VIENNA 2018 TRA TRANSPORT RESEARCH ARENA
A digital era for transport
solutions for society, economy and environment

Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

Rail freight research: How market trends and customers' needs drive technology innovation

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Abstract

The article presents an investigation of current market trends and customers' requirements, which have driven research aimed at developing a novel wagon concept that integrates innovative solutions relating to the identified major challenges for the freight vehicles of the future. These challenges are: *i. Freight condition monitoring; ii. Lightweight wagon design; and iii. Predictive maintenance.* This research was initiated by the INNOWAG project, which is funded by the Shift2Rail Joint Undertaking under the EU's Horizon 2020 research and innovation programme.
The major challenges in rail freight competitiveness relate to the increasing complexity and sophistication of supply chains, increasing transport capacity and logistic capability, as well as improving RAMS and lowering LCC. Therefore, the goal is to develop intelligent cargo monitoring and predictive maintenance solutions integrated on a novel concept of lightweight wagon.

Keywords: rail freight; market drivers; market trends; rail research; innovation.

Nomenclature

B2B	Business to Business
B2C	Business to Consumer
CBM	Condition Based Maintenance
C-ITS	Cooperative Intelligent Transport Systems
EC	European Commission
ERTMS	European Rail Traffic Management System
EU	European Union
ICT	Information and Communications Technology
LCC	Life Cycle Cost
LDHV	Low Density High Value goods
NST/R	The Standard goods classification for transport statistics/ Revised
OSS	Ones Stop Shop
RAMS	Reliability, Availability, Maintainability and Safety
Shift2Rail	The rail research joint undertaking within the Horizon 2020 framework
SPC	Single Point of Contact
TEN-T	Trans-European Transport Networks

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1. Introduction

Effective innovation in transport industry focuses on themes that are driven by market trends and determined by specific customers' requirements. External drivers of change such as economics, changing demographics, regulation, flexibility, environment impact protection, mobility and ICT evolution impact the future of European railways by changing the transport and distribution paradigm. Internal drivers of change, which dictate the transport product offered by rail and affect the supply chain and customers' choices, include new needs, cost reduction, sustainability, simplification of operations, hardware and software technologies implemented into rolling stock and infrastructure. The rail industry of central Europe needs to expand its capacity for improving the quality of the service, and to respond to the societal needs for the reduction of the carbon footprint of transportation The rail challenge is to achieve in the medium-long term a better use of its infrastructure in order to attract a greater market share, and increase capacity.

Major challenges in rail freight competitiveness relate to the increasing complexity and sophistication of supply chains, increasing transport capacity and logistic capability, as well as improving RAMS and lowering LCC.
Innovative technologies have to respond to the drivers of change, so as to induce the desired shift to rail by increasing the rail market share on the accessible segments. The study focuses on three key innovations that were identified by the Shift2Rail Joint Undertaking and further funded for research. These are:

- A cargo condition monitoring system based on an autonomous self-powered wireless sensor network for cargo tracing and monitoring the condition of key parameters, responding thus to the customer requirement to track and trace both cargo and equipment in real-time;
- Novel wagon design, with improved payload-dead weight ratio and modular flexible design, to reduce costs through improved efficiency and utilisation; and
- Predictive models and maintenance procedures for selected components of rail freight vehicles (along with tools for assessing the impact on LCC), to reduce costs and to maximise the vehicles' productivity.

2. Freight market drivers

2.1. External freight market drivers

The innovation in transport industry focusses around themes that are driven by market trends and, in few cases, determined by specific customer requirements. Key mega-trends that will impact on freight mobility and European railway marketplace in the years to come were identified by previous research (Spider Plus, 2015) as: *economics, changing demographics, regulations, sustainability, mobility and ICT evolution*.

As a result of these external market drivers, the extension of the EU to 28 member states led to a chain of changes which influenced the freight market. Delocalisation took place with industrial production shifting to Eastern EU countries helped by elimination of trade restrictions, lower wages and continuing infrastructure upgrades. At the same time, the production delocalisation increased the differences in transport demand between the old and new member states, enlarging the freight distribution. The changes in the influences on major logistics trends between 2008 and 2015, according to the German companies surveyed, are shown in Fig. 1. Germany was selected as a benchmark in this research due to its geographical position, its links to China via both the Tran-Siberian and TransAsia and its economy which has a driving effect on Europe. At the same time, there has been an increase in total freight transportation in the EU, which is expected to continue, as shown in Fig. 2.

Both building of new vehicles and future infrastructure development play an important role in ensuring the attractiveness of business locations and their ability to support logistics. Although the rail freight transport volume is increasing substantially, the modal split stays more or less the same. The long-term sustainability of transport mobility and environmental considerations encourage a greater use of rail to reduce the carbon footprint of transportation. This situation indicates that rail freight must improve considerably its total performance. Within the EU 27, the modal split for rail freight in 2012 was 17.2 %. If this figure is compared with results achieved in other markets outside Europe, such as the USA, where the modal split is 43.3%, the huge unexploited potential of rail freight becomes evident. Although the USA market is not directly comparable to the European one because of different infrastructure and historical circumstance, the challenge for Europe is to achieve in the medium/long term a better use of its capillary infrastructure extracting from it a much higher degree of productivity and efficiency thereby achieving the objectives in the European Commission White Paper. In this respect, wagon designs and

technologies suitable for better serving the customers' needs are important for achieving the desired objectives of shifting cargo to rail from competing modes.

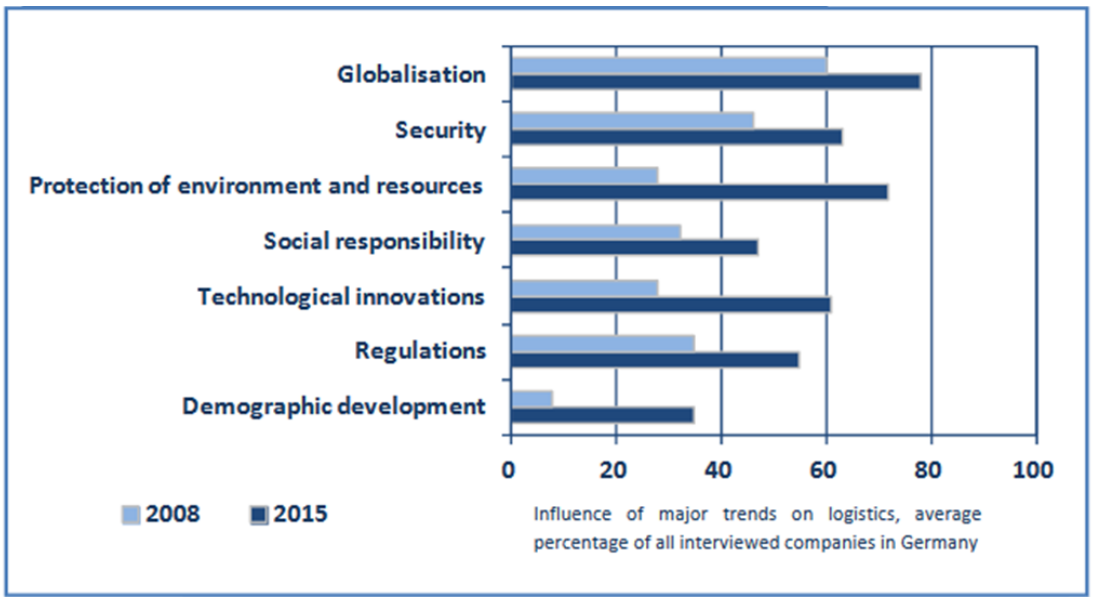

Fig. 1 Major trends in logistics, in Germany (König, R., Hecht, M., et al., 2012, from BVL study on trends and strategies in logistics)

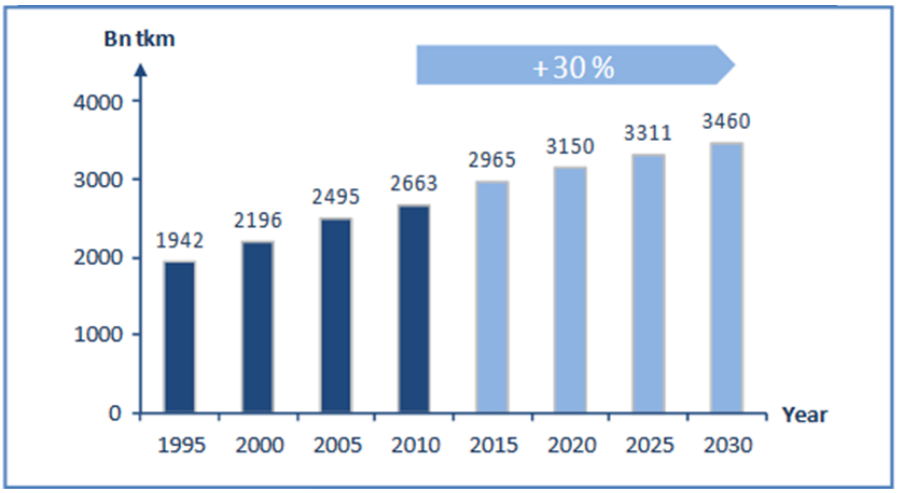

Fig. 2 Development of freight transport performance EU27 (König, R., Hecht, M., et al., 2012, from EU Commission/DG TREN: EU energy trends to 2030, update 2009, 2010 – baseline scenario)

2.2. Internal freight market drivers

The transport scenario for freight is evolving faster than anyone expected. Also, the organisation of transport on land does not benefit from the same economies of scale generated at Sea. Rail freight rejuvenation passes through the adoption of clear strategic choices where customer needs-services, cost reduction, sustainability, simplification of operations and transport, technology utilisation are the major drivers of change. Additional transport capacity is needed immediately, however significant improvements in rail infrastructure, particularly the building of new routes have a long delivery time and are very expensive. This implies that the rail system must find a way to transport more cargo with the available infrastructure; one way to achieve this is rolling stock modernisation and improved technologies and operations to better manage the rail freight transport.

Customers' needs and demand for services

Customers' needs and demand for services are driven by supply chain requirements. Managing global supply chains over time has become longer and more complex. The value of the products transported is influenced by time and distances, which affect their availability at the time and the location required. The service offered must be tangible and available for the customers to purchase them. This is the offer-driven approach which rail freight has failed to exploit. Logistics services imply real time information availability and direct connectivity for tracking and tracing cargo during transit. This is fundamental both for managing the corporations' traffic flows but also for preparing the emergency response in case of need. Rail freight has not been a frontrunner in introducing and applying the ICT and Cooperative Intelligent Transport Systems technology and data management tools for providing these services. These technologies are connected to the hardware applied to equipment, trains and wagons capable of monitoring in real time the cargo conditions, the wagons position and their running performances with additional potential indirect benefits from improved vehicle maintenance programs.

Other important requirements of the customer services are cost competitiveness, tariff transparency, accessibility, One Stop Shop (OSS) or Single Point of Contact (SPC), service/product branding, service segmentation, market orientation, e-freight, Business to Business (B2B) and Business to Consumer (B2C). The cost itself has significance when combined with the service quality provided and the customers' expectations. To this effect, service segmentation is very important for delivering to the customer a cost which is linked to the service level (Spectrum project). In a modern service driven society, efficient timetabling is essential since it will satisfy a basic requirement for managing time by the user. This is even more important for freight which must satisfy production lines, high street markets, and final consumers. Rail freight has not managed yet to provide a satisfactory answer to this market requirement. In the past, rail freight was transporting raw materials and basic commodities; the market has moved towards the satisfaction of more sophisticated consumer needs which has produced a substantial modification of the goods to be transported, involving services' categorisation and speed of information. Traditional rail services have been very slow to respond to this market evolution whilst companies carrying intermodal freight by rail have been somewhat more responsive to the customers' needs.

Cost reduction

The rail freight industry has neglected the fact that it is asset based. In order to fulfil the paradigm of transporting more with the available resources at substantially reduced costs, it should undertake the direction of managing longer, faster and heavier trains on existing infrastructure. The Marathon project proved this to be a realistic operational possibility implementable with a short lead time delivering cost reduction in the region of 30%. The rolling stock utilised for achieving the desired result was of the last generation. The logic prevailing in such an approach is guided by "capacity optimisation and capacity generation", being the driving force for cost reduction per unit transported.

One of the major advantages of rail freight on long hauls is the reduced cost per unit transported as the distance the freight is transported increases, whereas the road transport costs, which are primarily linked to fuel and drivers, has an opposite trend. Rail freight has a production cycle based on 24 hours round the clock and 365 working days per year allowing the exploitation of resources to the maximum time extension. The elements that in the past decades have contributed to interfering with the above basic philosophy are an inadequate modernisation of the wagon fleets which are generally more than 35 years old, no longer fulfilling the customers' needs. The inability to apply modular design, new construction methods and innovative materials towards standardised and more economic multi use wagons, generated and continues to generate high positioning costs, empty running and high maintenance. The management of the wagons fleets represents a critical issue. In particular, there needs to be greater development and implementation of more efficient maintenance processes for freight vehicles. These processes include intelligent systems capable of enabling predictive maintenance, such as diagnostic equipment, along with the development of tools for quantifying the benefits of applying predictive maintenance to various components to justify and encourage its adoption. Strategic choices and policy guidelines are the necessary ingredients for making predictive maintenance on various wagon components a realistic opportunity. Through long-term policies, the European Commission has imposed the implementation of the ERTMS system on 6 rail corridors. This advanced technology, in addition to improving considerably the safety aspects, will also produce an increase in capacity which will enable cost reductions through increased infrastructure productivity. The full effects of both the safety and economic aspects will be achieved in the third phase of implementation targeted at around 2030.

Sustainability

Rail freight is an environmentally friendly transport mode since it is more energy efficient per unit transported than other modes, thereby contributing to the reduction of the carbon footprint of freight transported by rail. This beneficial effect will be further increased when the various EU member States have a greater proportion of energy generated from renewable sources. Through the operation of longer, faster and heavier trains, substantial economic advantages can also be obtained. These factors make rail more sustainable over a long period of time. Trends towards improving sustainability are driven by economics and policies. Shifting to rail can assist in meeting these targets. EU policies are promoting modal shift to rail in an effort to re-balance the excessive dependence on road transport. Furthermore, in terms of accidents, rail is by far the safest transport mode.

Operations and transport simplification

In recent years, the diffusion of logistics and supply chain management, through freight villages, nodes, hubs and dry ports, has greatly increased and assumed a much greater relevance. The original concept of rail terminals has been greatly enlarged by having the objective of servicing a geographical cluster represented by traffic attractions zones. The maritime industry has largely decoupled cost from geographical distance by achieving economies of scale through the deployment of ultra large container vessels. The only way to achieve on land similar economies of scale is to utilise internal nodes connected by corridors, which are fulfilling the cargo bundling and the freight multiplier function into the clusters. Cargo bundling requires that the operators adopt a collaborative approach and by so doing minimise the costs and share the benefits. The increased services offered through the clusters provide wider accessibility to all transport modes enlarging considerably the competitive reach both for the consumers at large and for the industrial districts. The easy use of co-modal solutions together with the greater accessibility both physically and virtual through the internet, are leading to transport simplification. Rail freight by exploiting the nodes' capabilities combined with its extensive network, has a large role to play. The formidable development of B2B and B2C are a demonstration of this business evolution.

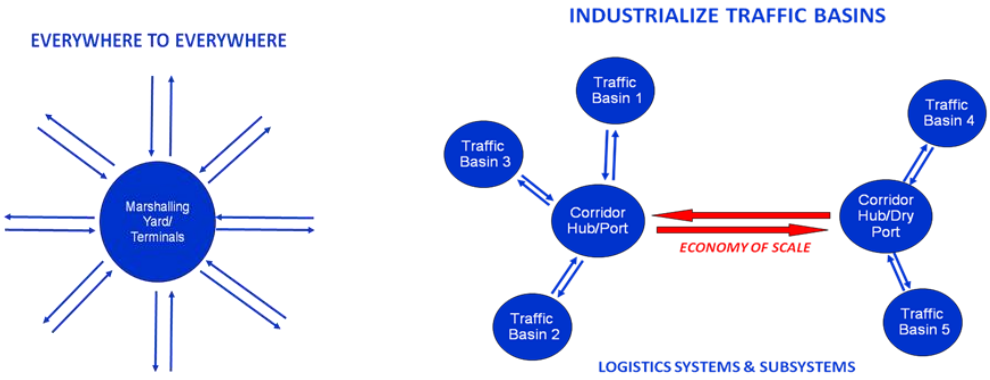

Fig. 3 Traffic industrialisation graphic impression for wagons load

Hardware/Software technologies applied to trains, wagons, rolling stock

The scope of the INNOWAG project is to consider the hardware and software technologies, together with the operative organisation involving connectivity, information and data process management, which can be applied to freight rolling stock to improve the service offer and reduce costs. Despite technologies being available, rail operators have not applied them extensively generating a gap that needs to be filled. Intelligent containers and sensors for cargo condition monitoring, integrated with monitoring systems which enable increases in wagons operating efficiency and equipment positioning, could be utilised as regular tools for improving services to customers and simplifying operations. It is anticipated that the use of wireless interfaces to communicate the data from these systems would be the most effective means of implementation, as this would be flexible and avoid the installation complexities and costs of wired communication systems. A representation of one potential configuration for communicating and centrally collecting freight and wagon condition data is shown in Fig. 4. The manoeuvring of wagons in terminals (freight nodes) for the formation of trains and positioning for loading and unloading remains an issue for rail freight; however, hybrid electric-diesel locomotives with the capability to operate without power from overhead electricity supplies (which is often not available in terminals) offer a

satisfactory solution.

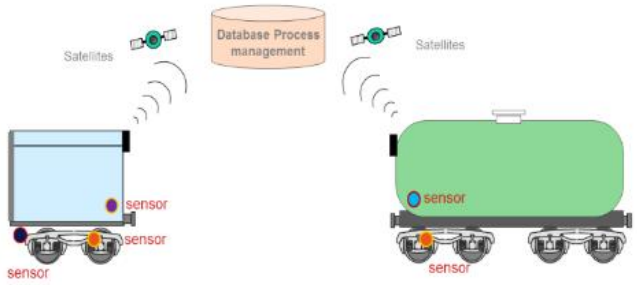

Fig. 4 Representation of sensors data management (Newopera re-elaboration from the Viwas project)

3. Trends and opportunities in railway freight market

3.1. Global Market Trends

A modern freight mobility concept must deal with the dimensions of environment, quality of life and economic sustainability. With regard to the environment, approximately 20% of total CO2 emissions come from the transport sector – with one third of this generated by road freight transport alone. More than 70% of total traffic depends on the availability of fossil fuels. Rail freight transport can substantially contribute to improving this situation. Decisions are already being taken to provide traction energy on electrified lines increasingly from renewable energy sources. The goal of the European Commission is to cut CO2 emissions in the transport sector by 20% by 2030 (compared to 2008) and by 60% by 2050 (compared to 1990) as well as to considerably reduce energy consumption.

Regarding the quality of life, noise emissions, transport congestion and accidents are the most relevant problems to be solved. Noise reduction has become a major challenge in order to satisfy the needs of the population living in the vicinity of rail tracks. Furthermore, minimising noise emissions is a pre-requisite for making new investments in rail more acceptable to the population at large. Data on the assumed cost of transport congestion expressed in billions of Euro have been elaborated by the European Commission. Likewise, despite the trend that road accidents have been on the decline for many years, the numbers in absolute terms are still unacceptable and this justifies the policies for shifting to rail the portion of the traffic carried by road.

Concerning Economic sustainability, freight wagons represent one of the central resource for achieving results. They are the tools for linking rail freight transport to logistics. Rail freight wagons are the core elements and equipment for putting together the services required by the customers. The rail freight network in its three components, TEN-T, core and comprehensive network has a capillary extension. The wagons are comparable to the trucks and when they respond to the new market needs they become acceptable and competitive. Moreover, due to the increased sophistication of supply chains, the logistics dimension becomes relevant. The wagons modernisation is part of this evolving process.

A study conducted by SCI (2017), assessed in detail 30 core markets and 8 world regions. It also analysed the main drivers of transport performance and points to the latest trends, including historical data since 2005 and forecasts of market development up to 2025. Overall, rail transport has had positive growth from 2005 to date. Although the rail freight segment has also been increasing, it has faced challenges in the recent past which has resulted in an absolute reduction in 2015.The main factors for rail freight growth are positive economic development linked to the political will to extend rail as a mode for rail freight transport and to implement new and improved rail infrastructure.

3.2. EU Market trends

Despite efforts by the EC to promote rail freight, market demands have led to an increase of road freight in the past two decades due to factors such as internationalisation, globalisation, online shopping, home delivery and

information systems. During the same period the share of rail freight has declined from 20.3% to 17.2%. Flexibility, reliability, customer tailored and door-to-door service characteristics are behind the successes in the road freight transport sector. There is, however, political will on the part of the EC demonstrated through the European Union (EU) Transport White Paper 2011 which has set targets to significantly increase the use of rail freight transport in the future. This is in recognition that within the freight transport domain, rail freight transport makes an important contribution to economic prosperity. Particularly, its perceived environmental friendliness and energy efficiency ensure that it is within the focus of policy makers who would like to see rail play a greater role in European transport than it currently does.

The evolving economic situation, transport business, and political directives within Europe generates a change in the rail transport market as the volumes and tendencies of rail freight transport in Germany are evidencing as shown in Fig. 5 below. The future of mobility-Scenarios for the year 2025 study indicates a change in the type and composition of transported goods from heavy bulk commodities that are well suited for rail transport, e.g. coal and ores, to more lightweight, high-value goods in smaller consignment volumes and requiring high quality services. This is consistent with the findings of the SPECTRUM project. The shares of the total goods transported were predicted to change from 40% individually packaged goods, and 53% bulk commodities in the year 2000, to 66% individually packaged goods and 27% bulk commodities by the year 2025, with the remaining 7% being made up of other goods types in both cases for.

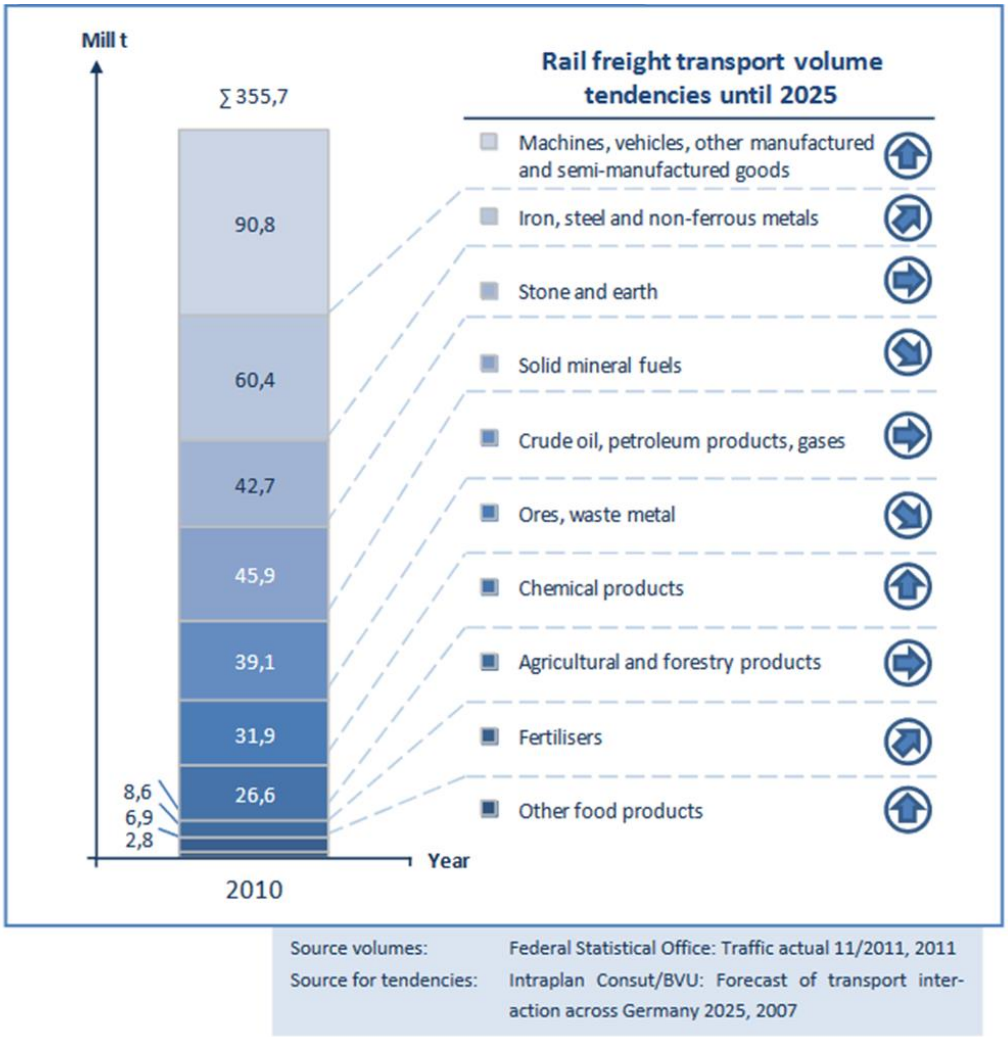

Fig. 5 Shares of rail freight volumes in Germany (König, R., Hecht, M., et al., 2012)

The EU 2011 White Paper on Transport set up a target of increasing rail freight to four times the 2010 levels by 2050. The service sophistication, widespread awareness of the environmental benefits delivered by the rail system,

the societal requirement of reducing the carbon footprint of freight transport and the TEN-T corridors implementation with the core and comprehensive network utilisation should permit the achievement of the ambitious White Paper targets for rail freight transport. The introduction of a new generation of rail freight wagons as outlined previously, constructed with new materials, and featuring innovative design and technologies to better suit the evolving market needs towards more sophisticated services required by the marketplace would contribute towards the achievement of these targets.

Freight vehicles

The market trends dictate that the wagon fleets' compositions, in terms of the proportion of each wagon type, should reflect the demand for the transportation of different types of commodities in order that the most effective investment in development of and procurement for the fleet wagon can be carried out. An analysis carried out by Islam et al. (2015) and D-Rail project (2012) show that three NST/R commodity types (crude, manufacturing and building materials; solid mineral fuels; and machinery and transport equipment) will be the most significant commodity types in 2050. This implies that open top wagons, flat wagons or covered wagons, and ordinary flat wagons would be the most demanded wagon types.

A study conducted as part of the EU Capacity for Rail project (C4R, 2017) showed that the most utilised freight wagon types are: Tank wagon; Ordinary flat wagons with bogies; and Special flat wagons with bogies. Also a study conducted through the SUSTRAIL Project (SUSTRAIL, 2011), indicated that flat wagons are increasingly being utilised in Europe. This trend is mainly due to their utilisation for intermodal freight and to the alternative freight loads (wood, steel, auto, etc.) offered by the special models. SUSTRAIL also noted that open high-sided wagons have the major share of freight in New Member States, but with a decreasing trend of their utilisation.

Clearly, flat wagons are leading the way in wagon utilisation, this finding is consistent with the outcomes of the market analysis conducted under the SPECTRUM Project (SPECTRUM, 2012), which also identified demand for lighter weight vehicles able to operate at higher speed in which would therefore have increase suitability for services aimed at LDHV goods. However improvements to the types of wagons aimed at the bulk cargos which railways are very effective at transporting should not be neglected in order to maintain and improve rails competitiveness in these markets.

The project CAPACITY4RAIL (C4R, 2017) has put forward an argument for a complete wagon redesign. For rail to be better for pallet, parcel and roll-cage movements, the key is the loading platform, with bogies/axles being of minor significance. A study conducted under the C4R project indicated that the greatest design opportunity to meet the market needs is lighter wagons with lower tare and higher payload, followed by the installation of detectors for predictive maintenance. This was closely followed by the need for a track friendly running gear to achieve higher axle loads and higher speeds whilst causing less track deterioration and wheel damage. Others are automatic couplers with an electrical connection, end of train device to reduce the duration of safety checks prior to departure and installation of electro-pneumatic brakes to allow for faster brake applications & support longer trains.

The SPECTRUM project also developed new technologies and service concepts aimed at improving the rail transport services in ways that would allow rail to enter market segments (particularly Low Density High Value LDHV goods) in which it could not compete with road transport using orthodox technology or business systems. Also, in those segments in which rail already has a share, but where it can improve its competitive position in the market (SPECTRUM, 2012). The greatest design opportunity lay in the design of a lightweight wagon for improved dynamic performance.

Although LDHV goods pose a great opportunity for promotion of a shift from road to rail, it is also key to remember that very heavy cargo cannot be economically transported by road. That is why projects such as the SUSTRAIL Project were advanced. In as much as the project indicated that (lower axle load) flat wagons are increasingly being utilised in Europe (SUSTRAIL, 2011), it also found that other types of wagons (some flat ones included), tended to carry high tonnage cargo. Subsequently, for these high-density goods (e.g. bulk and aggregates), there is a need to design wagons with higher axle load (25t to 30t). Inevitably, the new wagon solutions would have a tendency to be heavier, thereby increasing undesirable consequences such as impact on the infrastructure and noise. This presents an opportunity for development of innovative solutions; for example, for lightweighting and noise reduction. In addition, there could be a potential reduction in reliability from the maintenance point of view, in which case an opportunity exists for the assessment of application of condition based

maintenance (CBM).

From the wagon productivity perspective, current European wagon fleets are non-flexible. To improve the load factor and ultimately to achieve higher productivity, the development of flexible (e.g. modular) designs of wagons is expected to contribute to the solution of this problem by providing much greater flexibility (Islam et al, 2015). For example, such wagons could be used for a wide variety of commodity types ranging from bulk traffic to inter-modal with options to change the application through the life of the wagons. This would be an innovative step forward and the rail sector would be required to take radical steps in design and certification if it were to achieve such ambitious goals. However, modular design alone could incorporate a range of cargo loading/discharge options in terms of apertures/door designs and cargo loading/securing systems. Islam et al (2015) observe that commodity and application dependency needs to be considered as part of the design process to maximise commercial competitiveness. For safety and security, installation of monitoring system through 'tracking and tracing' would be a desirable feature increasing rail freight competitiveness.

The VIWAS project proved that the above desired flexibility can be achieved. Flat wagons can be easily converted to carry not only containers and swap bodies but also general cargo such as forest products, building materials, metal profiles and steel. This is possible by using a removable steel platform to be placed on the flat wagons having the characteristic of movable iron posts which once the transport has been executed become stackable to facilitate an easy and cost effective repositioning of the platforms. Likewise, another type of platform can be utilised for flat wagons carrying containers to handle them inside warehouses for accessing them by forklifts. Superstructures are also available for using flat cars in transporting other cargoes. These innovations deliver an increased flexibility to the use of wagons. Lack of flexibility has been for decades the major obstacle for competing with trucks.

Cargo Monitoring

The SPECTRUM project also considered tracking and tracing system for remote monitoring and management of refrigerated containers. Generally, each manufacturer has its own container imbedded system that is not necessarily compatible with others. A real-time container tracking and tracing solution is a system that incorporates data logging, satellite positioning and data communication to a back-office application. Container telematics are intended to help stakeholders comply with regulations and meet the high demands on security, information visibility and transport efficiency that comes with global supply chains (SPECTRUM, 2014).

The information collected via the tracking and tracing module and Global Positioning System (GPS) antenna are communicated via Global System for Mobile Communications (GSM)/ General Packet Radio Service (GPRS)/ Code Division Multiple Access (CDMA) communication module. The main features are:

- Monitoring of key parameters (i.e., temperature, temperature set point, alarms, status)
- Key indicators for preventive maintenance (run hours, fuel level,)
- Localisation of the container
- Interfacing at ISO 10368 standard
- Remote access via web-based application

Considering the division of responsibility between the transport companies and shippers the tracking and tracing of the refrigerated containers operate independently from any other tracking and tracing system that may be installed on the transport. In addition, the refrigerated containers are transported by multiple modes of transport. This means that the tracking and tracing system is operated though-out the journey irrespective of the transport mode. This study conducted for refrigerated containers can be applied to any other cargo of value.

4. Conclusions

In conclusion, with regard to the essence of the market drivers and trends, the following issues seem to be the determining factors for supporting and developing the wagon designs, particularly the innovation evolution, cargo and vehicle monitoring, and predictive maintenance which are the work streams of the INNOWAG project research:

- The external drivers of change affect the whole structure of the freight market and rail freight must adapt to it to remain competitive. Demographics, globalisation, technology, sustainability, economic competitiveness and regulations are ingredients of the new cargo mobility needs. Supply chains have become more complex and sophisticated.

- The internal drivers of change are attributed specifically to the rail freight market community. Time and distance have become vital for production and consumers preferences. The increased demand of logistic services is driven by the above complexity and sophistication of supply chains. Innovative services must satisfy the increased customer's needs whilst reducing cost to satisfy the requirement to be competitive. The awareness of environment protection suggests production systems capable of remaining sustainable over time in a greener perspective. The rail freight system including intermodality is more complex and less flexible than road therefore, to achieve a modal shift to rail it is necessary to simplify rail transport operations or through an One Stop Shop approach make it appear to the end customer that simplification has been achieved. All the above requirements need to be fulfilled by the hardware and software technologies applied to equipment and the management of information. These technologies, being the object of this research, require more detailed evidence.
- The capillarity of the European rail network should be complemented and supplemented by a vehicle fleet capable of satisfying the most advanced customers' needs. Today, the average age of the European wagons' fleet is about 35 years. The wagons' rejuvenation is mostly fulfilled by private wagon owners or rental companies rather than the rail operators themselves; this represents a tangible opportunity for modernisation. The new wagons will be more standardised and based on a modular design, built with lighter materials for carrying more cargo and have characteristics of flexibility to be adaptable for different types of goods.
- The track and trace of both cargo and equipment is a vital component for satisfying the supply chain and service requirements if the shift to rail is to become effective. The hardware technology is available for making this objective possible and the software and Cloud computing allows the incorporation of data into intelligent systems capable of real time management.
- The cost and competitiveness element is present in the above bullet points, therefore greater attention is to be given to the maintenance elements of the rolling stock. This is not only for the cost reduction achievable, but also to make maintenance predictable and to maximise the wagons productivity whilst avoiding avoid loss of time together with service interruptions resulting from wagons breakdowns. The maintenance cost is an issue which infrastructure managers are tackling with determination, applying predictive maintenance to rolling stock complements the action undertaken by the infrastructure managers so that the maximisation of the desired results is achieved.

Acknowledgements

The reported work was funded by the European Commission within the Shift2Rail project INNOWAG "Innovative Monitoring and Predictive Maintenance Solutions on Lightweight Wagon".

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