containers, bodies or semi-trailers) separate data should be assumed for that type of operations as well.

The features of the locomotive used in SPECTRUM will depend on train weight, which due to the focus on LDHV-cargo will be less than common in freight transport. It also depends on the segment that is served, e.g. it may involve shorter trains or the need of supplying power for refrigerating.

If SPECTRUM's innovation also concerns the locomotive the model will use an estimate of how investment and operational costs differ from existing locomotives.

Outputs of step 2 are:

- Operating costs per unit (which is ILU, pallet, ton or m3 … to defined per case)

Step 3, the comparison with the alternatives which SPECTRUM competes to, starts with a specification of rail and road operations in existing (or virtual) services and their costs in similar way as done for SPECTRUM service. Like in step2, this will provide operating costs and service capacity as outputs. For a comparison between the transport costs of the SPECTRUM-service and the existing road and rail alternatives more variables need to be added:

- Infrastructure charges or rail and road operations. These will be calculated for each O/D by a separate module. There is variation in charges between countries, modes and possibly between infrastructure categories (freight, express trains). These are high so assumption of common values is not appropriate;
- Attribution of management and other indirect costs of the transport companies. This may require rudimentary assumptions, particularly for rail transport, about the basis (driver costs, train-kilometres, total operating costs, etc.) and about the percentage or the amount to be added. In practice there may be much difference between e.g. small freight carriers and large conglomerates;
- Correction for the use of special transport equipment (road, rail. ILU) in temperature controlled traffic;
- Additional costs of monitoring cargo (equipment and communication) in some segments costs;
- Transhipment costs of ILU / pallets;
- Specification and costing of operations in pre- and end-haulage by road in intermodal chains.

Step 4, is a qualitative assessment or comment and will not be presented a standardised way, which is because the diversity of segments.

It will e.g. comment on:

- The results of step 3 and its sensitivity to assumptions;
- Ways to achieve good performance values on the criteria which are not quantified (reliability, flexibility, security, service availability, frequency);
- Needs for facilities or for services, apart from the transport service;
- Critical factors of success;
- Typical business risk and ways to mitigate them.

Step 5, will present preliminary conclusions about the contribution of a SPECTRUM-train in improving the competitiveness of rail in the different segments.

ANNEX VII: List of cases in the business economic model

Intermodal, continental

- Long distance international (Antwerp – Busto Arsizio)
- Medium distance international (Nurnberg – Verona)
- Medium distance domestic (Hamburg – Stuttgart)
- Short distance domestic (virtual)

Intermodal, port hinterland

- Short distance domestic (120 km, virtual)
- Short distance domestic (200 km, virtual)

Refrigerated transport

- Reefer transport, long distance international
- Reefer transport, medium distance international
- Reefer transport, medium distance domestic
- Reefer transport, short distance domestic

Intra-company

- Covered wagons short distance
- Covered wagons medium distance
- ILU, short distance
- ILU, medium distance

Urban delivery

- ILU, short distance

Assessment SPECTRUM in task 1.2 case studies

- Flora Holland/GreenRail
- Procter and Gamble
- Innovatrain

ANNEX VIII: Economic decision parameter: price versus cost

The business economic model takes costs as parameter. In the practice of logistics costs would be the long-run decision criterion, for example when it would concern investments. Prices fluctuate stronger than costs, because prices also take temporary market conditions on board. Measured over longer time frames, costs and prices tend to be balanced. This annex summarises differences between costs and price and their influencing factors.

1 Definition

The price is what the client pays for services rendered. Costs are related to the production of the full range of services and are a measurement of retrieving rewards of inputs, i.e. assets, staff, energy and of other expenses and of commercial risk.

2 Interpretation

- The price is the leading decision criterion in the transport spot market. Small companies or companies with irregular transport demand tend to rely more on actors in the spot market.
- Costs will be the leading criterion if the long-term perspective is more important. The more clients and logistic service providers have invested in a logistic solution and own specific assets like loading units of loading platforms the less sensitive they will be to price fluctuations in the sport market.
- A more stable market will have price fluctuations that are more in accordance with fluctuations of cost elements. For example fluctuations of energy prices are a given fact for the transport market. The fluctuation will affect costs and ideally would be reflected in (output) prices of transport services as well.

In a stable market the margin between prices and costs is a slight premium for taking business risks. In an unstable market prices tend to deviate from costs e.g.

- Strategies of coping with seasonal patterns in demand or with unbalanced demand;
- Entry deterring strategies;
- Cross-subsidising between services.

3 Assessment

Assessment of transport costs must include the complete transport chain, i.e. transport operations and transhipment. It concerns all assets used as well as costs such as labour costs, energy costs, business costs, and infrastructure use charges. In addition, if required, costs of customised packaging may be relevant.

The basis unit of the cost calculation must be well chosen. For a door-to-door calculation costs per loading unit is practical. Utilisation (percentage of train space occupied) and capacity features (x pallet places or m3 in truck/ILU) are very important in the overall comparison of logistic costs between alternatives.

Cost data in SPECTRUM are obtained from existing market studies. Cost data of SPECTRUM will depend on its design parameters and on service parameters. Both require assumptions or scenarios.

The likelihood of strongly deviated prices may be predicted by evaluating market conditions on specific corridors (unbalanced transport, strong seasonal pattern, transport capacity, ….).

Shippers and logistic service providers are likely to have price data of their transport service procurements, but it concerns sensitive business information and the willingness to share them tends to be low.

4 Benefit SPECTRUM may have to costs and prices

There are impacts of SPECTRUM on costs due to:

- Changed characteristics of the wagon itself which may involve:
    - Procurement costs of the wagon
    - The lifespan op the wagon
    - Maintenance costs – annual or distance-related - of the wagon
- Lighter train weight and higher speed and therefore a different locomotive with a different costs profile and different energy consumption;
- Operational characteristics which may involve lower train lengths, utilisation parameters;
- Logistics changes such as like pallets/unit and packaging requirements.

The distribution of savings or costs between shippers and operators depends on market relations and may differ between segments. (E.g. shippers which who have no added value of SPECTRUM's other service quality parameters will not accept any rise in price.)

5 Issues concerning introduction of SPECTRUM

- Cost competitiveness of SPECTRUM in comparison to road and conventional (intermodal) solutions is being investigated. This should include sensitivity to particularly the (uncertain) energy price developments and to uncertain parameters of the SPECTRUM-design.
- Since utilisation is an important variable in cost competitiveness also transport demand should be taken into account.

Successful introduction is more likely to sustain in a market with stable transport demand, which should be assessed before.

ANNEX IX: SPECTRUM Train characteristics, taken on board of the business economic model

Expected differences of SPECTRUM parameters compared to existing technology:

- Freight wagon issues. The wagons should not be treated as the dumb resource as now. They are key assets and need to be treated as such. This should be reflected in the way they are designed, allocated into service, monitored and maintained.
- Specifically the wagons should support a better tare to gross weight ratio by the use of lighter materials for the wagons irrespective of type (inter-modal/covered van/tanker). This mainly relates to the frame design, coupling equipment (including auto couplers) and draw gear.
- This may take the initial purchase price of the wagons to a higher level than now but should pay back in terms of lower through life costs, better commercial payload capability and reduced time to build and break train formations.
- The use of low track force bogies should be mandatory even at the higher target gross weights being considered. Heavier vehicles inflict proportionally a lot more by way of track attrition and damage and the use of LTF bogies could mitigate this. This factor is even more important as higher speeds are envisaged which also increases the propensity to damage the infrastructure. Bogies with this characteristic are available and used in the UK railway domain and these allow the users to secure a discount on track access charges. The bogie weight is reduced.
- Any new rolling stock should also be carrying equipment for real time location monitoring and status monitoring. The asset managers will need to know what is happening to the fleets they control, where the equipment is and what its status is (running, stopped/loading/discharging, available for commercial use, stopped for repairs (crippled)). It should also be possible to identify if the individual vehicle is running towards a required service or maintenance check (distance or time based) and whether it is possible to exceed this if no vital signs are flagging an issue. It should be possible to reduce maintenance costs by good design and regular wagon maintenance regimes driven by the monitoring systems by > 30% as an informed guess.
- New vehicles should also be fitted for cargo condition monitoring (reefer traffic, liquids, gases, etc.) again to allow intervention
- All of these will increase the initial purchase price of a wagon although this might be offset by volume purchases and sweetheart deals. I would suggest a premium of 25-30% compared to today's catalogue price for inter-modal, tanker and vans but this would be recovered by much more intensive use of the assets by knowing where they are, what they are doing and what condition they are in. There should be a minimal eventuality of in transit failures.
- Based on the above I see no reason why a vehicle with the design characteristics outlined above should not be able to be available and in service under load for a much greater part of the asset's life. There is a view that accepting 30 years as the life of a rail vehicle is too long. If the productivity is doubled by good design and strong interventionist management and related systems aiming to keep the assets moving and earning for a much then the asset life might be shorter. I am always uneasy about 30-year-old railway kit being compared to the shorter life cycle of large trucks/lorries. This might then suggest the need for a modular design for upgrading the core vehicle over its life similar lines to the aviation sector.
- The geometry and architecture of new vehicles to accommodate higher weights/volume will be constrained by the loading gauge of the railway domains where they are allowed to operate.

National domestic gauge limits vary and it would be useful to distinguish between any purely national applications and international use. I recognise that inter-operability suggests a theoretical freedom to deploy the kit anywhere but this may not yet be borne out in practice. This may also affect the weight capability being factored into the design. It may be that as route capabilities are enhanced the load factor for the wagon types could be up-rated to take advantage of this.

- In terms of cargo volume advantages I would suggest for inter-modal that the ability to accommodate a mix of ISO and 45' containers is essential plus swap bodies of varying dimensions. The variable width of containers will need to be accommodated.
- For a cargo wagon the real limit is the loading gauge/kinematic envelope and how close to overall limits any design is pressing this. It should be possible to go for 23 or 25 metre long 4-axle wagons on most major routes. With flat floors or a well design and with various apertures/doors/curtain sides it should be possible to increase the cargo volume significantly compared to existing orthodox wagons. A target volume of >250 cubic metres looks to be "do-able" based on crude calculations and even this might be improved upon. Floor space either as a flat floor or with a low well between the bogies will dictate how much can be achieved but the prevailing current limits should be pressed. Concerns about any mechanised access and lift points for forklift trucks would need to be considered. I'm not sure whether any form of articulation may or may not be advantageous but might be an option for a vehicle designed around high bulk low weight commodities.
- In relation to a power supply for reefer traffic this could be through a variety of mechanisms as now. The power pack small diesel units have the attraction of being relatively cheap but they do emit exhaust gases and noise. They are also quite long lasting in terms of fuel burn (>72 hours). It would be possible to replace these with some form of electrically powered device possibly with the power drawn from the loco and linked down the train formation but this pre-supposes all wagons irrespective of whether they are reefers or not. Autonomous power for individual reefer wagons (including inter-modal) could be supplied by batteries re-charged as the train is in transit or by some form of electro-voltaic roof mounted device to supply the power. This technology might be vulnerable to damage in the harsh rail environment.
- With reefer wagons some form of compartmentalisation may be needed for ambient, chilled and frozen products. There will also have to be recognition of the need to load/discharge using a range of mechanical handling and other devices. The vehicle dimensions could reflect the observations made in (10) in terms of size.
- In relation to longer and heavier trains being able to accelerate and brake and interact with streams of other fast moving passenger trains I have some difficulties with this or my basic understanding of physics is at fault. I think a TRAX loco may be struggling on its ability to accelerate and brake a train of 4-5000+ tonnes to a higher line speed as envisaged on a routine basis. The power to weight ratio suggests that the loco could be on maximum load for a lot of the time at this sort of gross train weight. The energy consumption will inevitably increase with the incremental train weight and this cost has to be recovered in freight revenue. I think the power to weight ratio would have to be increased by factor levels (10hp/tonne) to make this work and this suggests the need for two locos and so the cost of traction provision and operation increases. The problem obviously becomes even more acute in mountainous regions. The energy use assumptions may need re-visiting.
- Another big issue is what happens to these jumbo trains if the train operating sequence is disrupted and there are limited sidings/loops to hold them to allow passenger priority trains to overtake. I also have some real concerns that increasing train length and weight is not what the market wants or needs. The load/discharge time of a long train can be wholly out of synchronisation with the needs of shippers wanting regular replenishment and not one big block of cargo arriving intermittently. The truckers provide this sort of routine replenishment. Rail could fall into a supply side positional trap if the only product and service offer is built around the proposed jumbo trains.
- I just wonder whether the infrastructure managers will take a neutral view on faster freight services or whether the passenger priorities will always be prioritised. If there really is a method of making relatively orthodox freight move smoothly in total synchronisation with passenger with no delay being inflicted by either train type on the other then that would be terrific but I have my suspicions this may not always be feasible.

Contribution to the conclusions in Deliverable 1.1:

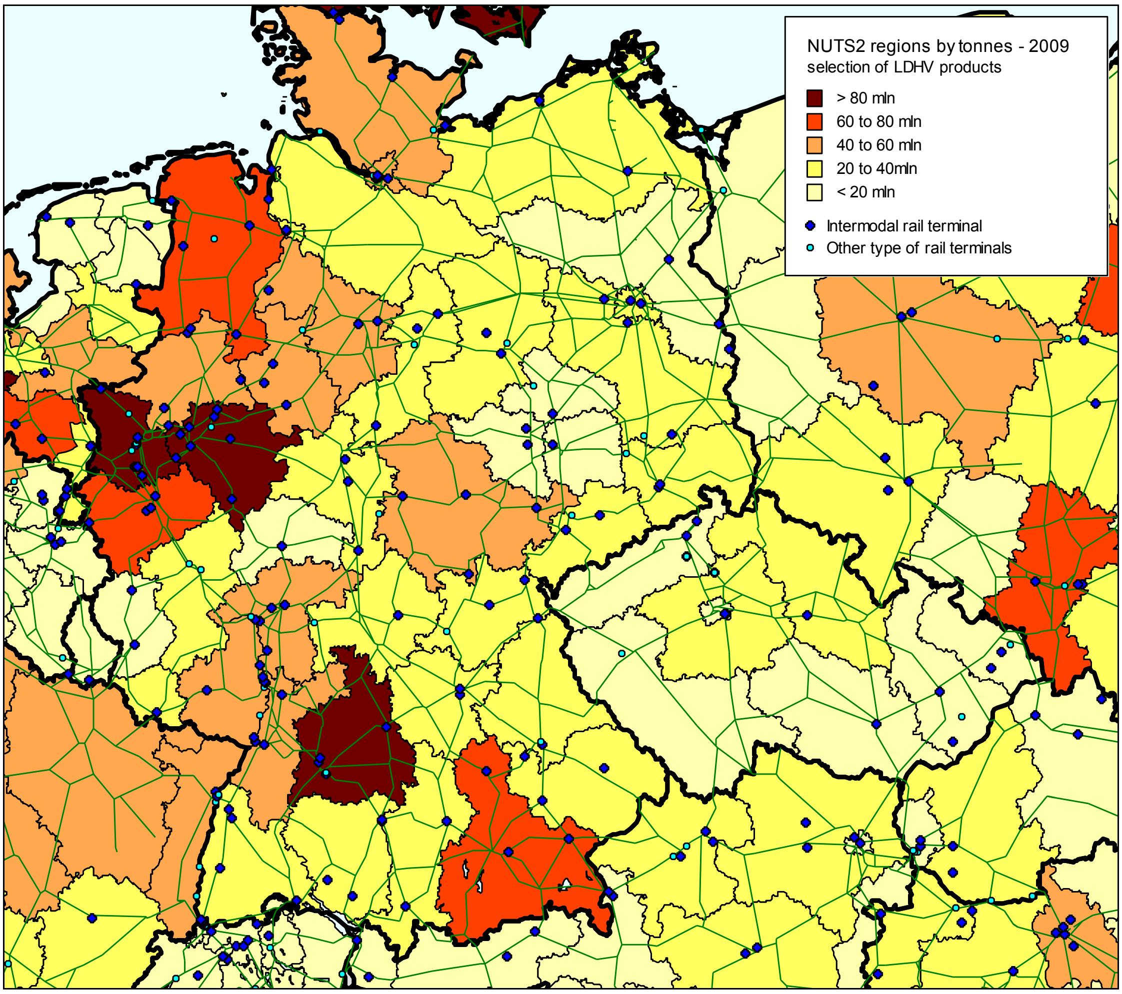
Based on the analysis of twelve business cases, the possible suited market segments, the likely commercial viability, and the potential contribution to the competiveness of the SPECTRUM-design are assessed. These findings will be further processed in WP2 and WP3 with a more focus on the technical and operational aspects. The result of WP2 and WP3 can help identify, among all these business cases, which of them will be more promising to be further investigated. Given this, a sensitivity analysis on these promising cases can be conducted in WP4 and the case-wise presentation will be followed by drawing conclusions on the expected commercial viability of the SPECTRUM-design in the different market segments. This will include an assessment of factors which are critical to successful implementation.

Subsequent steps after the preliminary assessment using micro economic business model:

- Investigating the expansion of SPECTRUM-technology into networks of railway and intermodal services where benefits appeared promising.
- Initial demand assessments for those promising segments, using the database of LDHV-trade flows of tasks 1.1. This will provide insight in the global size of the market relevant to the defined SPECTRUM service. There is a need to identify the market share that the new service needs to attract and is an indicator of the chances of successful introduction. This may need to be reinforced by contact with shippers.
- Identifying additional requirements to preceding and subsequent steps in the logistic chain (like packaging, warehouse space) and assessing any costs or savings;
- Assessing the need of investments (or savings) in ancillary infrastructure or facilities.
- Identification of further needs for successful implementation (e.g. new priority rules with Infrastructure Managers, liability regimes if it concerns modal shift, amendments in the communication structure between players in the chain).
- Analysis and comparison of alternative business models: Who is involved? Who leads? How are the commercial risks divided?
- Proposals of strategies of market entry. Single service application or wider roll out on a phased basis.
- Identify lead commercial partners (3PL or major shipper).

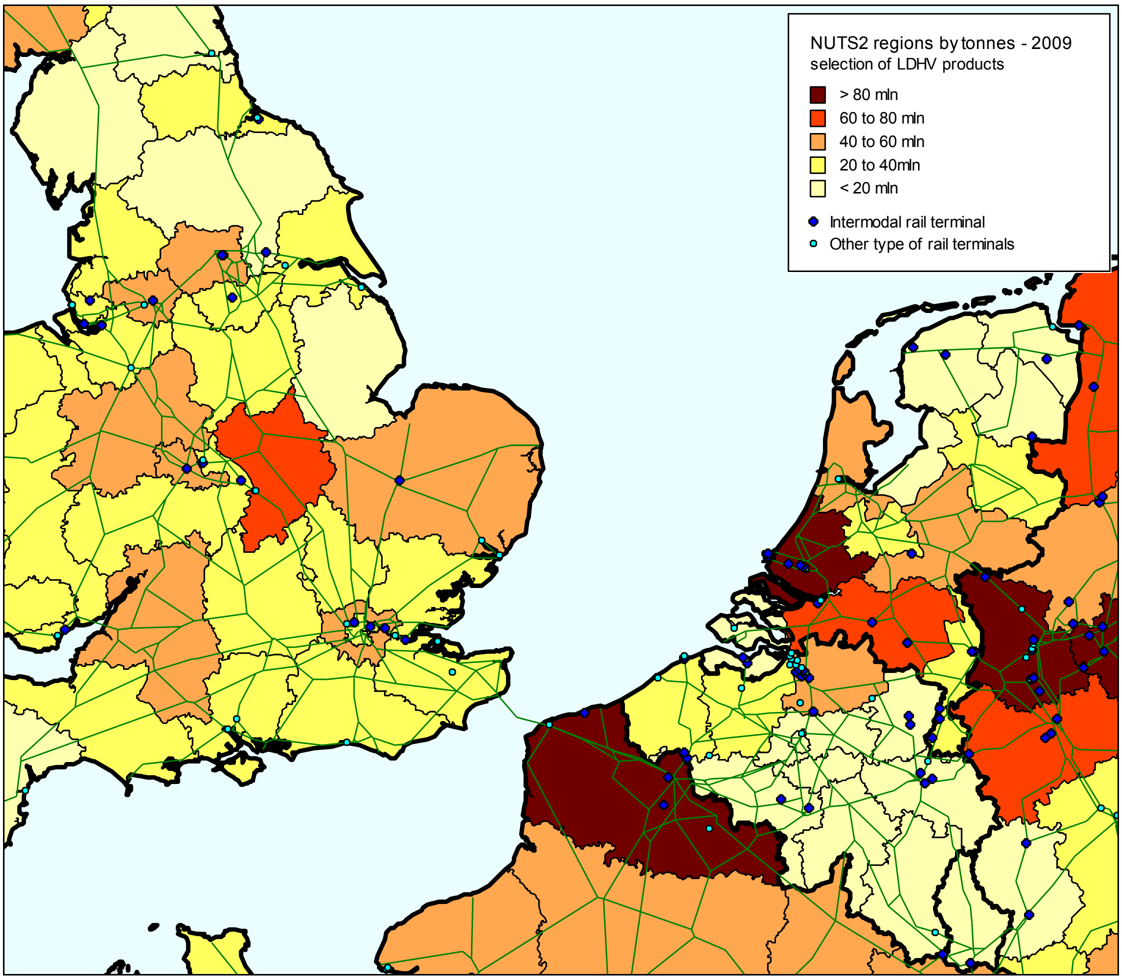
ANNEX X: Rail terminals and LDHV freight

Figure A.X.1: Rail terminals in and around Germany and LDHV goods (in tonnage) transported in 2009 by road



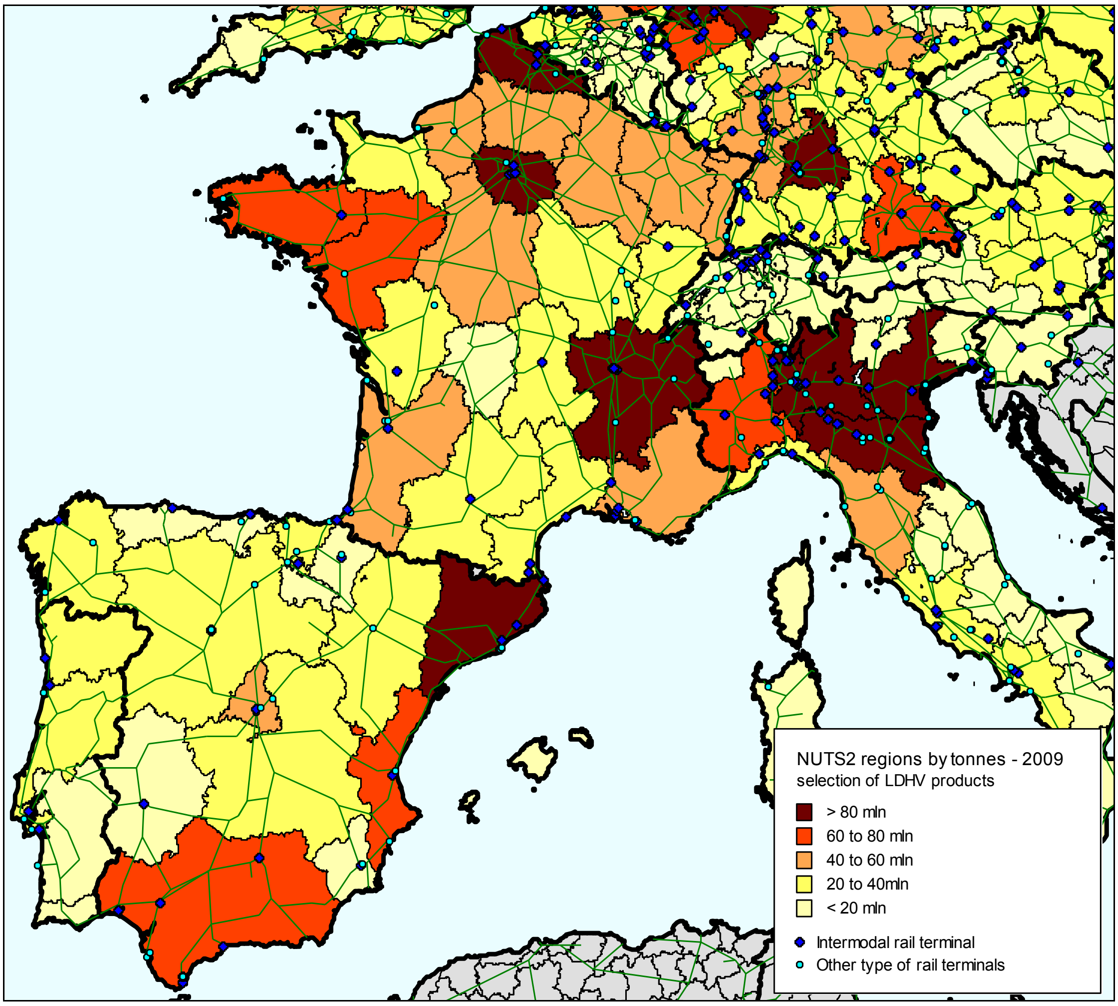
(source: EUROSTAT and SPECTRUM)

Figure A.X.2: Rail terminals in UK, Netherlands and Belgium and LDHV goods (in tonnage) transported in 2009 by road



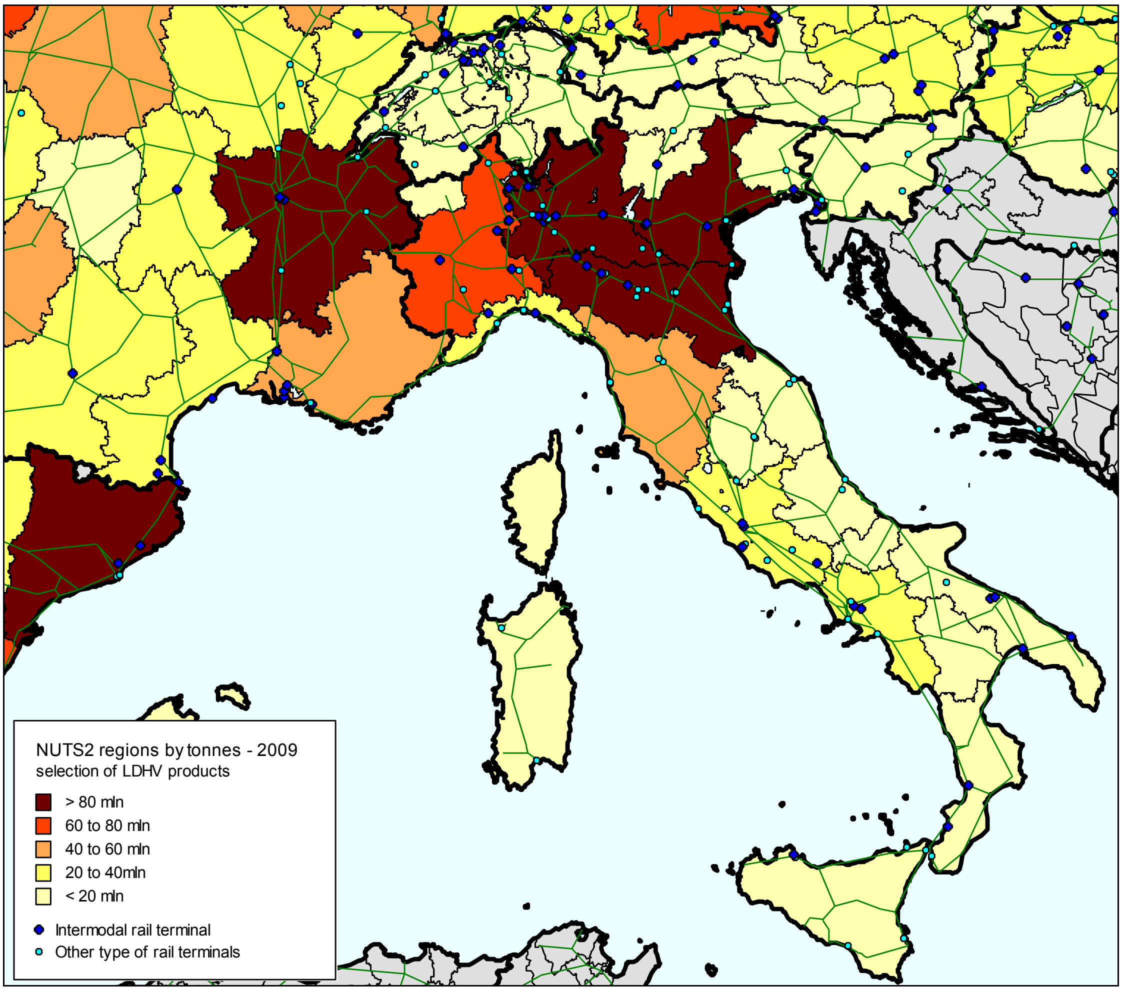
(source: EUROSTAT and SPECTRUM)

Figure A.X.3: Rail terminals in France, Spain and Portugal and LDHV goods (in tonnage) transported in 2009 by road



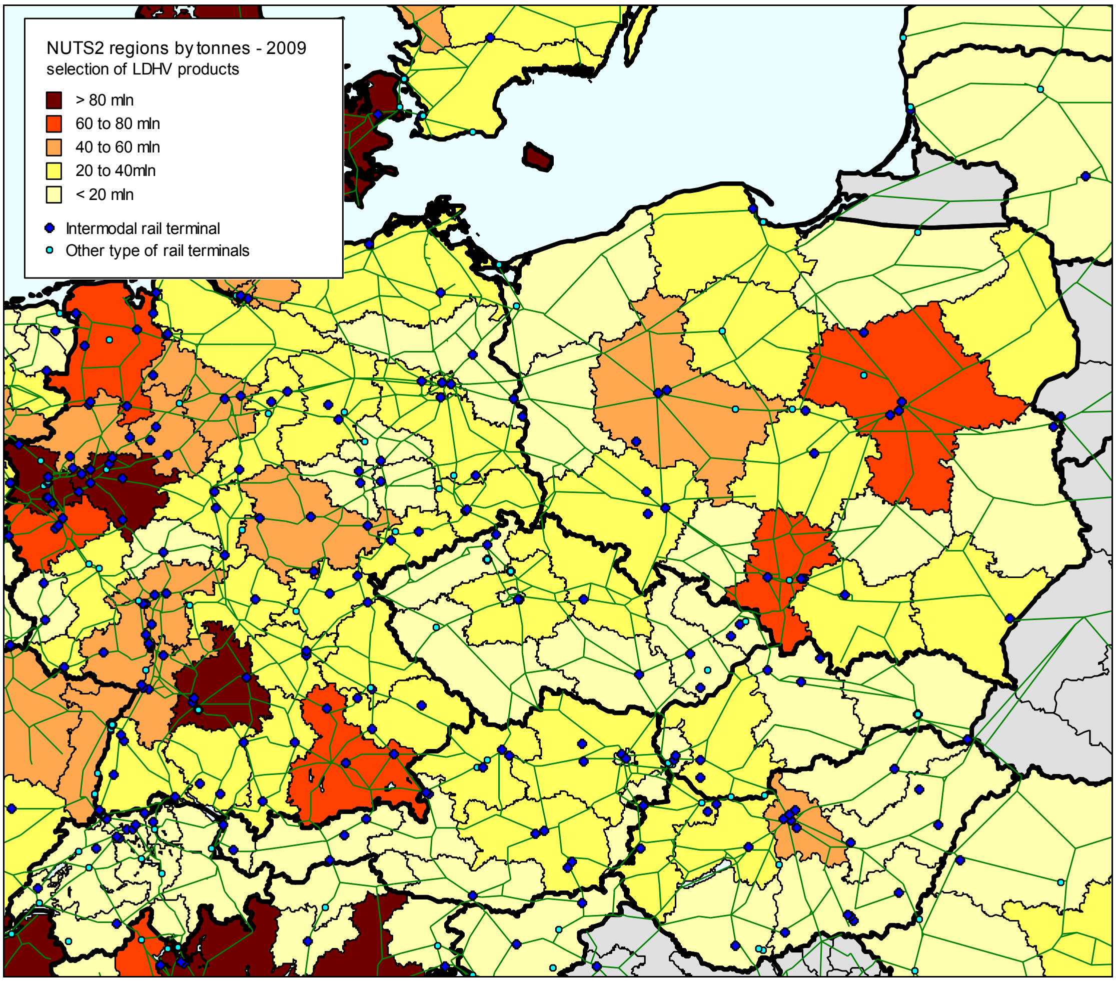
(source: EUROSTAT and SPECTRUM)

Figure A.X.4: Rail terminals in Italy and LDHV goods (in tonnage) transported in 2009 by road



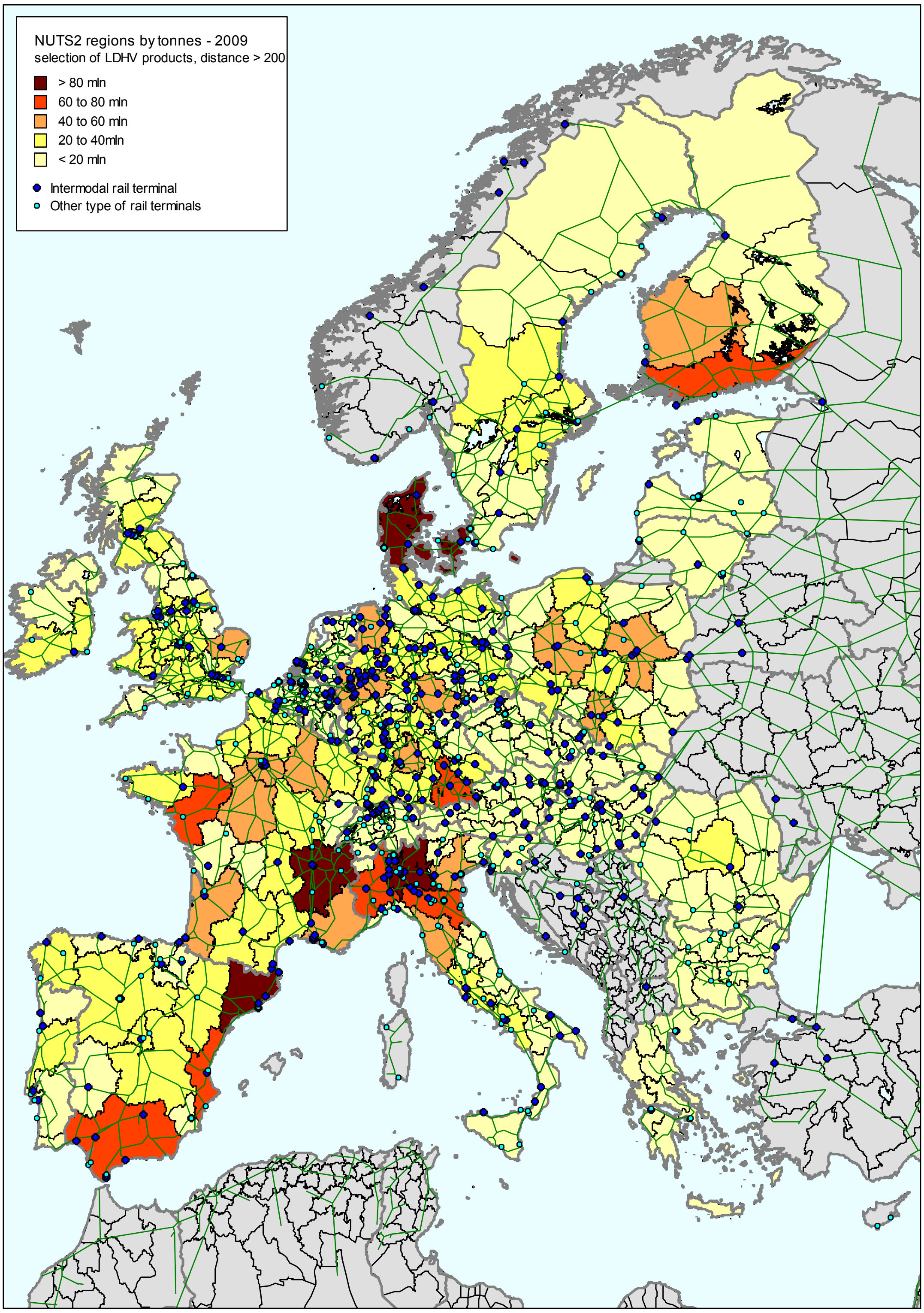
(source: EUROSTAT and SPECTRUM) *(source: EUROSTAT and SPECTRUM)*

Figure A.X.5: Rail terminals in Eastern Europe and LDHV goods (in tonnage) transported in 2009 by road



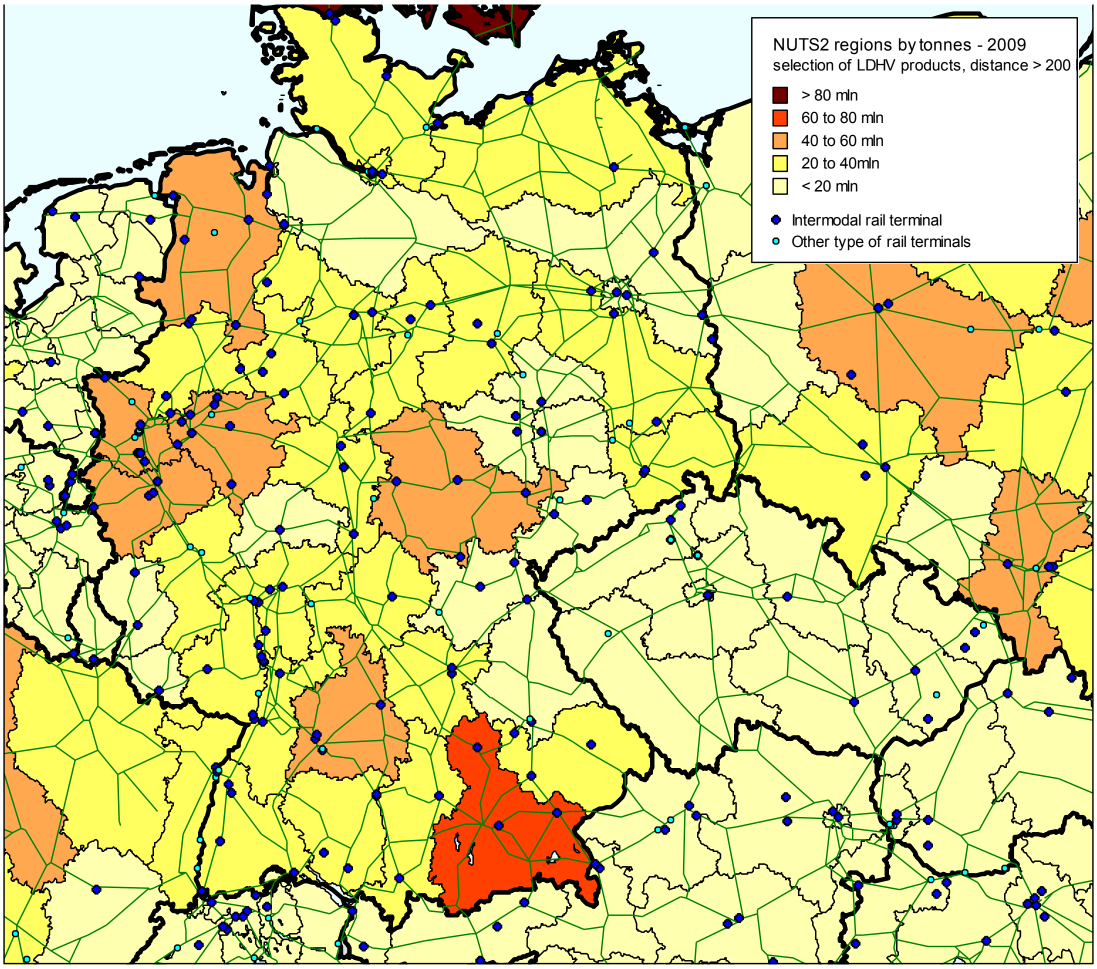
(source: EUROSTAT and SPECTRUM)

Figure A.X.6: Intermodal and other type of rail terminals in Europe and total LDHV goods (in tonnage) transported in 2009 by road in EU-27 and Switzerland (NUTS2 level), distance > 200 km



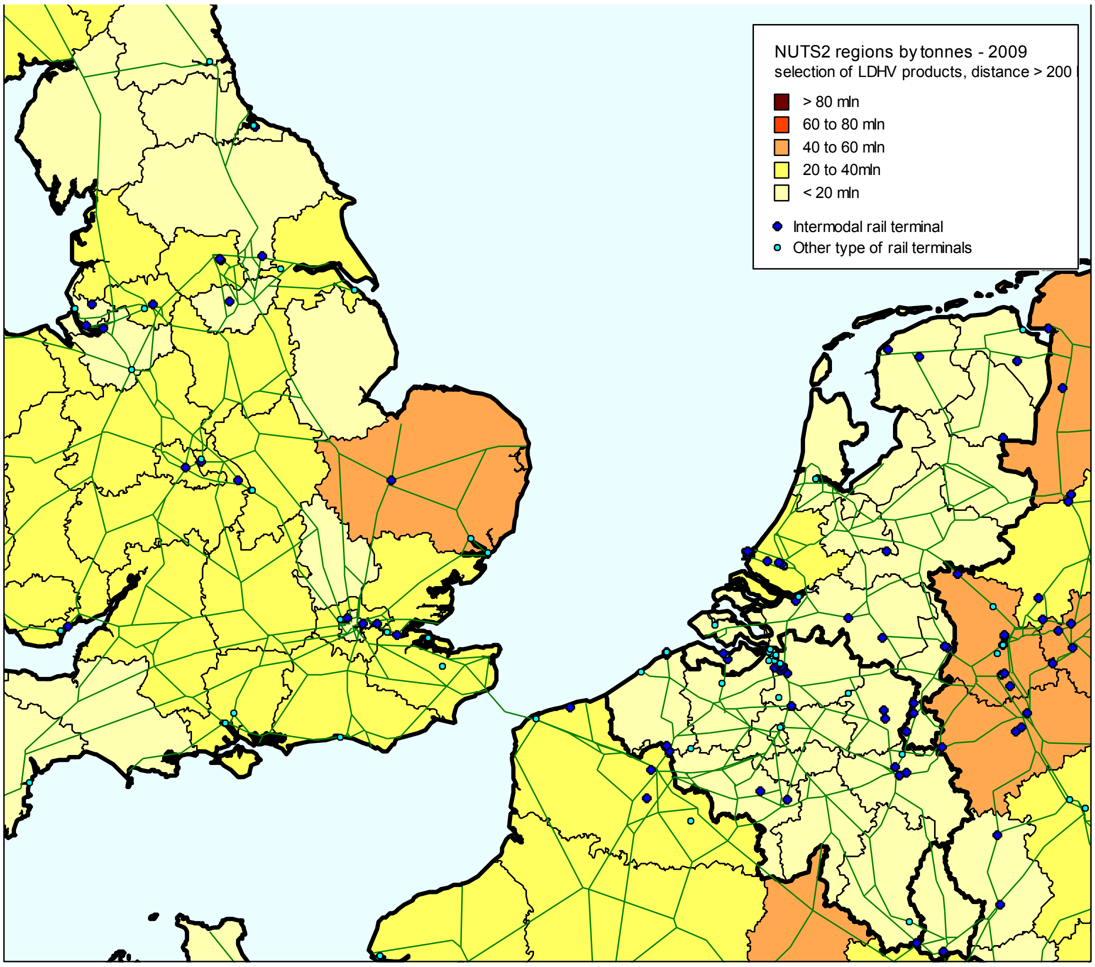
(source: EUROSTAT and SPECTRUM)

Figure A.X.7: Rail terminals in and around Germany and LDHV goods (in tonnage) transported in 2009 by road, distance >200 km



(source: EUROSTAT and SPECTRUM)

Figure A.X.8: Rail terminals in UK, Netherlands and Belgium and LDHV goods (in tonnage) transported in 2009 by road, distance > 200 km



(source: EUROSTAT and SPECTRUM)

Figure A.X.9: Rail terminals in France, Spain and Portugal and LDHV goods (in tonnage) transported in 2009 by road, distance 200km

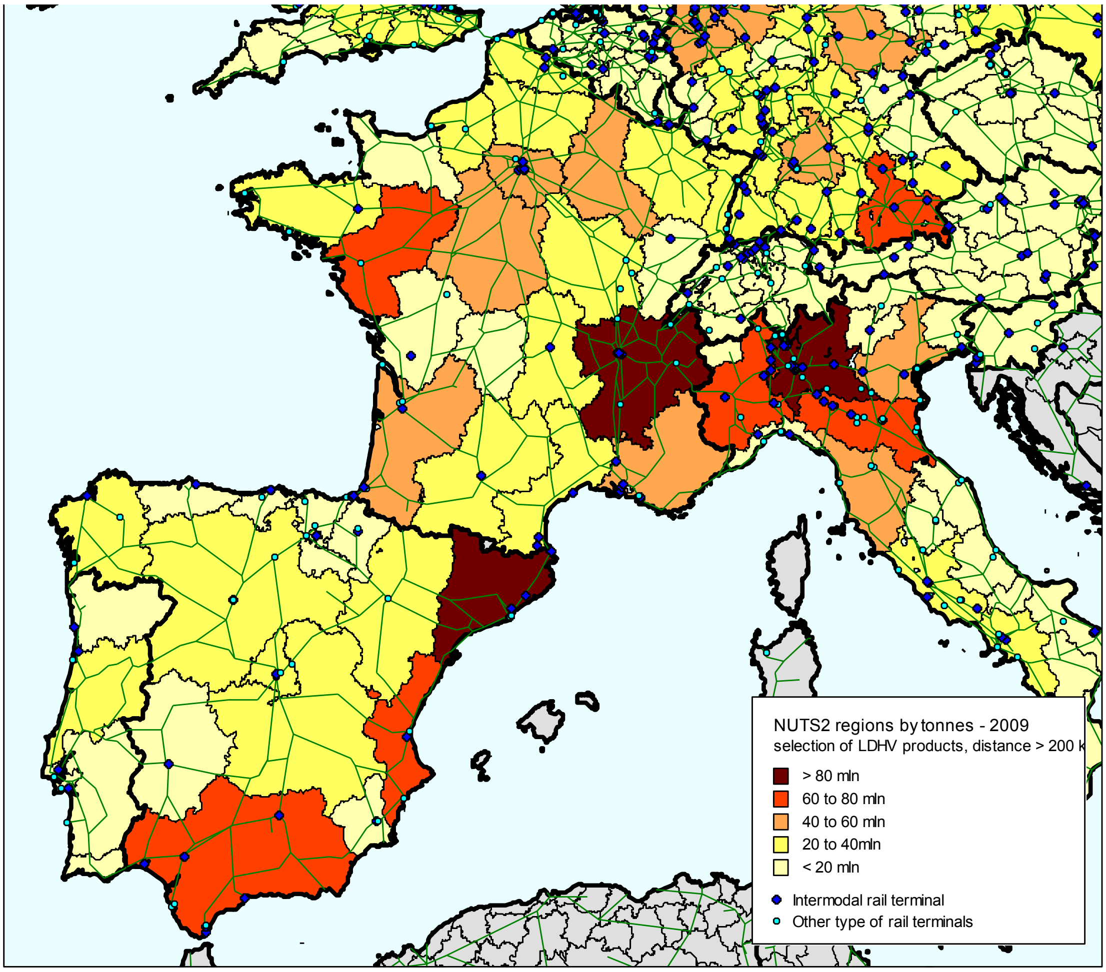
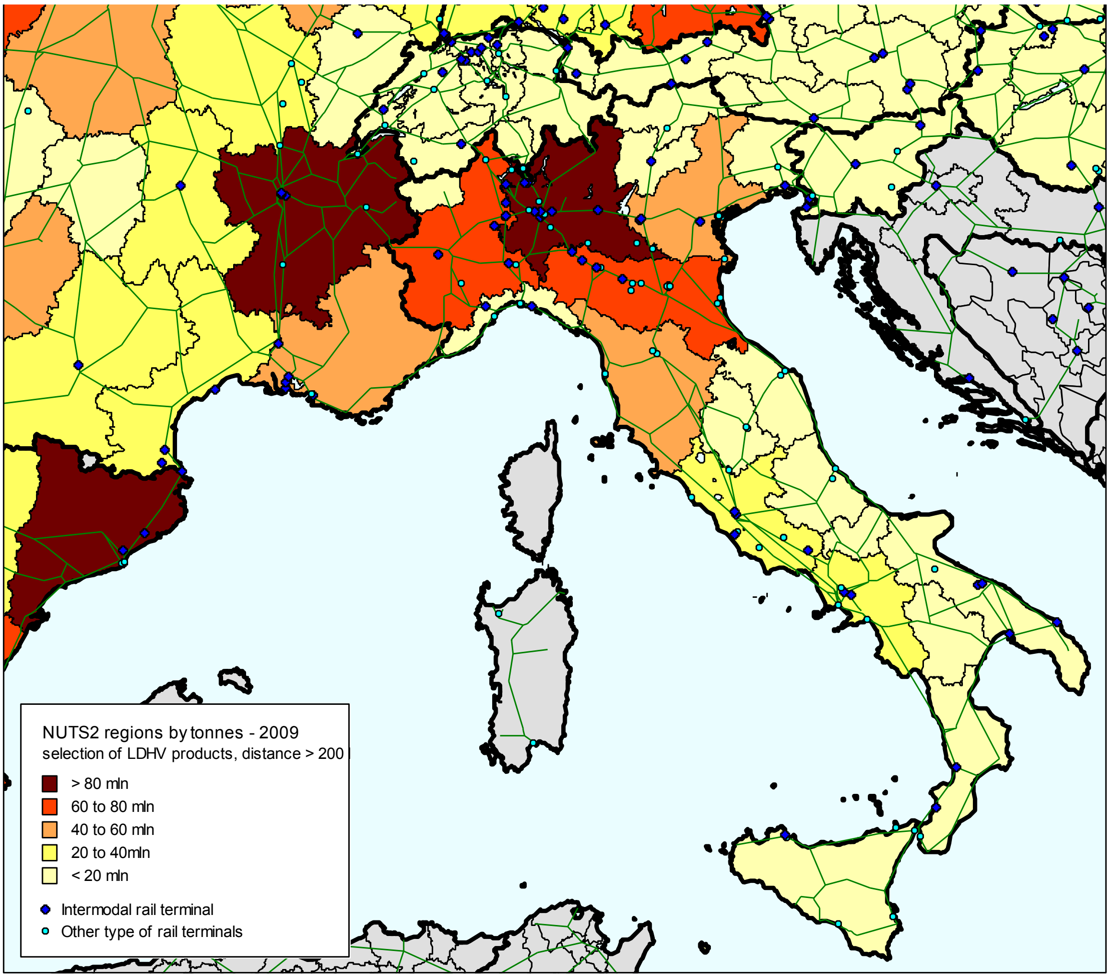
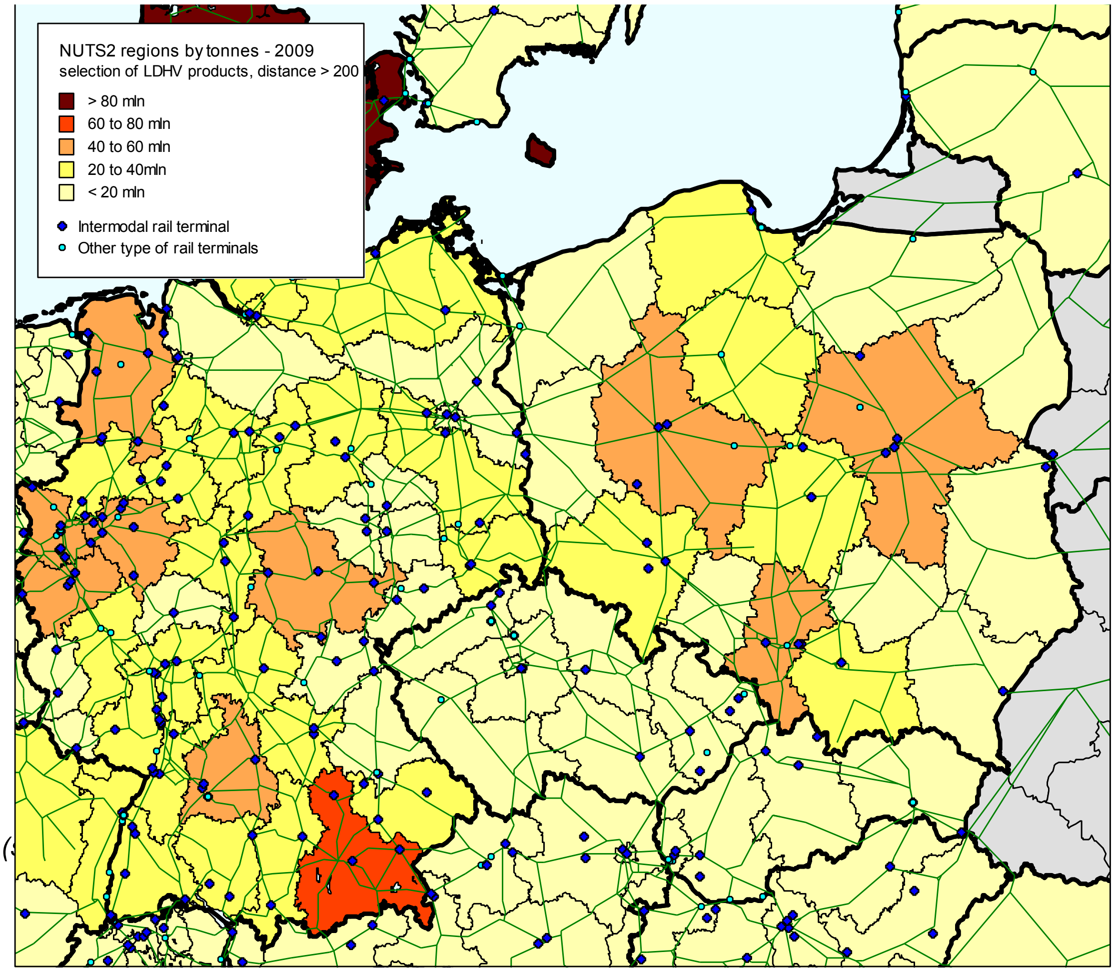


Figure A.X.10: Rail terminals in Italy and LDHV goods (in tonnage) transported in 2009 by road, distance > 200 km



(source: EUROSTAT and SPECTRUM)

Figure A.X.11: Rail terminals in Eastern Europe and LDHV goods (in tonnage) transported in 2009 by road, distance > 200 km



ANNEX XI: Analysis of major relations based on value of goods for the selected commodities

Table A.XI.1: Top 10 international traffic relations (NUTS 2 level), based on estimated transported agricultural (NST0) time sensitive LDHV goods by road over distances between 400-700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Aquitaine (France) – Cataluña (Spain)	57,888	50,135	467
Oberösterreich (Austria) – Lombardia (Italy)	36,364	31,494	610
Steiermark (Austria) – Lombardia (Italy)	35,272	30,548	617
Aquitaine (France) – Aragón (Spain)	32,734	28,350	429
Cataluña (Spain) – Rhône-Alpes (France)	32,217	27,902	655

Table A.XI.2: Top 10 international traffic relations (NUTS 2 level), based on estimated transported agricultural (NST1) time sensitive LDHV goods by road over distances between 400-700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Cataluña (Spain) – Rhône-Alpes (France)	173,858	109,191	655
Aquitaine (France) – Cataluña (Spain)	165,819	104,142	467
Weser-Ems (Germany) – Denmark (this is 1 region)	163,146	102,464	573
Denmark (this is 1 region) – Västsverige (Sweden)	115,666	726,44	567
Cataluña (Spain) – Provence-Alpes-Côte d'Azur (France)	109,103	68,522	479

Table A.XI.3: Top 10 international traffic relations (NUTS 2 level), based on estimated transported metal (NST5) time sensitive LDHV goods by road over distances between 400-700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Lombardia (Italy) – Rhône-Alpes (France)	120,839	44,481	444
Arnsberg (Germany) – Nord - Pas-de-Calais (France)	102,377	37,685	425
Cataluña (Spain) – Rhône-Alpes (France)	97,780	35,993	655
Pais Vasco (Spain) – Rhône-Alpes (France)	89,623	32,990	674
Nord - Pas-de-Calais (France) – Arnsberg (Germany)	88,858	32,708	425

Table A.XI.4: Top 10 international traffic relations (NUTS 2 level), based on estimated transported chemical (NST8) time sensitive LDHV goods by road over distances between 400-700 km in 2009

Relation	**Value in million Euros**	**Tonnage transported by road**	**Average distance (in km)**
Aquitaine (France) – Cataluña (Spain)	287,241	68,227	467
Provence-Alpes-Côte d'Azur (France) – Cataluña (Spain)	281,022	66,749	565
Cataluña (Spain) – Provence-Alpes-Côte d'Azur (France)	266,666	63,340	567
Cataluña (Spain) – Rhône-Alpes (France)	179,553	42,648	655
Antwerpen (Belgium) – Alsace (France)	162,675	38,639	482

Table A.XI.5: Top 10 international traffic relations (NUTS 2 level), based on estimated transported miscellaneous/container (NST9) time sensitive LDHV goods by road over distances between 400-700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Cataluña (Spain) – Rhône-Alpes (France)	2,670,945	534,643	655
Cataluña (Spain) – Provence-Alpes-Côte d'Azur (France)	2,128,140	425,990	567
Rhône-Alpes (France) – Cataluña (Spain)	2,039,209	408,189	654
Västsverige (Sweden) – Denmark (this is 1 region)	1,816,134	363,536	479
Provence-Alpes-Côte d'Azur (France) – Cataluña (Spain)	1,763,356	352,971	565

Table A.XI.6: Top 10 international traffic relations (NUTS 2 level), based on estimated transported agricultural (NST0) time sensitive LDHV goods by road over distances longer than 700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Cataluña (Spain) – Nord - Pas-de-Calais (France)	34,864	30,195	1,172
Niederösterreich (Austria) – Lombardia (Italy)	34,361	29,759	758
Cataluña (Spain) – Île de France (France)	34,328	29,731	964
Nyugat-Dunántúl (Hungary) – Lombardia (Italy)	26,505	22,956,	755
Zuid-Holland (Netherlands) – Denmark (this is 1 region)	25,992	22,511	845

Table A.XI.7: Top 10 international traffic relations (NUTS 2 level), based on estimated transported agricultural (NST1) time sensitive LDHV goods by road over distances longer than 700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Düsseldorf(Germany) – Denmark (this is 1 region)	81,424	51,138	759
Île de France (France) – Cataluña (Spain)	78,309	49,181	964
Denmark (this is 1 region) – Lombardia (Italy)	77,137	48,445	1,492
Cataluña (Spain) – Pays de la Loire (France)	76,040	47,757	858
Cataluña (Spain) – Nord - Pas-de-Calais (France)	69,224	43,476	1,172

Table A.XI.8: Top 10 international traffic relations (NUTS 2 level), based on estimated transported metal (NST5) time sensitive LDHV goods by road over distances longer than 700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Lombardia (Italy) – Arnsberg (Germany)	64,391	23,702	860
Etelä-Suomi (Finland) – Östra Mellansverige (Sweden)	47,035	17,313	1,759
Arnsberg (Germany) – Lombardia (Italy)	42,474	15,634	857
Lorraine (France) – Lombardia (Italy)	42,169	15,522	788
Oberösterreich (Austria)– Arnsberg (Germany)	41,865	15,410	706

Table A.XI.9: Top 10 international traffic relations (NUTS 2 level), based on estimated transported chemical (NST8) time sensitive LDHV goods by road over distances longer than 700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Antwerpen (Belgium) – Alsace (France)	111,188	26,410	763
Cataluña (Spain) – Lombardia (Italy)	93,815	22,283	987
Centro (PT)(Portugal) – Cataluña (Spain)	79,419	18,864	1,020
Düsseldorf(Germany) – Denmark (this is 1 region)	77,401	18,384	760
Cataluña (Spain) – Centro (PT)(Portugal)	73,639	17,491	1,019

Table A.XI.10: Top 10 international traffic relations (NUTS 2 level), based on estimated transported miscellaneous/container (NST9) time sensitive LDHV goods by road over distances longer than 700 km in 2009

Relation	Value in million Euros	Tonnage transported by road	Average distance (in km)
Lombardia (Italy) – Île de France (France)	1,112,263	222,642	871
Lombardia (Italy) – Cataluña (Spain)	934,298	187,018	986
Pais Vasco (Spain) – Île de France (France)	874,893	175,127	902
Lombardia (Italy) – Nord - Pas-de-Calais (France)	777,980	155,728	1,058
Norra Mellansverige (Sweden) – Denmark (this is 1 region)	747,719	149,671	906