Containers, swap bodies and semi-trailers: How to transport them efficiently by rail

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In 1967, United Nations Economic Commission for Europe published a Survey on Engines and Means for Combined Transport in Europe. This survey showed a wide selection of containers, starting with boxes of 1 m^3 volume and ending at containers with the size of a semi-trailer. Furthermore, a wide selection of various techniques to carry semi-trailers on European railcars had been shown. In these days, intermodal transport (in these days described as combined transport) was a niche market for railways. In the meantime, the technical variations in container design have been greatly reduced, and the number of units in service has been immensely increased. UIC reports for the year 2012 an intermodal transport volume of 11 million TEU representing a freight volume of 115 million tons. Intermodal transport has developed towards a commercial backbone of European rail transport. The two main drivers of this growth had been the increase of world trade, and standardisation allowing to achieve economics of scale and reduction of costs.

Standardisation of intermodal transport units had always been pressed by two economic factors: the box must be able to move in as many modes and countries as possible, and it must match competition of conventional transport means. European freight rail operation has to serve two distinct markets:

- The hinterland transport of sea-borne containers between sea ports and production or consumption areas inland representing 7 million tons of cargo or 63 % of the intermodal rail transport market,

- The long distance transport of cargo within Europe by road-rail-road operation representing 3,9 million tons or 37 % of the market.

The design of the intermodal transport unit used in overseas transport reflects international standards fixed in ISO TC 104 Freight containers and is given in ISO 1496. The design and the dimensions of these boxes is fixed by the investments in more than 20 million boxes and thousands of container ships, representing an investment value of several billion of Dollars of Euros. These investments keep the system stable: Any commercial improvements that could be generated by another container design would certainly over-compensate the losses generated by the needs for system change. When ISO TC 104 discussed standardisation of a series 2 container with larger dimensions, this idea was abandoned because of the immense investment needs. European action COST 315 Large containers said in its final report: “Without doubt, the introduction of an ISO series 2 container will require a significant investment for the adaptation of the infrastructure and the rolling stock.” (EC Report COST 315 Large Containers, Brussel 1994). The dimensions of intermodal transport units used in this market did not undergo any basic change over the last 40 years, except some increase in height.

The intra-European transport market shows other market conditions. Whatever intermodal transport unit is used, it must match the competition with long distance road transport, i. e. it must offer the same cubic volume and/or weight carrying capability. And when road transport changes its dimensions, intermodal transport units have to follow. Such changes occurred rather frequently in the past. The maximum length of a semi-trailer for road transport in

Germany was, in the 1960s, limited to 12,0 m. It was increased to 12,50 m in the 1970s, to 13,60 m in the 1990s, and further increases up to 14,9 m are advocated while North America has already arrived at 15,3 m.

Intermodal rail freight transport is confronted with a double bias: They have to serve two markets with differing intermodal loading dimensions, and one of these markets has been subject to frequent changes of dimensions, and some uncertainty about which changes may come.

Container hinterland traffic

The base dimensions of ISO containers never changed in the last 40 years. Meanwhile the sea container system has arrived at more than 25 million TEU. Some 95 % of all containers have been built to ISO 1496 standard.

This facilitated rail transport greatly. The standard wagon for this traffic in Europe (Sgnss) has a loading length of 60 ft. (=18,4 m) and 2 bogies with 4 axles. It can carry three 20 ft. container or two 30 ft. containers of one 40 ft. container + one 20 ft. container. The main optimisation problem in capacity use is the weight versus cubic capacity. If a container block train has to carry many empty units, it will make full use of the possible maximum train weight. If the train carries mainly full tank containers (this is the case in some north-south routes with milk as main commodity), the train load will arrive at the weight limit earlier than at the volume capacity limit. Detailed calculation on volume/weight capacity are described in the UN Report “Physical Requirements of Transport Systems for Large Containers”, New York 1973, p. 90 + 91.

Another combination is an articulated railcar with 3 bogies and 6 axles that offers two platform each with a loading length of 12 370 mm (2 x 40 ft),

The first problem arrives with the 45 ft. container standard. This container fits on a 60 ft. railcar, but it uses only 75 % of its length capacity.

The other problem was created by the growing height of containers: The first standard height for ISO containers had been fixed with 8 ft. (2,44 m), soon it was increased to 8 ½ ft. (2,59 m), and the 1990s the high cube with 9 ½ ft. height (2,89 m) came into service. The standard European railcar has a loading height of 1,1 – 1,2 m above rail. It can carry high cube containers on most trunk lines in Central Europe, North Europe and East Europe, but there are difficulties with the gauge in the net works of Great Britain, France, Central and South Italy, and Spain. There are railcars available with lower platform height allowing the carriage of high cubes even in these networks. The multi-fret railcar offers a platform height of 945 mm, and a loading length of 2 x 16 580 mm 2 x 54 ft.) and is equipped with 4 bogies/ 8 axles.

Summing up: The stability of container standards offered a favourable business model to railway operators: They can rather freely choose between some variations on loading length and maximum loading weight, and they have investment security: As a railcar may have a commercial life of 30 years, such stability of standards on loading units can greatly reduce investment risks and improve the economics of intermodal rail transport.

A side effect of such long-term stability is the fact that meanwhile leasing companies have invested in intermodal railcars and removed a long term bottleneck in intermodal rail transport capacity.

Intermodal rail transport inside Europe

The other big intermodal rail market is the carriage of intermodal loading units between European inland points. This market has definitely other competition patterns than container hinterland transport. The intra-European intermodal transport competes with international long-distance road transport and is faced with the fact that road transport fixes the logistic requirements in this market. With other words: Intermodal road/rail operation must offer the same quality, a similar load carriage device, the same degree of flexibility and service as international road transport.

If road transport changes its dimensions, intermodal transport has to follow, or they will loose the market. When this type of traffic started in the 1980s, the actors had been faced by a wide set of different rules for truck weight and dimensions. Going from Rotterdam to Milano would mean that you have to fit into the legislation of the Netherlands, Germany, Switzerland, and Italy. And these regulations were very different.

Things became much easier when the European Commission created a common regulation for sizes and weights of road vehicles for all the member states of the European Union(Directive 96/53/EC), and Switzerland adapted to the system. This has been basis of European standards for loading units, mass production and mass operation, the basis for competitive economics of the system. Another advantageous pattern had been the stability: Such a regulation needs a compromise between very many actors with very differing interests, and this is difficult to achieve. So the actors assumed that the road vehicle dimensions that have been fixed Europe-wide in 1996 would not change basically – and this was true until the current days.

Europe has meanwhile established CEN TC 119 Swap bodies for intermodal transport, and this standards committee followed immediately the European legislation: The width for road vehicles had been increased to 2550 mm, and the new standard fixed the width for swap bodies accordingly. The European legislation had fixed 18300 mm for road train length; this allows for 2 transport units (truck + trailer) of 7450 mm each or 2780 mm with a sophisticated short coupling system. So, European standard set a length system of class C swap bodies

- 71500 mm for traditional swap bodies
- 7450 mm for a pair of swap bodies on standard road trains
- 7820 mm for a pair of swap bodies on short-coupled road trains.

The articulated unit was fixed at 16500 mm total with a semi-trailer length of 13600 mm; so, CEN TC 119 set up a standard length for the longer class A swap body to be carried on a semi-trailer, of 13600 mm.

Intra-European intermodal transport had been now confronted with a multitude of length parameters. The easiest solution would be to use a 60 ft. (18300 mm) loading length railcar. This would result in a length capacity use of 74 % with a single class A swap body, and 81 % for a pair of class C swap bodies. This solution means a certain capacity loss, but on the other hand the operation of standard railcars. As far as the actors in European intermodal transport have gone this way, they can even handle the 45 ft. (13720 mm) unit that has emerged recently and that will become a new European standard as the European Union is preparing an adaptation of its legislation to allow this length in European road transport.

Semi-trailers in European intermodal transport

Intermodal transport of semi-trailers is a fast growing market in Europe. As these trailers have been fixed to a length of 13600 mm, pocket railcars carrying them could be designed as standard rolling stock device. But this creates a height problem in some rail networks. A European semi-trailer is allowed for a height of 4000 mm. This height road vehicle loaded on s pocket railcar ends up in a total combined height of rail and road rolling stock that exceeds the rail gauge of some major south European railway networks so that these railway undertaking cannot serve this interesting market.

The most popular railcar for this market is the articulated unit Sdggmrss-L with three bogies that can accommodate 2 semi-trailers (2 x 13600 mm) or 4 class C swap bodies (4 x 7820 mm). Of course, it can be used, as well, for the carriage of ISO containers, but this would incur some capacity loss.

Multiple loading lengths

Summing up: European rail transport is confronted with a multiplicity of loading lengths in intermodal units:

- 6100 mm for 20 ft. containers
- 12200 mm for 40 ft. containers
- 13720 mm for 45 ft. containers
- 7140 – 7820 mm for class C swap bodies
- 13600 mm for semi-trailers

Whatever you do, you almost never can achieve a 100 % length capacity use.

There is a small relief: Some intermodal operators are specialised to hinterland container transport, others to intra-European road/rail operation. The container operators are confronted only with a length variety of 6100 mm (20 ft.), 9150 mm (30 ft.), 12200 mm (40 ft.), and a considerably small number of containers 13720 mm (45 ft.) long. Normally, they can use the standard railcar with 12300 mm loading length which accommodates all varieties with no or with small capacity loss.

The operators specialising in intra-European transport are confronted with more problems. Normally they have to invest in railcars either accommodating 13600 mm long road units such as semi-trailers, or a combination of 2 x 7820 mm swap bodies. But whatever they decide, they will be confronted by their clients with a mix of units that will make optimisation difficult, at least incur some capacity loss.

Larger road vehicles

Some 50 % of the cost of long distance road transport is created by the driver’s salary and reimbursements. If the road vehicle becomes bigger in capacity, the cost per tonne or per cubic metre payload becomes lower. So, there is a considerable pressure of the commercial actors to achieve legislation for bigger road vehicles. The discussion in the last years in Europe has brought forward two cornerstones:

- a road train with 25,25 m length
- a semi-trailer with 14,9 m length.

Both suggestions would be disastrous for the economy of intermodal rail transport. If considerable greater vehicles would be permitted, the road transport industry will immediately change their fleet to make use of these greater dimensions. The normal depreciation period for road vehicles operating in international long distance transport is 5 – 10 years. Railcars with a commercial lifetime of 30 years, and terminals with an even longer commercial lifetime are the counterpart of the system on the railways side.

Most intermodal terminals for road/rail interface are built for the current fleet of road vehicles. Parking lots, intermediate stowage areas, driving lanes, U-turn facilities: They all are optimised for the current loading units. If another generation of loading units appear, terminal operators (very many of them railway undertakings) have to re-built their facilities, in most cases losing capacity.

In parallel, the railcar fleet will be affected. The main disaster would be an enlargement of semi-trailers. The current pocket railcars are built for 13600 mm semi-trailers. If the rolling stock patterns change and a large number of semi-trailers with increased length appears, the business for the current railcars ends. Whether technique allows for a re-shaping of these rail-cars or whether they have to go to scrap is yet not clear. But something is sure: The current actors in intermodal transport will face huge losses, and many of them will be forced to abandon this market. The banking and financing industry will no longer invest in rail-car leasing when they learn about the risks in this business. Whatever road transport industry would achieve in benefits, the intermodal transport industry would be hit by great losses.

Double stack rail transport

Double stack transport of containers exists in North-America, and there it shows fine economic patterns on very long distances. European transport politics discusses how far Euroopean railways can go the same way.

The clearance needed would be

Rail-car platform height	1,1 m
Bottom container high cube	2,9 m
Top container high cube	2,9 m
Total	6,9 m

Such height would certainly exceed any catenaries clearance, so that type of operation can only considered for non-electrified rail lines.

But this is not the only problem. A 60 ft. railcar carrying containers in double stack would accommodate six 20 ft. containers. If each of them is laden to a gross mass of 24 tons, this rail-car has to carry 144 tons – certainly out of view for current axle load patterns in Europe. Any compromise solutions, i. e. operating in remote railway lines without electrification and without bridge crossings, and organising a combination of laden and empty containers in the terminal observing the weight limit of each rail-car, are pure fantasy and never will fit into the reality of current intermodal operation.