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CONFRONTATION AND COOPERATION

1000 YEARS OF POLISH–GERMAN–RUSSIAN RELATIONS

Vol. I(IV)/2018: 3–10

DOI: 10.2478/conc-2018-0001

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Impact of creating evacuate tube transportation technology for connecting European Union and China

Key words: high speed rail, vacuum train, FlexSim

Abstract

The article presents an economic potential of the trade exchange between China and European Union using the new type of transport – basing on vacuum trains. This technology bases on transporting goods in a capsule. The capsule is moving inside an airtight tube, where the air pressure is decreased to about 100Pa. Owing to the low pressure, an air friction value is very low too, what is enabling to move the capsule inside the tube without meaningful energy loss from the air friction. The transport will provide a very fast and economical shipping of goods between China and Europe. It is expected, that the capsules can reach the speed about 1000 km/h.

Taking all these factors into account, there are new opportunities for the trade exchange with China. It applies especially to the transshipment- industrial districts like Sichuan, Yunnan, Kweichow, and the Chongqing city. The potential of these provinces is a population about 200 millions people, a territory which is twice the size of France and quick economic growth – about 10%. In 2016, the train from Chengdu to Łódź have left 463 times, in 2017 there are 1000 trains planned. The economy of Sichuan is basing on: agriculture, hydropower, big resources of natural gas, heavy industry, and electronics. In Chongqing, there are mainly: automotive, heavy industry, electronics, and chemical industry. In Yunnan dominate agricultural processing, natural resources, and heavy industry. From the viewpoint of polish business, the Sichuan province and the Chongqing city are especially noteworthy. These two are firstly making use of developing Chinese economy. They are also contributing to the „New Silk Road" – OBOR project (One Belt and One Road Initiative) and aspiring to become the trade, financial, scientific-technological and telecommunication-transport center.

Introduction

The trade exchange between China and Europe is an important part of economic cooperation for each other. The enormous market of China and unlimited customer needs of Europe have been strongly connected for hundreds of years due to the Silk Road. Fast development needs a fast and cheap exchange of goods and now it is possible to achieve, due to the new technologies in transport and The New Silk Road.

Historical overview (The Silk Road)

The Silk Road is an ancient trade road connecting China with Europe and the Middle East. This name has been used for both inland and maritime routes connecting Europe with Asia. The inland road had about 12 000 km of length and people started to use it in III century BCE. The maritime one became common in I century BCE. As the name suggests, the silk was the subject of trade exchange but it was only a little part of

that exchange[1]. The main subjects were[2]:

- From the east: gold, precious metals, and stones, textiles, ivories, corals, silk, paper, iron,
- From the west: furs, ceramics, cinnamon, weapons, gold, perfumes, jewelry, grapes, and crops.

The inland part of the road, passed through the desert, surrounded by mountains from the south and from the north, so the cities which were on the road-oasis, became very important trade centers.

They have benefited from buying and selling goods, and they often mediated transactions. It was impossible to travel the all road long in those times. It was not just because of distance, but of hard location too. People with their merchandise moved on foot or with animals. Camels were the most popular animals to use because they could walk long distances without water. Therefore, the subjects of the trade exchange were quite light and small – people didn't want to load camels too much.

Silk Road played important role in the development of civilization for nations, which it has connected. The advantages were not only for trade and economy but for politics, religion, and culture too.

The Silk Road consisted of four routes:

- north route
- south route
- south-west route
- maritime route

The Silk Road stopped to matter about 1650.

Fig. 1. Main routes of the Silk Road.

Source: [3]

[1] https://pl.wikipedia.org/wiki/Jedwabny_szlak, [30.11.2017].

[2] https://www.advantour.com/silkroad/goods.htm, [29.01.2018].

The New Silk Road

The New Silk Road and XXI Century Maritime Silk Road are also known as „One Belt, One Road" initiative. The strategy of development was initiated by a Chinese leader Xi Jinping in 2013. It refers to an old road connecting Asia, Europe, and Middle East. The aim of the initiative is to develop economy by intensification of ties. The reinforcement of relations should happen through expansion of infrastructure of the New Silk Road areas. The road will connect Asia, Europe, and Africa.

The New Silk Road envisages establishing network of corridors, which would connect China with European Union countries, which means building or upgrading transport – railway, including high-speed railway and also the creation of industrial and telecoms infrastructure. China set Central, East and Mediterranean Europe apart to promoting the New Silk Road. In August of 2015, the connection Łódź – Chengdu has been lengthened to Xiamen. In 2016 the new railway line connecting Kutno and Chengdu has been launched[3].

There is an expansion of existing terminal needed in Łódź. In Małaszewicze town there is a building of a dry logistics center for container consignments between China and Europe planned. The statistics show, that from 2013 when the line was launched to the end of 2015, there were 300 trains from Chengdu to Europe. They have shipped over 38 thousand tons of goods, worth a billion dollars. In 2016 there were over 400 trains, and there are about 1000 courses expected in 2017. There are two railway lines, where the trains between China and Poland travel: Trans-Siberian route and across Kazakhstan. The cost of shipping a 20-foot container from China to Poland is about 5000$ but due to prognoses, prices can be reduced to about 2,500––3000$. An export of polish products to China is about 15 times lower than import. Poland exports mainly food, jewelry and machines and imports electronics, toys, cases, bags, clothes, and glass[4].

The OBOR initiative is an opportunity for expansion of polish export to China, by using existing and

[3] Frans-Paul van der Putten, John Seaman, Mikko Huotari, Alice Ekman, Miguel Otero-Iglesias, Europe and China's New Silk Roads, ETNC Report, December 2016, [30.11.2017].

[4] Frans-Paul van der Putten, John Seaman, Mikko Huotari, Alice Ekman, Miguel Otero-Iglesias, Europe and China's New Silk Roads, ETNC Report, December 2016, [30.11.2017].

new transport connections, as inland as maritime too (between Shanghai, Tianjin, and Gdańsk). In addition, OBOR includes creating of economic and industrial special areas.

The New Silk Road is benefiting for China. Overcapacity in this country, especially in the heavy industry could find points of sale along the road.

An investment is estimated to about 500 billions of dollars.

Fig. 2. New Silk Road.

Source: [12]

The current railway route

The current railway line connecting Poland and China is running from Łódź to Chengdu and is about 9826 km long. It was started in April of 2013, when the Chinese train, consisted of 22 carriages with components of cars and electronics, came to the Łódź Olechów station. In 2015 the first train to China with polish goods left Łódź. The railway is running across the cities like Brześć, Moscow, Jekaterynburg, Astana, and Urumchi. The train leaves Łódź once a week, and its travel takes 14 days.[5] Shipping goods by train is about 30% cheaper than by plane, and three times faster than maritime transport.

Fig. 3. The current railway route.

Fig. 4. The current railway route model in FlexSim.

The vacuum train

The vacuum train is a project of the new type of transport which will be able to move people and goods and which is proposed by a billionaire- Elon Musk, founder of Tesla and SpaceX.

This is how SpaceX describes vacuum train like: *"Short of figuring out real teleportation, which would, of course, be awesome (someone please do this), the only option for super fast travel is to build a tube over or under the ground that contains a special environment. This is where things get tricky"*[6].

The main objective of the project is to make a system, which would be as fast and safe as an air transport and as cheap as a land one[7].

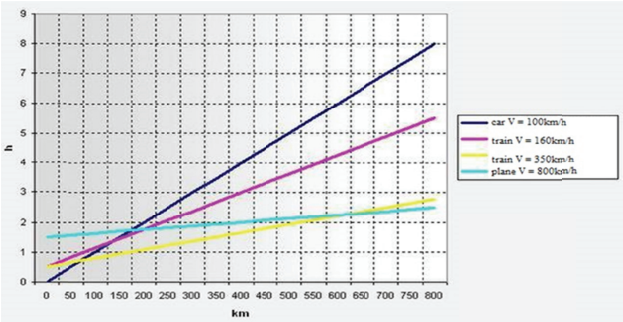
The chart below shows travel time by the different modes of transport, to take into account their average speed.

[5] http://trojmiasto.wyborcza.pl/trojmiasto/7,35612,21417281,nowy-jedwabny-szlak-laczy-europe-z-dalekim-wschodem.html, 30.11.2017.

[6] http://www.spacex.com/sites/spacex/files/hyperloop_alpha-20130812.pdf, 30.11.2017.

[7] https://pl.wikipedia.org/wiki/Hyperloop, [30.11.2017].

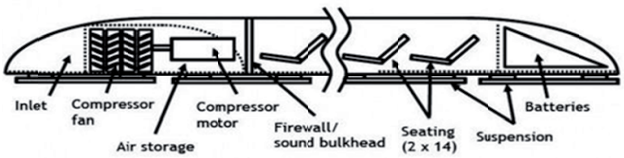
Fig. 5. Comparison of travel time.



Source: [4]

The system consists of a long tunnel with a capsule inside, which can move with the speed of about 1200 km/h. That high speed can be reached owing to the low air friction inside the tube, where the air pressure is decreased to about 1% of an atmospheric pressure. Key factors in achieving such high speed are drive and thin air. This kind of transport will be quiet and need a smaller area than an airport. These are reasons, why a terminal could be constructed even in the middle of a city. Along the route will be located solar panels, which will provide a power supply for driving the capsules[8].

Fig. 6. Passenger transport capsule.



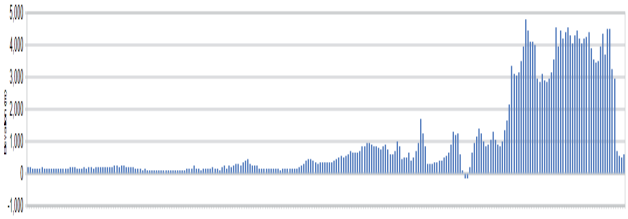
Source: [4]

Project of a vacuum train line along railway line

Fig. 7. FlexSim model of vacuum train line.

[8] https://www.forbes.pl/technologie/hyperloop-szybka-kolej-nadchodzi-rewolucja/0ljvzwc, [29.01.2018].

Fig. 8. Height chart.



Input data for the simulation model

Simulation is carried out for a period of two weeks. Trains have to travel 9050,57 km. Train and high-speed train contain 40 wagons, carrying 40 containers. The vacuum trains consist of one intermodal container. Trains leave station every 3 hours. For the vacuum train has been adopted two scenarios. The first one takes into account the time of transshipment and the waiting time at the border. The vacuum trains leave station every 10 minutes. The second scenario assumes, that there is customs clearance only at the origin station. The vacuum trains leave the station every hour (including 50 minutes for customs clearance).

Tab. 1. Input data for trains and track

	Train	High speed train			Vacuum train			
Velocity (km/h)	33,77	100	120	140	300	600	900	1200
Schedule	3h				10 min			
Simulation time	2 weeks (1209600s)							
Track length (km)	9050,57							

Tab. 2. Input data – border activities times (h) for tran and high speed train

	Dostyk (China – Kazakhstan border)	Brest (Poland – Belarus border)	KZ–RU border	RU–BY border
Transshipment	8,6	8,6	n/a	n/a
Inspection/ /clearance	3,3	3,3	1	1
Others	1	n/a	n/a	n/a
Number of stations	2	1	1	1

Fig. 9. Border crossing.

Tab. 3. Input data – border activities times for vacuum train (1)

	Dostyk	Brest	KZ-RU border	RU-BY border
Total time (h)	1	1	1	1
Number of stations	1	1	1	1

Tab. 4. Input data – custom clearance for vacuum train (2)

	Chengdu
Total time (mins)	50
Number of stations	1

Simulation model

FlexSim is a software designed for mapping, simulating and optimizing advanced processes in an analyzed branch. It is used mainly in production, logistics, and services. The software is easy to use, it lets the user make a 3D simulation by adding objects from the library with „drag and drop" method. After entering model data and creating relations between objects, FlexSim shows us veridical 3D model. Moreover, we can show the process statistics in the form of charts or numbers in real time, what impacts on time and efficiency significantly.[9]

The additional advantage is that the standard object library can be enlarged with your own 3D models, and you can build models based on plans or maps created in CAD programs or even bitmaps by importing them.

One of the FlexSim tools is FlexTerm. It is specialized for simulating ports and container terminal operations. It is very useful because it has a rail module that can be used to simulate various rail sequences and train processes. Using FlexTerm's detailed dynamic discrete event simulation capability, the software can model activities and constraints that impact a bulk terminal's unloading and loading process, including train movements, train cutting and connecting, switching, sequencing of bulk unloading, working schedule, and storage[10].

Fig. 10. The marine terminal

Source: [13]

Below is the model made in FlexSim 3D Simulation Software. It is based on the current railway route. In the model are „queue" object types serve as terminals, in which trains await for transshipment. Behind them have been added „processor" object types, which are used as transshipment terminals. The input data for simulation model are presented in the tables 1-3.

Fig. 11. The current route model and vacuum train line model in FlexSim

[9] http://flexsim.pl/flexsim/, [30.11.2017].

[10] http://www.flexterm.com/solutions/marine-terminals, [29.01.2018].

Tab. 4. Statistics

	Train	High-speed train			Vacuum train (1)			
Velocity (km/h)	33,77	100	120	140	300	600	900	1200
Number of trains	7	59	63	66	305	320	324	327
Number of carriages	280	2360	2520	2640	305	320	324	327
Travel time (mins)	16666, 67	6000	5000	4666,67	–	–	–	–
Schedule	8h				10 min			
Simulation time	2 weeks (1209600s)							
Track length (km)	9050,57							

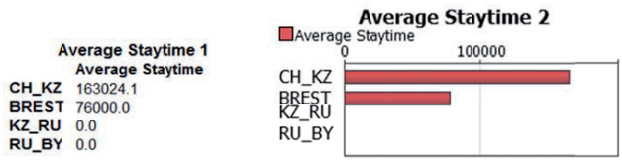
Tab. 5. Vacuum train statistics

Vacuum train (2)				
Velocity (km/h)	300	600	900	1200
Number of trains	1222	1282	1302	3940
Number of carriages	3668	3850	3910	3940
Travel time (mins)	1606, 67	923, 33	600	450
Schedule	10 min			
Simulation time	2 weeks			
Track length (km)	9050,57			

Below are the statistics achieved after simulations:

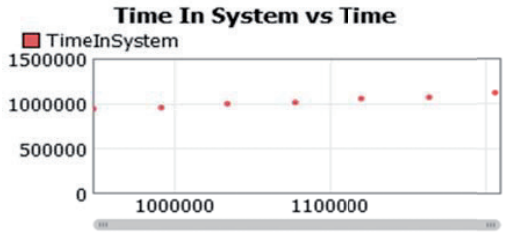
a) for train

Fig. 12. Staytime at the transhipment station



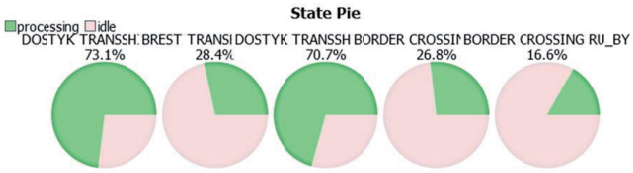
These charts show the average time of crossing border. As we can see, in Dostyk crossing border takes almost two days (45,3h) and in Brest it is about a day (21,1h). That long times are caused by transshipment because of track gauge change.

Fig. 13. Travel time



This chart shows time, which is needed to travel the whole route by train. This time takes into account the time of crossing border. As we can see, the train needs about 12 days to travel from China to Poland.

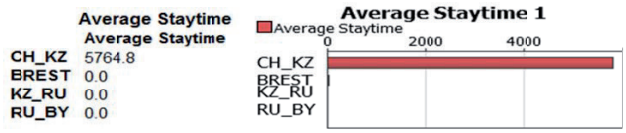
Fig. 14. Burden of transhipment station



b) for high speed train

– speed 100 km/h

Fig. 15. Staytime at the clearing station



Charts on figures 16, 19 and 22 show average waiting time, for the new high speed railway, with the same track gauge (no transshipment needed).

Fig. 16. Travel time

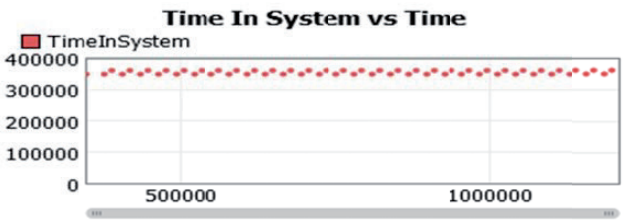
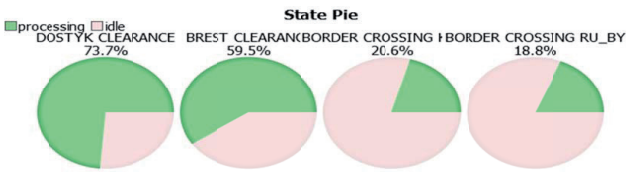


Fig. 17. Burden of transhipment station



– speed 120 km/h

Fig. 18. Staytime at the clearing station

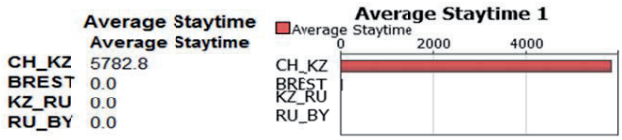


Fig. 19. Travel time

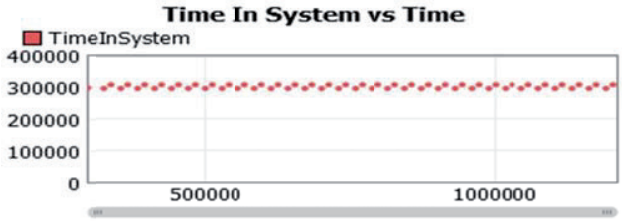
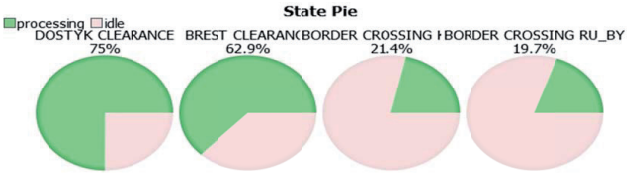


Fig. 20. Burden of transhipment station



– speed 140 km/h

Fig. 21. Staytime at the clearing station

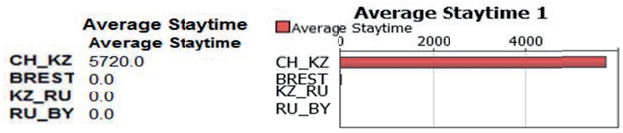
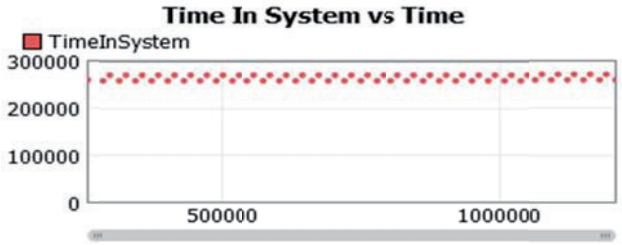
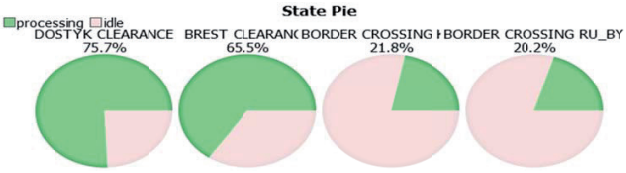


Fig. 22. Travel time



Charts 16, 19 and 22 show times needed to travel the whole route by high speed train. As we can see - high speed train could travel from 2 to 3 times faster than standard train.

Fig. 23. Burden of clearing station



c) for vacuum train (1)
speed 1200 km/h

Fig. 24. Staytime at the clearing station

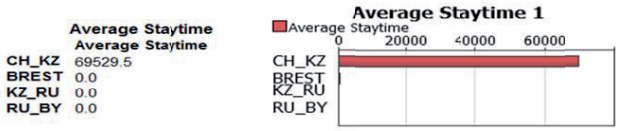
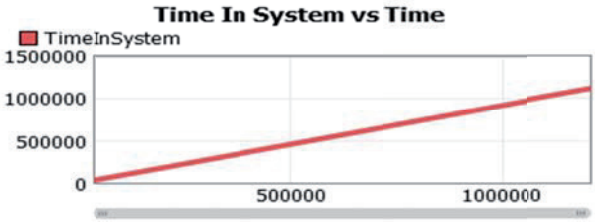
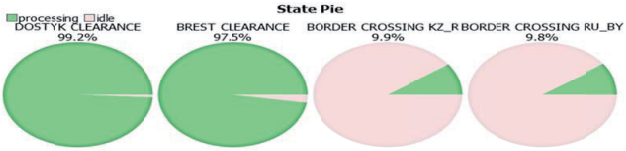


Fig. 25. Travel time



This chart show time, which is needed to travel the whole route by vacuum train. This time takes into account the time of crossing border. In the course of time, the time spent by train on the route increases. This is because trains often leave the station (every 10 minutes) and spend a lot of time waiting at border crossings. Therefore, it is hard to tell how much time trains need to travel.

Fig. 26. Burden of transhipment station.



d) for vacuum train (2)
speed 1200 km/h

Fig. 27. Staytime at the clearing statnion.

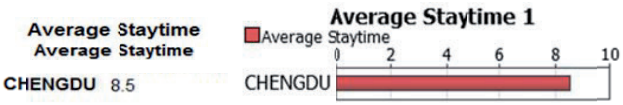
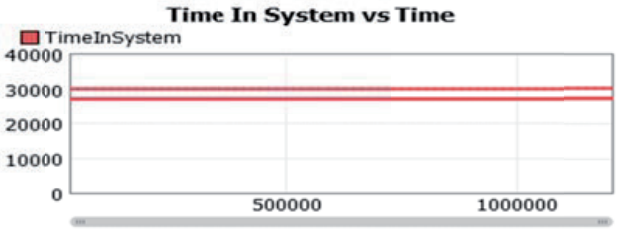
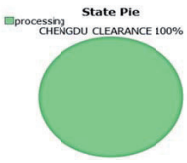


Fig. 28. Travel time



This chart shows time needed to travel the whole route by vacuum train. As we can see - vacuum train is much more faster than train.

Fig. 29. Burden of clearing station



Conclusions

There is a big potential in the transport of goods between China and Europe. Nevertheless, there are some barriers like – distance, time and costs, which are undoubtedly hindering that potential. The vacuum train connection could make the flow of goods between nations more efficient due to very high velocity, which it is able to reach.

Our simulation shows, that vacuum train can transport more containers than conventional railway in the same time, although the train can transport 40 containers at once. In order to use the full potential of vacuum train, customs clearance must be only at the origin station as in air transport. The good solution are high-speed trains. They can transport a few times more containers than conventional railway in the same time. Taking into account the possibility of introducing only one custom clearance, the best solution seems to be a vacuum train. All models in this publication are very simplified, but they are made to show, that there are new opportunities in international transport due to new technologies, like high-speed rail and vacuum trains.

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