Technological Barriers to Interoperability in Railway Transport Between Europe and China

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Summary

The growth in freight-traffic between Europe and China is driving the quest for new transport routes between these regions. One of the options is to use railway routes. The concept of using railway connections is referred to as the New Silk Route. A number of analyses of freight traffic point to a huge demand for this type of transport since sea freight is marked by seasonality, long travel times and the growing problem of congested ports, both in China and Europe.

Currently, there are several railway connections between China and Europe. These connections are hindered by intermodal transport and transhipment, which extend freight travel time, generate extra costs and result in the low capacity of these connections. In order to increase capacity, new connections should be developed using the interoperability of all the railway routes between Europe and China. Many barriers, however, impede this idea. Many of those barriers are technological in nature.

This paper looks into technological barriers that constrain interoperability in railway transport between Europe and China. The first section sheds some light on the idea of interoperability, as well as railway connections between Europe and China. The second section points to the technological barriers in this kind of transport. The next section presents some possible solutions for removing the barriers. The final section provides a summary.

Keywords: transport Europe – China, Silk Road, barriers to rail transport, interoperability

1. Europe – Asia railway transport

With the ever-greater freight possibilities, railway freight transport between Europe and Asia is becoming increasingly attractive. The UIC report of 2017 (*fr. Union Internationale des Chemins de fer*) shows that the years 2014–2016 saw a steady increase in cargo transported between Europe and Asia by rail, which amounted to 140.4% of CAGR (cumulative annual growth rate). In 2014, 308 freight wagons travelled between Europe and Asia, shipping ca. 25,000 TEUs (*twenty-foot equivalent units*). In 2015, the number of train sets amounted to 815 (ca. 65,000 TEUs), and, in 2016, 1,777 train sets transported ca. 145,000 TEUs. The values presented in the report are shown in Figure 1.

By 2027, freight traffic between Asia and Europe is optimistically forecast to reach 742,000 TEUs, corresponding to 16.3% of CAGR growth. This growth forecast is contingent on the following factors: the growth of FMCG transport; Chinese government support and subsidies for transport; infrastructural investments; the growth of sea freight and permits for the railway transport of hazardous goods. The pessimistic scenario is that the amount of goods transported in 2027 will be 437,000 TEUs, meaning that CAGR will equal 10.8%. This is the scenario for the slow growth of trade between Europe and Asia; the end of subsidizing Europe-China transport; lower share of sea transport; the lack of air transport and inappropriate infrastructural investments. The trend of freight growth in 2011–2017 is shown in Fig. 2.

An important factor behind the growth is the Silk Railway Route, linking Europe and China. The concept of the Silk Route presented by Secretary General Xi Jinping in 2013 is shown in Fig. 3.

The presented concept assumes the use of railway transport. Initiated in this fashion and aimed at connecting Europe and China, the project has resulted in train connections such as Chengdu-Rotterdam [15],

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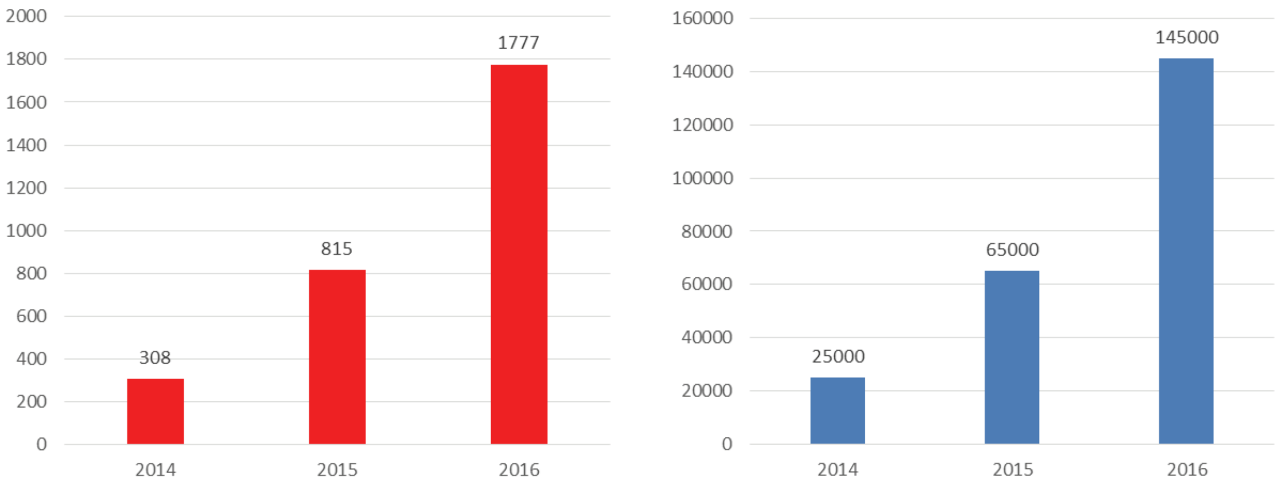

Fig. 1. The graphs for railway transport between Europe and Asia: the number of train sets on the left, TEUs on the right [9]

Yiwu-Madrid [14] and Changdu-Warsaw [9]. The use of railways can reduce transport costs by 30% compared to air transport and reduces travel time from 42 (sea transport) to 14 days. However, railway transport faces a number of barriers that impede this kind of transport between Europe and Asia.

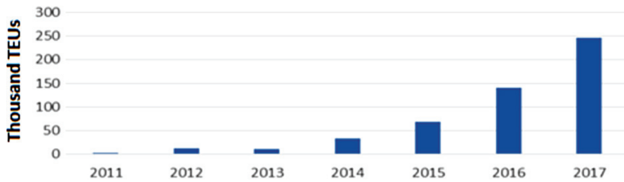

Fig. 2. The growth of railway freight transport between Europe and Asia [1]

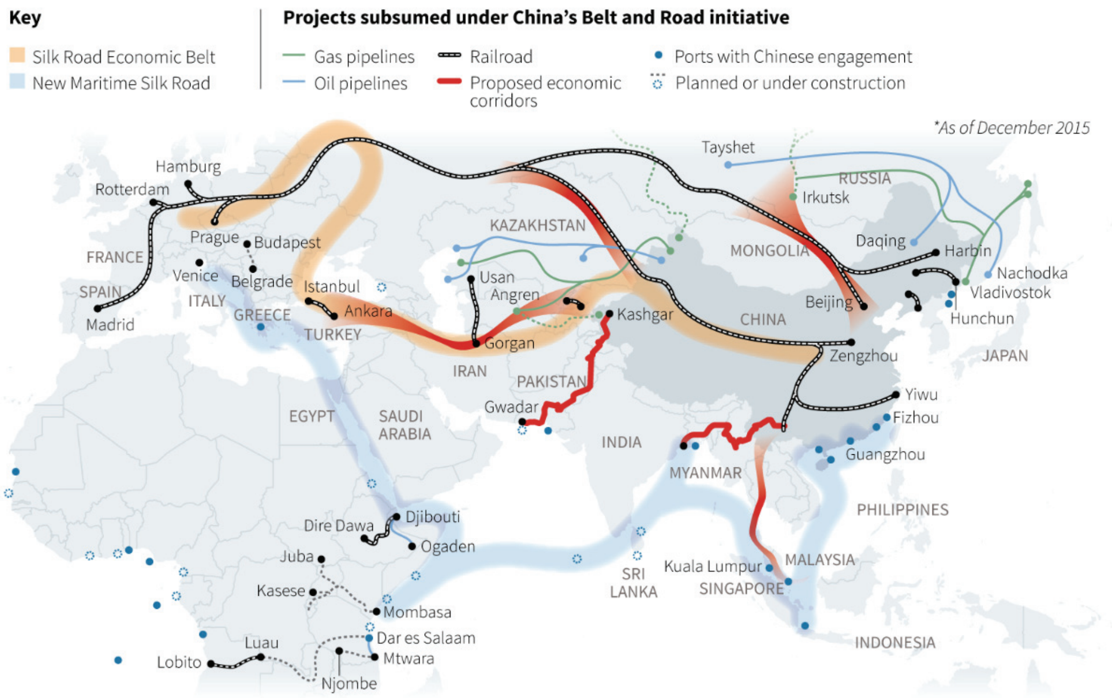

Fig. 3 A map for the concept of Europe-China transport making use of railway transport [12]

2. Barriers impeding the interoperability of Europe-Asia railways

The barriers to the interoperability of railways may be divided into non-technological and technological ones. Non-technological barriers to interoperability regard the organization of railways. The most important of those are:

- Differences in railway regulations;
- Language differences;
- The way of calculating payments for the use of infrastructure;
- Various levels of securing transported cargo across transport routes;
- Smuggling across the states.

Technological barriers to interoperability are related to the differences between technological solutions used in various railway systems. The most important technological barriers are:

- Traffic control systems;
- Various communication systems;
- Braking systems;
- Coupling and buffer systems;
- Traction powering systems;
- Track gauge and vehicle gauge;
- Rail cant (inclination);
- Rail and wheel profile;
- Maximum loading gauge; maximum train length;
- Maximum rail pressure.

3. Non-technological barriers

The legal grounds for railway traffic between Europe and Asia are based on the domestic laws of individual states. In Eastern Europe and Asia, railway enterprises used to be state-owned, developed their own technological specifications, manuals and followed state norms and regulations. The rise of organizations such as UIC and OSJD (Russian: Организация сотрудничества железных дорог – ОСЖД) primarily supported the unification of norms, but also of the regulations and requirements for railway transport within states related to respective organizations. In Europe, the process of railway unification commenced with the EU's efforts to create a single common railway system. Originally, this process covered high-speed lines only [13], but it has eventually covered the entire railway system.

A particularly strong impulse came with the publication of the directive on interoperability [4], the launch of a body concerned with railway safety ERA (European Union Agency for Railways), as well as the process of adopting subsequent railway packages.

Language differences are also a threat as railways have no single international language standard, as opposed to the air transport industry. This is because one of the practices of international transport is to swap conductors at state borders.

The methods of settling payments for the use of railway infrastructure also pose a problem as in Russia the fees are charged per train. In other countries, the fees are charged per car or even per axle. The profitability of bringing the same number of wagons across different infrastructures differs depending on the system of charges. Another problem is the need to protect the cargo. In EU states, it is rare to see cargo stolen across transport routes. In the steppes of Asia, this phenomenon is widespread, though. Major railway companies use special mobile protection units, which generate extra costs of transporting cargo along the very long routes [5].

4. Technological barriers

Technical barriers within the European Union were mostly regulated for each subsystems by Technical Specifications of Interoperability (TSI). However, there are still specific cases for individual countries and for some technical solutions open points. The technical requirements for newly manufactured and modernized vehicles that are or will be used in the European Union's rail system are described in Regulation 1302/2014 of the LOC & PAS TSI [3].

Railway traffic control systems are responsible for controlling trains across railway infrastructure and for providing appropriate levels of safety while, at the same time, maintaining the adequate capacity of the railway infrastructure. In the case of controlling wagon trains with locomotives, swapping locomotives and conductors on the borders of various systems may solve the problem of varying railway traffic control systems (Fig. 4). However, to reduce the need to swap locomotives and conductors within the EU, locomotives should be properly upgraded and staff trained to handle a greater number of railway traffic control systems. An example of the differences between railway traffic control systems is the route between Rotterdam and Małaszewicze, covering a number of traffic control systems; in the Netherlands ATB 17 (*nl. Automatische TreinBeïnvloeding*), *Germany* – PZB (German *Punktförmige Zugbeeinflussung*) and LZB (German *Linienzugbeeinflussung*), and in Poland SHP (Automatic Train Break), CA (DVD) and Radio-Stop.

Implemented within many European lines, the ETCS system (*European Train Control System*) facilitates the harmonization of the systems across Europe. Countries such as China also order systems developed on the basis of the ETCS idea. In the future, this might facilitate the development of a single system across the whole Europe-

Fig. 4. Various railway traffic control systems [6]

Asia connection. The process of replacing domestic railway traffic control systems with the pan-European ETCS system is long-term in nature and is primarily implemented within major transport corridors. It is worth pointing out that the replacement process can generate threats related to the contact point between various traffic control systems. An example of an undesirable event resulting from such a threat is the accident of the high-speed train in Santiago de Compostela, with one of the indirect causes of that accident being the boundary between the ETCS and ASFA systems (Spanish *Anuncio de Señales y Frenado Automático*) within the section of the route where the accident occurred.

Communication systems are also unified with the use of GSM-R technology. In Europe, the decision was made to base future mobile radio communication systems on the GSM-R standard, in line with UIC directives. Another barrier is connected with the different braking systems of the vehicles, primarily the differences between European and post-Soviet states. The most popular systems in European states are Knorr Wabco and others. The most popular system in eastern states is Matrosow. The differences in distribution valves and the structure of the entire braking system in the vehicles may affect brake parameters, and this can result in frequent wheel locking or inadequate brake weight of the train set.

Other differences between the trains of European and post-Soviet countries are in the coupling and buffer systems. In European states, freight wagons mostly use screw coupling with buffers. Countries such as Russia, Kazakhstan, Belarus and Ukraine use freight wagons with the automatic SA3 coupling. Automatic coupling is also used by Chinese railways.

Another barrier is the various systems that power electrical traction, differing within Europe itself. The most frequent systems are:

- 1.5 kV DC;
- 3 kV DC;
- 3 kV AC;
- 25 kV 50 Hz AC.

The problem of varying power supply systems across the routes is resolved by the use of multi-system locomotives. The distribution of power supply systems is shown in Figure 5.

The majority of routes in Asia are not electrified because of the length of the routes. As a result, the use of combustion traction is necessary. The market offers multi-traction locomotives, but the range of combustion traction is too short. For this reason, the prevalent practice is to replace the locomotive on the border to solve the problem of various distances between the wheels of locomotives.

With the differences in the distance between tracks, it is necessary to change the distance between wheels while crossing the border between one gauge and another. This can be done by exchanging wheel sets, bogies or using wheel sets with adjustable wheel distance. The most popular track distance used in Western Europe is referred to as a standard-gauge railway, with 1435 mm (except for Portugal and Spain, where the distance is 1668 mm) [2]. In countries of Eastern Europe and Asia, the vehicles travel along tracks with a distance of 1520 mm (Fig. 6).

The problem of different distances also applies to Asia. The countries that used to be part of the Soviet Union have a track distance equal to 1520 mm. The

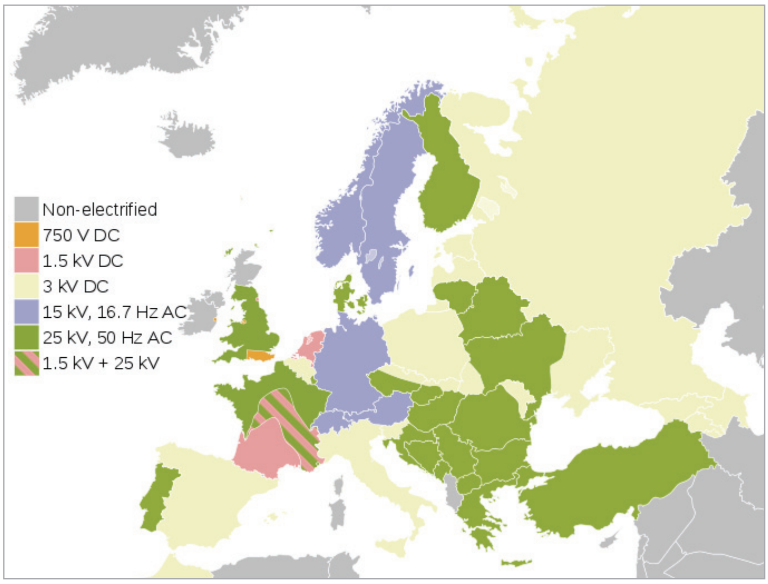

Fig. 5. Various electrical traction systems in Europe [8]

tracks in China and Iran have the standard-gauge railway distance of 1435 mm. The track gauge in Pakistan and India is 1676 mm, and in the states of the Indo-China peninsula – 1000 mm. A very effective solution to tackle the track distance barrier is to use the wheel distance exchange systems, such as SUW 2000, Rafil DBV and Talgo and other systems for which implementation concepts are underway or which are used within internal traffic [10]. The most frequently used solutions are designed for handling goods within specialist handling terminals. This is because no changeover system for freight trains has been fully implemented yet.

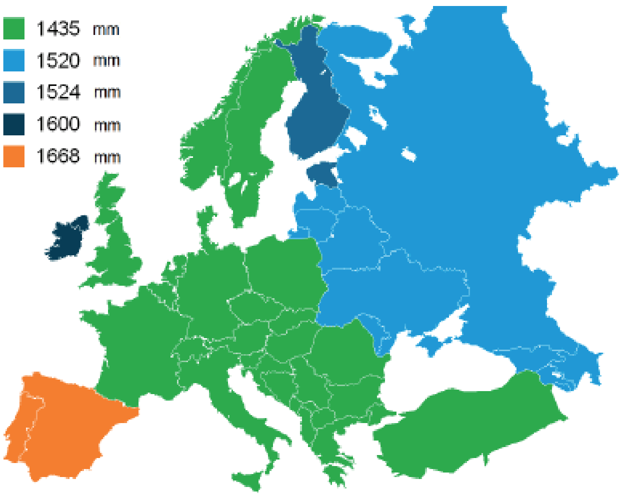

Fig. 6. Various track gauge in Europe [6]

The maximum track pressure in Russia is more than in the EU and is 25 tons/axle, while the standard in Europe is 22.5 tons. This situation limits the maximum mass of the vehicle, which, combined with various systems of fees calculated for train travel and the maximum length of trains, affects the cost-effectiveness of services along those routes. This makes it necessary to shunt trains on the boundary of different systems [5].

5. Summary

Trade between Europe and China will drive the economic growth of many states. An important role in this process will be played by railway transport and the growth of railway services between Europe and Asia. Although this kind of transport is more reliable (it does not rely on weather conditions so much) and faster than sea transport, it needs to be constantly improved to increase its efficiency, i.e. the final transport cost born by exporters and importers. This can be done by, among other things, eliminating the barriers for railway transport between Europe and Asia. As for the lifting of non-technological barriers, the responsibility falls on international policies from the states concerned and international railway organizations. Technological barriers require funds and efforts from many specialist teams to increase the capacity of railway connections. Technological barriers can be reduced and eventually eliminated with further unification and the development of new infrastructure and railway vehicles that will allow new services to be delivered in a timely, reliable and safe way.

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