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FREIGHT TRANSPORT INNOVATIONS OF EUROPEAN RAILWAYS – NEW MARKET CHANCES AND TECHNOLOGICAL PERSPECTIVES

ABSTRACT

The paper analyses the main technical and economic elements of the current European rail freight market and presents the basic concepts of possible new technologies in the rail freight system. They would enable the railways to enter the more rewarding niches of the freight transport market. In an attempt to understand better the problems of introducing innovations into the transport sector this paper also considers the theoretical framework and analyses the implementation paths of the proposed technological innovations. New technologies are confronted with various barriers and difficulties created by the existing and dominant technological paradigms. These are often powerful enough to prevent the introduction of alternatives and promising innovations. The empirical part of the paper focuses on the possibilities of combining the existing innovative rail freight technologies which could, with the appropriate organizational solutions (time-tables) and political support, increase the competitiveness of the rail freight transport in new and promising market segments.

KEY WORDS

rail freight, rail freight vehicles, innovations in freight transport

1. CHARACTERISTICS OF THE EXISTING RAIL FREIGHT MARKET

1.1. The evolution of the European freight transport market

The trends in freight transportation in Europe during the last decades are characterized by sharp increase in volume of goods carried (Tonnes and Ton-Kilometres) and a very strong bias towards road transport even in the long haul market segment [1].

This has been predicted by forecasts within the research project EUFRANET [2], which expected the highest growth rates for road and combined transport, according to Table 1.

For conventional rail transports and inland navigation the volumes are set to change only slightly and the performance should increase by 13% that is 19% from 1992 to 2020.

Figure 1 - also shows the modal split in 1992 by volume, which left 89.5% to road transport, a figure that should reach 91.7% by the year 2020.

The reasons for decline of rail freight services are many and varied, including major physical and organizational changes in industrial and commercial practice, rising service and performance requirements set by shippers and consignees and the near to total dominance of road transport as the preferred means of moving cargo.

Rail has either withdrawn voluntarily or has been forced to do so from the key high value and/or time sensitive markets. For these, it has been poorly equipped to serve on grounds of service, product, cost and reliability, notably in relation to road haulage. Shippers' expectations have risen in terms of service, reliability, security, availability and management competence and these have been met more thoroughly by the road transport sector. Traditional rail freight services and technologies have largely failed to adapt to meet the increasingly demanding requirements and values and the revolutionary new technologies like the Maglev train are still waiting for their breakthrough [3].

The adoption by large manufacturing and retail concerns of Just-in-Time (JIT) techniques demands degrees of precision in terms of freight operations that rail has generically failed to meet. There is no reason to suppose that the benefits derived by users from the adoption of JIT techniques will be given up in order to accommodate the present product and service weaknesses of the rail [4]. The continuous conflict derived

Table 1 - EU (15 states) – Development of freight transport 1992 to 2020 (estimates) by volume (Tonnes p. a.) and Performance (Tonnes-Kilometres - tkm)

Mode	1992 Mill. Tonnes	2020 Mill. Tonnes	Difference Mill. Tonnes	Change p.a.	Share of Market 1992	Share of Market 2020
Road	9,113.7	11,934.6	+2,820,9	+0.9%	89.5%	91.7%
Rail (conventional)	621.7	604.9	-2.7	-0.01%	6.1%	4.6%
Rail (combined)	35.5	48.3	+12.7	+1.1%	0.3%	0.4%
Ship (inland)	414.5	426.4	+11.9	+0.1%	4.1%	3.3%
Total	10,185.4	13,014.1	2,828.7	+0.9%	100%	100%

Mode	1992 bn. tkm	2020 bn. tkm	Difference bn. tkm	Change p.a.	Share of Market 1992	Share of Market 2020
Road	995.5	1,849.2	+ 853.7	+2.2%	77.4%	84.3%
Rail (conventional)	168.5	190.4	+21.9	+0.4%	13.1%	8.7%
Rail (combined)	22.4	34.2	+11.8	+1.5%	1.7%	1.6%
Ship (inland)	99.9	119.1	+19.2	+0.6%	7.8%	5.4%
Total	1,286.3	2,192.9	906.6	+1.9%	100%	100%

Source: EUFRANET, page 38

from these findings has been described, for the German example, by Schliephake [5].

1.2. Current freight transport systems of the railways

With reference to Bukold [6], who analyzed the transformation of different systems of freight transport due to technological, organizational and political factors, the core of any transportation system is made of at least three elements:

- Technological elements: locomotive, loading units, wagons, railway, transhipment technologies or terminals;
- Organizational elements: organizational functions of the different segments of freight transport (pre- and end-haulage, intermodal transport chain etc.), schedules, slot management, slot attribution, priority attribution;
- Institutional elements: market regulation, financial aspects, standardization, norms, labour regulations etc. (see Bozicnik [7]).

Railway freight transport is a specific combination of the above listed elements. The basic positive characteristics of the present railway freight transport system are:

- powerful locomotives,
- long trains,
- large shunting areas for classical terminals,
- large volumes of low value goods,
- long distances,
- fixed schedules,
- large specialized terminals for intermodal transport etc.

Summing up the major problems of the railway, we also have to point to the negative elements typically linked to the current system which centres on the following key issues:

- Poor reliability and precision;
- Poor availability and responsiveness to shipper's imperatives under JIT expectations;
- Low asset utilization reflecting unclear 'ownership', executive responsibility and failure to recognize the strength of the competition in relation to these;
- Lack of flexibility and responsiveness to scheduling and routing to meet shipper/consignees imperatives;
- Slow loading, discharge and inter-modal transfers;
- Heavy and over-engineered equipment leading to excess train length and weight;
- Poor monitoring of progress and status;
- High entry costs for new players using conventional equipment.

Today's railways freight production system generally reflects the principles of mass-production and its principles are based on economies of scale. Their economic concepts stem from a period, when the predominant freight volumes consisted of heavy and bulky raw materials. This required considerable capacities in the railway network, highly specialized know-how and expertise reaching from the production of locomotives to the design of schedules. The system has proven to be very resistant to innovations and is concentrated in a few (mainly monopolistic) enterprises [8].

The same applies to railway companies and their strategies. In a period of restructuring of the railway sector, railway companies tend to emphasize their "corridor strategy" and continue to develop long trains and huge terminal or shunting infrastructures. The results of such strategies are obvious: less than 22% of the EU railway network length carried in 1992 about 60% of the traffic volume [2].

The aim of the traditional strategy is to concentrate transport flows on a few corridors and large terminals where they can yield economies of scales. This corresponds to the abandonment of the formerly dense network and to a dangerous reduction of feeder services. In the last decades, the railway response to the falling revenues has been to institute a near continuous process of cost-reduction by slimming or cutting of services and route networks. Eventually, this drove the residual traffic even more rapidly away and into the arms of the competing modes.

1.3. The role of the railways as traction providers in the EU

Numerous field surveys[1] among intermodal operators and customers have identified the behaviour of the existing national railway companies as traction providers as being unsatisfying. Freight shippers see liberalization and deregulation of the rail transport sector as one of the key issues in achieving better rail performance and, correspondingly, a generally better intermodal performance.

The EU-Commission enacted the directive 91/440 [9] which aims at separating the rail infrastructure from the rail operating systems and tries to create equal market conditions for all railway companies, if they want to use tracks not owned by themselves. While the EU-directive 91/440 was providing the necessary legal background for a liberalized railway market that should have lead to a better efficiency of the involved railway companies for the benefit of the transport customers, up to now the new business activities are only slowly appearing among the European traction providers.

In order to improve the services in offer, liberalization was expected to overcome the national monopolies, to foster more competition on the market and to increase the overall productivity of the rail transport sector. This liberalization then could have lead to more private investments into rail transport. Finally, the liberalization should have made the rail transport sector more competitive in comparison to the already deregulated road transport market.

Free access to the market is a crucial prerequisite to bring more competition and to offer, in the end, improved services to the railway customers, which also means better services for the rail leg in intermodal transportation [10].

Ultimately, these factors could be combined and thus contribute to the breakthrough of a new transportation concept in the railway sector. In this perspective the opening of the railway network to free access will not only help to overcome an institutional setting which has cemented the monopoly of a few operators, but also constitute the necessary framework for radical innovation. This should abolish the current concepts of freight transport and create competition with a high number of stakeholders on the market.

To succeed on a sustained basis the railway has to become profoundly more commercially minded, competitive and acceptable to users. This includes a better response to customers' operational and strategic requirements in terms of services, products and management competence, and an adoption of the Just-in-Time concept in its internal processes. A fundamental re-appraisal of the overall rail freight product, service and market approach is therefore essential. Surveys undertaken on behalf of the Office of the Rail Regulator in the United Kingdom underline the need for profound change in the positioning of the freight sector in terms of technologies and the commercial support of services.

In order to achieve this, an efficient system where cargo is delivered and collected as required in response to the customers' imperatives has to be established. Unfailingly high levels of reliability, accuracy, security and safety in transit with full knowledge of the location and condition of the cargo throughout the transit process are an absolute imperative. This must be supported by minimal wastage through loss or damage in transit. The shipper, that is, the consignee should be in the position to reduce inventories and to call for rail transport services according to his demand. This implies moving from the supply side vision to a position where the focus is on the considerations driving the industry innovations and demand for improved commercial services.

Addressing the problem requires, for a new generation of railway transport companies, the general acceptance and recognition of the following demands formulated by the market:

- Need for routine availability of numerous small trains offered at any convenient time by the existing and potential operators including infrastructure owners and managers;
- Full interchangeability of technical and commercial vehicles with high performance and unfailing reliability;
- Rail service cost structures comparable to and competitive with road transport;
- Commercial pricing attractive to the market;

- Vehicle concepts and detailed technical packaging with short lead times to deployment;
- Continuous improvement of technical and commercial performance;
- Intensive, productive and profitable use of new concepts for rail vehicles as assets for shippers, operators and owners, using the economies of their introduction and deployment [4].

2.0. Toward better understanding and support of rail freight innovations

The ongoing policy debate in the EU has neglected to a certain extent the technical innovations and their possible contributions to alleviate the domination of road transport. On the other hand, the technical innovations have been considered as the domain of engineering and the emergence and dissemination of technical innovations are often seen as a purely technical question.

According to these prevailing opinions, the technologies emerge due to their superior technical characteristics. Virtually all models dealing with technical innovations understand technical development as a process that can be predicted and/or planned in advance [11], although in reality this is not always true. Engineers tend to ignore the principles of uncertainty and fail to notice barriers that often impede the implementation of the technological innovations [12].

These are the reasons why a more comprehensive analytical framework to evaluate the importance and the potential of technical innovations has to be applied. It should notably include the findings of evolutionary economics and the theories of social shaping of technology. According to the concept of evolutionary economics, technological change results from a process of selection and possible alternatives. It sees technology and preferences as part of the market process. The given technological concept is the result of the combination of appropriate technological, organizational and institutional parameters [13]. In this way the analyst tries to describe and explain technological innovations within the framework of the development process (path dependency), which is characterized by continuous changes (incremental innovations) and discontinuities (radical innovations).

The theory of the social shaping of technologies [14] mainly focuses on the social and cultural integration of technical innovations. Such new technologies are not necessarily accepted by virtue of their intrinsic technological properties, but they have to fit into the social and cultural preferences, expectations and lifestyles of the economic environment. The theory also underlines the fundamental role of social networks in the development and diffusion of new technologies.

Both theories stress the shortcomings of the general neo-classical assumption of isolated individuals maximizing their utility by adopting technological innovations.

Taking into consideration this theoretical framework concerning technological innovations it may be concluded that the major barrier against the implementation of the innovation in the rail freight sector is the existing paradigm of the rail freight transport.

There are numbers of historical case studies clearly demonstrating that the evolution of technologies is handicapped by organizational and institutional factors, creating a major barrier to innovations on one hand. On the other hand, they stress the importance of social and cultural values and preferences in the process of the selection and adaptation of technological innovations [8].

3.0. Fundamentals of new rail transport concept for new freight markets

The flexibility of trucks, possibility of door-to-door service without transhipment operations and smaller risks for the goods damage is the basic reason for the success of road freight transport.

However, its capacity is limited by the overall volume of cargo that can be transported by one truck i. e. driver. Road transport is not in the position to decrease the costs by combining several trucks in a specific unified transport formation, which is the typical advantage of the railway. The railway freight transport allows thus the yielding economies of scale and networking economies, which are not available to road transport.

The challenge, the potential and the need for modern rail freight transport lies in a combination of the advantages of the flexible freight technology offered by heavy trucks together with the possibilities to achieve economies of scale and an environment friendly performance, as it is typical for the railways.

The ideal freight transport technology should be a combination of the positive elements of the truck (high flexibility) and the rail (mass production). Small and fast-moving units can easily be coupled, if necessary to a long train and/or uncoupled to single self-propelled "railway-truck(s)".

This is the fundamental concept within a modern railway freight system. Thus, it would be competitive in comparison to today's predominant road freight and could enter the market niche of small consignments, shorter distances and high value goods.

It would require a reconsideration of the role of policy in transportation and a strategy to support promising innovations containing the potential for a substantial transformation of rail freight industry.

4.0. Existing solutions for new rail freight opportunities

New innovative rail freight technological concepts and solutions are still in the test phase or in the pilot development phase. They were developed by concerned individual initiatives or are results of various research projects such as **IRIS** (**I**nnovative **R**ail **I**nter-modal **S**ervices) [15], deriving from the earlier EU-sponsored project OSIRIS. Currently, we are facing a confrontation of several development concepts and views.

The results of this competition are uncertain and they depend on a formal or informal "selective process" exercised by the users and politicians. In other words, the emerging technological concept cannot yet be defined on the basis of its technological properties. The success of a technological solution depends on its integration in the modern logistic chains.

In the last few years the following innovative ideas have been proposed which might fit into the new railway freight concept:

- Horizontal transhipment technology (Switzerland) "Mobilier" (see Ch. 4.1.);
- "Cargosprinter" (Germany), a flexible train system with automatic coupling. Its load capacities equal five truckloads and it is propelled by gasoline, electric or hybrid engines (see Ch. 4.2.);
- "Truck train" (GB), a small self-propelled freight train (see Ch. 3.3.);
- Small container boxes recently developed within the framework of EU-sponsored projects Idioma [16] and Cost 339, constituting further step in the radical change of the existing production paradigm pertaining to railways. They are particularly designed to capture the increasing and very large market segment of Less than Container Load shipments.

4.1. MOBILIER concept of horizontal transhipments

The Mobilier is - in purely technological terms - a rather simple solution to load and unload swap bodies and containers from rail to road and vice versa. The Mobilier is a kind of double fork mounted on a conventional truck.

The forks glide on two rails and move from the truck under the swap body or container. The swap body/container is lifted by the hydraulic system of the truck and moved from the railway wagon to the truck or vice versa.

Mobilier is able to lift and transfer containers weighing up to 32 tons. The equipment itself weighs about 2.5 tons and can be mounted on any conventional truck. The adaptation of the railway wagon is

Figure 1 - Mobilier

very simple and cheap. It just needs two additional iron plates to accommodate the rail on which the two forks can be moved back and forth. Mobilier itself can easily transform every conventional container truck into a mobile intermodal terminal. The only infrastructure needed by this "terminal" is sufficient space along the railway wagon to station the truck. With this technology any rail station or rail track segment can be transformed into an "intermodal terminal".

The advantages of Mobilier, which radically moves away from the classical concept of large volume modal cargo and large intermodal terminals are as follows:

- Flexibility. Containers or swap bodies can be loaded/unloaded at numerous localities along the entire railway network. Swap bodies/containers unloaded from railway to trucks can also be transported on trucks without the Mobilier equipment. Mobilier is able to unload and/or load several transport units one after another.
- Low transhipment costs and time. The single truck driver can easily operate the transhipment process within 5 to 10 minutes.
- Economical use of railway for intermodal transport with a minimum distance of approximately 100 to 150 km (conventional trains: more than 500 km).
- Low investment costs for transhipment technologies and terminals. A truck equipped with Mobilier acts at the same time as a terminal and a truck for the distribution of units, and it can be used basically all along the railway network. The price of a Mobilier unit is about EUR 35,000.
- New opportunities for new operators, new synergies and new forms of cooperation among forwarders and between railway operators and terminal operators. One Mobilier unit at a railway station can serve different railway clients.
- Network economies rather than economies of scale. Mobilier does not require high transhipment volumes to cover the (low) initial investment cost.
- Reduction of external costs such as high emissions and congestion around intermodal terminals.

Certain disadvantages of Mobilier should also be mentioned:

- Requirement of a (minor) adaptation of swap bodies/containers. However this adaptation neither reduces the transport capacity of the adapted transport units nor does it increase its dead weight.
- The transhipment capacity of the Mobilier is limited to about 50 intermodal transport units (i. e. containers) per day. Mobilier cannot be a substitute for large intermodal terminals in seaports or along principal European freight corridors.
- Mobilier requires high quality of the railway services. To be competitive with the road system the entire shipment time should be reduced in order to serve time-sensitive freight segments.

Recent introduction of Mobilier in Switzerland has shown that it has opened new perspectives for horizontal transhipment and the use of railway in general, and it can reshape the entire logistics chains [8].

There are also other interesting technical solutions and innovations such as the proposal for a vertical gantry crane loading and unloading system for railways, developed by Bernard Kortschak (Fachhochschule / Higher Technical Institute at Erfurt), etc. The optimal solution for individual purposes may be designed by combining various innovative technologies that have been neglected to a great extent, up to now, by the major state railways.

4.2. DB Cargo Sprinter

The Cargo Sprinter is one of the very few technical and organizational innovations that is operated in Germany. The traction unit of the Cargo Sprinter is basically a truck on rail-wheels and must not be regarded as a 'new technology' (see Fig. 2). But the Cargo Sprinter system uses synergetic effects of either new, advanced or rather simple technological and organizational solutions, making it a successful model for small-distance intermodal flows.

Through its design the Cargo Sprinter is well suited to short-distance transport. It is generally used as a feeder train within a hub and spoke system. In the total cost calculation of pre- and end haulage plus two transhipments plus rail traction, the Cargo Sprinter contributes with the following new solutions:

- The operational rail costs are minimized due to:
  - no need for shunting;
  - modular system with small train units, and
  - easy and reliable truck technology.

The Cargo Sprinter gains advantage as a concept mainly in feeding intermodal hubs. With its high possible speed it perfectly suits the requirements of time-sensitive cargo.

Short-distance intermodal transport is feasible and competitive, but not as a standalone service just to replace short-distance truck haul. The intermodal short-distance services are most efficient and reasonable between hubs or as feeders to hubs.

Examples like the NEN in Belgium show that networks of fast and efficient short-distance shuttles in small countries are feasible once the critical mass of cross-border links - feeding the national hub - is achieved. The advantage of NEN is the network of fast shuttle trains that regularly travel over the short distances between the hub.

Cargo-Sprinter consists of a new modular five-wagon train using railcars instead of locomotives powered by truck-diesel engines. The advantages that make the Cargo Sprinter well suited for short distances are as follows:

Figure 2 - DB Cargo Sprinter

- no locomotive shunting is required;
- automatic coupling system which eases the coupling and sharing between Cargo-Sprinter units;
- efficient brake system;
- modular system,
- simple technology consisting of many components that are already used in truck production and are therefore relatively cheap,
- configuration suitable for a circle-train concept,
- adaptation to minor rail sidings,

The disadvantages of the system include the following:

- the actual track fee system does not favour short trains. The fees appear to be over-proportionally high per load unit;
- the maximum speed (110 km/h) is not sufficient to run at a speed of fast passenger trains (approx. 160 km/h), so that Cargo Sprinter cannot be well integrated into passenger traffic flows.

4.3. TRUCK TRAIN ®

This is a small self-propelled freight train designed to be used in intermodal, logistics and tanker applications (according to [17]). The basic concept consists of the economically viable small train formations com-

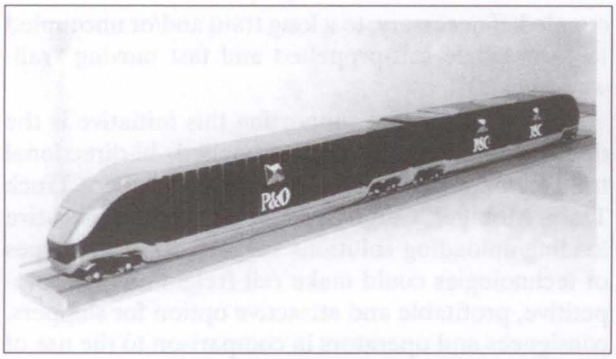

Figure 3

bining integral power with the existing and developing technology commonly used in the trucking industries, and in modern interurban passenger train formations (see Fig. 3). These train formations must be capable of operating at fast interurban passenger train speeds. This supports the case for high levels of installed power on each vehicle and offers the prospect of an increased departure frequency adapted to the concept of "Just-in-Time" services.

The use of a bi-directional formation allows operation on complex networks including secondary and branch lines as well as private sidings without complex and costly re-marshalling facilities, avoiding 'escape' lines required by locomotive hauled stock.

The design of cab structures, driver workstation, self-diagnostics and cargo condition monitoring systems and all their depending devices will incorporate a high level of common design features and components already certificated (see Fig. 4). They will be fully compliant with or exceed the prevailing railway industry standards for proof-loading.

The basic design has incorporated diesel electric traction with motors on each axle. This gives freedom of operation over the network independent of the availability and configuration of the differing power supply systems. The use of diesel engines designed by the truck industry with a strength of approx. 550kw per vehicle gives a power-to-weight ratio of ~10hp/tonne. This is governed by the need to accelerate the trains at full payload to comply with passenger traffic streams, without inflicting delay on their movement.

Figure 4

For the TruckTrain® the following core concept was suggested: a platform with two two-axle bogies, which is to be able to accommodate three TEUs (20' containers) in the intermodal configuration. The key to accommodate this type of cargo is to secure the lowest possible cargo deck height within the loading gauge and design around a bogie able to operate with the type of payloads detailed at the high service speeds required.

The logistic or tanker variants (approximately 175 cubic metres per vehicle) are aimed at high value, medium density type products. (15lbs per cubic foot range for density which would give full volume payload of ~40tonnes).

Target speeds of 75 mph/120kmph are envisaged with minimal infrastructure attrition. This shifts the train concept at full load into the heavy and fast category with the need to minimize track attrition as an absolute requirement, demanding track-friendly bogie systems. For very large heavy containers (45' high cube reefer units of ~34 tonnes gross weight capability) a special variant using a cranked frame design is proposed.

The freight trains will be able to operate in a minimum formation of two units for bi-directional operation, and capable of operation in combination with other TruckTrain formations in response to individual commercial and operational circumstances. The design of the trains is focused on the need to maintain high levels of availability and productivity.

The ability of the trains to operate extensively over the network, possibly on a mix and match basis with other formations, imposes a requirement for crew scheduling and positioning to be able to meet and operate train segments on a pre-planned basis in response to varying traffic volume and routing needs.

The availability of a crew management system that can dynamically plan and schedule competent personnel around changing traffic and train operations is a vital means of achieving the productivity targets for the new trains. Such systems have been identified and are already deployed in the rail and other transport sectors.

Finally, it will be important to supply the train sets with a detailed knowledge of the condition, status and topography of the infrastructure network over which it operates, including continuous updating. Thus, the train always knows where it is, respects the current line speed limits (permanent or temporary), and localizes any line side signal and other indicators. Such navigation systems are nowadays a regular feature in the trucking business (see Nijkamp et al. [18]), and there is no reason to prevent their adaptation to the rail system. The train driver will not forcibly need route knowledge any more but rather has to intervene in emergency cases.

The economics of operation demonstrates the following economic results:

- savings of over 27% would be achievable in comparison to road transport;
- it is competitive on specific lines with distances of less than 120 miles (200 km);
- it needs a minimum annual transport value of approx. £1.7 million.

The model calculation is based on two round trips per day between Southampton and Cardiff, a route not well served by conventional rail and which, up to now, included an extended stay at marshalling points.

Initial calculations suggest that investment in TruckTrain® type technology would be recovered in less than three years. At higher (achievable) levels of utilization and the ability to re-deploy trains to other route sectors the earnings and profit potential of the new train technology would yet increase. The return on the investment in the new equipment could rise correspondingly [4].

5. CONCLUSIONS

The main argument presented by the authors points to the fact that the state monopolies in the railway sector have blocked competition and are one of the major causes of the visible decline of the railway freight sector. The ongoing process of opening the market access to new actors should create the necessary competition to improve the railway services and to give them a new impact on the market. However, there are signs that the barriers for new entrants in the railway transport market remain still very high, unless new operators start with innovative technologies, requiring very modest investments. This could finally lead to a completely different situation, where a high number of actors can offer railway services according to the needs of their clients.

A serious approach to the freight markets requires fundamental shift in the overall product and service performance of the rail in order to be able to compete with road transport in terms of reliability, service performance and costs. This in turn implies the integration of innovative vehicle concepts with commercial, planning operational and technical systems to deliver higher levels of service, reliability, availability, productivity and reduced cost. By moving towards these goals through the adoption of novel technologies and operating methods the railways will be able to seriously compete with the road transport present market dominance.

The ideal freight transport technology would be a combination of truck (symbol of high flexibility) on the rail (symbol of mass production and efficiency in terms of energy consumption), which can easily be coupled, if necessary, to a long train and/or uncoupled to form single self-propelled and fast moving "railway-truck(s)".

The core concept supporting this initiative is the deployment of small, self- propelled, bi-directional train formations like TruckTrain ®. The use of Truck Train, Mobilier, Cargo Sprinter and other innovative loading/unloading solutions suggests that such types of technologies could make rail freight a more competitive, profitable and attractive option for shippers, consignees and operators in comparison to the use of traditional railway freight systems.

The major rail freight operators have potentials to implement this type of innovative equipment but they seem to be focused on bulk trainload traffic (mainly in corridors) as their staple revenue element. Unfortunately, it has to be stated that there is an inability or unwillingness of the railways to pursue with more success the large and growing market in high value and time-sensitive traffic.

The use of large train formations is neither cost-effective nor appropriate for the requirements of clients who compare with products and services offers provided by the road transport [17].

The key point is that a large part of today's intermodal transport market consists of intermittent and infrequent volumes and rail is effectively kept out of the market by the cost and services based on the technology it presently deploys. The decreasing market share and modal split figures demonstrate the magnitude of this omission (see Tables 1 to 3).

The deficiencies in the present rail products and services are well known and do not include only limitations in the technical venue but also the management, planning, control and operational elements [19].

It seems absolutely vital that concept vehicle formations such as TruckTrain®, Cargo Sprinter etc. are recognized generically by the infrastructure operators as a fast train concept and not as freight train that is given low priority in the system.

The ability to establish routes, schedules, slot availability and prices for track access on sector transits is essential and the ability to fix, confirm, swap and trade these in real time is as important as the actual train hardware, if a significant impact on the market is to be secured.

The scale of the market opportunity is such as to suggest that rail can re-assert itself as an important player in the markets where it has not been a credible partner over the recent decades. In the event, some of the fundamental technical, organizational and operational limitations that restrict its competitiveness under the existing rules of engagement have to be removed.

In spite of all that has been deployed with regard to rail freight through grants, subsidies and privatization the rail sector still fails to meet adequately the needs and imperatives of most customers. It lost market share as well as customer confidence and failed to earn a reasonable return on investment.

This suggests that rail must look elsewhere for answers in terms of innovation, technology and adequate services, if it is to re-enter the market with credibility and prospect of sustained success.

Analysts may have the impression that the innovative concepts proposed in our article are not technically mature and that it would be, therefore, too early for their introduction. However, if we look at the continuing shrinkage of those parts of the network offering potentials for rail freight transport, it rather seems that the new technologies present the last chance to induce a shift of making sense in economic and ecological terms.

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