Digital Technologies for Railways

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Russian Railways
# Global Industrial Trends

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<th>Research and innovative solutions under development</th>
<th>IPID 2020</th>
<th>EU White Paper</th>
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<td>Reduction of risks related to the human factor</td>
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<td>Increased business efficiency and streamlining of logistics</td>
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<td>Development of multimodal transportation</td>
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<td>Development of virtual and cloud-based client services</td>
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<td>Computerization and digitalization of traffic management processes</td>
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<td>High-speed traffic development</td>
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<td>New rolling stock</td>
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<td>Increased energy efficiency</td>
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<td>New powerplants. New types of energy resources</td>
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<td>Focus on rational environmental management</td>
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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

*Shift2Rail*
Digital Railway Architecture

CONTROL SYSTEMS ARCHITECTURE

- Integrated process model
- RZD development strategy
- Key performance indicators
- Objective tree
- Consolidated service catalogue
- Organization structure.

PROCESS AND IT ARCHITECTURE

Holistic approach to systems integration:

- Single architecture management principles
- Standardized IT infrastructure
- General safety requirements.
Digital Ways to Increase Traffic Efficiency

1. **Digital track models**
   - High-precision design and maintenance of infrastructure facilities

2. **Digital communications systems**
   - Centralized traffic management in large operations areas with transmission of commands to trains

3. **Control centers for operations areas**
   - Capacity modeling and traffic planning allowing for cost reduction

4. **Onboard computer systems**
   - Improvement of control systems dependability and safety
   - Real-time infrastructure monitoring using rolling stock

5. **High-precision design and maintenance of infrastructure facilities**
   - Automation of electronic map generation and track maintenance

6. **Centralized traffic management in large operations areas with transmission of commands to trains**
   - Cost reduction and real-time information exchange

7. **Capacity modeling and traffic planning allowing for cost reduction**
   - On-schedule power-efficient traffic

8. **Improvement of control systems dependability and safety**
   - Migration to one-man crew operation

9. **Real-time infrastructure monitoring using rolling stock**
   - Reduction of labor effort related to infrastructure monitoring

10. **Automation of electronic map generation and track maintenance**
    - Complete automation of infrastructure monitoring, planning and maintenance activities quality control

11. **Cost reduction and real-time information exchange**
    - Reduction of costs related to signalling infrastructure facilities construction

12. **On-schedule power-efficient traffic**
    - Complete automation of rolling stock condition monitoring

13. **Migration to one-man crew operation**
    - Transition to power-efficient traffic management in operations areas

14. **Reduction of labor effort related to infrastructure monitoring**
    - Complete automation of rolling stock condition monitoring

15. **Transition to power-efficient traffic management in operations areas**
    - Driverless control of certain types of rolling stock

16. **Driverless control of certain types of rolling stock**
**Integrated Traffic Management**

- **Upper control level**
  - Automatic train schedule execution
  - Conflict identification and resolution
  - Infrastructure and rolling stock monitoring

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

- **Train separation and automatic train operation level**
  - Digital electronic map onboard
  - Energy-efficient train separation without trackside devices
  - Automatic train operation

**Digital Communications Systems**
- LTE
- Satellite positioning

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

**Digital Technologies for Railways**
Moscow Central Circle

- Number of trains – 134 pairs a day
- Track length – 54 km
- Number of stations – 34 (including 17 transfer hubs)
- Headway – 3-5 minutes in peak hours
- Expected passenger flow – 250 mil a year.
Automatic Management of Shunting Operations

- Automatic control of shunting engine's traction and braking systems
- Visual, sound and speech warning of driver on route and maximum allowed speed
- Emergency stop in case of roll-back, loss of communication between station-based and onboard systems, as well as upon station duty officer's command
- Logging of onboard and station-based equipment operation and personnel's actions
- Capability to move in automatic mode (without driver) and with no wagons coupled

- Automatic stop before a restrictive signal
- Supervision and control of shunting engine movement speed
- Communication with the shunting engine via a redundant radio channel
- Automatic positioning of shunting engine accurate within 1 m
- Assignment of shunting engine stop command and permission to pass restrictive signal using a workstation
- Integration with any type of power interlocking
- Capability to set routes through parts of a station equipped with different interlocking systems.
High-Precision Coordinate Network

Differential global navigation satellite system (DGNSS) GLONASS/GPS
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.
Common Database for Electronic Maps

Satellite imagery
- Digital track models
- Digital terrain models
- Coordinate system generated using satellite methods
- Mobile topographic cameras
- Satellite survey
- Track-measuring trolley

Digital Technologies for Railways
Integrated Telecommunications

INTEGRATED TELECOMMUNICATIONS INFRASTRUCTURE FOR EFFICIENT OPERATION OF ALL RZD AUTOMATED SYSTEMS

SDCM (LUCH)

GLONASS
GPS

DISPATCHERS

GSM-R

OPTIC FIBRE

DIGITAL IN-STATION ROUTE CONTROL SYSTEM
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)

**RZD SECURE NETWORK**

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

**CONNECTED DEVICES**
New Approaches to Diagnostics & Monitoring

- diagnostic equipment is installed on existing rolling stock with no intrusion into the standard onboard equipment
- diagnostics activities do not interfere with the traffic process, while insuring high frequency of high-speed lines condition monitoring
- condition diagnostics are performed without interrupting the operation of high-speed rolling stock, track infrastructure and catenary line
- complete automation of all control of diagnostics equipment, measurements, processing and evaluation not requiring the presence of an operator
New Potential Solutions Based on Optical Fiber

- Distributed sensing system for generating warning signals to level crossing protection systems, PIS/PAS, hot box detection posts, etc.
- Identification of a train category (freight, passenger, single loco, trolley, etc.)
- Identification of axle parameters (flat wheel, hot boxes)
- Sensing of rolling stock derailment
- Identification of cars with vibration (modulation) higher than standard one
- Check for efficiency of track lubrication through a sound profile of curve passing
- Detection of violations related to fixing of track elements such as screws on joint fishplates, choker bridges etc., track box caps, trackside cabinet doors etc.
- Control of alien objects falling down on track (trees, stones, lamp masts, etc.)
Threats and Hazards for Train Safety

Radio Block Centre RBC
GSM-R / TETRA

Intentional or unintentional electromagnetic interference with the radio signal

Attack against GSM-R/TETRA network might result in loss of infrastructure service (from a temporary loss of service to catastrophic infrastructure failure affecting multiple areas for an extended duration)

Balise

Broken line
Falling object on track

due to occasional or malicious events
Cybersecurity of Digital Railways

Functional safety
GOST R IEC 61508

Information security
GOST R ISO/IEC 27005

Cybersecurity APCS hardware and software in railway transportation
JSC RZD Standard STO 02.049-2014

Approach followed by Russian Railways

• FSTEK requirements (order dated 14.03.2014 No.31)

• Requirements of technical regulations of the Customs Union (items 25-b, c)

• Risk assessment
GOST R 54505
GOST R ISO/IEC 27005

• Certification tests for UFs
Cybersecurity of Digital Railways

Compromise between system safety and its operating costs is achieved or not achieved at the first stage of system design.
Asset Management

UIC ISO 55000 Guidelines Document
ISO 55001 Implementation Guidelines for Railway Infrastructure Organisations
# Asset Management in URRAN System

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<tr>
<th>Facility</th>
<th>Goals</th>
<th>Document</th>
<th>Quantity, units</th>
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<td>Track facilities</td>
<td>Reduction of lifecycle cost of track facilities through redistribution of resources while ensuring the required level of operational dependability and allowed level of train traffic safety</td>
<td>International standard (GOST)</td>
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<tr>
<td>Automation and remote control</td>
<td>Improvement of operational dependability of railway automation and remote control devices while ensuring allowed (required) level of train traffic safety based on optimization of resource management and lifecycle cost</td>
<td>National standard (GOST R)</td>
<td>6</td>
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<tr>
<td>Electrification and power supply</td>
<td>Extension of the lifecycle of power supply facilities based on risk evaluation while ensuring the required level of operational dependability and allowed level of train traffic safety</td>
<td>JSC RZD standard (STO RZD)</td>
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<td>Motive power facilities</td>
<td>Reduction of lifecycle cost of locomotives through more efficient resource management while ensuring the required level of operational dependability and allowed level of train traffic safety</td>
<td>Method</td>
<td>67</td>
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<tr>
<td>Central Directorate for Multiple Unit Rolling Stock</td>
<td>Reduction of lifecycle cost of MURS through efficient resource distribution while ensuring the allowed level of train traffic safety and passenger comfort.</td>
<td>Recommended practices</td>
<td>8</td>
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<tr>
<td>Communications</td>
<td>Reduction of lifecycle cost of railway telecommunications systems through more efficient resource management based on improved telecommunications networks operation procedures while ensuring required safety and dependability of telecommunications services.</td>
<td>Guidelines</td>
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<td>Classifier</td>
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<td>Norms</td>
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<td>Classifier and norms</td>
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URRAN Coverage

Over 30 publications in several languages in a number of countries in 2012-2016.
- Austria, Armenia, Germany, China, Romania, Slovakia, USA, Switzerland, Czech Republic, etc.
- EI, Eisenbahn Österreich, Schweizer Eisenbahn Revue, NŽT, RailwayPRO, Reliability: Theory & Applications, Signal+Draht, etc.

Presentations in prominent international conferences and railway forums
- InnoTrans 2012, 2014
- Standardization and Technical Regulations in the New Environment (Almaty, Kazakhstan, October 28-29, 2014)
- International symposium Probabilistic Models in Dependability Technology and Industrial Process Control

RailwayPRO (Romania) 02/2015
VÚZ Nova Zeleznicni Technika (Czech Republic) 02/2015
Schweizer Eisenbahn Revue (Switzerland) 12/2015
Schweizer Eisenbahn Revue (Switzerland) 01/2016

"URRAN" – Entwicklung von RAMS bei den russischen Eisenbahnen 01/2014

Harmonization of single approaches to the methods of resource, risks and dependability management as part of working meetings
Thank you.
Questions?

www.vniias.ru