Application of bimodal vehicles with respect to capacity of rail lines

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Abstract - **The paper, within the area of Multimodality, deals with adjustment (harmonization) of the transport capacity of trains - whatever traction - to the demanded capacity of lines, the multimodal vehicles are passing through. The actual problem of multimodality is, that a variety of passenger trains, ... further a variety in modes of cars and of motive power, may be limited by the given capacity of line section. By introducing rail buses or other new type of rolling stock, attention should be paid not only to the technical feasibility but also to possible performance of transport tasks on each section of rail line.**

1. Introduction

Words like **Multimodal** and **Multimodality** may be used in two different meanings. In the first one it is used to the choice of mode of transport, modal split and organization of transport chains including various modes of transportation. Let me call it an economic meaning. In the other one it is used to define vehicles, fitted for running with various motive power or over various ways. The same meaning applies to ways, that may be used for running various vehicles. Let me call it a **technical meaning**. I'd like to use the word multimodal, concerning vehicles and rail lines, in this meaning.

Let me consider the problem of multimodal vehicles from the viewpoint of the capacity of transport lines and let me consider only **bimodal rail vehicles**, because they are supposed to play a great role in public transport, owing to their transport capacity, higher than of other multimodal vehicles.

Nowadays, when a crisis of railways is announced in mass media all over this country and in many others too, followed by decrease of a railway share in serving passenger mobility in urban transport, **bimodal vehicles** are seen as a remedy for the crisis and a new possibility for serving the lines, that may fulfil requirements of many daily users for direct connections. Besides, the rolling stock industry is interested in construction, manufacturing and sale of new types of unusual or unconventional vehicles. And in advertising them, of course, too!

2. Direct connections

The common wish of commuters within any agglomeration is to spend as little time as possible for everyday journey, either it is made within administrative boundaries of a city or it crosses the boundary. For those using a public transport, **the common wish** is to board a vehicle, that brings them up to the destination of their journey.

Every change of a vehicle means an obstacle for any commuter passenger and an appropriate additional share of his overall journey time. The additional time may be set down by the proper choice, where to make a change and – sometime in the future - by the proper shape of the interchange station.

As an effect of contemporary urban development, it is difficult to satisfy the wishes of population for **direct connections**, because a system of urban transport has been growing up step by step as a network of lines and of various modes of transport. A network of **rail** transport represents an infrastructure of a great capital value, especially owing to location of many sections of transport lines within the inner city, in areas of dense population.

It is a proven fact that, when the quality of passenger transport into inner cities is improved and the need for a change of vehicle obviated, more journeys are made [Blazek]. When more journeys are made by the population of the area, the problem of over-congestion on the infrastructure arises. For an event like this, an allusion to the importance of a service to society is included in The White Paper "Transport policy for 2010" of 12th September 2001 [Rogissart].

Local goverments in various areas are going to organize new direct connections for numerous commuters. So the **new use is made of rail tracks**, being used up to now or just not used or used in another way than originally. This is the way on which multimodal vehicles and lines, suitable for running various vehicles, have come into being, even before the publishing of the White Paper.

3. Different vehicles on the rail lines

>From the standpoint of multimodality it may be distinguished between some situations of variety in technical means, that interfere on the rail lines. These types of situation are enumerated, starting from the situation of great difference between technical means, coming to the situation, where no essential difference is in technics, but in organization of traffic. No wonder, the last situation is often observed on lines, where the highest capacity in passenger transportation is needed.

3. 1 Difference in the width of tracks

There is an old concept, or rather a dream, of three rails track, being useful for vehicles of two different gauges. Many people look on the eastern boundary of Poland, when an experience should be gathered on exploitation of different gauges of railway track at the interface of the European standard 1435 mm gauge with the standard Soviet or Russian 1520 mm gauge. The difference of 85 mm is far too small for positioning two rails for right wheels of the different vehicles, opposite to one common rail for left wheels, because the foot of a typical rail is 150 or 180 mm broad. On special sections, as a bridge for common use by both European and Soviet vehicles, four rails had to be laid down, two of them for vehicles of each gauge, provided that vehicles of dfferent gauge do not use the same section simultanously.
In other places in Europe it happens that rails of different gauge are coming to the same station. It happens so in Spain, where a traditional Spanish track of 1668 mm gauge comes together with the standard European 1435 mm track, or in some towns on theEuropean continent, where the old tram network of meter gauge, approaches a station area or a siding with standard gauge.
In 2002 GIF the Spanish railway infrastructure company published, that it has developed a new type of sleeper to hold three rails [GIF]. With the given slight difference between widthes of both standard tracks 1668 and 1435 mm, there is only a short distance left between the

bases (or feet) of the two rails on the same side of the track. Pressure onto a sleeper like this, even of comparatively great dimensions, is asymmetric, either from vehicles of one gauge or of another or of both. So on these tracks the speed of trains must be limited. The great dimensions of the sleeper for three rails probably do not allow to apply it into the track, where only a little space is available for reconstructing a track in the city.

3. 2 Difference in gauge

There is a number of dimensions in standard for railway gauge, not only the width of track, that may be not observed along lines of urban rail transport, where the standard railway width of track is applied. The process of introducing new vehicles - especially railway rolling stock - onto streets and rail network of urban transport, may be limited by the difference in the height of platforms, the width of streets, the radius of track curves, and the dimensions of viaducts and bridges, the new vehicles are passing through [Braunschweig].

3. 3 Interface between tram and main-line train

For the interface tram-train some different properties of both modes are essential, even there where difference in gauge makes no obstacle. There are various systems of motive power with different voltage of electric current [Batisse, Ludwig, www.tramtrain.org]. Besides, some unelectrified rail sections may be included, served by autonomous vehicles, as rail buses or diesel motor units or even hybrid diesel-electric motor units [Hondius, Kassel]. Systems of signalisation for urban traffic are different from those adopted on railways and are not ready for interoperability. Special problems arise when urban rail transport is serving border-crossing connections [Blazek, Gauderon].

3. 4 Variety of trains along the line

For meeting the demand for transport in various destinations or connections trains are running with various destinations and with various train-consists. The variety of trains are coming together on a railway line. Even if there is no essential difference in technics of the rolling stock, problems arise in organizing the common use of various rail sections by trains serving different sets of stations.

4. Rail capacity problem

The best use of the line capacity by trains is achieved if trains are following one another at the same speed or with the same occupation time of the given section of the line. The rational way of dealing with passenger flow along the line, is not to run the greatest number of trains in the given period of time, but to run a number of trains that is necessary to cope with the flow. From this number an interval between consecutive trains may be calculated (Takt). When mixed train traffic must be run along the section, any train other than the typical one may disturb the traffic.

If the untypical train is much slower than the typical one, it may disturb the running of typical even-interval trains on the schedule. But if the untypical train must go much faster than the typical one, it may disturb the run of even-interval trains even more [Potthoff, Łaszkiewicz].

5. Passenger transport capacity problems

If the number of suburban trains on a given line within the peak period is adjusted to the flow of passengers to be forwarded, the other train may run if there is enough space available on the time-route diagram only. Otherwise the other train should be allowed to run, if it may

carry the number of suburban passenger as great as a typical suburban train does. Mostly this is not the case: either the untypical train is shorter, so it carries less passengers, or it is longer and then it takes more time for acceleration after each stop on the section. Consequently, either the train does not keep the occupation time (Sperrzeit), or it does not stop at every station the suburban trains serve.

6. Some figures on rolling stock

Some figures on rolling stock may be useful for illustration of differencies between various types of vehicles, used on rail urban transport in great numbers nowaday.

The electric motor unit EN57, typical for the **Polish Railways**, not of modern construction, has about 212 seats in three cars. A number of passengers, transported in peak-period on the emu is evaluated as 400 to 600, mostly about 500. Suburban trains around great cities consist mostly of two emus, so a train may carry about 1000 people. Other three-car emus have nearly the same capacity. Trains may be built up of three emus, then a train may carry 1500 people; tracks and platforms at the intermediate stations are long enough. Where not so many passengers are to be carried, a passenger train consists of one emu. On some lines four-car emus are operating, they have a little higher acceleration.

Over the **Warsaw underground** (metro) line two types of trains are operating. The older type of the Soviet Union consists of 4 cars. This stock is not delivered any more. The modern rolling stock comes from Chorzów, Poland, a Konstal factory, partly owned by Alstom. The train consists of 6 cars, using the entire length of platforms on the stations. A number of this type new trains has been ordered by the Warsaw city-council. The city-council evaluate a number of passengers, that may be carried on the train, seating and standing all together, as 500.

A modern rolling stock for **LRV**, running over some tram lines in Poland and in Germany, are Combino trains. The trains for Poznań consist each of five sections, taking 172 passengers, including 57 seated, and achieving 70 km/h. Combino LRVs have been ordered for some cities in Germany: Augsburg, Freiburg, Nordhausen. They may be build for maximum speed 120 km/h. Some trains should consist of five sections, some others – of seven sections; these can take about 220 passengers.
The given numbers are telling that the trains of modern vehicles for city transport can carry much **less passengers** than the typical emus of the railway. If vehicles are running over the old tracks in the city-streets or over winding tracks in tunnels constructed under the streets, the cars are about 2.20 ÷ 2.40 m wide, mostly 2.30 m, instead of some over 3 m wide railway coaches, as 3.15 m is an upper limit of width, allowed mostly along the continental main-line railways.
If some day a common use of the railway tracks is introduced for trains consisting of either Combino or underground (metro) vehicles, not many passengers may be served by a single train of these vehicles.
At the long distances between consecutive stations, a great difference arises in **running time** of various types of trains, because various vehicles of city transport cannot achieve a speed of railway vehicles. So the common use of line may not be introduced where is a dense traffic of suburban railway trains. It must not be introduced on lines, where high-speed passenger trains are operating either. Whenever anybody tells about application of multimodal vehicles at Karlsruhe or Kassel, it does not mean a coexistence of ICE high speed trains with bimodal vehicles on the same tracks [Hondius].

7. Some cases of rail transport

Some cases will be given, each presenting, how the problem of capacity of railway lines may influence on the possibility for running various trains from suburbs directly to the inner city.

7. 1 Case Szczecin (Stettin)

Three lines are coming together to the big railway node from the west side of the Odra (Oder) River, each of them is used for stop trains, mostly terminating at the main station Szczecin Główny, carrying a little number of passengers. Two lines from east, being most important for passenger and freight traffic, are coming together at the station Stargard, about 40 km from the Szczecin inner city. Trains from these two and also from the third and fourth electrified main lines come together at the east bank of the Oder River, each train being destinated to cross the bridges on the river and to terminate mostly at the main station Szczecin Główny, or at the freight yard.
In the situation like this, with many trains passing the 25 km section between stations Stargard and Szczecin Dąbie and still more - over the Oder bridges, passenger trains serving non-electrified secondary lines from the south-east, terminate at Stargard station.
In the 1970s, a railway line from Szczecin to the harbour station Świnoujście was essentially modernised and electrified. The same time a short branch line about 17 km long, was electrified, leading from the station Wysoka Kamieńska about 70 km north from Szczecin, down to the end station at Kamień Pomorski, a resort for sunday rest, with hospitals, sanatories, yacht harbour and the only 10 km distance to the seashore. Daily services with direct trains of electric motor units (emu) seemed to be the ideal means for bringing workers to the resort from the city of Szczecin.

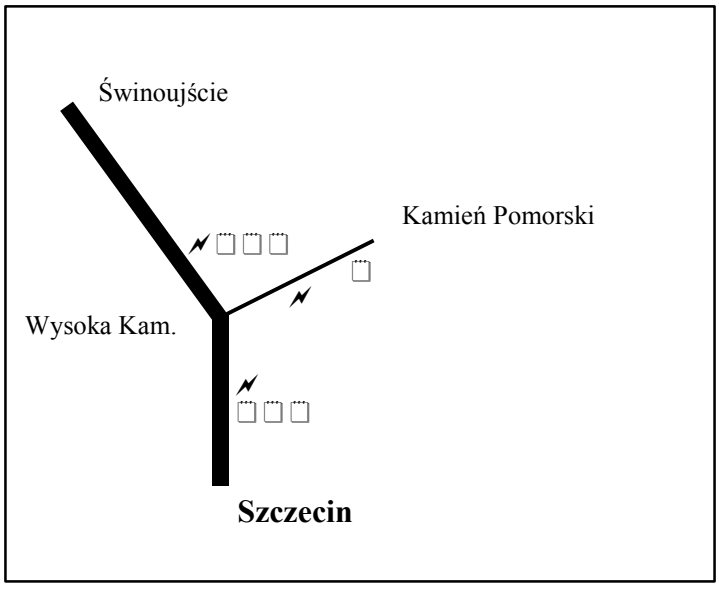

Fig 1. Szczecin – Kamień Pomorski, before suspending an operation

But during some years, the direct trains from Szczecin to Kamień Pomorski were full or good populated only on some summer days. On other days they were operating on the section behind Wysoka Kamieńska nearly empty. It was not reasonable to shorten the train-consist down to only one emu, because a single emu would be overcrowded in the vicinity of Szczecin.
Then another solution was introduced in the new timetable: short trains of a single emu on the short distance between Wysoka Kamieńska and Kamień Pomorski, each of them adjusted to the scheduled time of a passenger train from or to Szczecin. But then, the time for interchange between two trains, with respect on the possible delay of a given passenger train was rising too high and passengers were losing their interest in the journey between Kamień Pomorski and Szczecin by rail. So the railway administration suspended the operation on the branch line to Kamień.

7. 2 Case Warszawa (Warsaw)

Seven main lines are coming together to the railway node, each of them is used for commuter services and for far-distance or international passenger trains. The limited rail capacity of the central section of the line between the East station and West station – the so called diameter line – causes that not all the commuter services are passing through this section, although mostly commuters would like to achieve the inner city through any station along this central section.

A short branch line was electrified and partly modernised, leading from a little town Legionowo at the main line 25 km north from Warszawa, down to the end station Zegrze at the new artificial lake, a resort for sunday rest, fishing, sailing, sport and various entertainment. It happened in the early 1970s, when not so many individuals at Warszawa possessed their cars and only few buses were operating between the city and this resort. Daily services with direct trains of electric motor units (emu) seemed to be the ideal means for bringing workers from the city to the lakeshore and back again.

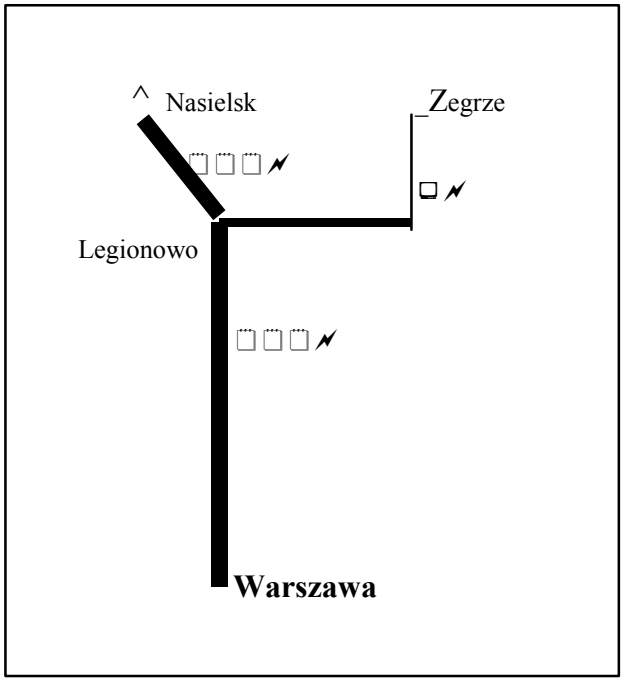

Fig. 2. Warszawa – Zegrze, with interchange

But after some years, the railway administration has realised the direct trains from station Warszawa Gdańska to Zegrze are full or good populated only on some sunny, spring or summer days. On other days the trains are operating on the section between Legionowo and Zegrze nearly empty. It was not advisable to shorten the train consist down to only one emu, because the only one unit would be overcrowded along the main line, where all the stop trains are available to every passenger.

Another solution was introduced after some years to the new timetable: short trains of one unit on the short distance between Zegrze and Legionowo, each of them connected in Legionowo with a main-line stop train. But then, the time for interchange (correspondance) between two trains calling at various platforms, also with respect on the possible delay of a train on the main-line, was rising too high and passengers were losing their interest in the journey between Zegrze and Warszawa with two trains. Finally Zegrze has lost its rail connection to Warszawa.

This loss may be seen as a consequence of shortage in the rail capacity of the main line section between Warszawa and Legionowo. The capacity did not allowed to run any special kind of suburban trains, other than the typical suburban trains running there their normal route over a distance of 80 km or more. No special vehicle, no rail-bus could be introduced to this section, because a given number of typical trains was necessary to bring the everyday flow of passengers to the city during the pick hours and then back again, each train keeping the standard running time on the schedule.

7. 3 Case Poznań (Posen)

Nine main lines are coming together to the big node, four of them are loaded with far-distance passenger trains and two others are not electrified. But each of the nine is used for commuter services. Mostly commuters want to arrive or depart at the main station Poznań Główny. Three lines from east and north are coming together at the East station and all the

passenger trains from these lines are passing the common section over the bridges on the Warta River, running to the main station and back again. In the year 2000 a study on integration of rail urban transport at Poznań was drawn the group of transport specialists. According to the study, four lines for commuter operation are pointed out, running through the city and outside the city boundaries, each served by special vehicles. At least three of the proposed lines would make use of sections of Poznań railway junction, that are used by many passenger trains now.

Taking into account the capacity of these sections it seems difficult to introduce there any other train, with different running time and less number of passengers carried, during the peak hours.

7. 4 Case Dresden

A new railway line was constructed, linking the busy station Dresden Neustadt on the right bank of the Elbe River with a modern airport, situated just behind the city boundary to the north. This airport rail link was served by the passenger trains, consisting of a two-section diesel motor unit VT 642. The single unit did for serving the airport in even intervals. Eventually this link might be served by trains, consisting of two motor units.
The heavy traffic over the Neustadt station consists mainly of suburban, IC and EC trains, coming from Meissen, Leipzig and Berlin, all of them with electric motive power, and of suburban and interregional trains, coming from Bautzen, Goerlitz and Wrocław, powered with diesel locomotives. Many freight trains are passing the Neustadt station as well. Every train coming from the east or north to this station has to be forwarded farther over the bridge on the river to the main station of Dresden or to any other station on the left side of the river.
In the situation like this, trains serving the airport rail link mostly terminated at Neustadt station during the day time. Passengers had to change the airport train for the other passenger train, approaching the inner city; similarly they had to change in the opposite direction. It would be irrational to allow short airport trains to run over the bridge section, when the section is loaded with heavy traffic of different trains.

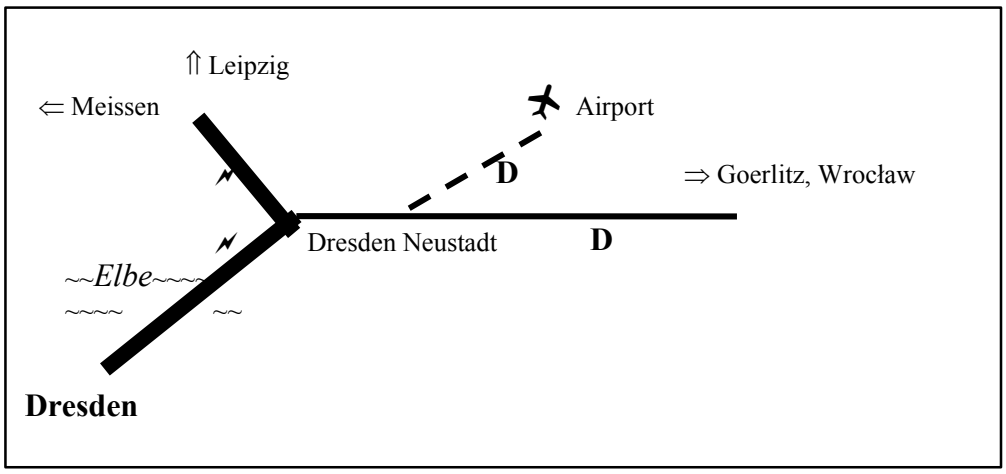

Fig. 3. Dresden before electrification of the airport link

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The situation has changed after the catastrophic flood in August 2002 and then after upgrading the railway bridge over the Elbe and completing the electrification of the airport link in December [Elektrischer]. Now, instead of diesel, electric motor units may be serving the airport trains and their route may be extended to the inner city and farther, according to the actual plan for development the S-Bahn suburban service of the city of Dresden.

7. 5 Cases Stralsund and London Heathrow

In both cases the capacity is sufficient for running main-line trains and those coming from a branch line. Various trains consisting of one or several emus or coaches with variety of stops are operating between Velgast and Stralsund. Far-distance Great Western trains and Heathrow Expresses are running non-stop on the same tracks close to Paddington Station in London.

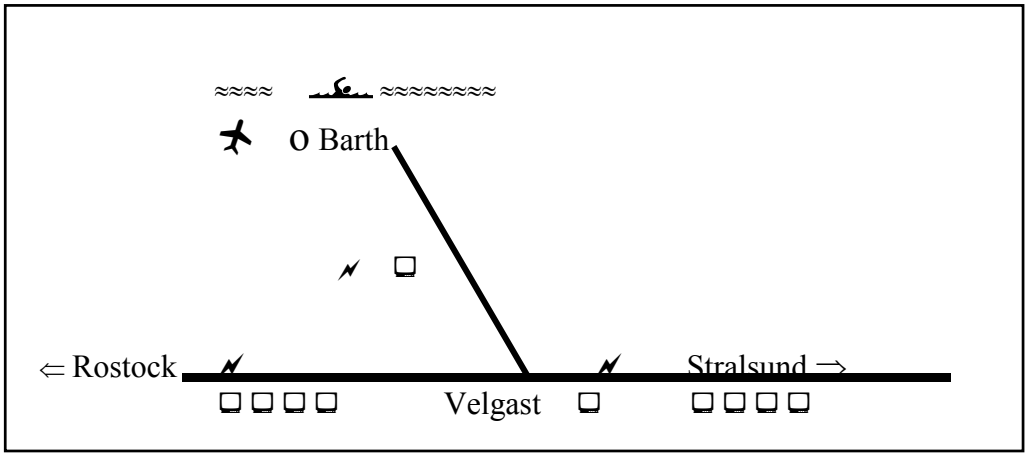

Fig. 4. Stralsund – Barth

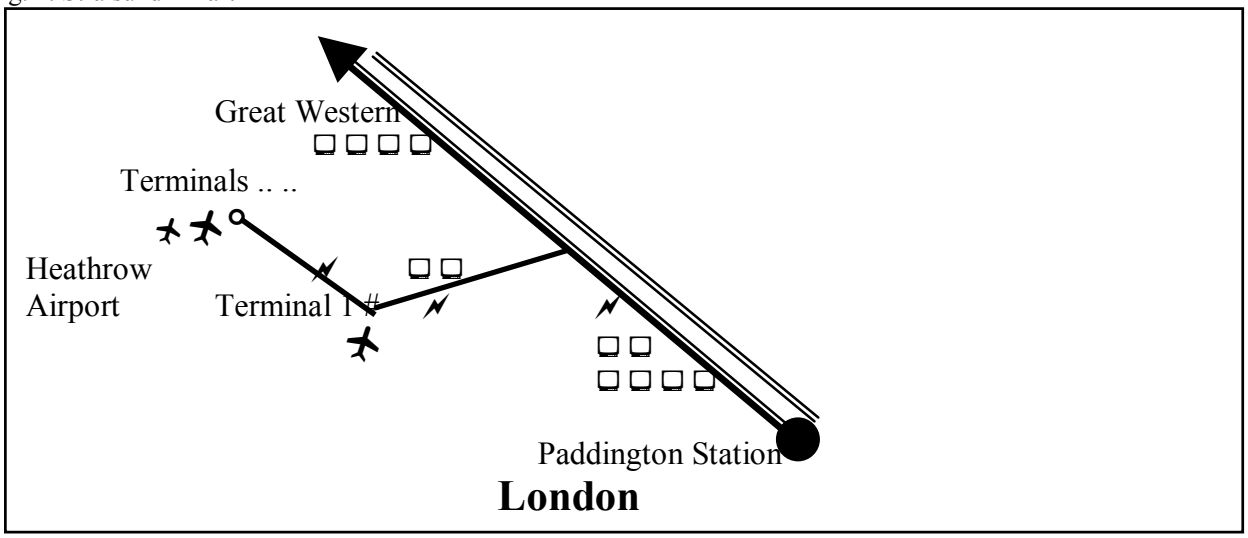

Fig. 5. London - Heathrow

8. Conclusion

As a new type of rolling stock is introduced onto the given line, conditions of the capacity should be observed on every section, used by the new rolling stock.

Nowadays many projects are prepared intending to use rail-buses or single diesel motor units or other special rolling stock, including bimodal vehicles, over the line with heavy traffic. They are supposed to be a solution for running direct trains down to the city from various dispersed localities. Some of these projects do not respect the rail capacity of the main line and the overall capacity of the transport system, that is bringing thousands and thousands commuters daily to and from the city. This applies also to introducing short trains of the typical rolling stock.

If the conditions of the line capacity are not respected, it may lead to the inefficient use of the line or to the bad use of the vehicles.

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