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EDN BUYFAZ

Engineering of an electric train for the first phase of the high-speed railway network in Russia

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ABSTRACT Creating Russia's first high-speed railway line between Moscow and St. Petersburg is an important socio-political, complex engineering and technical, as well as major economic project.

In addition to the design and construction of fixed track, power supply, automation, telecontrol and telecommunication facilities and other infrastructure components, the project includes, in a single package, the design and commercial production of a Russian-made high-speed train. In 2025, the *BRICS Transport* (vol. 4, issues 1 and 2) published the Report on the plenary session of the VI Betancourt International Engineering Forum "High-speed railway line St. Petersburg–Moscow: Challenges, solutions, personnel" in both Russian and English. The Report presented the background of the project and its infrastructure component. To complete the picture, we are publishing the slightly abridged presentation "On engineering of an electric train for the first phase of the high-speed railway network in Russia" made by Head of the Department of Technical Policy of JSC Russian Railways, Candidate of Engineering Sciences Vladimir E. Andreev for students and professors of Emperor Alexander I St. Petersburg State Transport University on April 2, 2025.

KEYWORDS: high-speed railway rolling stock; train; railway coach; bogie; power supply system; brake system; travel conditions; passenger comfort

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Информационная статья

Разработка электропоезда для первого этапа сети высокоскоростных магистралей в России

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АННОТАЦИЯ Создание первой в стране высокоскоростной железнодорожной магистрали Москва – Санкт-Петербург — важный социально-политический, сложный технический, технологический и большой экономический проект.

Проект комплексно включает, помимо проектирования и строительства стационарных объектов путевого хозяйства, электроснабжения, автоматики, телемеханики и связи и других инфраструктурных компонентов, разработку и освоение производства отечественного высокоскоростного поезда. В журнале «Транспорт БРИКС» в 2025 году (т. 4, вып. 1 и 2) на русском и английском языках был опубликован репортаж-отчет о пленарном заседании VI Бетанкуровского международного инженерного форума «Высокоскоростная железнодорожная магистраль Санкт-Петербург – Москва: вызовы, решения, кадры», в котором были представлены основные сведения о проекте, его инфраструктурной составляющей. Для полноты картины с небольшими сокращениями публикуется лекция-доклад начальника Департамента технической политики ОАО «РЖД», к.т.н. В.Е. Андреева «О разработке электропоезда для первого этапа сети высокоскоростных магистралей в России», прочитанный 2 апреля 2025 г. для студентов и преподавателей Петербургского государственного университета путей сообщения Императора Александра I.

КЛЮЧЕВЫЕ СЛОВА: высокоскоростной железнодорожный подвижной состав; поезд; вагон; тележка; система электропитания; тормозная система; условия проезда; комфорт пассажиров

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BASIC CHARACTERISTICS OF THE HIGH-SPEED TRAIN

To operate on high-speed lines electrified with 25 kV 50 Hz alternating current and high-speed lines electrified with 3 kV direct current as the first phase of the high-speed railway network, a dual-voltage electric train consisting of eight coaches (*Fig. 1*, *2*) with a design speed of 360 km/h will be built in Russia. The trains will be designed to operate in the environments with outside air temperatures from –40°C to +40°C. It will be possible to operate them in double train sets of 16 coaches with multiple-unit (MU) control.

The preparation of the working design documentation for the main train components, including the body, bogies, traction, brake and other systems is currently underway (*Fig. 3*).

The engineering documentation is being worked out by the specially created Engineering Centre for Railway Transport JSC established in 2019. Its current shareholders are Russian Railways JSC, the Government of Moscow, and Sinara Group JSC[1]. The Centre's activities are aimed at solving relevant engineering problems and implementing knowledge-intensive projects in the field of railway transport. Engineering of high-speed passenger rolling stock is a pilot one.

Maximum test speed, km/h	400
Maximum operating speed when powered by 25 kV alternating current, km/h	360
Maximum operating speed when powered by 3 kV direct current, km/h	250
Basic train set, coaches	8
Continuous travel time in one direction St. Petersburg–Moscow; h:min	2:15
Number of passenger seats	454
Basic train set length, m	208
Maximum static load per axle, t	18
Multiple-unit control functionality	Available

Fig. 1. Exterior design of the driving trailer; interior of the first-class compartment, and basic specifications of the train

Fig. 2. Basic systems, components, units and assemblies of the train

[1] Sinara Group JSC is a Russian multi-industry holding company operating in transport engineering, financial services, etc. Their head office is based in Yekaterinburg.

Fig. 3. Organizations involved in the train engineering and production

The development and manufacture of the high-speed electric train and its component parts involve more than 150 Russian transport engineering companies and eight research centres.

MAIN TECHNICAL AND ENGINEERING SOLUTIONS FOR THE RUSSIAN HIGH-SPEED TRAIN

The engineering documentation is worked out in strict compliance with the schedule agreed upon by all the parties on the basis of the Technical Specifications for the Electric Train approved by Russian Railway JSC on December 9, 2020. The documentation is worked out along with a set of research studies on relevant issues to substantiate the standards and select sound engineering solutions.

The project will for the first time provide Russia with the following technologies and technical solutions (*Fig. 4, 5*):

- New friction materials for the friction pair in the braking system (brake shoes and brake discs) that can effectively perform at high speeds in all climate environments;
- LTE-based railway radio communication systems;
- New generation high-speed electric motors and traction gearboxes;
- An open-architecture hardware and software platform for building an electric train control system;
- Combined automatic couplers and coupling devices;
- Inter-carriage gangways with outer bellows for better aerodynamic performance;
- Underframe, bogies, and traction drive;
- Spring bases.

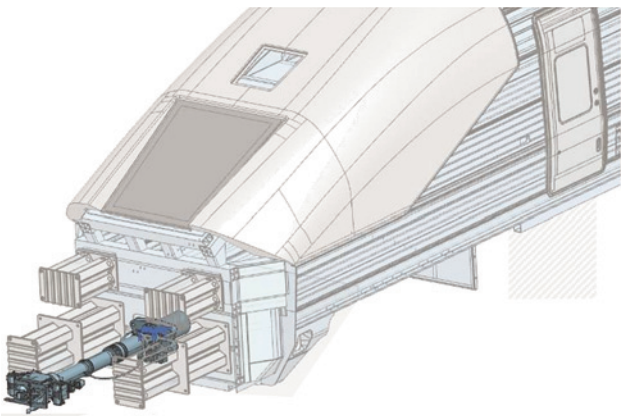


Fig. 4. Head carriage body nose elements: damper and fairing

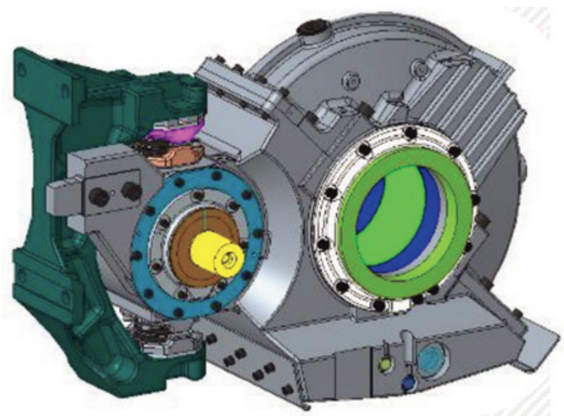


Fig. 5. Traction gearbox

The manufacturers of the component parts and sub-systems of the train have been set the task to use advanced materials and technology to ensure high reliability and the smallest possible weight and dimensions of the products.

The first prototypes of parts and assemblies for the electric train were manufactured in the second half of 2024. The first frame of the trailer bogie is being tested to destruction in order to determine the limit loads. The bulk of prototypes will be manufactured in 2025.

LAYOUT AND PASSENGER TRAVEL CLASSES

The eight-coach electric train will have four passenger service classes: First Class, Business, Comfort, and Standard coaches. This will allow to offer transportation services to passengers providing a wide range of comfort levels based on their budget (*Fig. 6–17*). The total capacity of the eight-coach train set is 454 passengers.

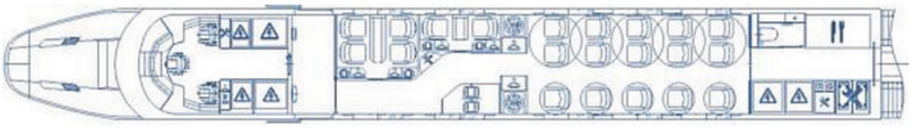


Fig. 6. Layout of First Class seats and compartments in Coach 1 (a driving trailer)

Fig. 7. Meeting room compartment in Coach 1

Fig. 8. Interior of the First Class passenger compartment in Coach 1

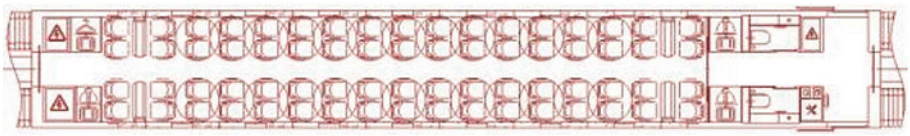


Fig. 9. Layout of Business seats in Coach 2

Fig. 10. Layout of Comfort seats in Coach 3

Fig. 11. Interior of the Comfort passenger compartment

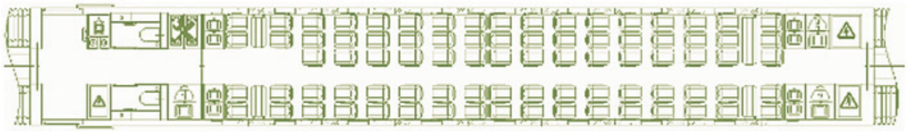


Fig. 12. Layout of Standard seats in Coach 4

Fig. 13. Interior of the Standard passenger compartment

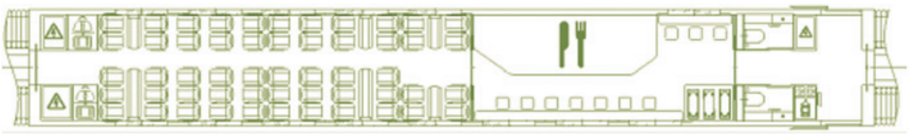


Fig. 14. Layout of Standard seats in Coach 5 with a bar

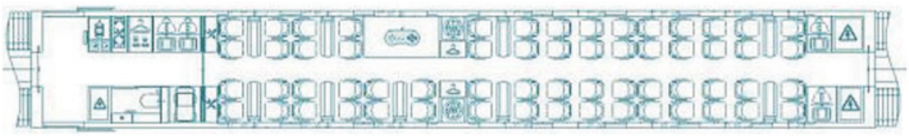


Fig. 15. Layout of Comfort seats in Coach 6 and areas with wheelchairs securement systems for people with disabilities

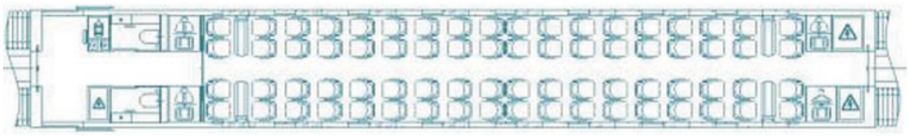


Fig. 16. Layout of Comfort seats in Coach 7

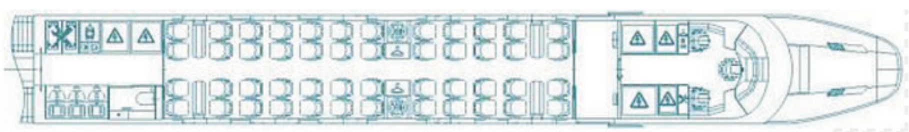


Fig. 17. Layout of Comfort seats in Coach 8 (a driving trailer)

The design of the electric train will be in line with the world's modern engineering and artistic trends and materials taking into account the experience of operating the Sapsan train and passenger demands.

In Standard coaches, it was decided to use the "2+3" seating arrangement (two seats – aisle – three seats).

Coach 1 has two compartments: a four-person meeting room compartment and a two-person luxury compartment. In Coach 1, the First Class seats are arranged in "2+1" configuration. The power-assisted design of the seats equipped with electric drives enables the passengers to convert them into a sleeping berth. Passengers in Coaches 1 and 2 will be offered individual service and will be served food and drinks at their seats. For this purpose, Coach 1 has a mini-kitchen and serving equipment.

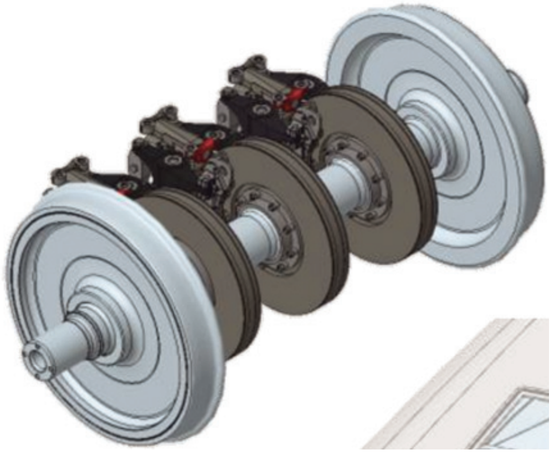


Fig. 18. Elements of the braking system on the axle of the carrier bogie: brake discs and calliper brake assemblies

Coach 2 has seats for Business class passengers with "2+2" seating arrangement in a row. The seats are also convertible. Coaches 3, 6 and 8 are intended for Comfort class passengers and have "2+2" seating configuration in a row.

Coach 3 has the train master's compartment. It is also equipped with special systems for placing and securing wheelchairs and thus can accommodate wheelchair-bound passengers.

Coach 6 has a play area for children. Coaches 4 and 5 are designed for Standard class passengers and have "3+2" seating arrangement in a row. Coach 5 has a bar area with a kitchen which is accessible to all passengers on the train.

TRAIN BRAKING SYSTEM

The main solutions being prerequisite for the implementation of a high-speed electric train project involve designing the vital systems: the traction and braking systems of the train, and train protection systems.

The braking system is a very important component of the electric train. The project places a particular focus on the creation of necessary equipment for the full cycle of tests. It is necessary to select materials for the friction pair of the disc brake (disc — brake shoe). Until now, Russia did not produce necessary materials for the friction elements of braking devices that could operate at speeds of up to (and including) 400 km/h, and there was no technology for manufacturing them (*Fig. 18*, *19*).

The existing brake test rigs in Russia allow for simulating the operation of brakes at speeds of up to 250–300 km/h, but their capability for simulating operating conditions with high braked weight values is limited.

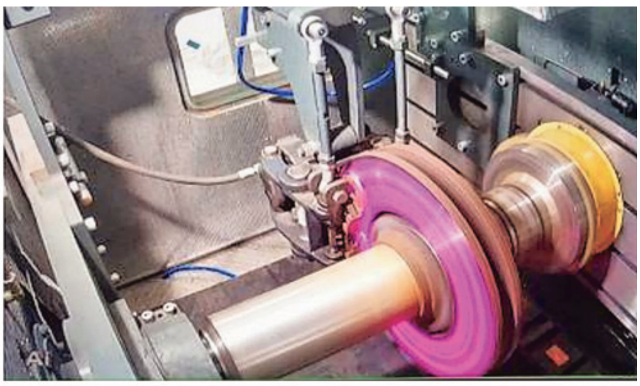
To address these challenges, arrangements have been made to develop a technology and manufacture a relevant brake friction test setup at the facilities of the Railway Research Institute (VNIIZhT), where the parameters of the disc brake friction pair will be determined and necessary tests will be conducted in 2025–2026.

36 new sub-systems comprising 10,000 components, parts and assemblies will be developed for the high-speed electric train. All train elements will be manufactured in Russia.

Most systems and components are subject to high requirements to weight, dimensions, reliability, and life cycle costs. The implementation of the project will enable many designers and manufacturers of component parts to move to a qualitatively new technology level. At least one manufacturer was identified for all essential systems and components, and several manufacturers were selected for many of them. Technical specifications have been developed and approved for all components of the electric train.

The manufacturer of the electric train is the Ural Locomotives Plant (Ural Locomotives LLC) located in Verkhnyaya Pyshma, Sverdlovsk Region. They will manufacture the essential components (bogies and carriage bodies) and will provide complete assembly,

a



b

Fig. 19: *a* — General view of the testing facility for braking equipment; *b* — Test unit for brake discs and brake assembly

Fig. 20. General view of the production buildings of the Ural Locomotives Plant[2]

adjustment and certification of the train (*Fig. 20*). New assembly workshops are under construction on the premises of the plant.

Other project participants are member companies of Transmashholding Group. They will design and manufacture six electric train systems (components and devices for the inter-carriage gangway, external doors, ventilation and air conditioning systems, internal doors, lighting systems, and interior elements).

CONCLUSION

The implementation of the project that is so important for the country will use the full weight of intellectual, technological and financial resources. The project for creating a high-speed electric train and building the first high-speed railway line is given special attention by the Russian President, the Government of the Russian Federation, the Government of Moscow, the Ministry of Industry and Trade of Russia, the Ministry of Transport of Russia, other ministries and departments, and Russian Railways JSC. The transport engineering companies engaged in the implementation of the project receive comprehensive support from these entities.

The implementation of such an ambitious project will allow the country's industrial sector to acquire new competencies that will both contribute to the creation of a Russian high-speed train and help improve the quality of locomotives, carriages and railway infrastructure systems manufactured in the country. Russian Railways Holding will gain unique competencies in the development of a high-speed train and its components, technologies and design procedures, modeling and testing. This will make it possible to create new types of rolling stock in the future.

Bionotes

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[2] https://opzt.ru/news/ooo-uralskie-lokomotivy-ispolnilos-10-let/