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PROSPECTS OF ESTABLISHMENT OF EAST-WEST TRANSIT TRANSPORT CORRIDOR DEPLOYING MAGNETIC LEVITATION TECHNOLOGY

According to economist Klaus Schwab, the today's community is at the threshold of the Fourth Industrial Revolution which will influence transport branch especially. Today, we see a fundamental change of assessment of the place and role of transport in the world progress. At the governmental level the tasks of realisation of large-scale projects have been determined, which will be able to strengthen Russia's positions at the world freight transport market, namely container transport, increase Russia's transit potential, speed, quality of passenger service and freight transport.

The authors suggest options to solve the set tasks building on the idea of implementation of innovative magnetic levitation technology while establishing East-West Transport Transit Corridor.

Magnetic levitation technology is competitive with the existing modes of transport in key speed, sustainability, energy efficiency and safety parameters, namely ecological safety. The main purpose of establishment of a transit transport corridor is to introduce a new transport service with a unique number of properties. Accordingly, transport and technology tasks are solved which are associated with construction and modernisation of transport lines, terminals, information systems, etc. The project of transport transit corridor in question is suggested to undertake in three stages. The assessment of Russian container transport market and comparison study of maglev and conventional railway transport parameters confirm efficiency of the project. To deliver this project, the decision should be made at the governmental level.

Keywords: Transport Transit Corridor, Magnetic Levitation, Industrial Revolution, Innovations.

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ПЕРСПЕКТИВЫ СОЗДАНИЯ ТРАНЗИТНОГО ТРАНСПОРТНОГО КОРИДОРА «ВОСТОК – ЗАПАД» С ПРИМЕНЕНИЕМ МАГНИТОЛЕВИТАЦИОННОЙ ТЕХНОЛОГИИ

Современное общество, по мнению экономиста Клауса Шваба, стоит на пороге четвертой промышленной революции, которая, окажет особое влияние на развитие транспортной отрасли. Сегодня принципиально меняется оценка места и роли транспорта в мировом прогрессе. На государственном уровне определены задачи по реализации крупных проектов, способных укрепить позиции России на мировом рынке грузоперевозок, в частности контейнерных; наращиванию транзитного потенциала России, увеличению скорости, повышению качества обслуживания пассажиров и перевозки грузов. Авторы предлагают варианты решений поставленных задач, в основе которых лежит идея внедрения инновационной магнитолевитационной технологии при создании транзитного транспортного коридора «Восток – Запад».

Магнитолевитационная технология конкурентоспособна с существующими видами транспорта по ключевым показателям скорости, энергоэффективности и безопасности, в частности эколгтической. Основная цель создания транзитного коридора – предоставление новой транспортной услуги с уникальным набором характеристик. При этом решаются главным образом транспортно-технологические задачи, связанные с сооружением и модернизацией путей сообщения, терминалов, информационных систем и т. п. Рассматриваемый проект создания транзитного транспортного коридора «Восток – Запад» на основе магнитолевитационной технологии предполагается выполнить в три этапа. Оценка российского рынка контейнерных перевозок и сравнительный анализ характеристик магнитолевитационного и железнодорожного транспорта подтверждают эффективность проекта. Для его реализации требуется принятие решения на государственном уровне.

Ключевые слова: транзитный транспортный коридор, магнитная левитация, промышленная революция, инновации

INTRODUCTION

Railway transport in Russia possesses a most significant strategic role to strengthen its economic sovereignty. Vast territory of the country having scarce population on most part of it justifies peculiarities of new technology revolution which is being encountered by the modern community.

The German economist, the founder and Executive Chair of the World Economic Forum in Davos, in his book “The Fourth Industrial Revolution”

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substantiated fundamental changes of the way humankind lives. Klaus Schwab does not provide operational definition of the Fourth Industrial Revolution but provides the basis for its assessment: coexistence of society and technology with the focus on technological innovations [1]. "The fundamental and global nature of this revolution means it will affect and be influenced by all countries, economies, sectors and people", the authors says [2].

When it comes to studying transport sphere, it becomes clear that assessment of the place and role of transport in the world progress has changed fundamentally.

Russia's transport network connecting densely populated eastern and western regions possesses a unique intellectual potential. In the 2030 Transport Strategy, which defines official policy in modernisation and is utilitarian centered, there is no emphasis laid on those revolutionary processes the today's world is living on now. It is necessary to apply qualitatively new approaches to use those enormous opportunities granted by the technology revolution of the new era.

SETTING THE TASK

During the plenary session at the III Railway Congress (Moscow, November 29, 2017), the President of Russia Vladimir Putin put certain tasks the transport branch is facing, and which require prioritised and continuous attention, coordinated actions of the state, regions, and business [3]:

1) it is important to deliver large-scale projects which form an area for perspective development of industries and territories, will mitigate national producers expenditures, enable strengthening Russia's positions at the world freight transport market, namely container transport market;

2) for a successful work at the internal market and improvement of transit potential of Russia, the national transport operators need constantly improve, increase speed and quality of freight and passenger transportation. It means that there is need in upgrade of transportation management systems, application of more efficient technical means, and logistics services.

The set tasks may be systematised in three blocks, each of which having their certain solutions.

Task 1. Delivering large-scale projects for the benefit of perspective development of industries and territories, strengthening of Russia's positions at the world freight (container) transport market.

The Cluster "Russian Maglev" have addressed their developed offers on realisation of the project maglev transport mainlines from ports of Saint Petersburg and Leningrad Oblast extending to freight terminals in Moscow, which is seen as

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the main section of the East-West Transport Transit Corridor (TTC). According to the data available, the existing opinion that maglev technology is expensive is no more than a myth. Besides, on implementing this technology Russia will acquire an immense economic and image-building effect. Also, the task of debottlenecking of the entire country will be completed.

Task 2. Exploitation of transit potential of Russia at the expense of its railway transport.

The completion of this task is hindered by a number of limitations. In many extended parts of the mainlines during more than 100 years of their operation, a number of defects in the railway formation and civil structures, predominantly bridges, have accumulated. A crucial hindrance to augmentation of performance and capacity of mainlines, especially those in Siberia, is the curves limiting the permissive speed. For instance, Trans-Baikal Railway is 60 % equipped with curves which require smoothing.

Today, the solution to that problem centers around constant increase in investment in railway infrastructure "healing".

The average speed of freight transportation (commercial) in Russia is approximately 17 km/h, the technical speed – ca 40 km/h, which is unacceptable for a vast territory.

Considering the actual state of railway transport, wheel-rail system specifics and railway transport infrastructure state, establishment of highly efficient TTC, which could be competitive to other modes of transport, does not seem to feasible.

The realisation of the project of establishment of a new railway mainline extending from the Far East ports to Russia's western borders, as proposed by V.A. Trapeznikov Institute of Control Sciences of the Russian Academy of Sciences, will cost 18 trillion roubles, whereby the speed required by business will not be achieved [4].

The solution to that may become introduction of maglev technologies into transport industry.

Task 3. Transition to innovative freight transportation means.

In order to achieve transition to innovative freight transportation means, it is vital to introduce qualitatively new transport and associated technologies, which have proactively been developed for decades by Russian scientists and engineers. At JSC "Russian Railways" Joint Scientific Council meetings, this suggestion was considered. As a result, the following decisions were made, which provide answers to the key questions:

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1) magnetic levitation transport technology is another stage of innovative development of the most widespread transport in the territory of Russia – the railway transport [5];

2) degree of readiness for application is determined by completion of the following stages:

– scientific surveys;
– mathematical and computer modelling;
– full-scale modelling.

Maglev transport technology meets demands of business and requirements of a new technology pattern in terms of:

– transportation speed;
– safety;
– minimal impact on environment, the opportunity to preserve natural area;
– power consumption;
– riding comfort;
– full automation during the entire course of operation;
– economic efficiency.

Using assessment of the actual state of railway transport in Russia and the tasks indicated by the Russian President, it is vital to develop a long-term development programme covering a span of 20–25 years. This time frame is determined by a long realisation period of such large-scale transport projects as East-West and North-South Transit Corridors, mastering new technologies while creating digital transport system, targeted development of transport engineering education, engineering science, and science.

ASSUMPTIONS

The world maglev transport technologies (MLTS) market is flourishing. The development of transport systems capable of commercial outdoing the speed limit of wheel-rail system has become the world trend. The best results in this competition of various ground transport in terms of speed, energy efficiency, safety are shown by MLTS having linear traction motors.

It needs to be pointed out that MTLS is used only for passenger transportation. Researches and development in freight maglev transportation are undertaken at Emperor Alexander I St. Petersburg State Transport University (Russia) and Hyperloop One (USA). However, the latter is at the marketing concept stage and has a number of problems which are thought to be insoluble at the present level of engineering and science.

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The development of freight maglev transportation using national technology is envisaged as part of East-West Transit Transport Corridor. Today, transportation at this direction is organised on several routes using maritime, railway, and air transport. More than 90 % of cargo is carried by maritime transport, according to Dee Sea (via ehe Suez Canal).

The popularity of maritime transport is explained by two factors, in general:

1) low shipment fees;

2) seamless shipment environment, ensuring minimal volume of customs procedures, repacking, reloading. All this fosters maximum safety of cargo;

Among the routes within TTC, there are [6]:

– Deep Sea – a 24 000 km maritime route via the Suez Canal. Transportation takes up to 45 days;

– The Northern Sea Route – a 15 000 km route through the southern part of the Arctic Ocean having. Transportation takes up to 35 days;

– The Trans-Siberian Railway – railway route spanning 11 500 km through Russia's territory. Transportation takes up to 14 days (works to increase the delivery speed are in progress);

– New Silk Road routes – both railway and combined (railway and maritime) routes via the territories of China, Kazakhstan, Russia, and Belorussia (as on option – bypassing Russia through Transcaucasia and Ukraine with two sea travels or through Marmaray tunnel) spanning approximately 9 000 km. Transportation takes 15 days (works to increase performance are in progress).

All mentioned routes have their disadvantages:

– Deep Sea is characterised by "bottleneck" in the Suez Canal. Besides, the route runs through politically volatile and unsafe Gulf of Aden;

– The Northern Sea Route – complicated navigation (ice-bound waters), infrastructure demands considerably high level of development;

– The Trans-Siberian Railway, acting as the main transport artery between Northwest (mainly Baltic ports), Volga, Siberian, and Far Eastern Federal Districts, has a very limited performance and significantly long "bottlenecks". When transporting goods to Western Europe, the conversion from 1520 mm to 1435 mm gauge is needed;

– The routes of the New Silk Road run through the territories of a number of states with the goods subject to customs procedures. At some directions, modes of transport are changed (reloading), and gauge conversion is needed as well.

China subsidises and actively develops ground alternatives to maritime routes at the expense of railway transport.

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In this situation, implementation of innovative transport technologies within TTC East-West is a duly prepared solution of realisation of Russia's transit potential.

As it was said before, the project is expected to be delivered in three stages.

1. At the first stage, the line connecting the Bronka and Lomonosov ports with a dry port at the Vladimirskaya railway station will be constructed. According to technical and economic parameters of the multifunctional handling terminal Bronka, the maximum capacity of the port is expected to reach 21.6 million tonnes per year. According to the data of Lengiprotrans Company, the potential performance of the existing line after debottlenecking will not exceed 8 million tonnes per year. So, there will be 13.6 million tonnes left without access to railway lines. The Lomonosov freight port plans to handle up to 9 million tonnes per year. As a result, it will necessitate to transport additional 22.6 million tonnes of container freight through Saint Petersburg, which is not possible with the existing urban road network [7, 8].

2. At the second stage, it is planned to extend the line to terminals in Moscow. In the total volume of containers to be handled in Russian ports, over half of them will be processed in northwestern ports. Among them, the Big Port Saint Petersburg is the leading one, owing to its proximity to the regions having 57 % of population and 60 % of GDP of Russia. 20 % of containers arriving in Saint-Petersburg ports are intended for processing and consumption within the city, Leningrad Oblast and Northwest District. 80 % of containers are delivered to terminals in Moscow for further distribution within the Moscow agglomeration or transportation to other parts of Russia. The overall capacity of container terminals of Saint Petersburg and Leningrad Oblast makes 5.3 million TEU per year. After realisation of the planned projects of expansion of the terminals, their overall capacity will make 11 million TEU per year [9]. There are almost no reserves for enhancement of the capacity. By 2020, it is foreseen that there will be a dramatic lack of carrying capacity of railways and plenty of bottlenecks in road infrastructure.

3. At the third stage, the construction of the key transport artery, namely TTC East-West is planned.

EAST-WEST TRANSIT TRANSPORT CORRIDOR

The fundamental idea of any transport corridor is that transport, freight and passenger flows are brought together on mainlines characterised by maximum carrying capacity and developed infrastructure. Owing to this, acceleration of freight and passenger transportation is achieved as well as cost reduction as a

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result of economics of scale. Additional effect is seen in the case of multimodal transportation, when there are several communications of interacting modes of transport running through one corridor [10].

The main purpose of creation a transit transport corridor is to provide conditions for unhindered and economically efficient transport traffic. At this point, one generally solves transport and technology tasks, associated with construction and upgrade of ways of communication, terminals, hubs, informational systems, etc.

Apart from that, creation of TTC includes favourable customs, tax, administrative regimes and provision of a complex of additional logistics services for trade development between the regions connected by this TTC.

The transport and logistics system of TTC East-West encompasses the following operations:

– unloading ships arriving directly at ports; provision of those with electronic blocking device;

– customs clearance in rear terminals;

– transportation of goods to terminal and logistics centres.

TTCs are designed to play a systematic role in economic and social development of territories affected. Their establishment stirs development of industries and social sphere of adjacent regions.

GENERAL CHARACTERISTICS OF CONTAINER TRANSPORTATION MARKET

Container transportation is the most advanced and economical type of freight transportation used in international and national communication. Transportation of freight by containers is much sought after both by large production and trade companies, and small and medium business companies, which engage themselves in export and import of various products. Application of standard containers enables reloading-free delivery of goods from the sender to the customer, thus singificantly reducing the volume of interim handling operations.

The volume of the world sea container transportation is growing annually. The greatest volume of transported containers was recorded at short Asian internal distances. According to Container Trade Statistics Ltd (CTS) data, during 2017, approximately 40.9 million TEU (+4.3 % to 2016) were transported between Asian ports. At most important “long” trades CTS counted 18.5 million TEU transported from the Far East to North America (+7.3 % to 2016), and 15.8 million TEU on routes from the Far East to (+3.7 % to 2016).

The demand for trade connecting the Far East with African countries below the Sahara has also increased. In 2017, 2.8 TEU were transported using this route

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(+5.9 % to 2016). The most considerable growth was achieved in trade on the route Far East – South and Central America – 3.6 million TEU, which is 10.7 % bigger than year before [11].

One of the key factors influencing development of international market of container transportation is adoption of transport strategies in a number of countries in order to increase containerisation, which is dictated by environmental, safety and other requirements.

Considering the Russian market, one should note that it has been rapidly developing over the last 10–15 years, significantly outrunning the world ones. This is connected with the following factors [12]:

– low initial freight containerisation degree;

– growth of containerisation of export (containerisation degree of internal transportation – 25 %, the export one – 7 %);

– stable economy growth rates;

– integration of transport complex of Russia and the world transport system;

– expansion of the list of the goods that can be transported in containers.

The Russian economy is characterised by high involvement of transport in products pricing. According to the data of the Ministry of Transport of Russia, the volume of transport expenditures in the cost of goods makes 15–20 %, with 7–8 % in developed western countries [13]. Apart from reasonable grounds (vast terrirory, unfavourable climate conditions) this is influenceb by poor development of transport and logistics complex of Russia. Therefore, development of container transportation (namely internal, export and import, and transit ones) is one of the strategic priorities of the government. The expansion of application container transportation technologies is included in one of the sections of Russia's Transport Strategy 2030. Within this section the construction of container terminals, acceleration of delivery speed, development of sea ports infrastructure, introduction of new approaches into transportation organisation (forming of container routes), and developmen of intermodal routes are planned.

Reduction of transport expenditures and optimisation of supply chains are highly relevant for subjects of economic relations. Increase of share of container transportation and ramp-up of quantity of fixed route shipments (provided that there is growth of external trade) can partially solve this problem.

Today, development of container transportation is hampered by the following factors:

– lack of modern logistics and storage terminals designed to provide container supplies;

– insufficient intake capacity of ports, especially container port terminals;

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– obsolete container ships;

– shortage of rolling stock (container flat wagons for carrying containers by railway) and container equipment;

– instability in organisation of transit container trasnportation by the Trans-Siberian Railway.

The Russian container transportation market is at its shaping and development stage. At the same time, the factors given and long-term tendency show that there is a potential for further growth of external and internal container transportation.

MAGLEV TECHNOLOGY – THE BASIS FOR EFFICIENCY OF EAST-WEST CORRIDOR

As a result of the study of economic and technological factors of freight maglev and railway transport, a number of conclusions has been made, which determine efficiency of establishment of TTC East-West (Table 1–4).

Table 1. Line design and structure components

Factor	Maglev transport	Railway transport
Track structure	Flyover; guideway (levitation, stabilisation assemblies, linear motor inductor)	formation; blanket; ballast layer; anti-creepers, guard rail, bumper bars, etc; underrail base (sleepers, bars, etc.); rails; fastenings
Land allocation (right-of-way width)	7.2 m	20 m
Construction period for 100 km track	18 months	39 months in case of double steam construction, parallel electrification, without considering additional facilities construction period [14]

Conclusion: maglev transport infrastructure is considerably simpler than that of railway transport in terms of construction and installation works; considering lesser degree of necessity in land allocation, this is justified by high construction tempos.

Table 2. Operational characteristics

Factor	Maglev transport	Railway transport
Commercial speed	500 km/h	43.75 km/h (programme “Transsib in 7 days” will allow 62.5 km/h)

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Factor	Maglev transport	Railway transport
Power consumption	0.53 kWh per 1 wagon kilometre	0.61 kWh per 1 wagon kilometre
Carrying capacity for 720 km line	At least 10.3 million TEU per annum	352 052 TEU per annum
Demand in rolling stock for carrying 3 million TEU per annum via 11.3 thousand km TTC	16 295	81 474
Rolling stock life cycle	50 years	30 years
Minimal degree of curvature	50 m	160 m in specially complex conditions [15]
Maximum gradient degree	10 %	4 %
Overhaul intervals	Not required before 50 years of services	Every 1.4 billion of passed tonnage (on highly stressed lines – once in 5 years)
Physical wear	Justified only by environment as a result of contactless interaction of guideway and rolling stock	Formation; permanent way; bogies and frames of wagons; coupling (contact-based interaction of track structure and rolling stock)
Requirements to freight sizes	No limitations for oversize freight	Limited

Conclusion: technical characteristics of maglev transport allow larger volumes of transportation as compared to railway transport having higher commercial speed and energy efficiency. Due to a shorter turnover period, the demand in rolling stock is reduced. The infrastructure of a maglev transport is less demanding in terms of landscape and allows construction in complex conditions. The infrastructure and rolling stock of the maglev transport interact without physical contact, which significantly enhances their life cycle and also significantly reduces the need for diagnostics and all types of repairs.

Table 3. Economic characteristics

Factor	Maglev transport	Railway transport
Cost of one year of life cycle for 11.3 thousand km, having 3 million TEU per annum	196 428 million roubles	304 091 million roubles (with new structure); 229 265 million roubles (with reconstructed line)

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Factor	Maglev transport	Railway transport
Cost of construction of one kilometre of track	582.4 million roubles	409.8 million roubles
Operational costs	448.73 kopeks per 10 tkm	590.44 kopeks per 10 tkm
Cost of rolling stock for carrying containers	15.25 million roubles	15.25 million roubles

Conclusion: despite higher cost of infrastructure construction, life cycle cost of maglev transport is considerably lower than that of railway transport, due to discrepancy in operational costs and number of repairs.

Table 4. Ecological characteristics and riding safety

Factor	Maglev transport	Railway transport
Level crossings	No	Yes
Derailment risks	Excluded due to magnetic forces and preventers	Yes
Collision risk	Excluded by operation system	Possible
Noise pollution	15 decibel	110 decibel
Emissions	No	From one train as follows: up to 1.5–20 mg/m^3 of dust; up to 1.0 mg/m^3 of sodium carbonate to; pollution with oil products 5–20 gr per 1 km of soil

Conclusion: maglev transport is more safe, namely in terms of ecology, than railway transport.

Summarising the above data confirms that in terms of the parameters considered maglev transport significantly excels railway transport, it is more efficient and is capable of meeting demand in large volume of transportation.

CONCLUSION

Considering the humankind's inevitable entering a new era of technological revolution, the priorities of the state policy in Russia's transport complex development using innovative transport and logistics technologies, necessity to strengthen Russia's positions at the world transit transportation market, the relevance of the East-West Transit Transport Corridor is obvious.

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After the comparison study of transport technologies for freight transportation, the conclusion was made that application of maglev technologies for competitive TTC East-West is possible and necessary.

It needs to be pointed out that deliberate hampering of innovative development of transport, underestimation of significance of speed, breakthrough Russian engineering solutions decreases integral economic effect of the transport system as the most crucial element of the country's economy.

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