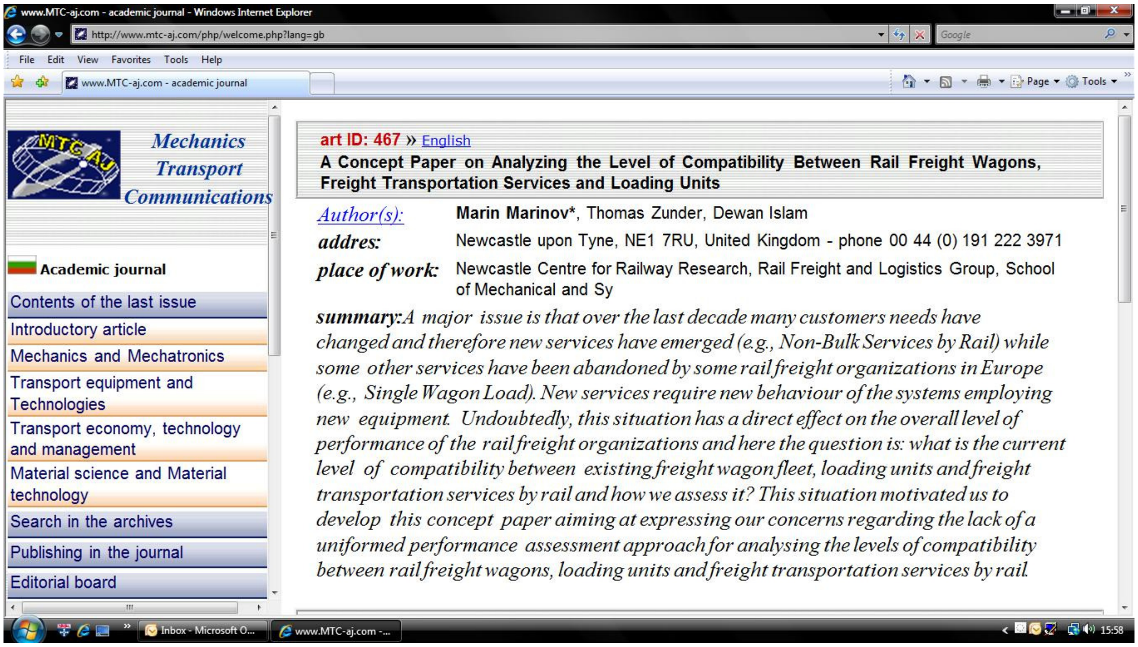


# A CONCEPT PAPER ON ANALYZING THE LEVEL OF COMPATIBILITY BETWEEN RAIL FREIGHT WAGONS, FREIGHT TRANSPORTATION SERVICES AND LOADING UNITS

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***Key words:*** *Rail Freight Systems, Rail Freight Wagons, Loading Units, Rail Freight Transportation Services, Performance Assessment*

***Summary:*** *A major issue is that over the last decade many customers needs have changed and therefore new services have emerged (e.g., Non-Bulk Services by Rail) while some other services have been abandoned by some rail freight organizations in Europe (e.g., Single Wagon Load). New services require new behaviour of the systems employing new equipment. Undoubtedly, this situation has a direct effect on the overall level of performance of the rail freight organizations and here the question is: what is the current level of compatibility between existing freight wagon fleet, loading units and freight transportation services by rail and how we assess it? This situation motivated us to develop this concept*

*paper aiming at expressing our concerns regarding the lack of a uniformed performance assessment approach for analysing the levels of compatibility between rail freight wagons, loading units and freight transportation services by rail.*

## 1. Introduction

From a customer perspective, it is of great importance that each rail freight operator is able to offer freight wagons that are suitable and adaptable for the customers' requirements and needs; freight wagons that are explicitly designed and produced for customising transport solutions and transportation of particular products. From an operator perspective, to some extent this situation has a negative effect on the inventory and therefore there is a large variety of freight wagons types in existence, many with specialized functions that are not interchangeable staying idle for the majority of the year.

On the one hand, in order to succeed the rail freight wagons manufacturers, the railway freight operators have to be successful. On the other hand, the railway freight operators have to recognise the real need for better customer focus and efficiency in the service provided.

Either way, within the context of open access in the rail sector in Europe, it is critical for the rail freight operators to operate with flexible, compact and, to the extent possible, interchangeable freight wagon fleets being able to satisfy the specific needs of all the market segments.

A major issue is that over the last decade many customers needs have changed and therefore new services have emerged, e.g., *Non-Bulk Services* by Rail (Marinov and White 2009) while some other services have been abandoned by some rail freight organizations in Europe e.g., *Single Wagon Load*. New services require new behaviour of the systems employing new equipment. Undoubtedly, this situation has a direct effect on the overall level of performance of the rail freight organizations and we shall put the following question for discussion here: *"What is the current level of compatibility between existing freight wagon fleet, loading units and freight transportation services by rail and how we assess it?"* This situation motivated us to develop this concept paper aiming at expressing our concerns regarding the lack of a uniformed performance assessment approach for analysing the level of compatibility between rail freight wagons, loading units and freight transportation services by rail.

Let us be reminded that in operating processes with freight wagons the following critical issues always remain certain:

- reduce costs.
- improve efficiency.
- increase availability.
- ensure high use of technology.
- good ability to work with clients in providing the service.
- ensure high level of customer satisfaction.

However, there are many situations in which rail freight operators incur a significant amount of costs because of unutilized inventory. In terms of seasonal traffic, for instance, such as cereals and other agricultural products for the majority of the year the freight wagons specialized for transporting these freights practically stay idle, which is quite costly for the company. It once again demonstrates that it is critical for the rail freight operators to operate with flexible, compact and, to the extent possible, interchangeable freight wagon fleet able to satisfy the specific needs of all the market segments.

Next, looking at the equipment and main actors involved, namely Rail Freight Wagon Manufacturers, Railway Freight Operators and Customers other questions arise such as: what is the current situation in the European market for rail freight equipment? What is the market position of the Rail Freight Wagon Manufacturers? And should there be any difference between small and big Rail Freight Wagon Manufacturers within the context of open access and vertical disintegration in the European rail sector? Such questions we discuss next.

## 2. The European Market for Rail Freight Equipment

Before proceeding, it is worth listing a few citations, as follows:

> *... the European market for freight equipment has been in decline for several years, there has been little technical development, and the number of manufacturers has grown since the fall of the iron curtain a decade ago. But, when you dig a little deeper, you quickly discover that things are changing and there is considerable potential for growth and a much-needed injection of modem technology and thinking* (Briginshaw 2001, pp. 1).

> *Dipl-Ing Albert Hartmann, who was recently appointed vice-president, marketing and sales, with Thrall Europa, described his assessment of the European freight wagon market to IRJ: "There were about 2 million freight wagons in Europe in 1980. The fleet is now down to about 1 million, but some of these wagons are idle. The average age is high--more than 20 years. Between 12,000 and 14,000 wagons are produced in Europe each year. "If nothing is done to improve rail competitiveness, the size of the fleet will fall to about 700,000 wagons in the long term. However, if you say the average life of a freight wagon is 25 to 30 years, then Europe will need 25,000 wagons a year. But if rail freight gets a boost politically, the railways start to work together, and others enter the market through open access, then traffic will increase. The signs are that there will be growth, so the need for new wagons will also grow.*

> *"Pipelines, shipping, and rail in Europe have all been static, whereas road has absorbed all the growth in freight traffic. Now, just-in-time doesn't work anymore because of road congestion,...* so other alternatives are of great interest today.

> Offices and workshops have been established by American wagon manufacturers in Europe. They believe ... *there is potential in Eastern Europe for supplying new wagons and re-engineering existing ones as these countries start to join the European Union and rail privatisation begins* ... (Briginshaw 2001, pp. 4).

On the other hand, a major driver is the European Union directives aimed at rail such as the creation of freight freeways and the right to free access which will drive growth. The rail freight systems have a significant support from governments and environmentalists and it shall play an important role for their further development.

New freight transportation services by rail have occurred and the question is whether the existing rail freight wagon fleet is compatible with the freight being transported and the adopted loading (transport) units. This situation motivated us to research this issue.

Next in studying the rail freight wagon market in Europe a number of critical factors should be considered as follows:

- What is the market demand and what are the specific cargoes like steel coils, finished cars, cereals and other aggregates that require specialized rail freight wagons designed for transporting a specific cargo category only (meaning they cannot be used for transporting different cargoes, i.e. they are interchangeable)
- Are there a significant amount of products that require refrigerated wagons or cistern wagons?
- What is the freight that can be transported on interchangeable rail freight wagons? What is the amount of general palletised and non-palletised ambient freights and how these freights are transported and what are the rail freight interchangeable wagons used in providing these services?
- What are the technical characteristics of the railway freight network? What are the technical restrictions? What category rail freight wagons and transport unites (intermodal containers, swap-bodies, others) can be accommodated on the rail freight network? What is the maximum capacity? What is the size of the freight wagons that can be accommodated on particular routes?
- What are the types/categories of rail freight wagons available in, say, EU countries for carrying transport/intermodal units?
- How the same types of transport/intermodal units are transported in, say, EU countries? What are the usual practices and what are the differences?
- Overall, what is the level of compatibility between freight wagons, Freight Categories and Transport/Intermodal Units in EU countries?
- In general, what the European market requires?: - Freight wagons with <u>greater</u> axle-loads or Freight wagons with <u>less</u> axle-loads?
- What is the political and economic climate for producing freight wagons and of what type should the freight wagons be?
- What is the marketing strategy of the freight wagon manufacturer? Has the manufacturer got it right?

- Do the manufacturers need to set up priorities and develop a portfolio of freight wagons according to the European market requirements? How should this portfolio look like?

It is worth noting that the whole process of producing freight cars that satisfy the European market is very time consuming and requires constant market analyses, close work with the rail freight operators and their clients, constant innovation for product development and new technologies. The whole process is capital intensive which requires a huge investment. Big manufacturers as Alstom e.g. are able to handle this process over time. However, it might be very tricky for smaller manufacturers to handle such a process if they do not have a unique product to sell, a product that would guarantee a minimum market share, critical for existence.

Generally speaking, it appears that, there are not many studies on rail freight wagon market in Europe. According to the best of our knowledge UIC conducts such analyses. In (Bergendorff 2004, p. 43) summary of the existing fleet in EU-rail-27 is reported. The current figures are as follows:

- The present fleet in EU-railway-27 consists of 825 000 vehicles.
- Around 30% of these are 2 axle wagons.
- The vast majority of these vehicles have an annual mileage between 10 000 and 30 000 km.
- Almost half of the fleet consist of flat wagons.
- There are about 10% of the wagons older than 30 year.
- Most of the wagons are between 10 and 20 years old.

Before to conclude, interesting issue to consider is that the estimated utilisation of the rail vehicle (freight wagons) fleet in EU 15 is between 11% and 25% at actual production level of approximately 232 billion tonnes km per year. This but of course demonstrates that expansion of the current rail freight fleet in Europe is not at all needed. Instead the rail freight operators need to focus on how they could improve the level of efficiency of their operating vehicle fleets including as well the issue of what is the level of compatibility between their available fleet, the loading units and the services that they do provide.

## 3. Types of Rail Freight Wagons

Many different types of rail freight wagons exist. The rail freight wagon fleet is very diverse. Let us have a quick look at rail freight wagon types, as follows:

**1. Open freight wagons** /gondolas - the international standard types are:

- Open freight wagons of standard design (UIC Class **E**) with at least 85 cm high walls, with side-doors, and without self-discharging equipment.
- Open freight wagons of special design (UIC Class **F**) – especially self-discharging wagons.

**2. Covered freight wagons or vans** / covered boxcars - have a fixed roof, with sliding doors, are mainly used for the transportation of part-load freight or parcels/pallets. Further, these are divided into:

- Ordinary classes (UIC Class **G**).
- Special classes (UIC Class **H**), which are often distinguished by their large loading volumes.

**3. Refrigerated vans** (Class **I** freight wagons), also known as *T* wagons (T comes from "Thermos") in some countries, are insulated covered vans, which are either cooled like conventional refrigerated vans by a cooling medium such as water or dry ice, or are machine-cooled wagons with their own cooling system.

**4. Flat freight wagons** /flat bed wagons - have no walls or low walls no higher than 60 cm. These are UIC Classes **K** (standard) or **L** (special), bogie wagons of UIC Classes **R** (standard) or **S** (special).

**5. Freight wagons with a sliding roof** (UIC Class **T**) either have a flat wagon floor or equipment for self-discharging.

**6. The special freight wagons of UIC** Class **U** include powder wagons and low-loading freight wagons.

**7. Tank wagons** (UIC Class **Z**) are suitable for a wide variety of fluids and gases.

**8. Freight wagons** for special purposes include:

- Works wagons are used by railway administrations exclusively for their own internal works purposes (such as the slag wagons of Class X in Germany which were mainly based on old open freight wagons of Class O)
- Ferry wagons with smaller loading gauges for traffic travelling to Great Britain, which were designated with a lower case letter *f*.
- The rarely mixed open flat wagons of UIC Class **O**, which are equipped with folding sides or stakes and can be used either as flats or as open freight wagons.

**9. Railway post vans** are also freight wagons.

**10. Modern Freight Wagons** (new generation freight wagons) specialized for handling "*Paper Rolls and Recycled Fibre"* - Green Cargo case, 2002, Sweden-wagon supplier: K Industrier in Malmö, Sweden.

**11. Specialized Freight Wagons**

- Wagons specialised for transportation of steel sheets.
- Wagons specialized for timber transports within the forest industry.
- Wagons with axle-motion bogies.
- A 90 or 102-tonne side tipper wagon, which can discharge 30 tonnes in just 5 seconds, manufacturer: Thrall.

- Container Flat Wagons (towards 60 ft).
- Coil Wagons (towards 25-tonne axle-loads) - because the steel industry is quite active again.
- Side tripping ballast wagons.

Recalling the foregoing types of freight wagons, one could conclude that the different types of freight wagons have been manufactured for the transportation of specific types of freight as the demand for such services has been influencing the market over the years. At this stage one may doubt, however, whether or not a type or a few types of freight wagons have been manufactured explicitly with the purpose of producing a freight wagon type that is interchangeable and can be used for the transportation of different types of freight.

## 4. Customers and Operating Forms

It has been already regarded in Marinov and White (2009) that the freight transportation services by rail should be categorized according to the type of *Customer* being served and according to the type of *Operating Form* being exercised.

The customers are classified as Bulk Customers and as Non-Bulk Customers. The Bulk Customers are further distinguished into Customers that require to transport *Primary Products* such as: Aggregates, Iron, Ore, Coal, Agricultural, Forestry Products, Sand, Petrochemicals and Customers that require to transport Manufactured Products such as: Cement, Processed Metals, Construction Materials, Nuclear Waste, Waste Products, Steel, Automobiles.

The Non-Bulk Customers are those that require the transportation of *Consumer Goods, Manufacturers, Retailers* as well as *Containers*.

The operating forms are subordinated to the Structure of Service being exercised. Structures of service can be:

- Hub and Spoke Structure – employed by rail freight systems[1] in which freight trains run according to classification (marshalling) yards of bigger dimensions. Demand origins and destinations are assigned to the classification yards over the railway network. Normally, there is one classification yard per region and all demand origins and destinations within this region are assigned to this yard. And there are daily freight trains between the classification yard and its demand origins and destinations as well as there are daily freight trains between the classification yards in the railway network;
- Point to Point Structure – typically exercised by truck systems, the point-to-point structure enables a greater number of routes over the network but some routes may have a low frequency of service, which is quite likely. Hub-and-Spoke structure is a mutation of the point-to-point structure and concentrates the movement on a lesser number of routes but the frequency of service is higher, thus minimizing time between most demand origins and destinations;

[1] Also successfully practised in the maritime and airline businesses for a long time service, namely by the dominant players who are thus able to serve many O/D pairs with greater productive efficiency.

- Collection and Distribution Structure – broadly spread among the freight transport modes focusing on the transshipment from one mode to another providing local solutions for "How to collect and How to distribute" the freight.

Relying on definitions provided by Ballis and Golias (2004, pp. 422 - 423), rail operating forms are introduced next, as follows (refer also to Figure 1):

- Direct trains - run between two terminals without handling on the way and are the most economic and rapid operating rail mode known today;
- Block trains are direct trains by nature and the number of freight cars that they carry in their compositions vary according to the daily demand for transport;
- Shuttle trains are direct trains too; however they are characterized with fixed composition seen in number of freight cars. The shuttle trains do not bear coupling/uncoupling services at terminals or yards;
- Group trains or feeder trains aim to link terminals of a region through—short—feeder links and fulfil the long distance transport in a complete train. Feeder trains are run in serving less-than-trainload (LTL) flows;
- Liner trains or multi-stopping trains are seen today as compositions which are loaded and unloaded and freight cars are coupled and uncoupled during the stops in way stations on their route. The number of freight cars in the multi-stopping train can be fixed, but this is not compulsory.

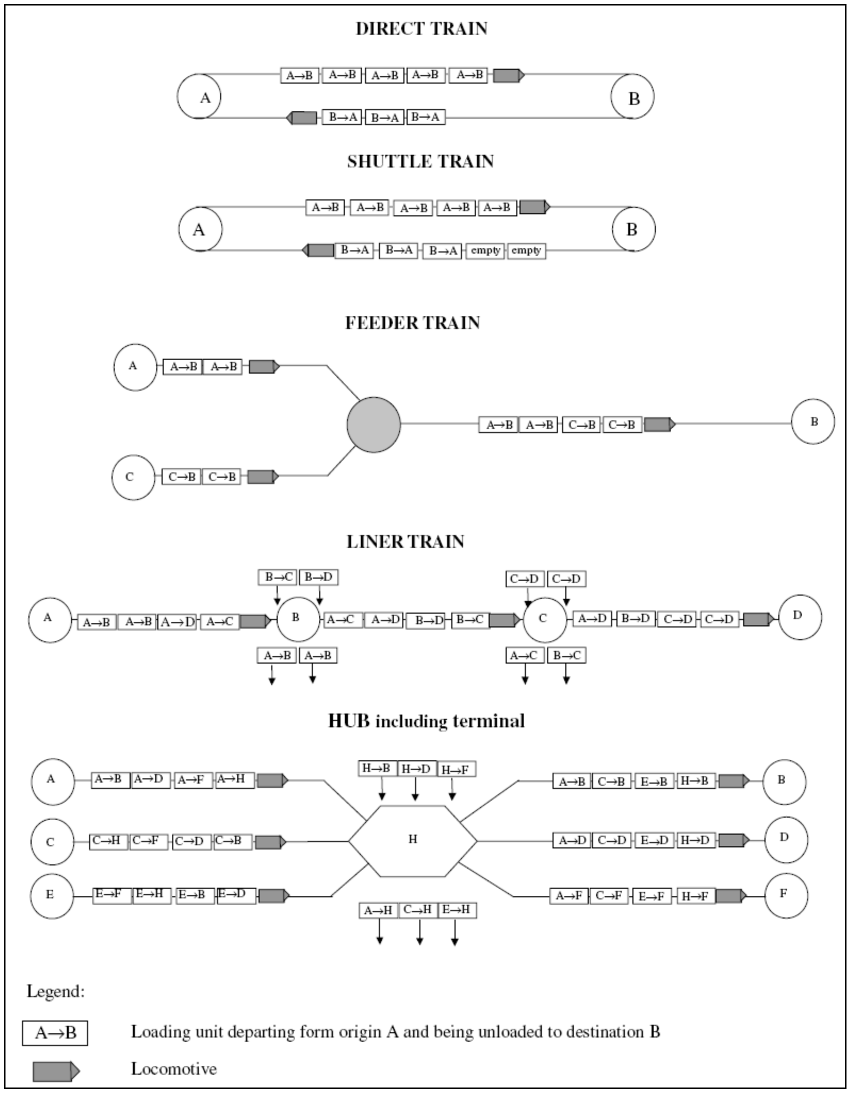


**Fig.1** Alternative Rail Operating Forms

Source: Ballis and Golias (2004, pp. 422); used by Marinov and White (2009, pp.14)

According to the official statistics of the EC for the last decades (Eurostat 2008), it appears that the freight transport markets of today suggest that traditional rail freight systems such as *Bulk Customers* mainly served by *Multi-stopping* and *Feeder trains* on *Hub and Spoke* principles deal with low level of reliability because of delays in the service provided and therefore are considered obsolete to a certain extent. New / alternative rail operating forms ought to be exercised and implemented in the future, starting from today as e.g. *Rotterdam* and *Genoa* rail corridor suggests: "*traffic performance has increased in recent years from around 5% to 10%. This growth has been realised mainly due to block train/shuttle train activities where the new entry of railway undertakings has so far been the strongest*". Source: http://ec.europa.eu/transport/rail/market/freight_en.htm , consulted on Nov., 5, 2008). It would be foreseen that Direct, Block and Shuttle trains running on rail corridors dedicated to freight serving more and more Non-Bulk Customers will become traditional operating forms of European Rail Freight Systems in the future and it appeas to be a good starting point towards analysing the level of compatibility between freight wagons, units and services.

## 5. Type of Services and Loading Units

Today the concept is that all freight transportation services provided by rail should be configured to meet the needs of any customer. Depending on how a given service is configured, it can be provided by a single, or combination of rail freight operators. There are different types of services each of which has its specificities. For instance, there can be services for one customer or for many customer, scheduled or unscheduled, operate on one route or on many routes, heterogeneous traffic, one type of loading units or homogeneous traffic, many types of loading units. Therefore, the types of services being provided by rail can be categorized as follows:

**Service for a single customer:**

- Services for a single customer that operate on one route, homogeneous traffic, one type of loading units, unscheduled;
- Services for a single customer that operate on one route, homogeneous traffic, one type of loading units, scheduled;
- Services for a single customer that operate on one route, heterogeneous traffic, many types of loading units, unscheduled;
- Services for a single customer that operate on one route, heterogeneous traffic, many types of loading units, scheduled;
- Services for a single customer that operate on set routes homogeneous traffic, one type of loading units, unscheduled;
- Services for a single customer that operate on set routes, homogeneous traffic, one type of loading units, scheduled;
- Services for a single customer that operate on set routes, heterogeneous traffic, many types of loading units, unscheduled;
- Services for a single customer that operate on set routes, heterogeneous traffic, many types of loading units, scheduled.

**Services for two or more (many) customers:**

- Services for two or more (many) customers that operate on one route, homogeneous traffic, one type of loading units, unscheduled;
- Services for two or more (many) customers that operate on one route, homogeneous traffic, one type of loading units, scheduled;
- Services for two or more (many) customers that operate on one route, heterogeneous traffic, many types of loading units, unscheduled;
- Services for two or more (many) customers that operate on one route, heterogeneous traffic, many types of loading units, scheduled;
- Services for two or more (many) customers that operate on set routes homogeneous traffic, one type of loading units, unscheduled;

- Services for two or more (many) customers that operate on set routes, homogeneous traffic, one type of loading units, scheduled;
- Services for two or more (many) customers that operate on set routes, heterogeneous traffic, many types of loading units, unscheduled;
- Services for two or more (many) customers that operate on set routes, heterogeneous traffic, many types of loading units, scheduled.

Further to the types of services, consider:

**Bulk markets:**, one to one relationship between customer and operator, on full train/load volumes also known as traditional model. This type of service appears to be ideal for the freight railways, because:

> *"The one to one relationship between customer and service provider allows for flexibility in service and optimisation of routing, pathing and timings. The full train nature of hauling similar products on single routes allows for development of more suitable wagon equipment to better facilitate loading and unloading requirements". (...*consulted on 22nd October 2009, available at: *http://www.railfreightonline.com/guide/making/types/)*

**Less than trainload network services**: this type of service operates usually on fixed schedules over a network that consists of many *hubs*, demand origins and destinations. The advantages of this type of service are that:

- It accommodates a variety of traffic types, connecting between a wide range of different terminals;
- The operation with the freight trains over the network is predictable;
- The system operates on schedules, which offers a certain level of flexibility to the customer;
- The service is customer-oriented;
- Because of the scheduled operation employed the operator experiences better utilization of its resources (crews and road locomotives).

However, there is a disadvantage; the system does not utilize the maximum capacity of its freight trains subject to traction and network restrictions.

**Less than wagon load services**: this type of service operates with multi-stopping freight trains that have run and still run in some rail corporations on an improvised basis. In other words the operation of the multi-stopping trains is dictated by the number of slots available in the timetable of passenger trains where the line is used for mixed traffic (passengers and freight) and priority is given to the passenger trains. This is typical in Europe. There are efforts to run multi-stopping trains on fixed scheduled, where the model of operation is usually a regular timetabled departure on dedicated routes where capacity is marketed and sold on a wagon or less than wagonload (pallet) basis, often through third party logistics companies. This concept is new and one cannot judge yet how well such operators and logistics companies are doing.

**Intermodal services by freight rail:** when scheduled these types of services have the advantage of scheduled routes, timings and pathways leading to good reliability and predictability. They generally serve the major intermodal container hubs from the ports with trainloads being consolidated by the freight operating company. Recent developments have seen major shipping lines take a greater interest in rail, procuring their own services on a haulage only basis and taking the risk on filling capacity with their own volumes and marketing spare capacity to others. Further, within intermodal services by rail freight the concept of Green Corridor holds.

The Green Corridors are characterized with a concentration of freight traffic between major hubs and also with relatively long distance of transportation. Green Corridors are envisaged, in all ways, to be environmentally-friendly, safe and secure as well as highly efficient. Advanced technologies (such as: smart ICT, information flows, e-freight, supply chain management, smarter planning and monitoring, scheduling, tracking and tracing), where implemented, and their smart utilisation improve significantly the level of performance of the entire green corridor. The environmental orientation of the freight transport modes is diverse in terms of energy consumption, emissions, noise, etc. However, when these modes are combined in a practical smart way to form co-/inter-/multi-modal freight transport and logistics chains, then the overall scenario for the environment may change significantly. Therefore, the role of each transport mode for freight that operates in a Green Corridor should be well specified and justified. And as further research avenues, we shall focus our attention on development and implementation of a consistent approach for analysing the level of compatibility between freight wagons, units and services within the concept of Green Corridor.

It would be of prime interest to also analyse and scrutinize streams, such as:

- Benefits of Automatic Couplers (the interested reader is advise to consult: http://www.ba-bautzen.de/wirtschaftssenioren/amk/amkenglish/index.html , accessed on the 30th October 2009)
- Trucks on Rails (CARGOSPEED: http://www.cargospeed.net/ , accessed on the 30th October 2009)
- Double-Stack Container Wagons - well-type freight cars (Kumar 2006)

Last but not least, **High-speed rail freight services:** these services require specific High-Speed Track, Freight Wagons /Rolling Stock for High Speed Rail Freight, which is quite expensive, however, there is a range of services already in operation, including a fast parcel network and a high-speed intermodal service. For instance, the postal TGV trains of Fret GV in France. The interested reader is encouraged to consult the official web site of Fret GV: http://fret.sncf.com/fret/580-high_speed_freight.html , accessed on January, 23rd, 2009.

> The 2008 - 2015 vision of Fret GV is to operate "*on the Paris – Mâcon - Cavaillon line, with a processing capability of 60,000 tons, that is, 2000 trains per year, of mail and express parcels. On track for 2010 with the opening of new terminals in Lyon and Marseille, 2 additional Freight TGVs a day are planned to be available on this route.*"

Therefore, it might be of interest to scrutinize a concept of "High Speed Green Corridor in the coming future.

## 6. A Concept for Analysing the Level of Compatibility between Freight Wagons, Loading Units and Freight Services by Rail

Analysing the level of compatibility between freight wagons, loading units and freight services by rail is a multi-factorial task, meaning it involves several factors. Therefore, we immediately encounter a problem familiar to many complex systems, where in order to estimate correctly the level of performances we need to take account of many factors – production; type of freight traffic, type of freight wagons available, type of loading units, type of services required, competition, traffic rules, infrastructure and network (corridor) restrictions, profit and costs, etc,... - whilst at the same time presenting an overall picture. It is worth mentioning that what we are generally interested is the overall picture. Unclear as to how to present the overall picture, however, usually one generates different indicators of performance each based on two simple factors, such as: profit per a certain period of time; profit per freight wagon fleet; profit per cost adjusted to competition; cost per type of service; production per freight wagon. Next, one ranks rail freight systems according to each of the indicators and compare the rankings.

Different indicators present different pictures. Whilst a few systems may have considerably high rankings and a few may have considerably low rankings, the majority exhibit considerable variation depending on the indicators chosen. In such an awkward situation the results become even more unclear and one can speculate easily. Therefore it becomes essential to identify and take into account all possible factors. Also one should clearly distinguish internal factors from external factors. Normally, external factors cannot be changed and they are taken for granted. Next to consider is that measuring system performance alone usually gives unclear indication of realistic targets. Whatever target is set, there is still the question of what efforts and resources are needed to achieve it. Therefore, it might be of interest to observe and analyse similar freight systems that have similar structures, dimensions, core business and objectives. For such purposes comparisons analyses may come into play. However, there is always a problem to face: to collect and analyse the data in depth in order to understand the underlying relationships but at the same time present an overall picture. On the other hand, when it comes to analyse the data there will often be a requirement for a variety of techniques rather than just one that is pre-eminently suitable.

When we wish to analyse freight systems and solve multi-factorial tasks such as: analysing the level of compatibility between freight wagons, loading units and freight services by rail, firstly we wish to indentify: *What would it be nice to know*?, secondly we wish to understand: *How well are the freight systems doing*?, and thirdly we wish to advise on: *How much better could the freight systems do*? To answer these three simple questions at first glance, a powerful technique is needed that would be able to provide a more comprehensive insight into how well a rail freight system is actually performing.

Since we wish to understand: how well are the rail freight systems doing?, we wish to identify their production functions. However, in many cases there are no known forms for the production function and therefore we shall make no assumptions about the form of the production functions. Instead, we shall try to build an empirical best practice production function from observed (collected or available) inputs and outputs. This shall necessarily be piecewise linear and as such should be an approximation to the real production function of the rail freight systems in question. Further to this, we wish to analyse the level of compatibility between freight wagons, loading units and freight services by rail which requires technological data on the micro level of performance. Therefore, for our purposes a parameter-free approach for production analyses based on technical information on the micro level of performance is required and this is where we research further.

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