RESEARCH AND DESIGN INSTITUTE FOR INFORMATION TECHNOLOGY, SIGNALLING AND TELECOMMUNICATIONS IN RAILWAY TRANSPORTATION
The team of JSC NIIAS has developed **1087 innovative technical solutions and software products**. Being JSC RZD’s designated engineering organization, the Institute has created intellectual property assets in the following strategic areas of development of the industry:

- transportation process management .......... 351
- telecommunication systems ...................... 300
- train control and protection ...................... 225
- geoinformation systems and satellite technologies ...................... 113.

The contribution of JSC NIIAS to JSC RZD’s intellectual property portfolio amounts to **21 percent**.

High level of invention and novelty of the technical solutions have been noted by the experts of the Federal Institute of Industrial Design Rights of Russia. Over the last several years **inventions by JSC NIIAS have been on the list of Russia’s 100 best inventions**.

JSC NIIAS has developed and deployed the method and regulatory framework for activities involving intellectual right items, i.e. inventions, utility models, prototypes, software products, databases, know-how in all aspects of intellectual property management from identification of registrable deliverables and registration of exclusive right to commercialization of intellectual rights assets.

Preemptive patenting is of increasing importance as it allows building intellectual property portfolios of innovative solutions and prevent their use by competing companies. JSC NIIAS pays great attention to this activity and registers exclusive rights for the advanced technical solutions it develops.
The Institute employs over 100 doctors and candidates of sciences, over 1000 highly qualified engineers and experts involved in fundamental and applied research. The activities conducted by the Institute are innovative in their nature. JSC NIIAS holds a comprehensive range of state licenses, including authorizations to perform activities involving information classified as state secret.

The year 2016 marked 60 years since the establishment of the Research and Design Institute for Information Technology, Signalling and Telecommunications in Railway Transportation. The history of the Institute begins with the creation of the Design Bureau of the Main Directorate for Signalling and Communication of the Ministry of Railways of the USSR. On February 14, 1956 the Design Bureau was established by order of the Minister of Railways of the USSR.

Here, for the first time in the Soviet Union an automatic block system based on noncontact semiconductor elements was developed and later field tested at the Yakhroma – Dmitrov and Ramenskoye – Perovo lines of the Moscow Railway.

In mid-1990’s, following the adoption of the Railway industry information systems deployment program, the Institute was expanded and renamed NIIAS ZhT. Dedicated units of VNIIZHT were included in the Institute. Their experts brought advanced scientific know-how in automation, communication and information systems. The systems developed with their assistance remain in operation throughout the country’s railway network even today.

In 2000, in order to consolidate research and design activities in the area of railway information technology, NIIAS ZhT was reorganized into the head research establishment of the industry, Russian Research & Design Institute for Information Technology, Signalling and Telecommunications in Railway Transportation of the Ministry of Railways of the Russian Federation.

In the area of process automation the Institute has undertaken a significant amount of work on integrated traffic management centers. A single data communication network has been developed that ensures the interaction of all subscribers and remote computers in accordance with the requirements of international standards.

In 2007, due to the reorganization of the Russian Railways the Joint Stock Company NIIAS was established as a subsidiary of JSC RZD.

Today, JSC NIIAS is a leading industry research institute whose activity is aimed at increasing the efficiency and safety of railway operations based on advanced computer technology, automation, control, telecommunications and other advanced solutions.

JSC RZD has formally assigned JSC NIIAS to lead the following strategic industry development activities:

- development and implementation of integrated intelligent railway operations control and automation systems,
- deployment of satellite and geoinformation technologies,
- development and deployment of LED technology,
- development and deployment of train control and protection systems along with other railway automation technology,
- cybersecurity.
Main Areas and Strategy of Innovation

The Institute develops a holistic approach to the control of all process cycles of railway transportation based on a single integrated system for managing transportation process, infrastructure and safety using advanced software and intelligent technologies.

The significance and role of the activities performed by JSC NIIAS with regards to the innovative development of the railway industry is supported by the Institute’s leadership in a number of railway research areas:

- intelligent control systems,
- technologies for traffic management and transportation services,
- automation and remote control systems and devices,
- automated transportation management centers,
- railway information systems,
- digital engineering communication systems,
- geoinformation systems and satellite technologies,
- transportation safety,
- JSC RZD infrastructure and assets management systems,
- traction complex control systems,
- power consumption optimization and energy resources management systems,
- relevant-in-law electronic documents management systems for Russia’s transportation industry and transboundary cargo traffic,
- testing, certification and expert assessment,
- information security,
- regulatory support.

Innovation strategy

1. Development of the Integrated Intelligent Process Control and Automation System for Railway Transportation (ISUZHT)
   - Adaptive automatic real-time process planning.
   - Automation of end-to-end processes.
   - Development of fully functional workstations.
   - Principles of decentralization and self-organization of control and command with complete situational awareness.
   - Application of a single integration platform.
   - ISUZHT as the foundation of the Digital Railway.

2. Railway traffic management and logistics
   - Common integrated traffic management system based on modernized centralized traffic control and on-schedule operation.
   - Comprehensive automation and mechanization of station operations based on advanced electric interlocking and satellite positioning.
   - Location monitoring systems for cars, locomotives and maintenance personnel with automatic identification through integrated land-based RFID and GLONASS/GPS satellite positioning.
   - Intelligent operations control systems.

3. Train control and protection
   - Development of advanced onboard train control and protection systems.
   - Development of advanced computer-based automatic block, centralized traffic control and supervision systems.
   - Development of train control and protection systems for high-speed lines.

4. Railway infrastructure and energy efficiency management
   - Integrated railway infrastructure spatial data system. Use of GLONASS/GPS coordinates-based methods in automation of infrastructure (track) maintenance processes.
   - Common information environment of the railway industry including such crucial components as the common high-precision coordinate system and the digital geological maps generated with the use of GLONASS/GPS satellite systems while ensuring information protection.

5. Traction facilities management
   - Creation of traction facilities management centers.
   - Creation of dependability management centers.
   - Rolling stock diagnostics.
   - Improvement of traffic safety.
   - Rational management of train crews and training.

6. Safety management
   - Comprehensive information protection system and integration of JSC RZD ACSs.
   - JSC RZD Situation Center for Emergency Monitoring and Management.

7. Transportation Safety
   - Development and maintenance of integrated transportation safety systems.
   - Building and maintenance of transportation safety situation centers.
   - Development and deployment of technologies for integrated transportation safety systems design.
   - Development of technologies, software and hardware facilities, their adaptation and modification for the purposes of transportation safety.

8. Digital railway
   - Creation of a common system of interconnected intelligent information communication solutions to serve users, vehicles, traffic and infrastructure management system.
   - Deployment of client-oriented information technologies ensuring the highest level passenger information and interoperability of transportation systems.
• Ensuring non-discriminated customer access to railway infrastructure based on an integrated information management system to support freight transportation customer relationships.
• Implementation of the smart locomotive and smart train concepts, replacement of drivers with an automatic train control system, development of intelligent railway terminals management systems.
• Development of fault-tolerant and cybersecure intelligent traffic, freight and passenger flow management systems, railway automation and communication facilities.
• Deployment of monitoring technologies and Internet of things solutions for integration of information signals, analytical tools and control actions into a single environment in which business processes are performed with minimal human involvement or ultimately without it.
• Application of advanced computing resources virtualization platforms, implementation of cloud-based technologies that ensure radical changes in the way the services are provided to business units, enable the creation of an electronic platform to manage all the passenger and freight traffic, infrastructure and rolling stock related processes.

9. Development and implementation of information society technologies
• JSC RZD’s main digital signature certification authority.
• Relevant-in-law electronic documents management systems for the transportation industry and interdepartmental interaction with Russian federal authorities.
• Transboundary relevant-in-law electronic document management center for international and transit traffic based on trusted third party (TTP) services.
• Electronic invoice management via telecommunication channels.
• System of end-to-end information technologies for international freight traffic based on relevant-in-law electronic carriage and commercial documents (“Electronic train”).
• Identification systems involving electronic tickets based on advanced identification technologies.

10. Development of information security systems and facilities

11. Development of railway telecommunications systems
• Systems for digital radio communication and data transmission between infrastructure facilities.
• Integrated engineering communication system.
• Centralized passenger information and track maintenance personnel warning systems.
• Maintenance and recovery activities communication and warning systems.

Each of the above projects that represents a strategic initiative aimed to maximize the efficiency of traffic management and safety has been developed and implemented. Their functionality ensures:
• improved utilization of railway infrastructure by means of even distribution of traffic in time and space,
• higher process, information and social safety of traffic,
• provision of necessary information to all levels of management for operational and strategic decision-making based on simulation and impact analysis of new and modernized transportation facilities,
• development of rapid response procedures for transportation services enabling prompt reaction to malfunctions and failures, as well as adverse weather and other environmental conditions,
• development of transportation infrastructure and traffic conditions monitoring systems enabling real-time assessment of transportation system condition and forecasting of its evolution.
Common Intelligent Process Control and Automation System for Railway Transportation, ISUZHT

The development of ISUZHT aims to optimize JSC RZD business activities through comprehensive automation based on artificial intelligent methodology.

The Integrated Intelligent Process Control and Automation System for Railway Transportation is to become the main automated control and management system making use of advanced developments in business process management aimed at higher quality of transportation services and optimization of JSC RZD business units interaction.

ISUZHT functionality encompasses all existing transportation process planning timeframes from annual and monthly planning to supervisory control. In terms of vertical process control structures, ISUZHT automates end-to-end processes performed by the traffic management, traction and infrastructure directorates, as well as the Center for Corporate Transportation Services.

The ISUZHT functionality encompasses all JSC RZD business activities. In ISUZHT, the dispatcher who is involved with the planning, coordination and supervision tasks is replaced with an intelligent software module, the planner. The ISUZHT roadmap intends the implementation of a complete network of interacting planners.

Such system organization allows refining short and midterm plans in short-term periods and ensuring compliance with specified indicators in all planning timeframes.

It is important to note that ISUZHT aims to optimize the decisions made by specific dispatchers. The primary feature of the control system consists in the capability to generate plans and assignments both for the dispatchers and in the form of control signals transmitted to locomotives and infrastructure facilities.

ISUZHT is a completely Russian design. Strict adherence to the declared principles allows ISUZHT remaining a single system despite the monumental scope of both the tasks and deployment facilities.

The characteristic features of the ISUZHT information management system are as follows:

- Adaptive planning

The innovative aspect of ISUZHT consists in the use of adaptive planning methods based on network-centric approach and multiagent technologies. Real-time planning, coordination and plan execution control is ensured by a network of interacting dynamic planners. Each planner in turn represents a network of interacting agents. Planning based on multiagent technology is an evolutionary process with tens and hundreds of thousands of agents communicating in constant competition and cooperation.

Resource distribution and various planning tasks are performed in a way that as best possibly satisfies the interests of agents while observing all applicable restrictions, rules and regulations. Moreover, plans are not made anew but constantly updated as they are fulfilled or disturbances arise.

- Automation of end-to-end processes

The common process model of operational management is the methodological foundation of ISUZHT develop-
ment, implementation and deployment. This model allows eliminating the currently existing deficiencies in the management processes of individual operational units caused, in particular, by the lack of territorial integrity and non-existence of single vertical functional control structures.

In order to support the development of the common model, the project involves the design and implementation of end-to-end management processes taking into consideration the specific character of activities performed by various directorates of JSC RZD while simultaneously constructing, regulating and ensuring information support of all parties involved in the transportation process.

### Development of fully functional workstations

One of the key results of the development of the common process model of operational management is the definition of the full list of functions performed by each of the system users. Based on the common model, a fully-functional workstation (WS) is designed for each ISUZHT user.

WSs include a set of standard scenes displaying the traffic processes results. Each scene can be displayed by a number of WSs. The use of common interfacing solutions ensures the implementation of standard user interfaces and fast assembly of workstations from individual components.

Each workstation insures required situational awareness and display of built plans to dispatchers for confirmation.

### Use of Electronic Signature

As part of ISUZHT, the Electronic Signature for Relevant-in-Law Interaction system is being developed to support the operation of the single information environment intended for automation of decision support in planning, execution and performance control of end-to-end processes with regards to acquisition, processing, delivery and storage of electronic messages.

The primary function of the subsystem is to ensure integrity, authenticity, non-repudiation and relevance-in-law of exchanged electronic documents and messages.

### Common Integration Platform

The common integration platform of the intelligent control and automation system ensures:
- implementation of the new-generation dynamic process model,
- creation of the common information environment for automation of decision support in planning, execution and supervision of end-to-end processes,
- integration of JSC RZD’s systems into the common information environment,
- acquisition of comprehensive, consistent, immediate and reliable information by ISUZHT.

Based on the platform, an industry-specific language has been developed to help significantly reduce design complexity, changes management and increase the efficiency of subsequent system support. The industry-specific language makes it possible to design the system, ensure control of information integrity and continuity, assure compliance with predefined processes using the terms and definitions of railway transportation.

For the first time, the tasks of tens and thousands of existing information systems are solved within a common system while eliminating duplication of functions and ensuring end-to-end business process. A single ontology also creates a single base of regulatory reference documents.

### Deployment

**Train Traffic Management**

Subproject Train Traffic Management aims to ensure automation of decisions and actions of traffic controllers and division dispatchers through automatic real-time generation of train handling plans using methods of artificial intelligence.

The implementation of the Train Traffic Management subproject effectively solves the following tasks:
- passenger train schedule recovery in case of deviations and emergency situations,
- handling plans generation for non-scheduled trains,
- ensuring safety of high-speed traffic, i.e. route setting, level-crossing closing, high-speed traffic modes defini-
tion, prevention of Allegro and Sapsan trains meeting with freight trains carrying oversized or loose cargo,
• transmission of calculated train handling plans to the automatic route setting subsystem.

The system has been deployed in divisions of the Oktyabskaya Railway (Saint Petersburg – Buslovskaya, Saint Petersburg – Nevel, Saint Petersburg – Moscow) and is undergoing trial operation in the Vikhorevsky and Northern Baikal regions of the East Siberian Railway.

This ISUZHT subproject was also chosen for the automation of traffic management of the Moscow Central Circle.

Traction Resources Management

Subproject Traction Resources Management aims to ensure optimized and paced handling of traffic flow from departure station to destination station per current train paths and with timely provision of traction resources (locomotives and crews).

The subproject solves the following tasks:
• standardization, planning and supervision of operated locomotive fleet required for filed estimated daily traffic size per assigned locomotive operation areas put into permanent operation in the Eastern operating domain,
• adjustment, planning and supervision of locomotive balance within the boundaries of operating domains and at division points,
• automatic distribution of locomotives and crews. In trial operation in the Eastern operating domain,
• planning and supervision of shift-day/multiday size and current facility-level/number-specific distribution of locomotives and crews per trains and paths of alternative schedule.

Development Outlooks

The implementation of ISUZHT will allow optimizing freight traffic, reducing costs, creating redundant infrastructure capacity, ensuring freight delivery within guaranteed and scheduled time limits for high quality of customer service of the Russian railway industry.

The project execution plan envisages gradual implementation of process and information-based integration of task complexes for automatic scheduling, scheduled train handling, traction resources management and many more tasks in the primary freight corridors: Kuzbass – East, Kuzbass – North, Kuzbass – West, Kuzbass – South. It will ensure train flow handover between traffic control territories in accordance with the schedule agreed in terms of traction resources management while observing all operational restrictions and safety requirements.

Additionally, automatic planning and supervision by computer enables the implementation of commercial logistic products supported by higher adaptivity and objectivity of decision-making by the system.

Significant reduction of the human factor will allow merging a whole range of control facilities and achieve a major optimization of business processes. That will support the improvement of JSC RZD’s market-oriented management structures.

By 2018, ISUZHT should become fully operational on most railways of the national network.
For the past few decades, MCC (formerly known as the Small Ring Line of the Moscow Railway) has been used to deliver raw materials and ship finished goods from Moscow’s industrial enterprises. The city’s worsening transportation difficulties have on numerous occasions raised the issue of using the Small Ring for passenger traffic. In 2012, the Government of Moscow and JSC RZD took the common decision to overhaul the Small Ring Line of the Moscow Railway.

The Institute proposed to use the Small Ring Line of the Moscow Railway as a deployment site for integrated systems able to increase traffic safety and infrastructure capacity. A range of innovative infrastructure management technologies enabled short-headway traffic with guaranteed safety and higher passenger comfort.

The requirement of reduced train spacing limits the applicability of conventional technical solutions. Due to the large number of stations and short open lines, when using conventional technology the most significant time losses occur during in-station operations.

In order to ensure mixed passenger/freight traffic at the MCC, for the first time in the world practice a combined system of train separation with moving block sections is being implemented based on audio frequency track circuit block system and computer-based onboard devices. The system can operate in two modes, signal-based for freight operations with trains of specified mass and length and signal-free for speeded passenger traffic with headway as low as 3 minutes. According to leading foreign experts, the system and its components have a high export potential.

For the first time in world practice cyberattack protection facilities have been developed in order to improve the cybersecurity of the computer-based interlocking systems.

Further functional evolution of the train separation system that is being implemented on the MCC with regard to station-based devices control in the Autodispatcher mode and rolling stock control in the Autodriver mode will eventually enable fully automatic traffic management with safe remote monitoring in driverless mode.

In order to ensure continuous monitoring and automatic diagnostics of the MCC infrastructure condition, including ultrasonic rail flaw detection, without additional burden to the transportation process, activities are now underway to outfit the Lastochka EMUs with information and measurement systems.

Those systems would for the first time be used to improve the process of diagnostics by eliminating the application of conventional mobile laboratories (flaw detection, track recording, catenary testing car).

ISUZHT has been chosen as the integration platform for on-line monitoring and centralized traffic control on the MCC. It is designed to ensure automation of decisions and actions of traffic controllers through automatic real-time generation of train handling plans. The technology that allows communicating with the ES2-G Lastochka EMUs enables train handling plans to take into consideration the location and condition of rolling stock, transmission of timetables, warnings, dispatchers’ messages and orders to onboard systems. The train handling plans are also transmitted to stations for automatic route setting, as well as to passenger information displays.

The advanced technologies implemented as part of the overhauled Moscow Central Circle of the Moscow Railway are protected with 111 intellectual property items. Individual technical and process engineering solutions have been honored with awards of international exhibitions and included in the list of Russia’s 100 best inventions.
Integrated Traffic Safety System Using Satellite Navigation, Monitoring and Communication

The traffic safety system is based on the analysis of risk factors generated according to operational data on equipment condition and personnel’s operational discipline. The key element of the new traffic safety system is the situation center performing a range of tasks including collection and processing of monitoring data, as well as generation of managerial decisions.

Comprehensive safety requires monitoring of railway infrastructure facilities. The concept of digital coordinate model has been introduced to provide description of facility position and configuration in the given coordinate system. To ensure infrastructure facilities monitoring, a rail-mounted mobile measurement complex has been developed.

Traffic safety largely depends on the systems ensuring condition monitoring of vital components of rolling stock. Vertical dynamic stress monitoring devices and the AMS acoustic monitoring system provide two crucial advantages. They ensure long-term identification of rolling stock parameters variation trends and deliver information as to the fundamental causes rather than consequences or symptoms of defects.

Acoustic monitoring stations allow early identification of all axle-box defects long before failure risk and bearing overheating by means of measurement and analysis of acoustic noise emitted by axle-box bearings.

Growing traffic density, especially EMU operations in major suburban areas, requires shorter train spacing while retaining high standards of safety, which is only possible to achieve by means of communications and coordinate-based traffic control. Among the currently existing equipment the ABTC-M computer-based interlocking and the advanced ABTC-MSh interlocking systems are the most compliant with today’s requirements.

The integrated onboard safety system is the key element of traffic safety facilities. The Vital Integrated Onboard System, or BLOK, has been developed by consolidating the functionalities of the KLUB-U, SAUT and TSKBM systems, as well as the onboard components of the MALS system.

Emergency situation statistics show that as of late failures and malfunctions predominantly arise at stations. That proves that the level of traffic safety delivered by means of conventional technology is still clearly insufficient.

GLONASS/GPS satellite navigation technology is used for coordinate and time support of shunting automated cab signalling systems (MALS/GALS) and automatic positioning of shunting engines. Those technologies allow creating accurate models of shunting yard track arrangement required for efficient automatic control of shunting operations.

Satellite technology ensures quality control of key processes and increased information accuracy.

Safe train operation requires the availability of alternative radio train communication channels to ensure highly reliable railway traffic control architecture. Satellite communication with vehicles (locomotives) and railway personnel provides ample opportunities of control systems development. Mobile satellite communication enables voice communication, text messages and audio/video information transmission, positioning of moving vehicles.

The Institute is currently actively involved in the development of next-generation train separation systems able to radically improve traffic quality by reducing train spacing and allowing higher traffic speed. As its elements the system includes onboard (KLUB-U, BLOK) and trackside (ABTC-M, ABTC-MSh) safety systems developed by the Institute. The key distinctive features of those systems are the application of the moving block concept and the use of digital radio as the back-up vital information communication channel.

Innovative technology and new methods of traffic management ensure a high level of traffic safety.
The Integration Complex of Situation Center Process Automation Systems (ICOSCPAS) developed by JSC NIIAS automates the Situation Center duty shift and analysis units activities aimed at the prevention and recovery from incidents, events and emergences.

The tasks of the Situation Center include:

- preparation and performance of safety monitoring of railway infrastructure and rolling stock in operation,
- forecasting the risk level of traffic incidents and other events, development of measures to reduce the impact of destabilizing factors on the transportation process,
- ensuring stable operation of the quick response system in case of traffic incidents and other events,
- timely provision of information to JSC RZD management as regards to traffic, operations, transportation and fire safety at JSC RZD infrastructure facilities,
- provision of information as regards to natural conditions at Russian railway system’s facilities based on data collected by weather and gauging stations, identification of conditions that might affect traffic safety.
The deployment of satellite technologies is one of the key elements of the adopted Comprehensive Program of JSC RZD Innovative Development for the Period up to 2020. In respect to Russia’s railways operational requirements the following main aspects have been identified:

• centralized control and safety of traffic, maintenance vehicles, diagnostics equipment, fire and wreck trains,
• traffic management in open lines and stations including monitoring of hazardous and special freight,
• monitoring of track and other facilities condition and maintenance, including technologies for satellite observation, geodetic support of survey, design, construction and maintenance.

Since 2007, JSC NIIAS has been JSC RZD’s designated lead organization responsible for the deployment of satellite technologies, including satellite navigation, communication and Earth remote sensing (ERS).

The currently available information communication infrastructure enables GLONASS/GPS monitoring of rolling stock, including dangerous goods.

Mass deployment of GLONASS receivers is currently underway as part of integrated onboard safety systems (KLUB, BLOK, etc.), as well as on EMUs (including commuter trains) and special self-propelled rolling stock. 689 commuter and other passenger trains and all the Sapsan high-speed trains have been equipped (i.e. over 50 percent of vehicles to be fitted with appropriate systems). The system allows monitoring the position and movement parameters of passenger trains throughout the network from the Baltic Sea to the Atlantic coast with the capability to transmit the data to traffic management facilities and the JSC RZD Situation Center.

One of the innovative applications of GLONASS is the development of high-precision coordinate systems (HPCS), the crucial component of the infrastructure maintenance management system, condition monitoring data referencing, maintenance vehicles operation management and, eventually, transition from routine to condition-based maintenance.

A pilot project yet unheard of in Russian railway history has been completed with the deployment of the 800-kilometer Moscow – Saint-Petersburg – Buslovskaya high-speed line.

Taking into consideration the experience gained so far by JSC RZD, the following strategic short and mid-term GLONASS applications were identified:

• development of the single high-accuracy coordinate-time space of the whole railway network using ground-based high-accuracy GLONASS augmentation stations,
• development of integrated intelligent train control and protection systems, as well as station, traffic and logistical operations management systems for major traffic centers,
• development of an integrated spatial data system of railway infrastructure to ensure infrastructure management at all life cycle stages, including research, design, construction and maintenance of tracks and other facilities in order to achieve design-based maintenance and enable transition to condition-based maintenance.

Satellite Technologies
The Institute is researching ways to deploy satellite ERS technologies for efficient operation of a distributed railway infrastructure system at various lifecycle stages. The following aspects are being examined:

- front-end engineering and design (selection of rational locations of designed railway infrastructure facilities, engineering protection solutions),
- construction progress supervision (including the evaluation of environmental impact),
- ensuring faultless service with a specified level of safety (monitoring potentially hazardous natural and anthropogenic effects on infrastructure facilities, rational allocation of funds to protective measures),
- ensuring the safety of anthropogenic processes, resource saving (development of special maps and digital track and station track arrangement models for rational management of shunting and special self-propelled rolling stock operations),
- supervision of unauthorized use of right-of-way and protected zones (identification of unauthorized crossings, construction or business activities, protective structures integrity control),
- ensuring situational awareness in emergency situations (for real-time recovery management, evaluation of the scope of damage, management of remedial activities and minimization of the environmental impact),
- supervision of the impact of railway infrastructure facilities on the environment.

A number of major projects have been carried out that involved using satellite observation data in process operations of railway infrastructure management using the GBD ZUON, GIS RZD, KSPD IZHT and RZD Geoportal systems. Jointly with Roscosmos-related organizations (JSC Russian Space Systems), activities are underway to develop process engineering solutions that would allow using Russian satellite ERS data.

**Integrated Railway Infrastructure Spatial Data System (KSPD IZHT)**

KSPD IZHT is an information technology system intended for collection, processing, storage and provision to registered users of coordinate information on railway infrastructure facilities and vehicles. The KSPD IZHT system includes a high-precision coordinate system (HPCS) and a database of spatial information in the form of digital track models.

The main purpose of the HPCS is to create a single high-precision coordinate space that will be implemented on the basis of the GLONASS/GPS global satellite navigation systems and their augmentations, geodetic support of all types of engineering survey conducted as part of design activities, construction and operation of railways, as well as field location of new lines.

The digital track model is a mathematical description of geometrical characteristics and spatial position of track and railway infrastructure facilities that form the basis of the method.

The key features of the technology package ensuring track maintenance and overhauling are as follows:

- survey and design are carried out in a single coordinate space based on GLONASS/GPS data gathered using high-accuracy differential augmentation and geodetic control network with delivery of final materials in coordinate form,
- KSPD IZHT-based design takes into consideration factors that are otherwise problematic or neglected,
- design data for specific activities are prepared in coordinate form and are used in the digital track model generation,
- ballast cleaning and leveling and tamping machines equipped with satellite navigation systems and special software for onboard control devices operate in automatic mode as per design-based job program,
- preliminary high-accuracy measurements and calculations are performed at each operation in the track maintenance and overhaul process,
- acceptance of the deliverables of maintenance and overhaul activities and commissioning of tracks is made based on objective measurements of track geometry and comparison with design values.
Economic benefits are ensured by:
- availability of trial design and capability to choose the optimal solution for track maintenance and overhaul based on specified technical parameters and economic criteria taking into consideration the maximum possible number of factors affecting the adoption of the design concept,
- efficient track maintenance and overhaul project implementation supervision through a significantly improved performance of precision track geometry measurements at all stages of the process: track-laying, deep cleaning of ballast, insurance of higher allowed speed for compliance with the respective requirements,
- lower cost of heavy leveling and tamping machines operation through efficient control of attained target technical parameters,
- lower cost of survey and development of subsequent projects and performance of track maintenance and overhaul.

The Institute’s experts are developing a technology that would apply KSPD IZHT functions, e.g. coordinate-based methods, in the performance of track repair activities at railway infrastructure facilities, i.e. location survey, coordinate support of track laying, ballast cleaning, track alignment as per design by VPO and Duomatic machines, track as-built survey.

Since 2008, JSC NIIAS has been involved in the development and deployment of solutions that support the coordinate-based methods of design, construction, repair (reconstruction) and maintenance of railway track. As part of research, development and investment projects, as well as at its own initiative and its own cost the Institute has developed and is further improving the following competences:
- Expert evaluation of track geometry design for track alignment and tamping using coordinates-based methods.
- Geodetic survey for design, construction, repair (modernization) of track. Construction and application of high-accuracy coordinate systems.
- Equipment of track maintenance machinery to enable alignment and tamping according to coordinate-based methods. Ensuring required accuracy.
- Geodetic support of the track repair (modernization) process. Setup of jobs for track maintenance machines using coordinates-based methods. Verification of project implementation accuracy.

The developed methods, working regulations, process charts and technical solutions have been effectively in use since 2013 at reconstruction sites of the Moscow – Saint Petersburg line.
As part of the Resource-Saving Technologies for Railway Transportation investment project, JSC NIIAS is actively involved in the resource-saving program. As per Order No. 44r dated January 15, 2010 On the Organization of Activities Related to LED Technology Application, the Institute was assigned the leading role in the research and development activities aimed at LED technology application in JSC RZD.

The following four activities are currently underway:
- LED lighting in rolling stock,
- LED lighting in JSC RZD infrastructure facilities,
- low-maintenance LED signals,
- optical communication channels based on IR LED technology.

JSC NIIAS experts are carrying out the following activities:
- supervision of LED signals manufacturing procedure,
- supervision of LED signals installation procedure,
- expert assessment of LED signals acceptance procedure.

JSC NIIAS is also supervising the LED systems deployment at JSC RZD infrastructure facilities. The Institute’s experts evaluate lighting equipment, LED lights and working lighting designs.
Management of Resources, Risks and Dependability of Railway Facilities at Lifecycle Stages (URRAN)

Ensuring faultless operation of the railway network involves significant material expenditures due to the requirements to ensure traffic safety and dependability of infrastructure facilities and rolling stock. When resources are in limited supply, justified managerial decisions require the availability of a system for integrated highly automated management of railway facilities maintenance.

The Strategy of JSC RZD Technical Development for the Period up to 2020 (JSC RZD White Paper) defines the primary areas of the company’s innovative development. One of the objectives involves ensuring reliability, availability, maintainability and safety of railway facilities and systems. Accordingly, in 2010 the URRAN project was started. As of today, URRAN is the body of standards and procedures, as well as software and hardware facilities intended for integrated management of resources and processes for efficient delivery of railway transportation services in a resource-constrained environment.

The purpose of the URRAN system development is the implementation of adaptive management of facilities based on the criteria of dependability, safety and economic efficiency at lifecycle stages using a risk-based approach.

The operation of URRAN is to cover facilities and systems of railway transportation and the business processes they implement.

URRAN is based on the European methodology of RAMS. Yet beside the RAMS parameters related to reliability, availability, maintainability and safety, URRAN deals with the longevity, safety of business processes (occupational safety hazards), environmental impact (environmental risks) and economic performance.

Thus, URRAN is a methodology that implements a holistic approach to enterprise asset management in accordance with ISO 55000:2014.

In URRAN, dependability, safety, economic efficiency and risk management is carried out in terms of specific qualitative and quantitative indicators for each type of facility or process. A set of criteria has been developed and is being applied for extension of specified lifetime of technical facilities.

The approaches adopted by URRAN provide for:
- real-time estimation of dependability and safety indicators of facilities,
- evaluation of deterioration, remaining lifetime and limit state of facilities,
- risk management,
- evaluation of lifecycle cost of facilities,
- evaluation of JSC RZD business units performance subject to the results of activities aimed at ensuring dependability and safety of operated facilities,
- asset management with increasing efficiency of allocation of facilities maintenance funds,
- planning of activities based on economically substantiated requirements for facilities overhaul, modernization and lifetime extension while ensuring full compliance with traffic safety standards,
- ensuring managerial decision support using the URRAN Single Corporate Platform (SCP).

As part of the URRAN project more than 120 regulatory and guidance documents have been developed, i.e. international standards (GOST), national standards (GOST R), JSC RZD corporate standards and techniques. Those documents have been tested at trial sites.

The experience of URRAN deployment demonstrates the applicability of the developed approaches and criteria in ensuring reliable operation of infrastructure, extension of expected life of facilities before overhaul and investment planning.

The URRAN SCP automated system that is being deployed as part of the project aims to provide support for decision-making with regards to infrastructure facilities maintenance and is based on collection and classification of initial indicators used in existing industry-specific ACSs and calculation of required indicators according to the URRAN methodology.
High-Speed Traffic

High-Speed Traffic Management System

The deployment of a high-speed rail network is one of the Government's priority tasks of nationwide scale. The design of the traffic management system is based on the principle of multilevel control.

The upper control level ensures the analysis of the operational situation and status of infrastructure elements and subsystems throughout the high-speed line.

For the upper control level, the project provides the following functionality:

- assessment of capability to execute planned (target) train schedule (TS),
- suggestion of recommended changes to the alternative TSs,
- evaluation of possible conflict situations throughout an operational area depending on periods of journeys, stops, presence of planned and incidental infrastructure-specific restrictions, dynamic changes of situation at stations and connection hubs.

This hardware and software system is used for reference purposes and operates in the «advisor» mode.

For the upper control level, the project provides information management subsystems performing the Autodispatcher and Automated Train Traffic Management System (ASU-D) functions.

The Autodispatcher subsystem operates within the line-level control area (open lines and intermediate stations) that uses the acquired information to transmit control and command input to the CTC devices of the signalling subsystem to set routes and initiate interlocking and train separation operating modes, ensures safety «green wave», transmits orders to onboard train protection and automatic operation systems.

The ASU-D subsystem operates in the vicinity of large cities in mixed commuter traffic areas with reduced headway operation and optimized high-speed train schedule.

The upper control level is implemented by the Traffic Management Center and operationally coordinated with the Situation Center and the Infrastructure Monitoring Center.

Main Design Principles of High-Speed Line Automation and Remote Control (ARC) Systems

The design of high-speed line ARC systems is based on Russian systems and advanced foreign technology adapted to the Russian industry requirements using wireless access and satellite navigation.

High-speed line ARC systems include the following key components to ensure train traffic safety:

- train separation system that includes the automatic continuous multi-aspect cab signalling subsystem and the radio block subsystem using a digital radio channel and satellite navigation,
- in-station switches and signals control system (electric interlocking),
- centralized traffic control system,
- ARC devices diagnostics and status monitoring system.

All ARC systems are integrated into a single complex that interacts with onboard devices of the high-speed train via data communication channels including digital radio, as well as track data channels between ARC devices and onboard train control and protection equipment.
**Integrated Train Traffic Safety System**

### Vital Integrated Onboard System (BLOK)

For the purpose of increasing the efficiency of train protection devices and constructing an integrated rail traffic safety system, the Institute has performed a series of activities aimed at merging the existing individual onboard safety facilities KLUB, SAUT and TSKBM into a single Vital Integrated Onboard System, BLOK, that has incorporated the signalling, driver vigilance control and braking functions.

The BLOK system consists of self-contained modules providing functionality to the system and a device that ensures interaction with other systems involved in the overall train control process.

BLOK ensures train protection including when the train is operated by a single driver.

BLOK interfaces with automatic operation and diagnostics subsystems that are deployed only on new trainsets.

Trial operation of the BLOK system has allowed train crews assessing its performance, convenience and advantages over the legacy safety devices.

In the system, the vital information (cab signalling, movement authority) is reproduced on assistant driver’s display unit. Information on the trip is recorded on the common memory cartridge in a specialized unit. BLOK has a Russian-made open interface to the automatic operation system and diagnostics devices.

For the first time, the BLOK system design implements the principle of integration of functional elements with concentration of intelligent computer components within a single chassis.

During the design stage, a great deal of attention was given to perfecting the intelligent aspects of the algorithms involved in solving particular tasks. The Institute’s experts continue this activity by developing more elaborate algorithms that significantly increase the quality and quantity of functions that make use of intelligent methods.

### SUD-U Hardware and Software System for Trip Data Decryption

The Institute has developed and continues improving the hardware and software system for trip data decryption (SUD-U) that represents an integral part of the KLUB and BLOK intelligent safety systems. The current version of SUD-U can decrypt not only KLUB and BLOK trip data, but also information recorded by SAUT devices.

The SUD-U hardware and software system performs the following functions:

- data viewing for all BLOK subsystems,
- extended range of automatically analyzed situations related to driving process violations and onboard equipment malfunctions,
- in-motion brake test verification,
- SUD-U has been divided into the front end and the server end which allowed distributing the tasks of memory cartridge reading, data decryption and subsequent information storage over a number of different workstations,
- the new version of SUD-U was designed according to the modular principle which simplified software up-
dates, improved SUD-U functionality and provided for processing data generated by new systems,

- centralized storage of electronic map objects.

Further development of the SUD-U hardware and software system aimed to strengthen the intellectual functionality will take the following directions:

- automation of data decryption with minimum human involvement: selection of initial movement parameters, selection of route (this functionality undergoes in-house testing),
- expansion of the list of identifiable train operation disturbances,
- deployment of the single electronic map database (under in-house testing).

**Automatic Block System with Centralized Equipment Location, Audio Frequency Track Circuits and Back-Up Data Communication Channels (ABTC-MSh)**

ABTC-M is intended for train separation in open lines with freight, passenger and high-speed traffic. It is deployed on open lines with any type of traction and enables primary equipment location at stations adjacent to the open line.

ABTC-M performs the following functions:

- Improved reliability of train separation and traffic safety due to:
  - redundant primary system components,
  - more reliable hardware components,
  - use of additional track circuit signals coding,
  - use of the logic of train movement over the open line’s track circuits,
  - use of additional means of tracking trains on open lines,
  - ability of station operators to control trackside devices of open lines.

- Improved availability (robustness) of the train separation system due to:
  - use of redundant data channels to and from the locomotive,
  - capability to reconfigure the system in case of individual components failure,
  - redundant power supply system.

- Reduced capital and operational costs due to:
  - use of a limited number of standardized units with plug-and-socket connectors,
  - triple reduction of units dimensions,
  - reduction of signal cable use by 30-50%,
  - automated system parameters measurement and digital logging at the signalling and communications duty engineer’s workstation,
  - use of automated system condition verification equipment in maintenance facilities and service centers.

**MALS/GALS-R Shunting and/or Hump Yard Automatic Cab Signalling System**

The MALS/GALS-R system is designed to increase traffic safety in stations by preventing SPADs (namely during shunting operations), protecting station personnel, ensuring regular station operation rate, controlling shunting movements, ensuring optimal shunting engines utilization, providing an information management infrastructure for optimized station operation control.
The system ensures forced locomotive stop in case of spontaneous change of signal aspect, signalling devices failures, loss of radio communication, movement without authorization from the control system, by station operator’s remote order.

The system ensures:
- regular operating speed of shunting engines and shunting consists,
- timely stop of shunting engines or shunting consists before restrictive signals, buffer stops, work areas,
- engines speed limit supervision,
- engines and wagons in-station movement supervision,
- shunting consists length measurement,
- identification of the length of engines and shunting consists in stations accurate within 1 m using digital track layout model and satellite navigation receivers,
- interlocking devices behavior and engines speed recording,
- station operator and engine crew behavior supervision according to the station’s technical executive orders,
- preparation of information sheets on locomotives operation over a reference period.

In order to improve in-station operations safety, GPS/GLONASS satellite navigation facilities are deployed to provide coordinate and time support of the MALS/GALS-R systems and automatic positioning of shunting engines.

The satellite navigation component of the system and the digital station track arrangement model under development allow monitoring the location and orientation of engines irrespective of the interlocking devices which enables supervision and performance of shunting operations in sidings and parts of stations not equipped with interlocking devices.

**Innovative Integrated Station Operation Automation System (ITAUR)**

The ITAUR system is designed to organize the new operational procedure for station and shunting dispatcher eliminating manual train graphs and multiscreen display of current traffic situation with locations of trains, locomotives, cars, as well as start/end time of process operations and real-time indication of requirements/norms violations.

ITAUR performs the following functions:
- generation of an information model reflecting actual business processes of station operation,
- development of new CTC technologies based on the information model to ensure reduced wagon downtime, increased shunting engine performance, as well as coordination between in-station and open line operations,
- generation of a database for real-time, periodic and targeted performance analysis for the purpose of ongoing improvement of standard operational procedures and competent station infrastructure development decision-making; increased efficiency and completeness of daily station operation data, as well as the information supplied to the System for Reporting and Analysis of Process Violations (KASAT),
- establishment of an objective basis for distribution of responsibility for operational performance among personnel of various administrative structures involved in the traffic management process.

The system’s efficiency is ensured by:
- reduced operational costs,
- increased capacity and throughput of stations,
- higher overall operational efficiency.
The Institute’s priorities in the development and implementation of information society technologies are:

- migration to paper-free traffic management technology using electronic signature (ES),
- JSC RZD costs reduction through optimization of business processes and operations, identification of reserves and reduction of nonmanufacturing or inefficient expenditures,
- significant improvement of provided services.

The key element of successful achievement of the set goals is the certification authority established within the Institute (JSC NIIAS CA).

The JSC NIIAS CA is a crucial component of relevant-in-law electronic document communication between JSC RZD, customers and contractors using the following information systems employed by JSC RZD:

- AS ETRAN (execution of carriage documents),
- JSC RZD digital procurement platform,
- corporate relevant-in-law electronic document management system of JSC RZD subsidiaries, such as JSC Freight One, JSC Federal Freight, etc.

The CA currently serves over 30,000 companies and organizations. The ES technology and JSC NIIAS CA services ensure:

- booking of more than 90% of all transported freight,
- bills of lading for more than 65% of all empty wagons,
- bills of lading for more than 40% of all transported freight.

The electronic signature technology ensures information security of the ISUZHT system as part of its respective subsystem that is responsible for the integrity, reliability, non-repudiation and relevance-in-law of electronic messages exchanged within ISUZHT itself and in communication with other information systems operated by JSC RZD.

The Institute is developing information protection facilities that are being integrated into automated railway traffic management systems.

The CA continuously incorporates innovative technologies ensuring new client services, including:

- services of the trusted Operator of Electronic Invoice Management of the Federal Tax Service of the Russian Federation that ensure exchange of tax information and accounting records (invoices and other primary documents) in electronic form via telecommunication channels between JSC RZD, its customers and contractors and tax authorities,
- services of trusted third party for transboundary relevant-in-law electronic document management in international and transit traffic among member nations of the Organization for Cooperation of Railways,
- application of cloud technologies of electronic signature that simplify its use by small and medium consignors.
The Saint Petersburg Branch of JSC NIIAS specializes in the development and deployment of innovative methods and facilities for technical diagnostics of rolling stock, software and integrated analytical automated system, as well as post-warranty maintenance (support) of deployed products and software.

From 2011 to 2013 the Branch has developed and deployed a series of navigation and communication modules. The device was fitted on 1300 track maintenance machines, 250 wreck trains and 300 fire trains. The device enables rolling stock positioning using GLONASS satellite signals.

The major systems developed by the Saint Petersburg Branch are the Acoustic Monitoring Station (PAK), Integrated Monitoring Station (PKK), IK-PK ACS pick-up coils parameters checkout system, SPUTNIK autonomous diagnostics system, IP-ZU navigation and communication unit power source/recharger and automated system of the car fleet diagnostics center (AS DC).

Rolling Stock Technical Diagnostics Facilities

- The fixed PAK and PKK stations enable early diagnostics and flaw detection of axle box bearings, as well as in-motion flaw detection of freight cars’ wheel treads. 15 PAK systems and one PKK system have been deployed in Russia’s railway system. Their efficiency was confirmed by comparative tests conducted in 2015 at the VNIIZHT experimental circle line.
- The SPUTNIK autonomous diagnostics system (JSC NIIAS investment project) ensures continuous remote monitoring of rolling stock, including positioning accurate within several meters, real-time communication of over 40 vehicle parameters to a remote server. The operational self-sufficiency of the system is ensured by internal low-speed generator and battery. The system includes a self-diagnostics facility. The modified trial system SPUTNIK-B (an Internet of Things system) has been developed and is successfully undergoing tests. It is adapted to work with freight cars, special rolling stock and track maintenance machines.
- IK-PK is a measurement system for express monitoring and evaluation of primary parameters of KP and KPU-1 type ACS puck-up coils of the Sapsan high-speed trains. It ensures a significant reduction of the labor input associated with the process of measurement, as well as expands the functionality compared to the existing facilities. A trial prototype of the IK-PK system has been developed and successfully tested.

Software products

The experts of the Branch have developed the AS DC automated system of the car fleet diagnostics center (a three-level software system). The system ensures collection, analysis and visualization of the information received from trackside and onboard rolling stock (freight cars) diagnostics facilities. When deployed, AS DC can enable timely detection of critical states and prevention of hazardous incidents, generation of reports on diagnostics devices operation, warning of critical events via mobile application and e-mail.
JSC RZD Classification Yards Development Program and Location Plan imply a comprehensive approach to the improvement of classification operations to enhance capacity and throughput in strategically important heavy-traffic areas for the period up to 2025. The integrated classification process automation system developed by the Institute and extensively deployed throughout the network is to guarantee the successful achievement of the set goals.

The experts of the JSC NIIAS Rostov Branch perform a full cycle of activities from design, development and adaptation of software to commissioning and supervision of operation of integrated classification station automation systems.

Since 2003, the Branch has been deploying the enhanced hump process control system as part of the KSAU SP integrated classification process automation system. As of today, the enhanced hump process control systems are installed at 19 hump yards of Russia’s railway system. The system is being deployed in various climate zones, at hump yards of various layouts and throughputs, including those with parallel humping operation, equipped with various types of retarders and other facilities.

KSAU SP ensures complete automation and safety of key train-splitting operations at humps: preparation and automatic setting of routes with guaranteed prevention of switch throwing under moving cars, automatic spacing and target braking with control of classification track utilization, automatic tracking of shunting movements and prevention of forced switch opening.

Currently in Russia, KSAU SP is the only certified, mass-deployed domestically designed classification process automation system that beside its primary functions, i.e. operational personnel workload reduction, enhancement of station throughput and classification process safety, enables the performance of a number of other tasks, i.e. trackside and tower-based equipment diagnostics, condition-based hump devices maintenance, operational and maintenance personnel decision support, etc.

KSAU SP is modular and comprises subsystems for managing humping and classification, routes, rolling-down speed, automation of compressor stations, as well as diagnostic subsystems. The modularity of KSAU SP allows determining the optimal solutions for specific classification humps at the design stage. Additionally, in situations when investment funds are limited, this property of the system allows performing hump overhauls incrementally with the capability to further enhance the automation system functionality.

Certified hump process control systems developed by the Rostov Branch have been approved and recommended for mass deployment based on the results of operation at the dedicated trial sites, the Bekasovo Sortirovchnoie station of the Moscow Railway and the Krasnoyarsk Vostochny station of the Krasnoyarsk Railway.

The modularity, multifunctionality, adaptability and optimal price performance ratio of the KSAU SP system combined with innovative trackside equipment allowed JSC NIIAS winning the 2014 tender announced by the Ulaanbaatar Railway for the performance of activities per the Program of Technical Modernization of the Ulaanbaatar Railway that provides for the construction of a classification hump at the Zamyn-Üüd station and its equipment with interlocking, as well as classification process mechanization and automation devices.
As per JSC RZD Order No. 1355r, the permanent Coordination Council for Engineering Policy of Mechanization and Automation of Classification Station Processes has been established. Mr. Alexander Shabelnikov, director of the JSD NIIAS Rostov Branch, was appointed Deputy Chairman of the Coordination Council. In March 2009 he was also appointed chief engineer of station processes automation systems. Under the direction of the Council and the Institute, jointly with equipment manufacturers and with the approval of JSC RZD Central Traffic Management Directorate, Automation and Remote Control Department and its Research and Development Bureau, a number of new computer-based classification process automation devices has been developed and put into production. Among those are the UFPO-21 axle detector, the system of logical protection against hump switches throwing under moving cars (LZS), the equipment for supervision of classification track filling based on the pulse sensing principle (KZP IZD). A number of retarder designs and associated control equipment that are fully compliant with the requirements of automated humping operation management and ensure a significant reduction of operating costs has been put into production.

The Rostov Branch experts in cooperation with the Russian division of FESTO have developed and put into production innovative equipment for valve control for any type of pneumatic retarders. The Branch has also developed unique control equipment software that can be installed on computer-based control units regardless of the manufacturer. The software is copyrighted and in high demand among the retarder and control equipment manufacturers in Russia and abroad.

KSAU SP undergoes continual improvements. At the automated classification hump at the Krasnoyarsk Vostochny station of the Krasnoyarsk Railway the technology has been developed for automatic classification by a single operator under KSAU SP control. Currently, the smart unmanned classification hump is under development.

The deployment of KSAU SP in Russian and foreign railway systems ensures a significant increase in efficiency, dependability and safety of classification station operation.
The key areas of JSC NIIAS’ international activities include: representation in international industry organizations, coordination of international research and regulatory activities, certification and standardization, development of innovative technologies in cooperation with foreign partners, as well as execution of projects abroad.

As the leading industry institution in a number of areas of applied research, JSC NIIAS studies and adopts advanced global experience and know-how to the benefit of the Russian railway industry. A particular emphasis is given to the adaptation of foreign solutions to JSC RZD’s technical, operational and regulatory requirements.

JSC NIIAS is an affiliated member of the International Union of Railways (UIC). The Institute is actively involved in the activities of the Security platform, as well as research projects dedicated to cybersecurity and control systems implemented under the guidance of the UIC. The Institute is a permanent member of the UIC Asset Management Working Group that is involved in the development of guidelines for the management of resources, risks and cost of railway facilities (including such fundamental document as the Guidelines for railway application of the ISO 55000 standard).

The Institute's experts are members of working groups of the Organization for Cooperation between Railways (OSJD). Thus, as part of the OSJD Permanent Working Group on Coding and Information, JSC NIIAS experts take part in the development of single technical specifications and interfacing protocols for the use of electronic signature in ensuring relevant-in-law information traffic between railway administrations of OSJD member nations.

As part of international partnership initiatives, the Institute actively interacts with European research and education organizations. Cooperation agreements have been concluded with the universities of Pardubice and Ostrava (Czech Republic), Žilina (Slovakia), Budva (Montenegro), etc. Scientific contacts are maintained with the Swiss Federal Institute of Technology in Zurich, Vienna Institute for Safety and Systems Engineering, University of Belgrade, Polish Academy of Sciences, etc.

JSC NIIAS publishes the Dependability bilingual specialized journal included in international citation systems that publishes articles by international experts in the matters of dependability and covers the issues of development and deployment of the methodology for resources, risks and dependability management (URRAN). Papers by the Institute's experts regularly appear in foreign scientific publications. Over the last three years 30 articles on URRAN have appeared in a number of specialized foreign publications of Austria, Germany, Romania, Slovakia, USA, Switzerland, Czech Republic, etc.

JSC NIIAS maintains ongoing cooperation with the world’s leading railway technology suppliers with the goal of introducing advanced technical solutions to the Russian railway system.

Jointly with Ansaldo STS, the Institute has developed and deployed for trial operation on the Khosta – Mat-
sesta line of the North Caucasus Railway the innovative ITARUS-ATC train control and protection system based on satellite navigation, that was duly appreciated by UIC experts.

In cooperation with e-GEOS (a Telespazio subsidiary company) JSC NIIAS has developed a technology for COSMO-SkyMed SAR monitoring of potentially hazardous railway lines exposed to adverse natural and anthropogenic effects. The technology has been put into operation over the Tuapse – Adler line of the North Caucasus Railway.

The Institute actively cooperates with other leading foreign operators of space-based acquisition systems including Airbus DS (operator of the SPOT, Pleiades and Terra-SAR satellite constellations).

For several years, JSC NIIAS has also been developing cooperation in several areas with Siemens. The Sapsan high-speed trains are equipped with KLUB-U train protection systems, BLOK onboard systems are deployed on the Lastochka EMUs.

Joint activities with Siemens are performed on the comprehensive project of automation of the Luzhskaya classification station of the Oktyabrskaia Railway. A whole range of unique Russian solutions has been implemented, including the MALU shunting automatic cab signalling system that enables shunting engines operation in the Autodispatcher mode (driverless).

Jointly with Bombardier Transportation (Signal), an advanced control technology has been developed that is based on dynamic signal-free train separation in the Moscow Central Circle.

As part of the Moscow – Kazan high-speed line project, the Institute’s experts cooperate with representatives of Chinese engineering organizations.

In September 2016, at InnoTrans, the largest international railway industry forum in Berlin, JSC NIIAS has concluded cooperation agreements with a number of foreign companies, such as Schweizer Electronic and SAT4M2M of Switzerland, Eureka Navigation Solutions of Germany, ISKRATEL of Slovenia, CKD of the Czech Republic.

The Institute’s designs are being deployed in railway system of the CIS countries and the Baltics, where its onboard train protection devices, automatic block and other automated traffic control systems are in steadily high demand.

In the nearest future, JSC NIIAS through its Rostov branch will deploy the Integrated System for Automated Shunting Operations (KSAU SP) at the Zamyn-Üüd station of the Ulaanbaatar Railway (Mongolia).

In September, 2016 JSC NIIAS signed an agreement with the Serbian Railways for the development of the Single Railway Transportation Management Center in Belgrade. The agreement was concluded as the result of a competitive tender involving a number of European companies. The success of JSC NIIAS was made possible due to not only the competitive pricing proposal, but also the high quality of its engineering solution.
**JSC NIIAS** has received a number of international and Russian awards

**2014**

Archimedes 2014, Moscow International Salon of Inventions and Innovation Technologies:
- Gold medal, Train Control and Driver Vigilance Supervision System (patent RF No. 2499713),
- Gold medal, Wireless Operational Information Recording and Storage Device (patent RF No. 128748),
- Silver medal, Wagon Inspection Device (patent RF No. 2487034),
- Silver medal, System for Display of Information on the Line Section Ahead and its Transmission to the Locomotive (patent RF No. 133077).

International Exhibition of Inventions in Geneva:
- Silver medal, Train Control and Driver Vigilance Supervision System (patent RF No. 2499713),
- Silver medal, Wagon Inspection Device (patent RF No. 2487034).

World Exhibition of Inventions, Research and Technologies Brussels Innova 2014:
- Gold medal, Switch Clearing Device (patent RF No. 2517202),
- Silver medal, Device for Switch Clearing from Snow and Ice (patent RF No. 2517204).

**2015**

Archimedes 2015, Moscow International Salon of Inventions and Innovation Technologies:
- Gold medal, Safety Device for Backup Power Supply of Power Interlocking Control Tower (patent RF No. 2498477),
- Gold medal, Traction Engines Route Compliance Control Device (patent RF No. 2546750),
- Gold medal, Track Circuit Shunting Control Device (patent RF No. 2547953),
- Gold medal, Train Traffic Management Procedure Based on Alternative Schedules (patent RF No. 2524505).

International Exhibition of Inventions in Geneva:
- Silver medal, Train Traffic Management Procedure Based on Alternative Schedules (patent RF No. 2524505),
- Bronze medal, Traction Engines Route Compliance Control Device (patent RF No. 2546750).

Rospatent’s 100 Best Inventions of Russia:
- Train Traffic Management Procedure Based on Alternative Schedules (patent RF No. 2524505),
- System for Train Separation in Open Lines (patent RF No. 2513877),
- Switch Clearing Device (patent RF No. 2517202).

World Exhibition of Inventions, Research and Technologies Brussels Innova 2015:
- Gold medal, Centralized Automatic Block System with Jointless Radio-Frequency Track Circuits (patent RF No. 2562027),
- Gold medal, System for Train Separation in Open Lines (patent RF No. 2550795).

**2016**

Archimedes 2016, Moscow International Salon of Inventions and Innovation Technologies:
- Gold medal, System for Controlling Rail Vehicles and Identification of their Position on the Track (patent RF No. 2538498),
- Gold medal, System for Train Separation in Open Lines (patent RF No. 2550377),
- Gold medal, Vehicle for Motorways and Railways (patent RF No. 2551774),
- Gold medal, Method for Controlling Locomotive Movement in Shunting Operations (patent RF No. 2567099),
- Gold medal, Shunting Engine Radio Control System (Eurasian patent No. 021382).

International Exhibition of Inventions in Geneva:
- Silver medal, Method for Controlling Locomotive Movement in Shunting Operations (patent RF No. 2567099),
- Silver medal, System for Train Separation in Open Lines (patent RF No. 2550377).

Rospatent’s 100 Best Inventions of Russia:
- Approaching Train Warning Device for Track Workers (patent RF No. 2571844),
- Centralized Automatic Block System with Jointless Radio-Frequency Track Circuits (patent RF No. 2562027).