Concept of Freight Road-Railing Transport in Bimodal Technology[1]

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The article presents: the essence of bimodal transport, technical measures, technologies and setting bimodal trains in bimodal transport systems. Summary of the article is the analysis of advantages and disadvantages of road-rail freight transport in bimodal technology.

Keywords: bimodal transport, technology, bimodal transport systems, advantages and disadvantages of road-rail transport.

1. INTRODUCTION

The article presents technical, operational and economic advantages of bimodal transport. Disadvantages of this transport technology have been also presented. Achievements of civil engineering contributed to the development of a new technique, combined road-rail transport, called bimodal transport.

The essence of bimodal transport consists of the fact that special semi-trailers, meeting the requirements of both road trailers and rail wagons, are delivered to the terminal by a tractor unit, where they are formed into a train.

The concept of bimodal train involves replacing some classic elements of train by elements of road vehicles - semi-trailers, constructed in a particular way. These semi-trailers, when placed on railway trucks, equipped with, so-called, railway adapters and with superstructure, are able to act as a wagon body.

2. CONCEPT OF BIMODAL TRANSPORT

Bimodal trains are composed of repetitive elements in the form of:

- semi-trailers (closed wagon or tank);
- an adapter, i.e. a device, providing indirect support of two trailers in the same bogie, or a rail connection, with, either a railway engine, or with a freight train;
- a two-axle bogie, equipped with a set of brake devices (Fig. 1).

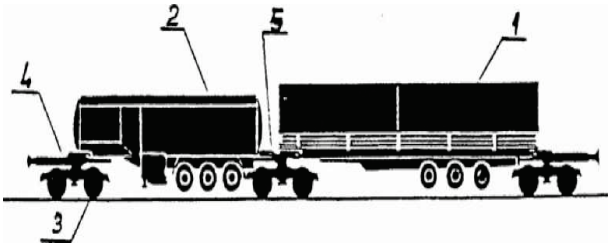

Fig. 1. Bimodal train elements: 1 - Chest road - rail trailer, 2 - tank semi-trailer road and railway, 3 - Standard bogie, 4 - utmost adapter train devices, 5 - middle adapter.
Source: own elaboration.

Despite the fact that such a train comprises semi-trailers components, it shall comply with all the technical standard requirements of freight trains, or with the conditions specified in UIC597endurance card.

Semi-trailers, produced in a standard way, must therefore be reengineered. First of all, the supporting structure must be strengthened, in order to ensure the transfer of static, compressive and tensile force of 850 kN but this should not lead to

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an excessive increase in the weight of the trailer, to prevent the growth of containers tare weigh and excessive axle pressure. At the same time, all the protruding parts, as well as the size of the semi-trailer must be situated within the UIC kinematic gauge. It requires, among other, collapsing of the upper corners of the semi-trailer outline, or reducing semi-trailers height. Also wheels have to be lifted during rail transport, with use of pneumatic lifting equipment. A semi-trailer vehicle, operating in bimodal transport system, should have the main tank of air and brake hose mounted in a safe way, not exposed to be damaged. Each cable must be provided with a coupling head, so that it is possible to link tightly the main cable with pneumatic installation of bogies. As the distance between the semi-trailers, transported on rail trucks, cannot exceed 450 mm, it is necessary to equip semi-trailers with a rear, swing-up bumper. It is also necessary to protect it in an appropriate way during the transport on wagon bogies, and not to exceed the allowable distance between the semi-trailers. The above mentioned UIC597card also describes a set of technical requirements, specifying precisely the necessary technical parameters of the wagon bogies load, adapters, coupling and regulating mechanism elements.

According to the presented structure of elements, forming a bimodal train, the rail transport is reduced to standard two-axle bogies, equipped with so called adapters and with a complete brake system. The same applies to road transport, as this system is composed only of a closed trailer or wagon tank with its own bearing system, and of a bearing tractor unit.

As the trailers are fitted with their own lifting units, forming and dismantling of bimodal trains is possible without using specialized machinery and loading equipment, since these activities can be performed by the means of the lifting units, operated by the driver. The only requirement is a paved square with recessed tracks, arranged in such a way that the railhead is aligned with the plane of the square. It enables manoeuvring freely of the car aggregate while the bimodal train is being assembled or disassembled. It is also possible to use a tractor unit for possible mixing of wagon bogies at the terminal, while a bimodal train is being formed.

3. TECHNOLOGY OF FORMING BIMODAL TRAINS

The assumption of bimodal transport is its high economic and social efficiency, as well as simplicity of the transport process. For these reasons uncomplicated device are designed, which connect the road-rail trailer with the bogie. Due to these solutions bimodal train can be formed by one person. Therefore cooperating systems have to be constructed in such a way, that when semi-trailers are placed and fixed on bogie wagons, there is no need to waste time on the accuracy of "targeting".

Three groups of construction solutions can be identified, depending on how the semi-trailers are placed on bogies and how they are connected.

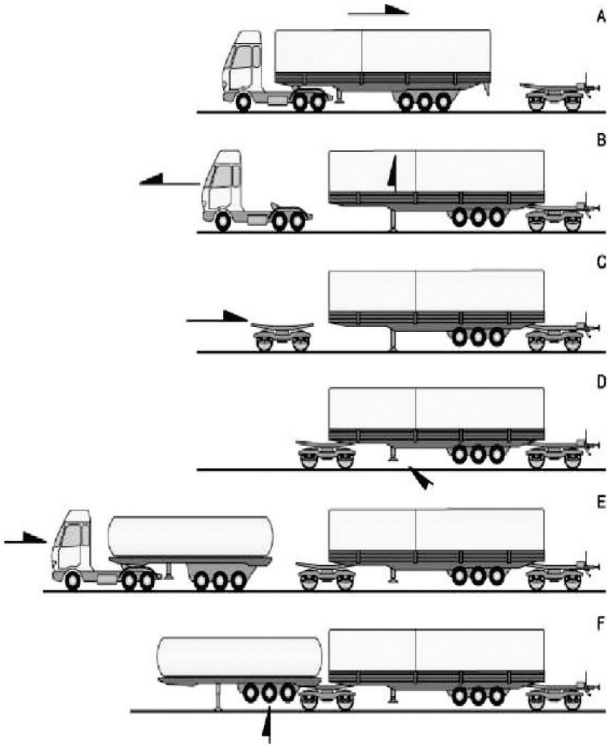
The first group consists of systems with so called rear-adapter on bogies, which allows to place all regulating devices (mobile) on the bogie, hence increasing safe train exploitation.

The second group includes so called semi-trailer coupling system. In this system the rear part of the semi-trailer leans, either directly on a spherical pin and bogie lateral slides, or on a special cross-bar, affixed on the bogie frame with a spherical pivot and bearers. The semi-trailer front part connects directly to the back of the neighbouring semi-trailer, through a node, transferring vertical loads, as well as transverse and axial strength to the back of the trailer and the adjacent bogie. The disadvantage of this system is necessity of using two types of wagon bogies (intermediate and rear) and affixing connecting nodes to chassis trailers.

The third construction group consists of a system where a semi-trailer leans on a bogie wagon through two independent torsion beams, mounted on a bogie frame with turning pivots and side-bearers. This system also requires use of two types of wagon bogies and does not provide equal wheel pressure on the track.

The above mentioned characteristics indicate that the most appropriate construction solution is the system of so called adapter-backed trailer. Operations of forming a bimodal train in this system are shown in Fig. 2.

Dismantling the bimodal train is the reverse process, and it can dismantled in any place, and the desired number of semi-trailers can be disengaged from the train set.



A – Lifting of the rear of the trailer and the raid on the trolley

B – trailer wheels lifting hyphention handle lowering departure of the of the tractor

C – placing the boogie under the trailer

D – lowering of the trailer on the boogie by lifting the hyphention handle

E, F – raid of the following trailer of the bimodal train

Fig. 2. Steps of forming bimodal train set and functional operations associated with it.
Source: http://www.wiz.pl/1997/97112300.asp (9.10.2006).

4. BASIC BIMODAL TRANSPORT SYSTEMS

The United States have the largest experience in the use of bimodal system, due to more favourable railway operating conditions than in Europe. It was also in the United States that the concept of a combined road-rail transport, being one of the varieties of bimodal transport, was born[2].

Due to advantages of bimodal system, in the late 80's, also in the Western Europe several construction varieties of bimodal systems were developed and put into test exploitation. Names of bimodal systems, used by some of the boards of the European rail transport are given in the table 1.

Each of the system listed in the table is based on a car-train trailer. Difference lies mainly in the draw gear construction.

Kombi-trailer, CODA-E Kombi and Semi-rail systems belong to the construction group with adapters, Trans-trailer and Road-railer systems to the construction group with semi-trailer coupling, while Rail-trailer systems are a construction group with two torsion beams.

Technical and operational features of the listed systems, of bimodal road-rail transport are given in the Table. 2.

According to expert assessment, adapter systems have the best construction solutions, and – the system based on draw- gear beam device the worst.

Table 1. European bimodal transport systems.

System name	Country or the producer	Railway administrations leading test operation of the system
Kombi-trailer	FRG TALBOT ACKERMANN-FRUEHAUF	DB, NSB, SBB
Coda-E	HOLAND STORK ALPHA ENG AAB HENSCHEL - Wagon Union	NS, SJ
Semi-rail	FRANCE REMAFER FRUEHAUF FRANCE	SNCF
Trans-trailer	SPAIN	RENFE
Road-railer	FRG	DB, SBB, DSB
Kombi-trail	FRG-FRANCE TALBOT FRUEHAUF	On display for the first time in October 1992 in Hague
Rail-trailer	FRANCE SAMBRE ET MEUSE KAISER	No data

Source: own elaboration.

[2] A train system Road-railer has operated successfully, in the US, being a part of so called structural coupling trailers.

Table 2. Comparison of bimodal transport systems.

Cecha	adapter systems		semi-trailer systems		draw- gear beam device system
	Kombi-trail	**Coda-E**	**Road-railer**	**Trans-trailer**	**Rail-trailer**
Placing bodies of bogies	four-point	three-point	three-point	three-point	four-point („wagon")
longitudinal looseness in coupling devices	yes	no	yes	no	no data
Vertical load of indirect truck	central	central	central	central	Non central
Pressure of wheels on the rails - truck: Intermediate final	identical identical	identical identical	identical identical	identical non identical	non identical non identical
Final trucks	identical	identical	different (DB) identical (SBB)	different	identical
Possibility of loading of intermediate truck from both sides	yes, but after the adapters turn	no	yes	yes	yes
Loading	horizontal with height of the trailer correction	horizontal + vertical	horizontal + vertical	horizontal + vertical	horizontal + vertical
Trailer hanging needed	pneumatic with height adjustment; wheels lifted and locked	pneumatic with height adjustment; wheels lifted and locked	pneumatic with height adjustment; wheels lifted and locked	pneumatic with height adjustment; wheels lifted and locked	pneumatic with height adjustment; wheels lifted and locked
Locking elements build on	adapter	adapter	Semi-trailer	Trailer and bogie	bogie

Source: own elaboration.

5. ADVANTAGES AND DISADVANTAGES OF BIMODAL TRANSPORT

Advantages of bimodal transport, comparing with other systems of combined road-rail transport are given in the Table. 3. Bimodal transport, in addition to typical benefits of combined road-rail transport, such as reduction of transport work energy intensity, reduction of ecological threat, shortening transport time through holidays breaks elimination and shortening waiting times at border checks, provides greater economic efficiency, mainly through increase of more than 1/3 ratio of capacity to train weight, compared to other forms of combined road-rail transport. The additional advantage of bimodal transport is the fact, that it is restricted to a small number of subjects (transport units) and means of transport, and does not require terminal handling equipment. At the same time, this system does not require additional work connected with reloading, as all the activities related to forming and dismantling bimodal trains can be performed by a driver, who uses the lift, which is attached to the vehicle.

Table 3. Advantages of bimodal road-rail transport.

Conventional systems of road-rail transport	**Future bimodal transport**
percentage ratio of capacity to train mass	
Trailers in pocket wagons 50% Swap bodies and containers 51% Systems and loaded car 45%	road-train semi- trailer 68%
Objects (transport units)	
sea containers land containers swap bodies semi-trailers Car assemblies	road-rail semi-trailers: - Closed vans - tankers
Means of transport	
Road vehicles for transport of: - Containers and swap bodies - Semi-trailers Railway wagons for the transport of containers, swap bodies, semi-trailers and automotive parts: - Container platform - Pocket wagons - "Wippenwagen" - "Rolling Highway"	Tractor units, standard bogies with so called adapters
Terminal handling equipment	
railway gantry cranes „Reach-Stackers" „Lift-Trucks"	Redundant

Source: own elaboration

Bimodal transport has also disadvantages, such as too short bimodal trains and relatively low speed possible to achieve with standard bogies.

According to information presented in the Materials of the 2nd National Symposium "Technical means of (bimodal) road-rail transport", some railway companies tested sets of two, three or exceptionally five semi-trailers. The research and calculations show that standard bogies allow the bimodal train to reach the speed of no more than 100 km / h. However, these are not obstacles that would override benefits of bimodal technology. Energy savings in bimodal system are so significant that transport, composed of at least one semi-trailer with a mass of 38 tones is already profitable. It has been also demonstrated, that with minor construction changes, such as introducing sets biding the wheels in the horizontal plane, outside of the bogie frame, a significant increase in speed can be achieved. Development of bimodal technology is therefore inevitable, particularly in long distances transportation.

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