Acta Polytechnica CTU Proceedings **35**:14–18, 2022
https://doi.org/10.14311/APP.2022.35.0014

Published by the Czech Technical University in Prague

MODERN RAILWAYS FOR THE 21st CENTURY – A CHALLENGE NOT ONLY FOR DESIGNERS

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Abstract. The paper outlines the basic goals for modern rail transport in the Czech Republic. This contribution points out some challenges and technical tasks that project engineers and operators of the rail transport in the Czech Republic will have to deal with if they want to succeed in the conditions of the liberalized European railway market after the year 2035. Moreover, the article assesses the demands placed on safety of the railway transport and presents suggestions for reduction of the consequences of a rolling stock-car collisions in the regional transport.

Keywords: Active safety, design vehicles, ETCS, high speed railway, modern railway transport, passive safety, regional railways.

1. Introduction

In the 21th century, modern railways must not be just an interconnected and interoperable network of European high-speed and corridor lines, e.g. see Figure 1.

It must represent a highly ecological and safe transport system, which offers customers fast and reliable transport throughout Europe by its services and quality.

The transport system, which will be more time- and cost-effective and acceptable than competitive air or individual car transport (ICT) for people and goods transportation to a distance of about 1000 km.

Modern rail transport in the Czech Republic has to meet the following basic goals:

- to be a leader in the safe, attractive and barrier-free passenger transport, not only in the long-distance transport, but also in the regional and suburban transport,
- with the quality services offered to passengers it has to offer a higher level of connectivity to the regional passenger transport to junctions (stations) and thus to contribute to a reduction of the part of the individual car transport in passenger transport for work or culture. The model of ecological, time-bound and affordable mobility needs to be strengthened,
- it has to offer operationally safe, energy-efficient and low-emission (noise, CO_2, NO_X, dust particles) transport of goods and freight, which will be more competitive and more environmentally friendly than individual truck transport,
- it must significantly increase its share on the international container transport and the European combined transport (road – railway), because this system is able to significantly decrease an accident rate of truck transport. Trucks should be mainly used for the first and the last mile freight transport from the railway junction (modern transshipment point) to the customer and back, not for transport across the whole country or the central Europe,
- within the freight transport it has to ensure the ecological collection of municipal waste to selected large-capacity incinerators and sorting plants, because by this way it is possible to meet the objective of the ban on landfilling of municipal waste and its secondary use.

By taking these steps with the high level of "traffic electrification" the modern railways, while maintaining a certain level of mobility, can make a significant contribution to meet the emission reduction targets defined in the EU program documents called as "White Book of Transport".

2. Challenges not only for Rolling Stocks Project Engineers

To meet these goals requires:

- Significant investments costs in the infrastructure (building HSR, modernization of the contemporary railways and a completion of electrification – transition to 25kV/50Hz AC traction system, modernization of railway network junctions – transfer points from the regional railway to HSR, loading hubs for European combined transport.
- Extensive investments in vehicles (purchase of new rolling stocks, new high-speed electric multiple units for speed of 300 kph, cost-effective fleet modernization, ETCS implementation, dual-powered vehicles for regional transport, new vehicles for combined transport, ...).
- Change of transport models and the passenger transport in order to achieve maximum and efficient

FIGURE 1. A Trans-European rail lines TEN-T [1].

utilization of new high-speed lines and vehicles.

- New models of mobility in the area of the Central Europe and a thinking and behaviour change of the people and passengers in favour of safe and environmental-friendly transport.

Only the rapid fulfilment of these points and elaborated training of new railway experts and employees is able to prepare Czech railway for a great competition in the conditions of the liberalized European railway market after 2035. Achieving of low operating costs while meeting high level of operational safety and environmental requirements will be key factors, which will decide about the success or failure of our operators on this market.

FIGURE 2. High speed AGV or ICE 4 for passenger transport in Czech Republic? [1].

2.1. HIGH-SPEED RAILWAY TRANSPORT VERSUS CORRIDOR LINES = NEW TRANSPORT MODELS

The requirements for a high safety level of high-speed railway traffic on HSR are embodied in the technical specifications for interoperability (TSIs) for the design of railway tracks and rolling stocks. TSI HS fulfilment and European Train Control System ETCS implementation (level 2 and level 3) shows that the HSR system, with the appropriate operational load of high-speed units, significantly contributes to economic and environmental mobility and demonstrate competitiveness against air or road transport.

The Czech Republic has to significantly accelerate building of HSR if it wants to offer an economic and fast connection between northern and southern Europe to European operators after the year 2035. It would be inappropriate if the Czech Republic is bypassed and the international transit passes through the Federal Republic of Germany and Austria.

The transfer of transport capacity in the international and the domestic long-distance passenger transport on high-speed railways with maximum axle load of 17 tonnes and speed limit up to 350 kph will require a change in transport models of regional services and transfer nodes. Daily operation between approx. 5-23 hours can be realized by electric multiple units with distributed power, see Figure 2. For night bed and lounger express trains with operation from about 9 pm to 7 am, it is more appropriate to use units with concentrated traction power in front and rear car with regard to passenger comfort. For HSR operation these multi-system drive head cars should not exceed the mass of 67 tonnes. At this point it is necessary to point to the fact that Czech operators will have to buy these vehicles in near future.

These new transport models should free up existing railway corridors for a high-speed regional transport and for international container and combined freight transport. For conventional freight-trains SŽ s. p. (Railways Administration S.E.) has to ensure suitable and efficient use of incline and directionally more demanding railway line Kolín – Kutná Hora – Havlíčkův Brod – Křižanov – Brno, see Figure 3.

However, modern railways have to maintain a high level of operational safety when meeting the new requirements.

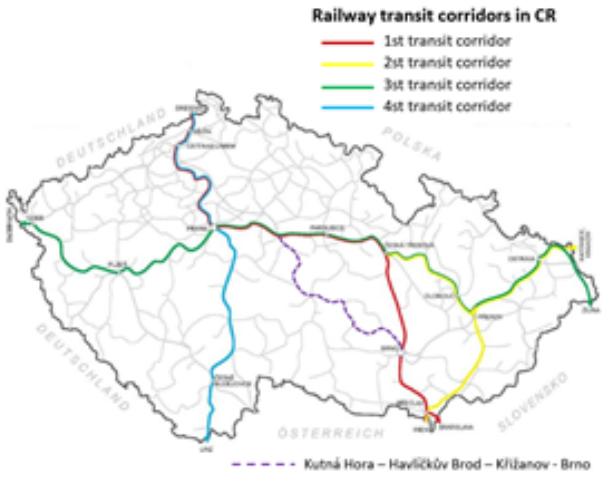

Figure 3. Railway transit corridors in Czech Republic.

2.2. Modern Regional Railway, Safety versus Railway Ecology

The safety of rolling stocks operation is divided into two groups:

- *Active safety* – represents elements and systems to prevent accidents of rolling stock among themselves or with road users.
- *Passive safety* – represents the components and systems designed to reduce the consequences of an accident.

2.2.1. Modern Speed Regional Railway

For railway lines with a speed limit above 160 kph, level crossing with road infrastructure is required. This requirement of separation of the railway line from the road provides a sufficient level of active safety. In the field of passive safety of rolling stock, new requirements for the strength (EN 12 663) and crash resistance of rolling stock (EN 15 227) were defined at the end of the 20th century, see train AVG – Figure 4.

The implementation of these new measures, together with the growing demands on multi-system (three-system, dual-powered or hybrid) vehicles, accessibility and better equipment of vehicle interiors (WIFI, better information systems, noise reduction, etc.) is reflected in an increase of vehicle body weights.

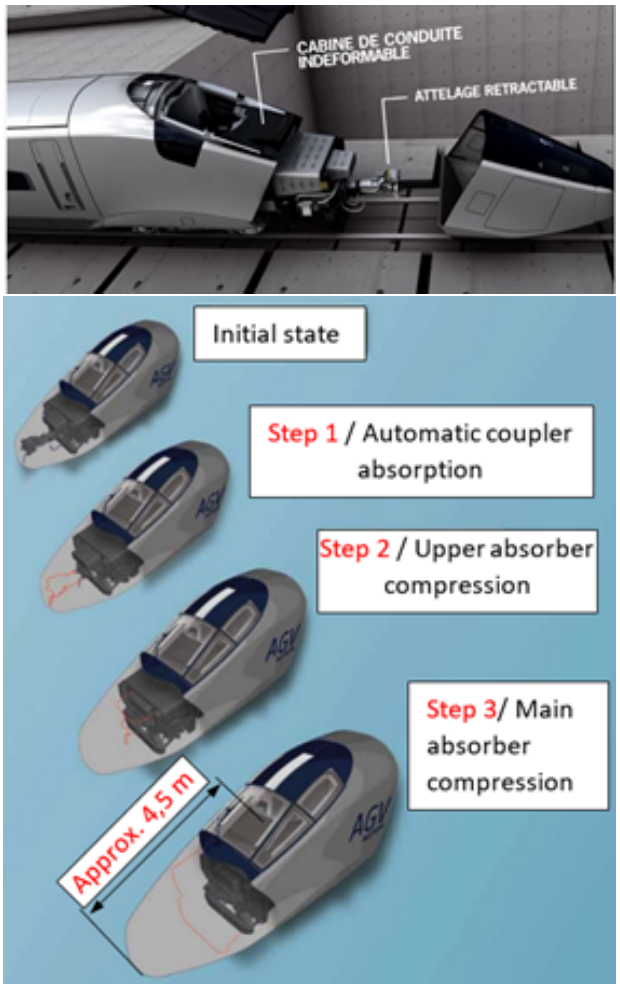

Figure 4. Visualization of energy absorption device – HSR train unit AGV [2].

The manufacturers are trying to compensate for this increase in weight with a light carbody design and with a change in the concept of vehicle running gear. Instead of bogies with outer frames, concepts with an inner frame are being developed. But even these solutions have their design limitations (eg. higher sensitivity to changes of wheel load forces, less space for installation of the wheelset drive, reduced angular stiffness of the primary and secondary suspension, which leads to utilization of torsional stabilizers, and others).

2.2.2. Regional and Suburban Railway Transport versus Road Transport

The situation is somewhat more demanding in terms of safety and ecology of operation in the regional transport. The requirement for a regional rolling stock to meet the requirements of EN 12 663 – category P2, EN 15 227 – category CI represents an increase in its weight and the resulting higher rolling resistance, greater inertia effects and thus higher energy consumption. Modern 21st-century regional railways must therefore use rolling stocks with electric power transmission, as only this type of drive makes possible to achieve a high percentage of vehicle kinetic

FIGURE 5. Bogie SIEMENS SF 7500 with inner frame and inside bearings – train unit MIREO [3].

energy recovery with the consistent application of electrodynamic brakes on all vehicle wheelsets.

FIGURE 6. Electric regional unit MIREO [3].

Regional railway lines quite often cross roads in the form of railway crossings. There are about 8,000 railway crossings in the Czech Republic with varying degrees of security, in [4]. Any unprotected level crossing increases the risk of crash between regional train and road vehicle. Compliance with the requirements of standards EN 12 663 (category P2), EN 15 227 (category CI) makes the railway vehicle a clear winner in the case of a collision with car.

Nowadays, most collisions of rolling stocks with the car leads to a significant car body destruction and serious injuries or death to car crew members.

In this context, the question arises for a broader expert discussion:

Should we equip vehicles for regional transport with additional increased weight (resulting from the installation of the additional passive safety elements and the requirement for controlled deformation of vehicle fronts) and thus increase vehicle weight, extend starting and braking distances, increase consumption and reduce competitiveness with bus transport?

Meeting the requirements of standards EN 12 663 (category P2), EN 15 227 (category CI) de facto means that economically operated and ecologically advantageous, light two-axle motor vehicles, called as rail buses, will disappear from regional railways.

Would it not be more appropriate to require regional rolling stock operated on local railways to meet the requirements of EN 12 663 - category P3, EN 15 227 – category CII and to equip both types of vehicles (rail and road) with active safety features that would significantly eliminate road vehicle collisions with a light rail vehicle (rail bus)?

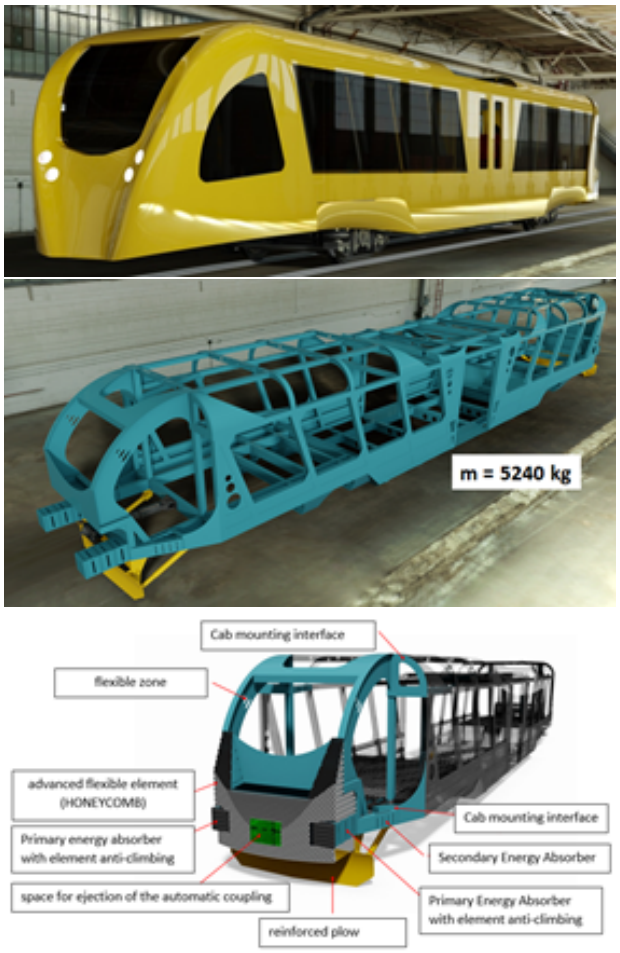

FIGURE 7. Design study of the Rail – electric bus [5].

The potential to reduce the consequences of a collision between a rail vehicle and cars is possible:

- **in the field of active safety, it is appropriate to consider and use the possibility of communication of the mobile part of ETCS placed in new rolling stocks with the navigation and control system of cars.** When all rolling stocks are equipped with an ETCS safety guard, which allows the vehicle 's position to be monitored on the track, it is possible to link the rolling stock communication with the level crossing or directly with the motor vehicle. Thanks to the exchange of information about the railway vehicle drive, car control units could control the driver's activity and possibly directly prevent the driver from driving over the railway crossing and thus prevent an accident.
- **in the field of passive safety, it is appropriate to assess the possibility and reality of the application of new safety features ("protective frames or panels") on the fronts of regional rolling stocks.** These more flexible protective frames, which the driver would "shoot" in

front of the rail vehicle in the event of an immediate avoidance of the accident. These forward-moved safety elements will absorb and "soften" the impact of the front of the light rail vehicle to the side of the car and reduce the penetration of the coupling into the passenger zone.

Figure 8. Revolution Very Light Rail [6].

3. Conclusions

The requirement to implement ETCS-level 2 will certainly make a significant contribution to a higher level of active safety in the regional rail traffic. However, the next, entirely logical step should be to start intensive cooperation between ETCS creators and car navigation and control system manufacturers. The transfer of information about train's position to the car navigation and its display to the driver and storage in a "black box" recording device can significantly increase the responsibility of car drivers for their behaviour at unprotected level crossings. This cooperation of the ETCS mobile part with road vehicles will be necessary for autonomous vehicles.

Figure 9. Very Light Rail for export to Turke [7].

Acknowledgements

This research has been realized using the support of The Technology Agency of the Czech Republic, programme National Competence Centres, project #TN01000026 Josef Bozek National Center of Competence for Surface Transport Vehicles This support is gratefully acknowledged.

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