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EXPERIENCE IN IMPLEMENTING HIGH-SPEED AND HIGH-SPEED TRAFFIC ON THE WORLD'S RAILWAYS

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Abstract: This article examines the international experienceof operating high-speed highways in foreign countries, as well as in the former post-Soviet space and the Republic of Uzbekistan. The calculation took into account the record speed of trains, operating speed, railway line coverage, population coverage and passenger expenses per 1 km of track.

Keywords: high-speedhighways, transportation, comfort, safety, traffic, railways, transport system, analysis.

The idea of developing high-speed highways in the XXI century literally captured the whole world. Japan was the first to recognize the importance of increasing the mobility of the population through the organization of high-speed communication. Europe soon joined the process. Currently, the importance of high-speed highways is being considered in the United States, India, the Emirates and other countries. At the same time, each of the countries goes its own way: some rely on increasing speed, while others focus on expanding infrastructure.

Regular high-speed train service began for the first time in Japan in 1964, in France in 1980, and in Italy in 1984. In these countries, as well as in Germany and Spain, national high-speed systems are based on domestic high-speed rolling stock, while in a number of other countries, including Uzbekistan, foreign trains are used. Today, the western part of Europe is now united by a single high-speed rail network Eurostar and Thalys.

As mentioned earlier, the world speed record for trains — 574.8 km / h-was set on April 3, 2007 by the French train TGV POS. This record is still valid today.

At the beginning of the XXI century, China became the world leader in the network of high-speed lines, as well as the operator of the first regular high-speed Maglev (maglev train).

Unlike high-speed traffic, as a rule, specially constructed railway tracks are used for high-speed traffic, rather than reconstructed conventional ones. At the same time, as of 2016, the total length of operating high-speed highways in the worldis more than 35 thousand km (Table 1).

Below are data on the organization of high-speed and high-speed traffic on the railways of Japan, China, France, Spain, Italy, Germany, Great Britain, South Korea, Russia, Uzbekistan and the United States.

Table 1-High-speed lines in operation or under construction

Country	in operation (km)	Under construction (km)	Total length (km)
Austria	292	210	502
Belgium	209-209	-	209
Great Britain	1337-1377	-	1377
Germany	1334	428	1762
Denmark	5	60	65
Spain	3100	1800	4900
Italy	923	125	1048
China	19366.8	16280	35269.8

Korea	819	585	1404
Morocco	-	200	200
Norway	64	54	118
Netherlands	120-120	-	120
Poland	82	322	407
Russia	1496-1496	-	1496
USA	362	483	845
Taiwan	345-345	-	345
Turkey	1420	1506	2926
Uzbekistan	600	400	1000
France	2036	757	2793
Switzerland	80	57	137
Japan	2664	782	3446

Japan The first solution to the problem of modernizing its railways with the introduction of high-speed traffic was taken up by the Japanese. This happened in the late 50s of the last century. It was a necessary event in the run-up to the 1964 Tokyo Olympics. This was primarily due to the fact that Japanese roads were archaic and technically backward. The track width was only 1067 mm (in Europe-1435 mm, in the CIS countries-1520 mm), the tracks were worn out, the fleet of locomotives was outdated. In record time, over 5.5 years, the Japanese built a 552-kilometer wide-gaugehigh-speed Shinkansen line», connecting Tokyo and Osaka (Figure 1).

With the creation of the first Tokyo — Osaka HSR, the original conceptual scheme of the high-speed rail system was changed: high-speed highways in their modern form, unlike most railways, are purely specialized passenger highways for mass transportation in strictly designated transport corridors. Attempts to use high-speed highways for freight (mail) transportation are still extremely limited.

Figure 1 Shikansen High-speed line Сикансенin Japan

Here, for the first time in the world, the technology of seamless rail laying was used: they are welded into kilometer-long whips and in this form are delivered on a platform to the place of laying.

On the world's first high-speed highway*Tokyo-Osaka*бесстыковой путьa non-jointed track of 53.3 kg/погм rails (later replaced with 60 kg/m rails) was laidon reinforcedconcrete sleeperson crushedstone ballastand on the roadbed. The high costs of maintaining the track of traditional construction at high traffic speeds predetermined the further choice of Japanese specialists — the use of rigid (slab) bases instead of a ballast prism and the almost complete rejection of the roadbed on new high-speed lines. This decision was also prompted by the fact that on new high-speed highways in Japan, the share of track on sections with artificial structures was approaching 100 %.

Naturally, there were no level crossings on high-speed lines, which required the construction of more than a hundred bridges and tunnels. On the"Shinkansen"a fundamentally new type of train was used, which with the light hand of journalists was nicknamed the "bullet train". The bullet train does not have a locomotive: the engine is installed on each wheel axle, which allows you to significantly increase power.

In 1964, trains ran between Tokyo and Osaka at a speed of 210 km/h. NowНодзомиthe N-700 Nozomi electric train flies 552 km in 2 hours and 25 minutes, reaching speeds of up to 300 km / h.

Currently,"Shinkansen", which connects all major cities in Japan, is the most popular mode of transport. Over 50 years of operation, Shinkansen trainshave carried almost 7 billion passengers, running in the morning and evening hours at six-minute intervals.

In 1982, two more lines were put into operation. Speeds on them reach 240 km/h, and on one of the sections - 300 km/h.

In 1998, on the eve of the XVIII Winter Olympic Games, a 300 km high-speed highway was built in Nagano.

To date, the total length of the lines exceeds 2 thousand km. The maximum speed is 300 km/h.

Magneticsuspension trains JR-Maglev ("Maglev", Fig. 2), operated in Japan, can be conditionally attributed to railway transport, although they hover over the track at a distance of 1.5 centimeters.

Figure 2 JR-Maglev high-speed Maglev train with magnetic suspension

This type of transport has been developed by the Japan Railway Technical Research Institute in collaboration with the operator Japan Railwayssince the 1970s. Currently, a test site has been built in Yamanashi Prefecture, where on April 21, 2015, a prototype of the Shinkansen L0 modification set an absolute speed record forrailway transport — 603 km / h

China has the world's largest networkof high-speed and high-speed railways, exceeding those in Japan and Europe combined.

China's high-speed and high-speed roads include: upgraded conventional railway lines, new lines built specifically for high-speed trains, and the world's first commercialmaglev train lines. The total length of such roads in China is about 20 thousand km by 2016 . The dynamics of their development is impressive: less than 20 years ago, the maximum speed on the Chinese railway network did not exceed 48 km/h, which made this type of transportation absolutely uncompetitive compared to road and air transportation. They set to work at a rapid pace: active construction of tunnels and bridges began, new modern rails were installed, and old tracks were electrified. As a result, it was possible to achieve a speed of 160 km/h. In 1998, thanks to the use of Swedish technology, the speed of trains on the Guangzhou – Shenzhen section reached 200 km/h. And in 2007, trains in China were accelerated to 250 km/h.

In terms of technology, the organization of high-speed rail communication in China is carried out through technology transfer agreements from well-established foreign manufacturers, such as Bombardier,Alstom, and Kawasaki. Adopting foreign technologies, China seeks to make its own developments based on them. An example is the development of trainsof the CRH-380A series produced in China, which reach speeds of over 350 km / h and have been in operation since 2010 (Figure 3). This train sets a record for high - speed roads in China-about 500 km/h.

The high-speed rail link is also expected to extend beyond China's borders. In January 2015, a promising Beijing — Moscow high-speed railway was announced, which will pass through Mongolia and Kazakhstan and reach the central part of Russia.

Figure 3. CRH-380A high-speed electric train

Its route will include the Moscow — Kazan — Yekaterinburg high-speed highway implemented with the participation of China (based on its technologies and machine-building products). The line will pass through Ulaanbaatar, Irkutsk, and Astana. The line will have a length of 7 thousand kilometers, a travel time of about 30 hours, a construction cost of more than 240 billion US dollars, and for the first time this line will be designed to handle both passenger and cargo container trains.

Since 2002, the Chinese 30-kilometer high-speed line connecting Shanghai with Padong Airport has been operating. On this road, a monorail is used, over which, after acceleration, the train hovers at a distance of 1.5 cm. The speed of the Shanghai Maglev, built by the German company Transrapid (a subsidiary of Siemens AG and ThyssenKruppssenKrupp), is 450 km / h

France is a leader in high-speed traffic in Europe and has been using high-speed trains for almost 30 years. The history of European high-speed TGV services began in 1981-1983, when the 410 km long Paris – Lyon line was put into operation. However, Europe responded to the Japanese railway breakthrough of the second half of the twentieth century with a significant delay. This is partly due to the fact that European designers in the 1950s and 60s were very enthusiastic about experimenting with a Maglev hovercraft and magnetic suspension.

The decision to create a high-speed line similar to the Japanese one was made in France in the second half of the 1960s. It took the National Society of Railways of France fifteen years to develop and launch the Paris-Lyon line, which was named TGV (train a ' grande vitesse-high-speed train). It reached a speed of 318 km / h, which is still a world record for trains without electric traction.

However, the energy crisis that occurred in 1973 forced the SNCF management to abandon the use of sharply increased fuel prices in TGVs. There was a reorientation to use less expensive electricity generated at French nuclear power plants.

In the end, by the 80th year, the Paris-Lyon line was also ready. The electric locomotive and wagons were produced by Alstom. On September 27, 1981, the line was put into operation. The train covered the distance between the two French cities in 2 hours, moving at a speed of 260 km/h. Now the speed on the TGV lines covering Europe reaches 350 km/h. As for the average speed of movement, it is 263.3 km/h.

At the same time, rolling stock is constantly being upgraded and new models are being created. On April 3, 2007, a new truncated TGV POStrain reached a speed of 574.8 km / h (Figure 4) on the new 106 km LGV EST line connecting Paris and Lorraine. This is an absolute record on the railway track.

France's high-speed routes have special requirements in addition to the seamless connection of rails. The turning radius is at least 4000 m. Center-to-center distances of adjacent tracks are at least 4.5 m, which reduces the aerodynamic effect when two oncoming trains travel, the relative speed of which can reach 700 km/h. The tunnels through which the track passes are specially designed to minimize wind impact when entering and exiting the tunnel. A special alarm system is used on the driver's dashboard and automatic braking is provided in case the driver's reaction is not fast enough. The paths are securely fenced to prevent collisions with animals.

Figure 4 World speed record set by the TGV POS electric train (France)

To prevent the pantograph from catching up with the wave traveling from it along the contact wire, the wire has a higher tension than on conventional lines. On TGV lines, there is a speed limit, but not from above, but from below. This is required to ensure that low-speed trains do not reduce the capacity of high-speed lines.

In France, after analyzing the Japanese experience, the design of the main tracks of high-speed highways was adopted, which provides for laying a non-jointed track made of rails weighing also 60.8 kg/pog. m on a sleeper-ballast base on the roadbed. At the same time, two decisive advantages of the ballast version in comparison with the slab one were taken into account: a significantly lower price of the structure itself (in areas with a predominance of the roadbed) and a larger margin of stability of the track against transverse shear from the impact of rolling stock.

The disadvantages of the slab foundation on the roadbed, which were manifested in Japan, were also taken into account, in particular, the high cost of such a structure, the difficulties of eliminating geometric deviations of the path (although they are smaller in size), the lack of a well-established technology for laying the path, and the uncertainty of its behavior on weak soils.

The long-term experience of operating the French high-speed line Paris-Lyon has confirmed the high operational qualities and reliability of the track on ballast. It is also laid on other high-speed highways in France, designed for trains with speeds up to 350 km/h.

Spain. The first 471 km high-speed highway from Madrid to Seville was commissioned in 1992.

In October 2004, the first 470 km long section of the new Madrid – Barcelona VSD line was put into operation (to Lleida).

Spain currently has more high-speed highways under construction (a total of 870 km) than any other country in the world. This is a high-speed rail system that operates at speeds of up to 300 km / h on a special track.

Spain, which has the longest network of high-speed highways in Europe (3,100 km), is also leading in terms of the pace of their construction.

One of the goals of high-speed construction is to integrate Spain's railways into the pan-European network. First of all, we are talking about connecting Madrid with France. At the same time, the development of the Madrid – Valencia corridor is being considered.

Modern trains "Talgo-250" and " Talgo-350 "(Fig. 5) can reach speeds of 250 and 350 km/h, respectively. These trains are also operated in Germany, Finland, Uzbekistan and Kazakhstan.

AVE Series 102 (or Talgo 350) electric trains were created by the Spanish company Talgo, together with the Canadian Bombardier, on the basis of standardTalgo trainsfor a maximum speed of 350 km / h and European gauge. Designed mainly for servicing the Madrid-Barcelona high-speed line.

In Spain, on high-speed lines, trains of the Talgo type have cars with wheelsets that allow you to move along the track with different track widths (for example, 1668/1520/1435 mm).

The Spanish Government has significantly increased public investment in railways, both high-speed and conventional, since 2003. Investments in rail transport exceed investments in highways and amount to at least 4 billion rubles. euro per year (approximately 0.6 % of the country's GDP). By 2020, it is planned to connect Madrid with high-speed lines to all provincial capitals.

The AVE high-speed rail system-an abbreviation for Alta Velocidad Española ("Spanish high-speed (train)") operates in Spain at speeds of up to 350 km / h on a special trackbed. Unlike the rest of the Spanish railway network with a gauge of 1,668 mm (Iberian gauge), AVE is built with a standard European gauge of 1,435 mm, making it possible to connect to high-speed systems outside of Spain.

Figure 5. AVE 102 (Talgo 350) high-speed electric train in Spain

Italy. Italians were among the pioneers of high-speed rail travel. In 1939, the ETR 200 electric train set a world record for the route speed between Milan and Bologna, then it was 165 km/h with a maximum of 203 km/h.

The first fully dedicated high-speed line in Italy began construction in the summer of 1970. It was a stretch between Rome and Florence. It was put into operation in parts. The first part was introduced in 1978, and the last-in 1992. This line is called "Direttissima". In 1978, the first track connected Rome with Florence (254 km), the maximum speed of this line was 250 km / h (with an average of 200 km/h), and the journey time was about 90 minutes.

In Italy, for the first time in Europe in the 1970s, the original "Pendolino" series of trains was created, which has a special tilt system that creates comfort for passengers and does not reduce speed in curved sections of the track.

At the moment, Italy's high-speed railways consist of two main corridors. The first, from north to south, connects Turin and Salerno, via Milan, Bologna, Florence, Rome and Naples. The second, mostly under construction, will connect Turin with Venice, via Milan, Brescia, Verona and Padua.

A speed limit of 300 km/h applies to selected high-speed sections. The exception is the Rome — Florence and Naples — Salerno sections with the 250 km/h limit.

The total length of the allocated high-speed sections of Italy today is 959 km. In this aspect, the Italians are far from the leaders, here the Chinese are the leaders, and in Europe the Spaniards are the first.

The newest high-speed trains in Italy are called Freccia (Fig. 8), that is, "arrow", and are divided into "red" - Frecciarossa, "silver" - Frecciargento and "white" - Frecciabianca. The fastest trains, the red arrow Frecciarossa, run between the cities of Turin, Milan, Bologna, Florence, Rome and Naples, without stopping anywhere else. FrecciarossaA separate railway line has been built for Frecciarossa, where these trains can reach speeds of up to 360 km / h.

Figure 6. Milan-Bologna high-speed railway,ETR 500 "Frecciarossa" electric train.

Frecciargento trains Frecciargentouse both regular and dedicated high-speed lines, reaching speeds of up to 250 km / h, and connect Rome with many cities across the country. The main destinations of Frecciargento are Venice, Verona, Bari and Reggio Calabria. There are also two pairs of Frecciargento trains Frecciargentoper day on the Rome – Trento – Bolzano line.

Frecciabianca trains Frecciabiancarun on regular railway lines with speeds of up to 200 km / h between Milan and the cities of Venice, Bologna, Udine, Trieste and Rome. In addition, Frecciabianca trains Frecciabiancaprovide connections between cities on the Adriatic Riviera.

Italian carrier Trenitalia in 2015 introduced the train of the future, created by Bombardier. Today it is the fastest train in Europe, capable of reaching speeds of up to 400 km/h. So far, such trains will operate at a speed of 300 km/h. According to the manufacturer, the design of the train is ideal for movement in curved sections of the track.

In Germany, almost all major cities are connected by high-speed traffic lines, and not only are new roads being built for high-speed traffic, but existing ones are also being upgraded. IIntercity-Express or ICE (Figure 7)is a network of high-speed trains, mainly distributed in Germany, developed by Deutsche Bahn.

Figure 7. ICE 3 on the Munich-Ingolstadt high-speed section

The latest generation of InterCityInterCity-Express trains, ICE 3, was developed by a consortium of Siemens AG and Bombardier under the overall leadership of Siemens AG. The maximum speed of ICE trains on specially constructed sections of the railway network is 320 km/h. On standard sections of the network, ICE speeds average 160 km/h. The length of sections where ICE can reach speeds of more than 230 km / h is 1200 km.

ICE is the main type of long-distance train service provided by the German Railways (Deutsche Bahn). They provide both maximum speed and maximum comfort of movement. ICE became the base for Siemens AG to develop its family of high-speed trains under the general brand name Siemens Velaro. Velaro projects have been implemented, in particular, in Spain and China. These trains are also delivered to Russia for use on the Moscow — Saint Petersburg and Moscow-Nizhny Novgorod high — speed lines.

In Germany, on the first lines of high-speed highways, preference was given to the track on the groundbed with a ballast prism. However, later, when the problem of building straightening passages with a large number of tunnels and other artificial structures arose, studies and tests of the path on a rigid foundation were carried out. As a result, it was considered appropriate to use the upper structure of the Japanese type with some adjustments made by German specialists in accordance with local conditions.

Great Britain.High-speed railways (with speeds of more than 200 km/h) first appeared in the UK in the 1970s during the British Rail era. The company conducted research in two directions: the development of tiltable train technology and the development of conventional high-speed diesel trains. British Rail Class 252 set the world speed limit for diesel locomotives at 230.4 km / h, but the trains were used in standard traffic with a speed limit of 201 km/h (125 miles)./h) and gradually appeared on the main lines of the country, with the subsequent rebranding in InterCity 125. After electrification, high-speed transportation in Britain was supplemented by British Rail Class 91, designed for transportation at speeds up to 225 km / h, so they received the InterCity 225 brand. However, over time, these trains were also limited to 201 km/h for safety reasons. The last attempt to develop this direction by British Rail was the canceled InterCity 250 project, which was developed in the 1990s for the West Coast Main Line.

The first use of high-speed trains with speeds up to 300 km/h in Britain was the Eurotunnel railway (now known as High Speed 1), when the first phase of construction was completed in 2003. The line uses Eurostar British Rail Class 373 trains.

In the post-privatisation period, plans to increase the speed on the West Coast Main Line to 225 km / h were cancelled, but the British Rail Class 390 Pendolino tilt Pendolinotrains designed for these speeds were still built and put into service in 2002 and operate with a 201 km/h limit. Other routes in the country were also upgraded to this speed, with the gradual introduction of the British Rail Class 180 Adelante and the Bombardier Voyager familyen(Classes 220, 221 and 222) from 2000 to 2005.

Following the construction of the first British Rail Class 395 for use partly on the High Speed 1 tracks and partly on the rest of the network, the first domestic route with speeds above 201 km/h (about 227 km/h) was introduced in December 2009, which was also used for the Olympic Javelin special route during the Summer 2012 Olympic Games. These routes are operated by Southeastern.

After several studies and consultations, the UK government announced the High Speed 2 projecten, creating a company to analyze the feasibility of the project, lay out the route and find funding. The project is based on the fact that it will be built from scratch high-speed tracks from London to the West Midlands via Heathrow to ease the load on the West Coast Main Line, using a regular high-speed train, not Maglev. Rolling stock should also be able to use existing Network Rail tracks if necessary.The High Speed 1 line is a 108 — kilometer-long high-speed line between London and the Eurotunnel that runs through the county of Kent. The line was built primarily to transport passengers and goods between the UK and continental Europe, but is also used for domestic transport between London and cities in Kent. The Eurostar passenger train (Figure 10) can reach speeds of up to 300 km/h on the English section of the line, which reduces the travel time between London and Paris to 2 hours and 15 minutes.

Figure 8. High-speed train British Rail Class 373, "Eurostar"

TGV TMST (French classification, French TransManche Super Train-the highest quality train crossing the English Channel) aka British Rail Class 373 (British classification), also known as "Eurostar" — a high-speed electric train designed to serve the Eurostar high-speed highway between the United Kingdom, France and Belgium through the Channel tunnel.

Of all the motor-car trains operating in the UK, the EurostarEurostaris the longest and fastest.

In general, experts of the European Union note that now the pace of development of high-speed highways in Europe has slowed down somewhat. In particular, only a little more than 500 km of new high – speed lines are planned to be built in France, about 400 km in Germany, and even less in Italy – about 125 km. This is mainly due to the fact that although high-speed rail takes passengers away from road carriers and slower trains, it continues to lose out to low-cost airlines, which offer extremely low fares in exchange for refusing most traditional passenger services.

South Korea.A high-speed railway known as Korea Train Express (KTX) operates between Seoul and Busan (Figure 11) via Cheonan, Asan, Daejeon, and Daegu. The railway uses French TGV technology. It started operating in 2004 and reached its full capacity in 2010. Trains can reach speeds of 300 km / h.

Проект The KTX project is based on French TGV technology, but with some differences regarding the path components. These are mainly sleepers (monoblock) and fasteners (Pandrol e-Clip). This was confirmed by the results of relevant studies and tests conducted in Korea. After 2 – 3 years of operation, trust was gained, due to the lack of negative results. We can conclude that the path met all expectations. As for laying the track and its maintenance, French technologies and techniques are best suited to Korean conditions. The laying speed and geometrical parameters of the track are comparable or even higher than in many European countries. Certain measurements were made to determine track elasticity as a function of rolling stock exposure and ambient temperature, compared to other countries. The results were positive and again met all expectations.

Another goal of the project was to take the latest technological advances and implement them in the Korean railway industry.

An example of such implementation of a new technology is the replacement of the e-Clip rail fastener, which is successfully used on the Test Track, with the Pandrol Fastclip fastener.

The fasteners were replaced on the Test Track and on the part of the next section where the e-Clip fasteners were installedClip. Replacement of fasteners will be carried out in the future along the entire ballast track. The replacement of rail fasteners is motivated by the simplicity and less expensive track maintenance achieved by the Fastclip systemFastclip, compared to the e-Clip fastening.

9. Alstom TGV-K (KTX-1) train on the Seoul-Busan line

Similar to the path with the e-Clipsystem, the Fastclip system Fastclipwas tested in the laboratory before it was installed on the path.

USA. Oddly enough, there are no truly high-speed lines in the US. The development of high-speed rail services in the United States has long been constrained by historical and geographical factors. Most of the network is owned by private companies, which almost completely eliminated passenger traffic 30 years ago. The date of the revival of rail passenger traffic in the United States can be considered December 12, 2000, when the first Acela Express passenger train left Washington via New York to Boston.

The only line resembling a high-speed highway connects Washington and Boston via Philadelphia and New York. Americanhigh-speed passenger train "Acela" (Fig. 10), owned byAmtrak, develops a maximum speed of 150 mph (240 km/h), although the average speed is twice as low, and it is practically the only high-speed train on the American continent. At the same time, the Acela is operated on conventional (but reconstructed) lines, and therefore the train is equipped with devices for tilting the body, which allows it to better fit at high speed into small-radius curves.

Figure 10. Acela high-speed passenger trainAcela» on the Washington-Boston line

The maximum speed of trains in regular passenger traffic is 241 km / h. The route speed is lower: when traveling from end to end along the entire 735-kilometer route, it is 110 km/h. This is explained by the fact that high-speed French trains are forced to "drag" along the old track.

Public opinion plays an important role in the construction of high-speed highways in the United States. Numerous environmentalists and residents of the territories through which the proposed branches should pass are opposed to such projects. According to citizens, high-speed rail transport in a country with well-developed highways will not be in demand. However, since 2013, the construction of a classic high-speed line between Los Angeles and San Francisco has begun. It is planned to put it into operation in 2020.

Russia.In 2009, Russia joined the list of countries with high-speed highways. The National system of High-speed traffic is a long-term strategic project of Russian Railways. Its implementation will reduce distances, bring cities closer together and increase the mobility of Russians.

The main strategic projects are the Moscow – Kazan – Yekaterinburg, Moscow – Rostov-on-Don – Adler and Moscow – Saint Petersburg high-speed highways. In addition, it is planned to create several high-speed and high-speed highways of small length, which can provide a significant economic and social effect by expanding the boundaries of existing agglomerations and optimizing the settlement system.

A network of high-speed and high-speed highways combined with suburban traffic will create an integrated transport system that provides the most efficient passenger transportation service in the country.

The program was implemented in three stages.

Stage 1: 2016-2020-implementation of pilot projects to create high-speed and high-speed traffic infrastructure, such as:

HSR Moscow-Kazan-Yekaterinburg on the Moscow-Kazan section;

HSR Moscow-Rostov-on-Don – Adler on the Moscow-Tula section;

SEE Tula – Orel – Kursk – Belgorod.

HSR Yekaterinburg-Chelyabinsk;

SEE Yekaterinburg – Nizhny Tagil.

SEE Novosibirsk-Barnaul.

Stage 2: 2021-2025-regional" expansion " of high-speed and high-speed traffic:

HSR Moscow-Rostov-on-Don-Adler on the Rostov – Krasnodar – Adler and Tula – Voronezh sections;

HSR Moscow-Kazan-Yekaterinburg on the Kazan – Yelabuga section;

SEE Novosibirsk – Kemerovo.

SEE Yurga – Tomsk.

SEE Moscow – Krasnoe.

SEE Kemerovo – Novokuznetsk.

SEE Yekaterinburg – Tyumen.

SEE Moscow – Yaroslavl.

SM Vladimir (HSR-2) – Ivanovo.

Stage 3: 2026-2030-formation of high-speed and high-speed railway corridors:

HSR Moscow – Saint Petersburg;

Moscow – Kazan – Yekaterinburg HSR on the Yelabuga-Yekaterinburg section;

Branch line from the Moscow – Kazan – Yekaterinburg HSR in the direction of Cheboksary – Ulyanovsk-Samara;

Moscow – Rostov-on-Don – Adler HSR on the Voronezh – Rostov-on-Don section;

SEE Stavropol-Nevinnomyssk-Mineralnye Vody

The implementation of the third stage of projects will complete the formation of the basic framework of the network of high-speed and high-speed highways, will connect the central part of Russia with the Volga region and the Urals with a single network of high-speed railways, which will help increase the level of mobility and life of the population, and integrate strategically important cities of the

On December 17, 2009, the Sapsan high — speed electric train (fig. 11) started operating regularly on the Moscow-St. Petersburg route.

Figure 11. Sapsan high-speed passenger train on Москвathe Moskav – Saint Petersburg line.

Today, the Moscow-St. Petersburg highway, along which the Sapsan train moves, should be considered conditionally high-speed, since for the most part it is a slightly modernized legacy of the Soviet track economy. In this connection, the train manufactured by the German company Siemens, which can reach speeds of up to 350 km / h, only develops a speed of 250 km / h in one section. The average speed is 140 km/h. The minimum travel time between the two capitals is 3 hours and 45 minutes.

In the summer of 2010, a high-speed Sapsan train service was opened on the Moscow — Nizhny Novgorod route (the minimum travel time is 3 hours and 55 minutes).

On December 12, 2010, the Allegro high-speed train service onAllegrothe St. Petersburg — Helsinki route was opened.

Until now, the operation of high-speed trains in Russia was carried out on existing railway lines. During this time, a number of significant shortcomings were identified: splashes of track after the passage of a high-speed train, the inability to pass suburban trains and long-distance trains, and high repair costs. Therefore, it was decided to build dedicated lines.

The main guideline for implementing the project of the first dedicated high — speed line in Russia on the Moscow-St. Petersburg route with speeds up to 400 km/h is the localization of production of machinery and materials on the territory of the Russian Federation. Currently, work is underway to form a regulatory framework for the construction and operation of such high-speed highways in Russia. Since there is no experience in organizing traffic at speeds up to 400 km/h in the country yet, the project will take into account world achievements in this area as much as possible and apply the most modern technologies.

Uzbekistan The Tashkent-Samarkand high-speed railway, which has a length of 344 kilometers, connects the two largest cities of Uzbekistan, Tashkent and Samarkand. The road passes through 4 regions: Tashkent, Syrdarya, Jizzakh and Samarkand. The line is served поезд «by the Afrosiab train(Figure 12), which runs daily at a maximum speed of 250 km/h and covers the distance to Samarkand in two hours.

Design work was carried out by the institutes "Boshtranshikha" and"Toshtemiryulloyikha"of JSC"Yzbekiston temir yllari". Construction of the line began on March 11, 2011, and was completed in 5 months.

The line includes both new and reconstructed railway tracks, which have been supplemented with a modern signal system, along the entire route from Tashkent to Samarkand.

High-speed and high-speed passenger train traffic has also spread to the following destinations in Uzbekistan:

- Samarkand – Bukhara;
- Samarkand-Karshi;
- Navoi-Kanimeh-Misken;
- Tashkent-Navoi-Urgench(Nukus);,
- Tashkent-Andijan
- Tashkent-Khojikent, etc.
- JSC "Uzbekiston Temir yllari" pursues a policy of intensive implementation of high-speed and high-speed passenger train traffic on the entire railway network of the Republic of Uzbekistan. According tothe authoritative European publication GoEuro, in the Global High-Speed Train Ranking» по степени развития железнодорожного транспорта , Uzbekistan ranks 17th in the world in terms of railway transport development and is ahead of the United States and a number of European countries.

Fig. 12.Afrosiab high-speed electrictrain on the Tashkent-Samarkand line

The calculation took into account the record speed of trains, operating speed, railway line coverage, population coverage and passenger expenses per 1 km of track. The top three countries in terms of the ratio of the maximum values of these parameters were represented by Asian countries: Japan, the Republic of Korea and the People's Republic of China. At the same time, each of these three countries outperforms the others in certain indicators. The record speed (603 km / h) was achieved in Japan, the highest population coverage at 44.67% was recorded in Korea, and China leads in two parameters at once. In China, trains run at the highest speed (350 km / h) and the percentage of high-speed highways from the total length of the country's railways is 29.22%.

Conclusion: The record speed of trains in Uzbekistan is 255 km/h, and the operating speed is 230-250 km/h. In the country's railway infrastructure, high-speed traffic occupies 8.21 percent. 9.01 percent of the country's population has access to such trains.

Uzbekistan surpassed such countries as Norway, the United States and Finland in the rating.

Currently, the introduction of high-speed and high-speed train traffic on the main main railway lines of the Republic of Uzbekistan is one of the most priority and promising areas of development of JSC "Uzbekiston Temir yllari".

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ANALYSIS OF THE CAPACITY OF THE TASHGUZAR - BOYSUN - KUMKURGAN RAILWAY LINE FOR SWITCHING TRANSIT CARGO FLOWS BETWEEN CHINA, CENTRAL AND SOUTH ASIA

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Abstract. The article deals with the construction of the Tashguzar - Baysun - Kumkurgan line, the reasons that contributed to the start of the construction of this line, the justification of technical solutions, the calculation of train running time, the throughput and carrying capacity of the section, the competitive ability with alternative transport in terms of international transportation.

Keywords: Tashguzar - Baysun - Kumkurgan line; capacity; carrying capacity

Until the nineties of the last century, railway communication in the northwestern and eastern outskirts of Uzbekistan was carried out through the territory of the Republics of Turkmenistan (Talimarjan - Boldir, Khojadavlet - Naymankul lines) and Tajikistan (Bekabad - Kokand lines). However, after the 1991 events, railways remained within each independent state, which inevitably affected the need for agreements between countries to carry out transportation. In this regard, the need arose to create a network of regional railway lines laid directly through the territory of the republic, connecting them with the center of the country, as well as to create a unified and independent railway transport system of the Republic of Uzbekistan.

The 223 km Tashguzar - Boysun - Kumkurgan railway line, built in 2003-2007, passes through Surkhandarya and Kashkadarya regions of the Republic. This railway line, in the context of current economic globalization, is of significant importance for the country's economic and industrial development, as well as for strengthening its foreign economic relations with neighboring countries, and for its future access through Afghanistan and Pakistan to the ports of the Persian Gulf [1,2].

The prospect of developing the existing Tashguzar - Boysun - Kumkurgan railway line as a link between China and South Asia may not provide large transit cargo flows between China and South Asia, as this Tashguzar - Boysun - Kumkurgan railway line has "narrow" areas that significantly reduce throughput and transport capacity, which must be subjected to increased line capacity when switching transit cargo flows between China and South Asia [3,4].

The railway consists of 15 railway crossings with a length of 9 km to 20 km. Maximum longitudinal slopes are 26‰, more than half of the route length is designed with slopes greater than 18‰. The Kumkurgan-Akrobat section contains predominantly elevations, including a prolonged elevation, with a length of 111.4 km and a maximum elevation value of +20.7‰. The Akrobat-Tashguzar section contains mainly deserts, with the length and magnitude of the maximum descent being 109.05 km and - 20.5 ‰. The Kumkurgan-Akrobat railway section, with a length of 111.4 km, contains 86 straightened elements and is characterized by a change in the steepness of the elements from -0.5‰ to -20.5‰, as well as elevations from +0.1‰ to +20.2‰, part of which falls on the share of conditionally "difficult" elements at $i \geq +7.0$ ‰. The Akrobat-Tashguzar railway section, with a length of 109.05 km, contains 166 elements and is characterized by a change in the steepness of the elements from 0‰ to -20.5‰, as well as from 0‰ to +12.8‰ [5].

The capacity of single-track crossings with a paired non-packet (parallel) train schedule is determined by the formula:

$$n = \frac{(1440 - t_{Tex}) \cdot \alpha_n}{t' + t'' + \tau_Б + \tau_A},$$

where: t', t'' - travel time along the run in odd and even directions, respectively, in min.; A, B - station intervals for stations A and B in min;

t_{Tex} - technological windows allocated for the production of work on the current maintenance and repair of the road and its infrastructure (contact network, CSB systems, etc.). Based on static data, t_{Tex} is assumed to be equal to 75 min on single-track lines.

α_n - is the reliability coefficient, taking into account rolling stock failures as a whole, and the reliability coefficient when calculating the available throughput capacity is assumed to be 0,93 on electrified single-track lines.

The number of freight trains on sections with predominant freight traffic under non-parallel schedule conditions is determined by the formula:

$$n_{гр} = n - n_{ps}^{sk} \cdot \varepsilon_{ps}^{sk} - n_{ps} \cdot \varepsilon_{ps} - n_{pg} \cdot \varepsilon_{pg} - n_{us}(\varepsilon_{us} - 1) - n_{sb}(\varepsilon_{sb} - 1)$$

where: n – parallel graph of the section's capacity; ε_{ps}, ε_{sb} – removal coefficient for passenger and combined freight trains ε_{ps} = 1,7; ε_{sb} = 1,8; n_{ps}, n_{sb} – movement sizes (trains, train pairs) of various categories; passenger, suburban, express and combined freight trains n_{ps} = 2; n_{sb} = 1.

Possible carrying capacity of the road, determined by the amount of cargo that the road can carry with this technical equipment in one or another direction per year

$$Pos = \frac{365 \cdot Q_{н} \cdot n_{gr}}{\gamma} \cdot 10^{-6}$$

where: Q_n - net weight of the freight train Q_n=0,65·Q_{br}=0,65·2750=1787 tons; Q_{br} - gross weight of the freight train, Q_{br}=2750 t; n_{gr} – the number of freight trains that the railway can pass in this direction; γ - unevenness coefficient of transportation 1,2;

The calculation results, the travel times of the throughput and carrying capacities, and the utilization of two 2O'zbekiston sections are presented in the table. 1 and 2.

Table 1 - Time of the Tashguzar - Boysun - Kumkurgan line

№	The stage	Running time, min.		
		odd	paired	total:
1	Tashguzar - Kairma	13,3	14,1	27,4
2	Kairma - Buzahur	10,8	11,8	22,6
3	Buzahur - Jarkuduk	12,9	14,1	27,0
4	Jarkuduk - Dehkanabad	10,9	11,9	22,8
5	Dehkanabad - Karadakhna	23,6	25,1	48,7
6	Karadahna - Chashmaihafizan	11,9	12,5	24,4

7	Chashmaihafizan - Akrabat	20,3	22,6	42,9
8	Akrabat - Aknazar	15,0	15,1	30,1
9	Aknazar - Shurab	12,4	13,1	25,5
10	Shurab - Darband	10,7	11,1	21,8
11	Darband - Baysun	20,9	22,2	43,1
12	Boysun - Pulhokim	11,6	12,6	33,1
13	Pulhokim - Tangimush	20,7	22,4	43,1
14	Tangimush - Akjar	12,1	13,4	25,5
15	Akjar - Kumkurgan	10,3	12,4	22,7

Depending on the steepness of the slopes (rise or descent) of the track profile elements along which the freight train is moving, its movement can be accelerated, uniform, or slowed. The use of curved sections in the plan ensures a reduction in work volume and a reduction in construction costs. At best, this goal is achieved by reducing the radii of curves. This is the important advantage of curves of small radii. At the same time, curves of small radii cause a deterioration in a number of operational and construction indicators.

Table 2. Possible capacity and carrying capacity of the Tashguzar - Boysun - Kumkurgan line

№	Name of indicator	Indicator value
1	**Tashguzar - Kairma** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 37 pair of trains 32 pair of trains 14.6 million tons/year
2	**Kairma - Buzahur** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 46 pair of trains 41 pair of trains 18,6 million tons/year
3	**Buzahur - Jarkuduk** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 38 pair of trains 33 pair of trains 15,0 million tons/year
4	**Jarkuduk - Dehkanabad** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 46 pair of trains 41 pair of trains 18,6 million tons/year
5	**Dehkanabad - Karadakhna** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 23 pair of trains 18 pair of trains 8,2 million tons/year
6	**Karadahna - Chashmaihafizan** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	 43 pair of trains 38 pair of trains 17,3 million tons/year

7	**Chashmaihafizan - Akrabat** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	27 pair of trains 22 pair of trains 10,1 million tons/year
8	**Akrabat - Aknazar** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	27 pair of trains 22 pair of trains 10,1 million tons/year
9	**Aknazar - Shurab** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	40 pair of trains 35 pair of trains 15.9 million tons/year
10	**Shurab - Darband** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	42 pair of trains 37 pair of trains 16,8 million tons/year
11	**Darband - Baysun** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	31 pair of trains 26 pair of trains 11,8 million tons/year
12	**Boysun - Pulhokim** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	46 pair of trains 41 pair of trains 18,6 million tons/year
13	**Pulhokim - Tangimush** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	28 pair of trains 23 pair of trains 10,5 million tons/year
14	**Tangimush - Akjar** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	42 pair of trains 37 pair of trains 16,8 million tons/year
15	**Akjar - Kumkurgan** – Possible capacity: – Number of freight trains: – Possible carrying capacity:	58 pair of trains 53 pair of trains 24,1 million tons/year

Conclusion

Based on the above, the following conclusions can be drawn:

1. The results of traction calculations showed that the capacity of the Tashguzar - Boysun - Kumkurgan railway line provides for the passage of 18 pairs of freight trains per day and the maximum possible carrying capacity of 8.2 million tons. The restrictive crossings are

"Dehkanabad - one. Karadahna," "one. Chashmaihafizan - Akrabat station" and "Akrabat station - Aknazar station."

2. Currently, the adopted design solutions for the Tashguzar - Boysun - Kumkurgan line require clarification, as they do not fully consider the possible prospects for implementing the Hayraton - Mazari-Sharif - Peshawar line route connecting China with the countries of Central and South Asia along the Tashguzar - Boysun - Kumkurgan line. With favorable conditions for the development of events, this can lead to a significant increase in transportation volumes. In this regard, it is necessary to substantiate the strengthening of the Tashguzar - Boysun - Kumkurgan railway line for the purpose of switching transit cargo flows between China, Central and South Asia.

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