Developments in the Scientific and Technical Complex for Transportation Management of the Research and Design Institute for Information Technology, Signaling and Telecommunications on Railway Transport (NIIAS). From automating production processes to making statistics reports.

Efim Rozenberg – first deputy director general of JSC NIIAS
Sergey Filipchenko – director of the scientific and technical complex at NIIAS
Sergey Kalinin – head of the station work technology modeling department at NIIAS
Alexey Ozerov – head of the international cooperation department at NIIAS
# Russian Railways Assets

## Infrastructure

<table>
<thead>
<tr>
<th>Description</th>
<th>Length/Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The operational length</td>
<td>85,513 km</td>
</tr>
<tr>
<td>The length of electrified lines</td>
<td>43,759 km</td>
</tr>
<tr>
<td>The length of tracks</td>
<td>104,563 km</td>
</tr>
<tr>
<td>Number of stations</td>
<td>5,428</td>
</tr>
</tbody>
</table>

## Rolling stock

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight wagons</td>
<td>more than 1,000,000</td>
</tr>
<tr>
<td>Passenger wagons</td>
<td>about 40,000</td>
</tr>
</tbody>
</table>

## Freight

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight transported in 2017</td>
<td>1,261.3 million tons</td>
</tr>
<tr>
<td>Freight turnover in 2017</td>
<td>3,176.2 billion tariff ton·km</td>
</tr>
</tbody>
</table>

## Passenger

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>People transported in 2017</td>
<td>1,118 million</td>
</tr>
<tr>
<td>Passenger turnover in 2017</td>
<td>122.8 billion passenger·km</td>
</tr>
</tbody>
</table>
Currently JSC RZD is using:

✓ Internal statistical reporting forms - 255 pcs;
✓ Primary documentation account forms - 1,079 pcs

For automated generation of 145 internal statistical reporting forms, we use 112 automated primary account forms with application of electronic digital signatures, including:

33 in locomotive complex;
19 in carriage facilities;
11 in track facilities;
35 in electrification facilities;
12 in freight complex;
2 in automation and telemechanics, communication and computing facilities;
### Global Industrial Trends

<table>
<thead>
<tr>
<th>Research and innovative solutions under development</th>
<th>IPID 2020</th>
<th>EU White Paper</th>
<th>Shift2Rail</th>
<th>US FRA Strategic Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased safety based on intelligent systems</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Reduction of risks related to the human factor</td>
<td>☑</td>
<td></td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Increased business efficiency and streamlining of logistics</td>
<td>☑</td>
<td>☑</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Development of multimodal transportation</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Harmonization of service-related requirements. “One stop”</td>
<td>☑</td>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Development of virtual and cloud-based client services</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Computerization and digitalization of traffic management processes</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>High-speed traffic development</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>New rolling stock</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Increased energy efficiency</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>New powerplants. New types of energy resources</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Focus on rational environmental management</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Infrastructure development</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Unmanned technologies</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>
Today’s Challenges. Tomorrow's Opportunities

**Connectivity**
Continuous connectivity will become critical differentiator between travel modes

**IoT – Internet of Things**
Connecting different objects to the internet opens a wide array of possibilities (e.g. sensors)

**Big data**
Big data and analytics capabilities provide different possibilities in both operational and sales aspects

**Digital platforms**
On-going engagement with customers and communities, e.g. through online platforms

**Industry 4.0**
Applying new tech tools to improve productivity

**Autonomous driving**
Autonomous driving trends with potential to change underlying costs structure

**Cyber security**
Mobility, as other industries, becoming a target for cyber attacks
Main Prerequisites of Migration to Digital Railway

- Digital models of infrastructure assets in a common coordinate-temporal space
- Digital communication networks and high-precision coordinate systems based on high-precision satellite positioning networks
- Continuous monitoring of infrastructure assets with automatic generation of speed restrictions and organization of maintenance
- Rolling stock condition monitoring with external and internal facilities with the capability of predicting residual operating life
- Set of computing facilities for remote control of infrastructure assets, real-time modification of traffic schedules with regard to energy efficiency and automation of individual operations
- Mobile facilities of personnel location and psychophysiological state supervision
Digital Ways to Increase Traffic Efficiency

- Digital track models
- Digital communications systems
- Control centers for operations areas
- Onboard computer systems

- High-precision design and maintenance of infrastructure facilities
- Centralized traffic management in large operations areas with transmission of commands to trains
- Capacity modeling and traffic planning allowing for cost reduction
- Improvement of control systems dependability and safety
- Real-time infrastructure monitoring using rolling stock

- Automation of electronic map generation and track maintenance
- Cost reduction and real-time information exchange
- On-schedule power-efficient traffic
- Migration to one-man crew operation
- Reduction of labor effort related to infrastructure monitoring

- Complete automation of infrastructure monitoring, planning and maintenance activities quality control
- Reduction of costs related to signalling infrastructure facilities construction
- Complete automation of rolling stock condition monitoring
- Transition to power-efficient traffic management in operations areas
- Driverless control of certain types of rolling stock
Asset Management in RZD (URRAN System)

**Basic Processes of Railway Transport Maintenance**

- Maintenance of infrastructure facilities and rolling stock
- Modernization of infrastructure and rolling stock
- Procurement management
- Management of environmental, fire, industrial and labor safety

**URRAN normative and methodological framework** — over 125 documents

**Objects of Technical Regulation**

- Track facilities
- Electrification and power supply
- Signalling and remote control
- Telecommunication facilities
- Fleet

**Operational Safety Technological Processes**

- Safety
- Ecology
- Survivability
- Economy

**LCC**

- Durability
- Reliability
- Maintainability
- Availability
- Cost
Integrated Asset Management System

Intellectual railway management system
- Work scheduling using URRAN system

Inspection results
- Infrastructure maintenance scheduling

Infrastructure management system
- Current and predictive state
- Work ranking using URRAN system

BIG DATA
- Storage and filtration of ALL data about facilities

Predictive maintenance
- Event ranking using URRAN system

User and program interfaces of infrastructure monitoring subsystems
- (Common IT architecture stack: DB MS, OS, Information and cybersecurity requirements)

Data from IoT sensors
- Transmission of measurements
- Manual entry of work results and measurements
- Registration of works and measurements

Stationary sensors and measuring devices
- Mobile diagnostics and repairing complexes
- Local operators’ work stations
- Mobile diagnostics and measuring devices

Data gathering on current state of facilities
- Application of specific methods of signals processing
- Preliminary noise filtration
- Identification of incidents requiring immediate activities

Planned maintenance (scheduling) - Online monitoring (supervision)
- High-level noise filtration
- Identification of pre-failure states

High-level noise filtration
- Identification of incidents requiring immediate activities

Application of specific methods of signals processing
- Preliminary noise filtration
- Identification of incidents requiring immediate activities

Data gathering on current state of facilities
- Application of specific methods of signals processing
- Preliminary noise filtration
- Identification of incidents requiring immediate activities

Execution control
- Work assignment
- Current and predictive state
- Storage and filtration of ALL data about facilities

Transactionary DB
- User and program interfaces of infrastructure monitoring subsystems
- (Common IT architecture stack: DB MS, OS, Information and cybersecurity requirements)
Building Russian Railways’ Digital Strategy: Modernising a Mega-Network

Industrial Internet of Things

**APPLICATIONS**
- Signalling
- Rolling stock
- Staff
- Finance
- Track
- Power supply
- Logistics
- ... 

**IoT PLATFORM**
- Industrial automated control systems
- Intellectual data analysis (URRAN, etc.)
- RZD Data Centre (Main Computing Centre, Regional Computing Centres)

**DATA GATHERING MEDIUM**
- Gateways
- WLAN (Wi-Fi, LoRa, Sigfox, RFID, etc.)
- Sensors
- Counters
- Actuators
- Data carriers
- Data carrying devices
- ... 

**CONNECTED DEVICES**

10 Building Russian Railways’ Digital Strategy: Modernising a Mega-Network
Diagnostics information is acquired from **900 sensors**. **The Central Control Unit (CCU)** generates a diagnostics data package that is transmitted to the server via GSM. Transmission occurs once every 3 hours in automatic or manual mode.

Diagnostics messages are assigned “**priorities**”. High-priority messages are to be treated at first convenience, lower-priority messages are planned for treatment when a train is submitted to routine maintenance. **The RRSD diagnostics data processing and communication system** complements the observations recorded in the TU-152 log and TU-28 maintenance book.
High-Precision Coordinate Network

Distance between base stations of DGNSS network is up to 50 km.

Distance between main points is up to 4-5 km. Distance between intermediate points is up to 250-750 m.
Integrated Traffic Management

- **TMS level**
  - Automatic traffic schedule execution
  - Conflict identification and resolution
  - Infrastructure and rolling stock monitoring

- **CTC level**
  - Automatic route setting
  - Train control commands: acceleration and deceleration, emergency stop
  - Diagnostics

- **Train separation and ATP/ATO level**
  - Smart ATP with digital route map
  - Energy-efficient train separation without trackside devices
  - Automatic train operation

- **Digital communications systems**
  - Satellite positioning
  - LTE

- **Common high-precision coordinate space positioning system**
  - Multipurpose electronic maps with high-accuracy positioning system

- **Digital in-station route control system**

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ISUZHT Software Components

**Technological Planning**

- **CFTO Freight Traffic Requests**
- **Compas Passenger Train Timetable**
- **Suburban Train Timetable**
- **Annual Planning of Possessions**
- **Monthly and Operating Planning of Possessions**
- **Automated Freight Transportation Management System**
- **Modeling of Railway Stations**
- **Planning of Traction Resources**
- **UTH Complex**
- **Planning of Locomotive Crew**
- **Variant Train Timetable**
- **Daily Timetable**
- **Form of Variant Train Timetable for Polygon**
- **GID Ural**
- **Executed Train Timetable, GID Ural, Automated Traffic Control System (ATCS)**
- **Calculation of Executed Timetable**

**ISUZHT**

- **External Systems**
- **Variant Train Timetable for Polygon**
- **Optimization of Possessions on Polygon**
- **Power-Efficient Plan for Polygon**
- **Maintenance Time**
- **Timetable for Arrival**

**CTC**

- **Railway Signalling and Interlocking System**
- **GID**
- **Board**
- **Network Interworking Node**
- **Computer Communication System**
- **CTC for Management of Traction Resources and Locomotive Crew**
- **Issue and Cancellation of Preventions**
- **Automated System of Issue and Cancellation of Preventions**
- **Automated System of Planning and Implementation of Possessions**
- **Plan of Possessions**
- **Issue and Cancellation of Preventions**

**Network Operations**

- **Control of Train Position**
- **Assignment on Slots**
- **Rescheduling Plan**
- **Orders**
- **Control and Analyze of Operations**

**Panel of Multiple Access**

- **Train Operator**
- **Station Operator**
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Digital Services for Passenger Transportation

- Trip Planning
- Ticket Purchase
- Railroad Complex Services
- Services on Board
- Multimodal Transportation

Innovative Mobility
Digital Services for Freight Transportation

- Freight
- Contract
- Storage
- Transportation
- Custom
- Multimodal Transportation

DIGITAL SERVICES
Digital Railway for RZD Units

INTELLIGENT SYSTEMS AND INFRASTRUCTURE

- PREDICTIVE ANALYTICS
- INFRASTRUCTURE MODELING
- ONLINE CLIENT INTERACTION
- PLM FOR INFRASTRUCTURE

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Digital Railway

CENTRALIZED RAILWAY MANAGEMENT WITH THE USE OF DIGITAL TECHNOLOGIES

Freight

- Cross-border cooperation

Passenger

- Station
- Tourism services

Railroad infrastructure operation and maintenance

Interaction with authorities
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Moscow Central Circle – “Moscow Digital Circle”

- Infrastructure availability factor - 0.99
- Rolling stock availability factor - 0.99
- Rise in labor productivity in 2019 by 27% compared to 2016

Digital transport environment
- GSM-R
- E-LTE
- «Automatic driver»
- «Automatic train supervision»
- «Embedded rail fault detection system»
- «Embedded infrastructure diagnostic system»
- «Big data»
- DPC «Rolling stock» «Big data»
- DPC «Infrastructure» «Big data»
- Passenger information

MORE TRAINS/FREIGHT/PASSENGERS. MORE CONNECTED. MORE CLIENT SERVICES.

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Building Russian Railways’ Digital Strategy: Modernising a Mega-Network

Application of Satellite Technologies

- GLONASS/GPS
- Common coordinate system
- Track models
- Logistics
- Construction & repairing
- Infrastructure monitoring
- Fleet management
- Train protection
- Train separation
Common Database for Digital Maps

- Satellite imagery
- Aerial survey and laser scanning
- Coordinate system generated using satellite methods
- Mobile topographic complex
- Georadar survey
- Track measuring trolley

Digital track models, Digital terrain models

RZD GIS
Database

INFRASTRUCTURE CONDITION MONITORING RESULTS
ATO in Russia

Firstly, we are considering autonomous driving for shunting locomotives with special requirements

- Standards IEC 62290, IEC 62267 define the requirements only for commuter trains (urban guided transport)

<table>
<thead>
<tr>
<th>ATO Targets in Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Train type</strong></td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Commuter train</td>
</tr>
<tr>
<td>Freight train</td>
</tr>
<tr>
<td>Passenger long distance train</td>
</tr>
<tr>
<td>Shunting train</td>
</tr>
<tr>
<td>High-speed train</td>
</tr>
</tbody>
</table>
Month: May
Road: OKT
Stations: SPB-SORT-MOS
Arrived trains - 115
Sent trains
Total - 108
Including of its own formation - 103
Wagon turnover - 12367
Number of transit wagons
With sorting - 5892
Without sorting - 246
Working fleet of wagons - 4216
Number of wagons uncoupled from finished trains both of its own formation and transit
For technical problems - 0
For commercial problems - 1
Yard sorting of wagons
Even system - 3215
Odd system - 4203
Idle time of a transit wagon without sorting
Total - 2,42
Idle time of wagons in detained trains- 0,00
Idle time without wagons n detained trains - 2,42
Fastening and guarding of a train (Д) - 0,46
Technical preparation of a train (В) - 0,49
Waiting for processing - 0,06
Train processing - 0,43
Waiting for a locomotive (Т) - 0,59
Providing a train with brakes (Т, В) - 0,69
Waiting for departure (Д) - 0,20
Processing of a train for a transit wagon without sorting went through a guarantee area - 0,51
Idle time of a transit wagon with sorting
Total - 15,50
From arrival to start of division- 2,15
Fastening and guarding of a train (Д) - 0,44
Technical preparation of a train - 0,49
including waiting for processing - 0,17
including train processing - 0,32
Waiting for division (Д) - 1,22
Division (Д) - 0,29
Idle time in a marshalling yard (Д) - 7,85
Accumulation - 6,34
Waiting for formation (gauge changing) - 0,61
Formation and gauge changing - 0,89
Idle time of a transit wagon with sorting
Idle time from the end of train formation or its transfer to a departure yard before departure - 5,21
Fastening and guarding of a train (Д) - 0,59
Technical preparation of a train (В) - 0,80
Waiting for processing - 0,13
Train processing - 0,67
Waiting for a locomotive - 2,87
Providing a train with brakes - 0,71
Waiting for departure - 0,25
Delayed in approaches as not accepted
Trains - 0
Hours - 87
Number of canceled and derailed trains
Total - 0
through the fault of the service ДД - 87
through the fault of the service Т - 0
through the fault of the service В - 0
through the fault of the service Э - 0
through the fault of the service Ш - 0
through the fault of the service С - 0
through the fault of the service П - 0
through the fault of the service Л - 0
through the fault of the service М - 0
through the fault of the service НКИ - 0
through the fault of the service ИВЦ - 0
Trains unaccepted by neighboring roads - 0
Other reasons - 0
Luzhskaya Sorting Yard
ISUZHT TS Dynamic display of the calculation process
ISUZHT TS Visualization of the calculation process – the work schedule of the station
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ISUZHT TS Analytical reporting

Station crews

Shunting locomotives

Wagons accumulation

Calculation options comparison

Idle time between operations

Trains departure
Thank you for your attention!