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Statistical activities and challenges faced by member States

Digitally transforming the statistical monitoring of rail transport in the Russian Federation

Submitted by the Russian Federation

Background

The annex to the present document provides a description of the development of statistical monitoring by the open joint-stock company Russian Railways with particular reference to the increasing use of new data flow management technologies. It also provides some detailed statistical data on the railways in the Russian Federation.

Annex

Statistical monitoring of the digital transformation of rail transport workflows

The Russian rail network is one of the largest in the world. The total length of rail track in use is over 80,000 km. The volume of rail freight in Russia is 3,000 billion tkm per year, which represents around 30 per cent of the world's rail freight (see figure 1).

Figure 1. **Russian Railways assets**

Инфраструктура	
Эксплуатационная длина	85 513 км
Длина электрофицированных линий	43 759 км
Длина путей	104 563 км
Количество станций	5 428

Подвижной состав	
Грузовые вагоны	более 1 000 000
Пассажирские вагоны	около 40 000

Грузы	
Грузовые перевозки в 2017	1 261,3 млн тонн
Грузооборот в 2017	3 176,2 млрд т-км тарифы

Пассажиры	
Пассажирские перевозки в 2017	1 118 млн
Пассажирооборот в 2017	122,8 млпд пассажиро-км

It is no simple task to manage such large assets. Modern rail transport statistics are therefore especially important.

Russian Railways currently has a total of over 260 internal statistical reporting forms and over 1,060 primary document reporting forms, which contain over 20,000 indicators, covering all aspects of productive and economic activities in rail transport.

More than half of the reporting forms in current use are submitted through the automated systems of Russian Railways with a view to reducing human error and improving the reliability of the information processed. Moreover, 112 internal primary reporting forms for various operations have been developed and approved for use as part of a technical documentation procedure involving electronic digital signatures.

For now and the foreseeable future, the challenge is to create statistical indicators based on the digitization of workflows, and the notion of a digital railway is the foundation for the development of modern railways both in Russia and throughout the world. Russian Railways developed the Integrated Programme of Innovative Development for 2016–2020.

The new approaches that are being created and developed around the world, as described in the publications in the list of references below (paras. 1 to 17), are aimed at (see table 1): increasing speed; increasing volumes; reducing operational costs; making rail transport more attractive; and improving safety.

Table 1: **Global industry trends**

Studies and innovative solutions under development	**Integrated Programme of Innovative Development 2020**	**European Union white paper**	**Shift2Rail**	**Strategic Plan of the Federal Railroad Administration (United States of America)**
Increasing safety through intelligent systems	☑	☑	☑	
Reducing human error risks	☑			☑
Increasing business efficiency and optimizing logistics	☑	☑	☑	☑
Developing multimodal transport	☑	☑	☑	
Harmonizing service requirements. “One stop”	☑	☑		
Developing virtual and cloud-based client services	☑	☑	☑	
Computerizing and digitizing transport management processes	☑	☑	☑	☑
Developing high-speed transport	☑	☑	☑	☑
New rolling stock	☑	☑	☑	☑
Increasing energy efficiency	☑	☑	☑	☑
New engines. New types of energy resources	☑	☑	☑	☑
Emphasis on rational environmental management	☑	☑		
Infrastructure development	☑	☑		☑
Driverless technologies	☑		☑	☑

The digital revolution is affecting most areas of industry and everyday life. Rail transport is no exception. The Integrated Programme of Innovative Development of the Russian Railways includes:

- Digital infrastructure models
- Digital communications networks and high-precision coordinate systems
- Monitoring of the state of infrastructure and rolling stock and computational tools for processing large quantities of data

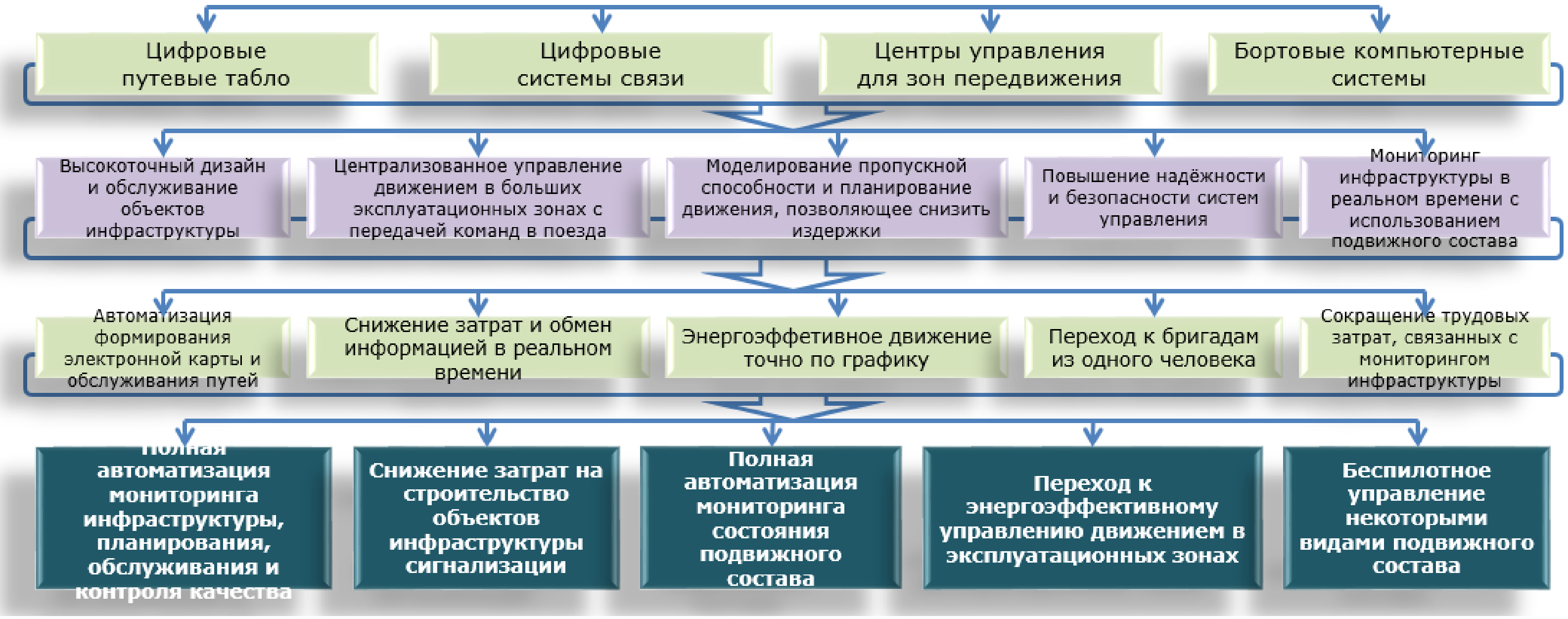
The fundamental prerequisites for the transition to a digital railway are:

- Digital models of infrastructure assets in a general coordinate and time frame system
- Digital communication networks and high-precision coordinate systems based on high-precision satellite positioning networks

- Continuous monitoring of infrastructure assets with automatically generated speed limits and maintenance scheduling
- Monitoring of the state of rolling stock at external and internal facilities so that its remaining useful life may be estimated
- A package of computational tools for the real-time remote management of infrastructure assets and amendment of rail schedules with due regard to energy efficiency and the automation of individual operations
- Mobile workstation arrangements for staff members and monitoring of their physical and psychological well-being

Figure 2 shows the digital solutions for improving the efficiency of traffic management. These include the use of digital platform display boards, digital communications systems, control centres for operational areas and on-board computer systems. The implementation of these technologies is intended to automate infrastructure and rolling stock monitoring, planning, maintenance and quality control, to reduce the costs associated with constructing infrastructure and to ensure energy-efficient traffic management in operational areas and driverless operation for some types of rolling stock.

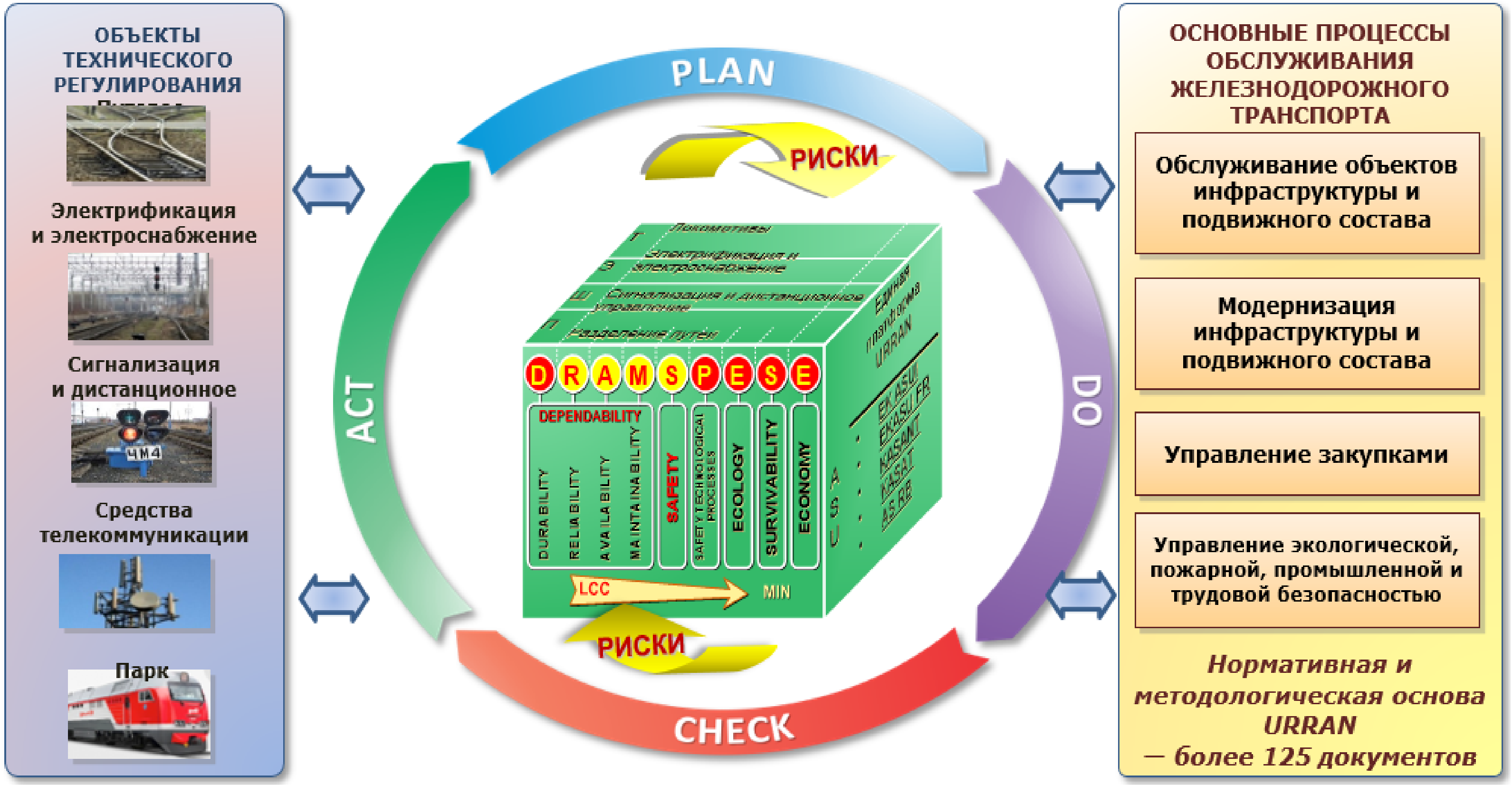
Figure 2. **Digital means of improving transport efficiency**



In Russia, an integrated risk assessment-based asset management system (the Resources, Risks and Reliability Analysis Management System) was introduced in 2010. It ensures the integrated management of the risks, reliability and cost of railway facilities at all stages of the operational cycle (see figure 3).

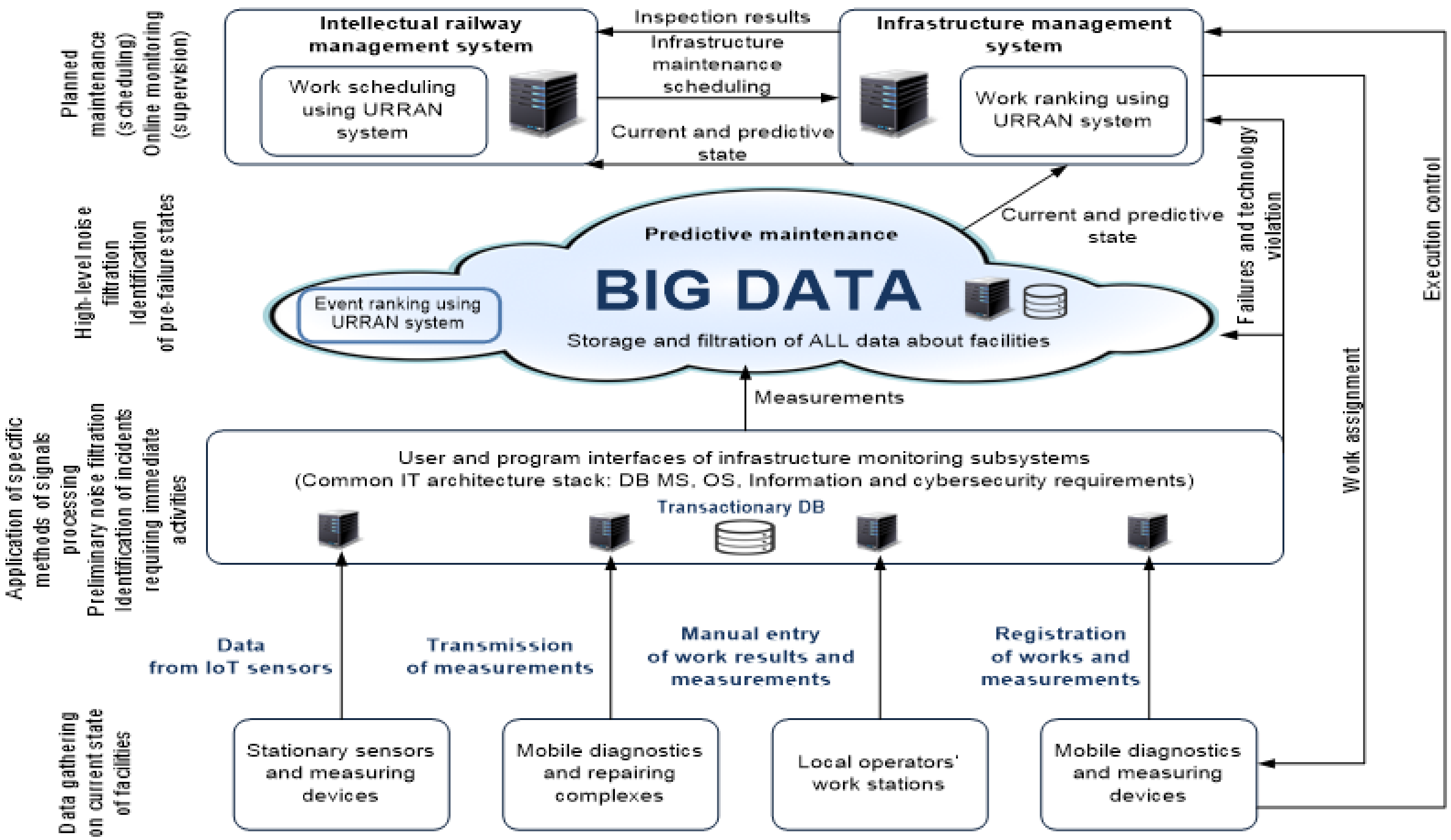
Based on information from various types of infrastructure (tracks, overhead lines, power supplies, signalling, etc.), the system supports high-level decision-making. The integrated asset management system covers such categories of risk as individual, social, environmental, technical and economic risks.

Figure 3. **Managing Russian Railways assets (resource, risk and reliability analysis management system)**



The use of big data technology is the next step for the asset management system. The target architecture of such a system is based on big data principles (see figure 4).

Figure 4. **Integrated asset management system**



This transition is based on new digital business models in which data is automatically collected from various devices. This is in keeping with the concept of the industrial Internet of things, which is becoming well known worldwide (see figure 5).

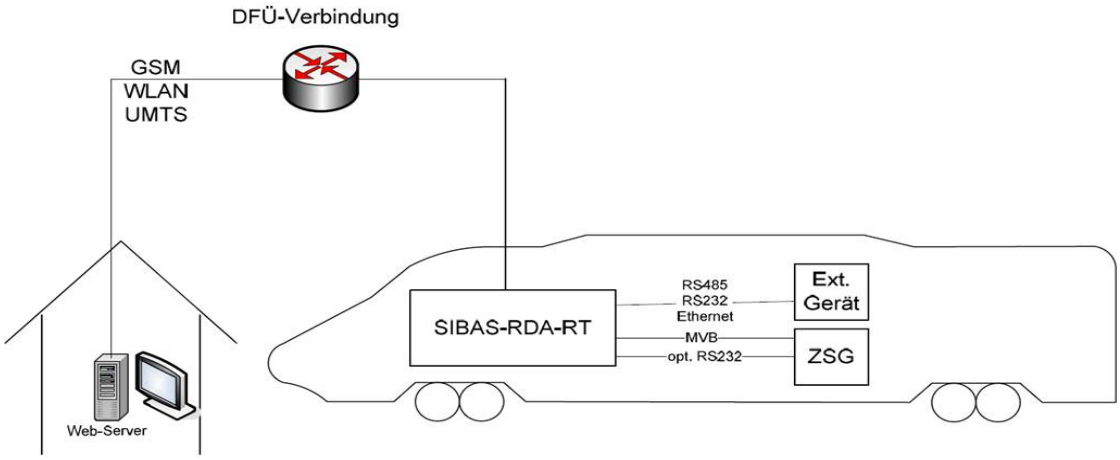
Figure 5. **Industrial Internet of things**

Some industrial Internet of things technologies are being tested at several Russian Railways subdivisions and facilities. Promising results are expected from wireless sensors for railway automation devices such as signalling systems, relay boxes, track equipment and hot axle box detection systems.

Maintenance based on operational conditions depends on reliable information about the state of railway infrastructure and facilities. The latest generation of Russian electric trains, such as Sapsan trains, are equipped with special on-board information and measurement systems. The systems receive information from 900 sensors and can assign different priority levels to diagnostics and decide which ones should be processed first.

The central control unit generates a diagnostic data packet, which is transmitted to the server via the Global System for Mobile Communications. The packets are transmitted every three hours, either automatically or manually. Diagnostics are assigned priority levels. Those assigned a high priority level are processed as soon as possible and those assigned a lower priority level are placed in a queue for processing when the train is sent for routine servicing. The regional Railway Station Directorate diagnostic data processing and transmission system supplements the information recorded in forms TU-152 and TU-28 (see figure 6).

Figure 6. **Transmission of diagnostic data to the X-Train web server**



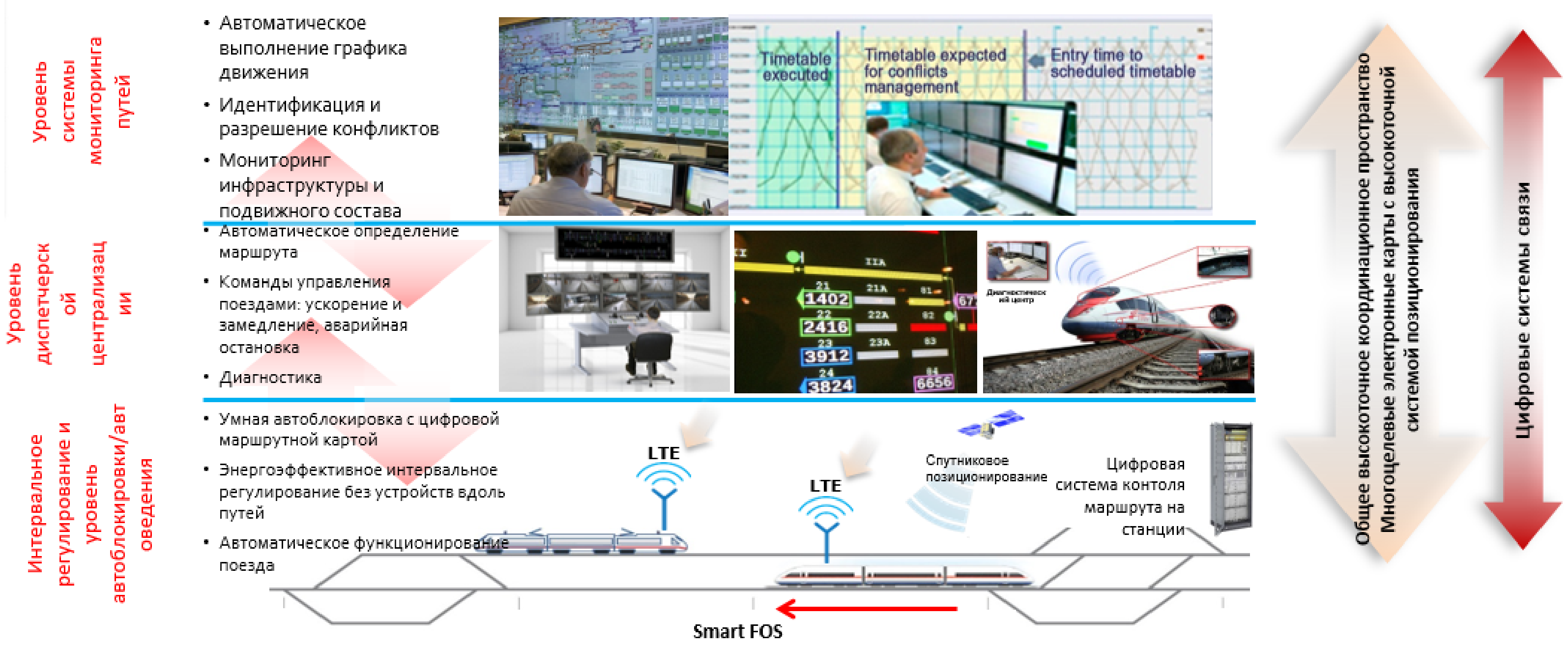
The deployment of a common high-precision coordinate system across the rail network is one of the foundations for the digitization of the railways (see figure 7).

Figure 7. **High-precision coordinate network**

The successful implementation of such technologies requires a mature geographical information system. Russia operates a high-precision coordinate network stretching over 6,000 km. It supports all kinds of activities relating to design, construction, repair, traffic management and automatic train protection.

The traffic management system can be represented as a three-level system. At the lower level, infrastructure facilities are decreasing in number, and new broadband systems for digital communications are being used (see figure 8).

Figure 8. **Integrated traffic management**

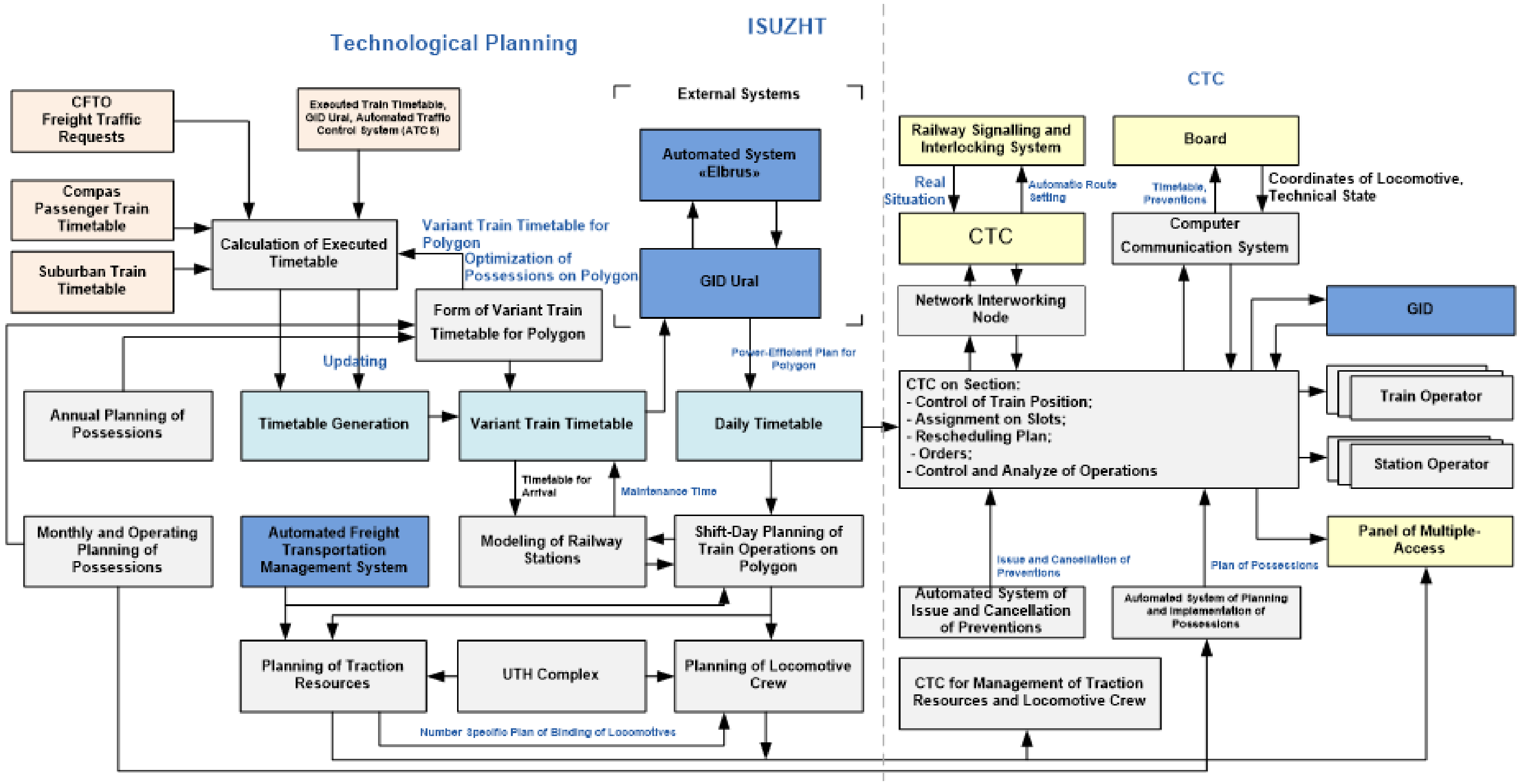


The intermediate level allows for automatic route-setting at the station from the control centre and monitoring of infrastructure from the rolling stock.

The highest intelligence level allows for the train movement schedule to be established automatically and conflicts to be identified and resolved.

The software components of the Intelligent Rail Transport Management System interact across the planning stage, the centralized automation of traffic management and the preparation of reports. Figure 9 shows the input data needed to generate the daily timetable.

Figure 9**. Software components of the Intelligent Rail Transport Management System**



Passenger transport services that are based on digital technologies include journey planning, ticket purchasing and real-time data transmission in railway stations and trains. These services are accessible on mobile devices that use various digital communication standards and relevant functional applications.

Paperless technologies should be implemented for freight transport to support multi-agent interaction among all the participants in the transport process. This includes:

- Customs formalities
- Preparing and transmitting the necessary documentation
- Adaptive and client-oriented traffic management

Digital services also enable the subdivisions of Russian Railways to carry out predictive analytics and infrastructure modelling, among other tasks.

Data from various areas of the activities of Russian Railways are processed and integrated in order to prevent interruptions to operations.

The Moscow Central Ring Railway offers a good example of the integrated implementation of digital technologies (see figure 10).

Figure 10. **Moscow Central Ring Railway – “Moscow Digital Ring”**

The digitization of all design plans for signalling systems and the creation of a high-precision coordinate system are ways of minimizing the number of operations performed by a human being.

A project is currently being developed to establish a centre to process data based on big data and industrial Internet technologies.

The use of satellite navigation (see figure 11) is currently a part of the digitization of the railways. There is a wide range of applications, which cover many areas. A few examples are:

- Logistics
- Monitoring rail infrastructure
- Track design, construction and repair
- Dispatching trains and optimizing traffic
- Train protection systems and collision avoidance
- Preparing reports without primary documents

The use of satellite navigation for signalling is inexpensive and requires less track equipment. However, safety and positioning accuracy remain high priorities.

Figure 11. **Use of satellite technologies**

As noted above, a high-precision coordinate network is a pillar of digital railway. It creates new opportunities for the management of rail assets and for signalling. Russian Railways experts are actively involved in developing methods for track design, construction and repair involving the use of an absolute coordinate system.

The notion of a digital railway is closely connected with fully automatic and autonomous trains. Russian Railways is actively developing this technology, and prototypes are already being tested at several test sites. We believe that special standards and requirements for different types of trains should be developed. Five train categories have been identified, each with different objectives, requirements and levels of automation.

Railway stations are the most complex elements of the rail system. It is thus a priority to automate their work and thereby generate reliable and timely statistical reports. Figure 12 shows a set of reporting indicators currently used by Russian Railways to evaluate the activities of marshalling yards. The Saint Petersburg marshalling yard is used as an example. These indicators are all automatically updated on the basis of messages sent to automated control systems by the staff on duty. Taking the example of the most modern marshalling yard, Luzhskaya Station, we shall examine the prerequisites for automatic report generation and the reduction of the impact of human error on reliability.

Figure 12. **Analysis sheet DO-24VT on the activities of marshalling yards**

Год: 2018
Месяц: Май
Дорога: ОКТ
Станции: СПБ-СОРТ-МОС
Прибыло поездов - 115
Отправлено поездов
Всего - 108
В т.ч. своего формирования - 103
Вагонооборот - 12367
Количество транзитных вагонов
С переработкой - 5892
Без переработки - 246
Рабочий парк вагонов - 4216
Количество отцепленных вагонов от готовых поездов своего формирования и транзитных
По техническим неисправностям - 0
По коммерческим неисправностям - 1
Переработка вагонов на горке
Четная система - 3215
Нечетная система - 4203
Простой транзитного вагона без переработки
Всего - 2,42
Простой вагонов в задержанных в продвижении составах - 0,00
Простой без учета вагонов в задержанных в продвижении составах - 2,42
Закрепление и ограждение состава (Д) - 0,46
Техническая подготовка состава (В) - 0,49
Ожидание обработки - 0,06
Обработка состава - 0,43
Ожидание локомотива (Т) - 0,59
Обеспечение поезда тормозами (Т, В) - 0,69
Ожидание отправления (Д) - 0,20
Обработка состава для транзитного вагона без переработки, проследовавшего гарантийный участок - 0,51
Простой транзитного вагона с переработкой
Всего - 15,50
От прибытия до начала расформирования - 2,15
Закрепление и ограждение состава (Д) - 0,44
Техническая подготовка состава - 0,49
в т.ч. ожидание обработки - 0,17
в т.ч. обработка состава - 0,32
Ожидание расформирования (Д) - 1,22
Расформирование (Д) - 0,29
Простой в сортировочном парке (Д) - 7,85
Накопление - 6,34
Ожидание формирования (перестановки) - 0,61
формирование и перестановка - 0,89
Простой транзитного вагона с переработкой
Простой от окончания формирования состава или перестановки его в парк отправления до отправления -5,21
Закрепление и ограждение состава (Д) - 0,59
Техническая подготовка состава (В) - 0,80
Ожидание обработки - 0,13
Обработка состава - 0,67
Ожидание локомотива - 2,87
Обеспечение поезда тормозами - 0,71
Ожидание отправления - 0,25
Задержано на подходах по неприему
Поездов - 0
Кол. Часов - 87
Количество отмененных и сорванных поездов
Всего - 0
по вине службы ДД - 87
по вине службы Т - 0
по вине службы В - 0
по вине службы Э - 0
по вине службы Ш - 0
по вине службы С - 0
по вине службы П - 0
по вине службы Л - 0
по вине службы М - 0
по вине службы НКИ - 0
По вине службы ИВЦ - 0
Неприем поездов соседними дорогами - 0
Прочие причины - 0

The next step in the introduction of digital techniques for traffic management is the fully remote control of trains by the dispatcher. There is an institute that conducts research and development work on the control of shunting locomotives at the Luzhskaya Station. This project began in 2015, and we now have three autonomous locomotives.

A dynamic simulation model of all station workflows is used to automatically generate the daily schedule of work performed (see figures 13, 14 and 15).

Figure 13. **Dynamic representation of the computation process**

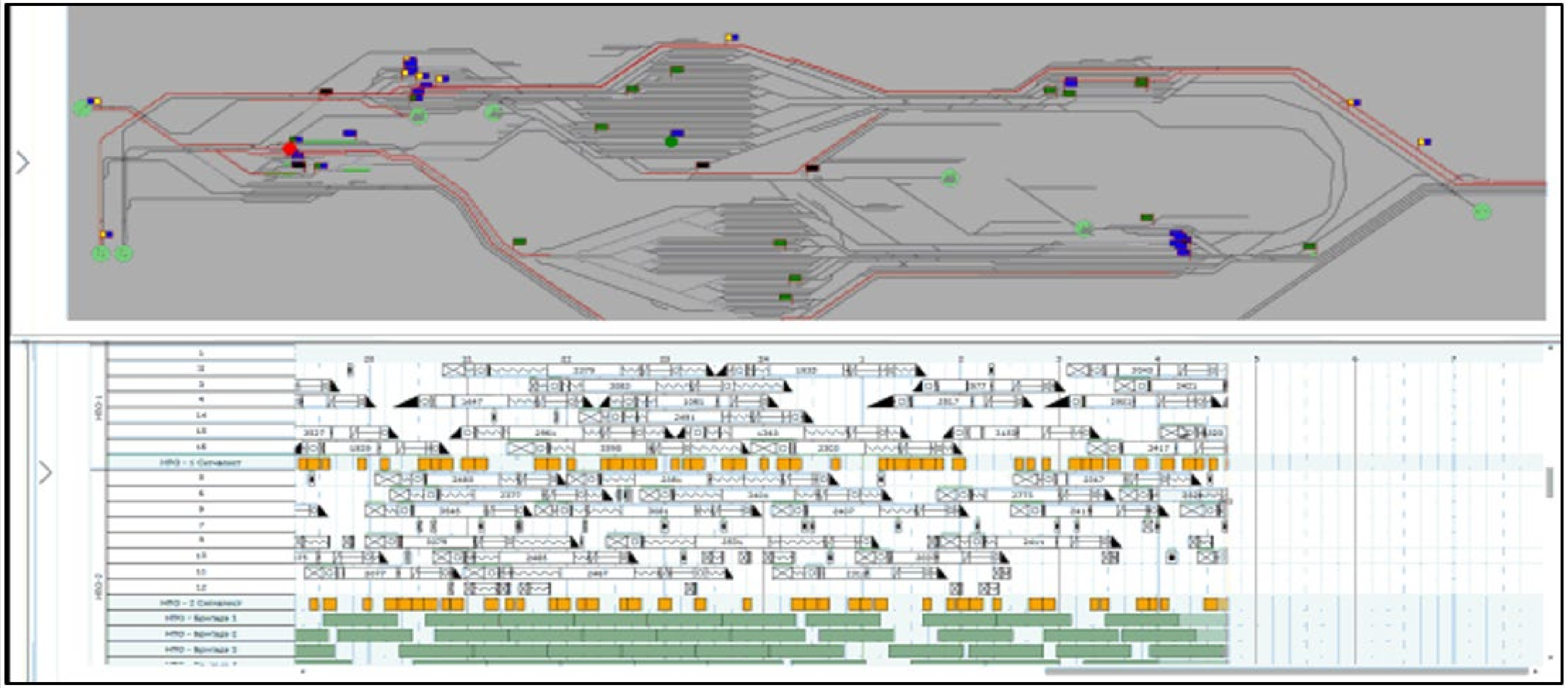


Figure 14. **Visualization of the computation process: marshalling yard operation schedule**

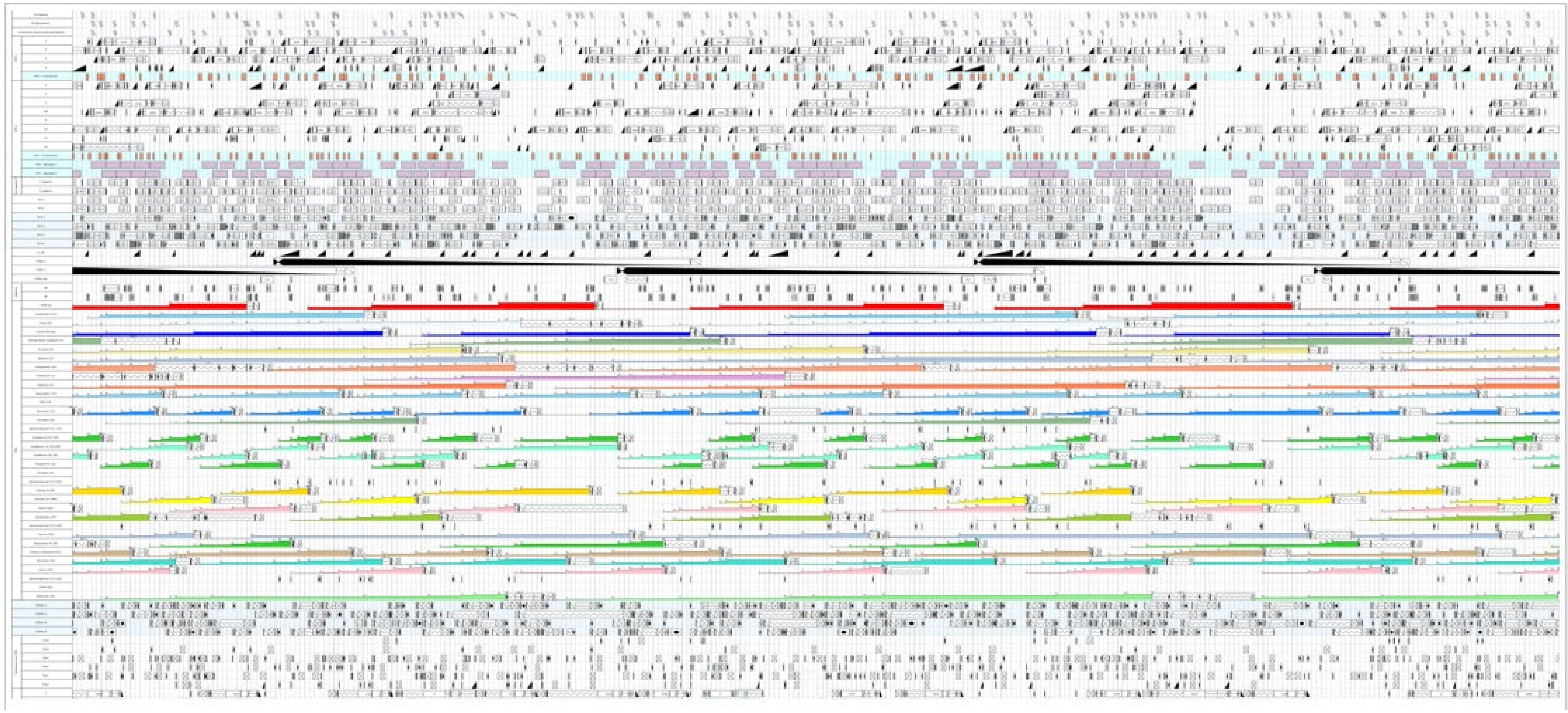
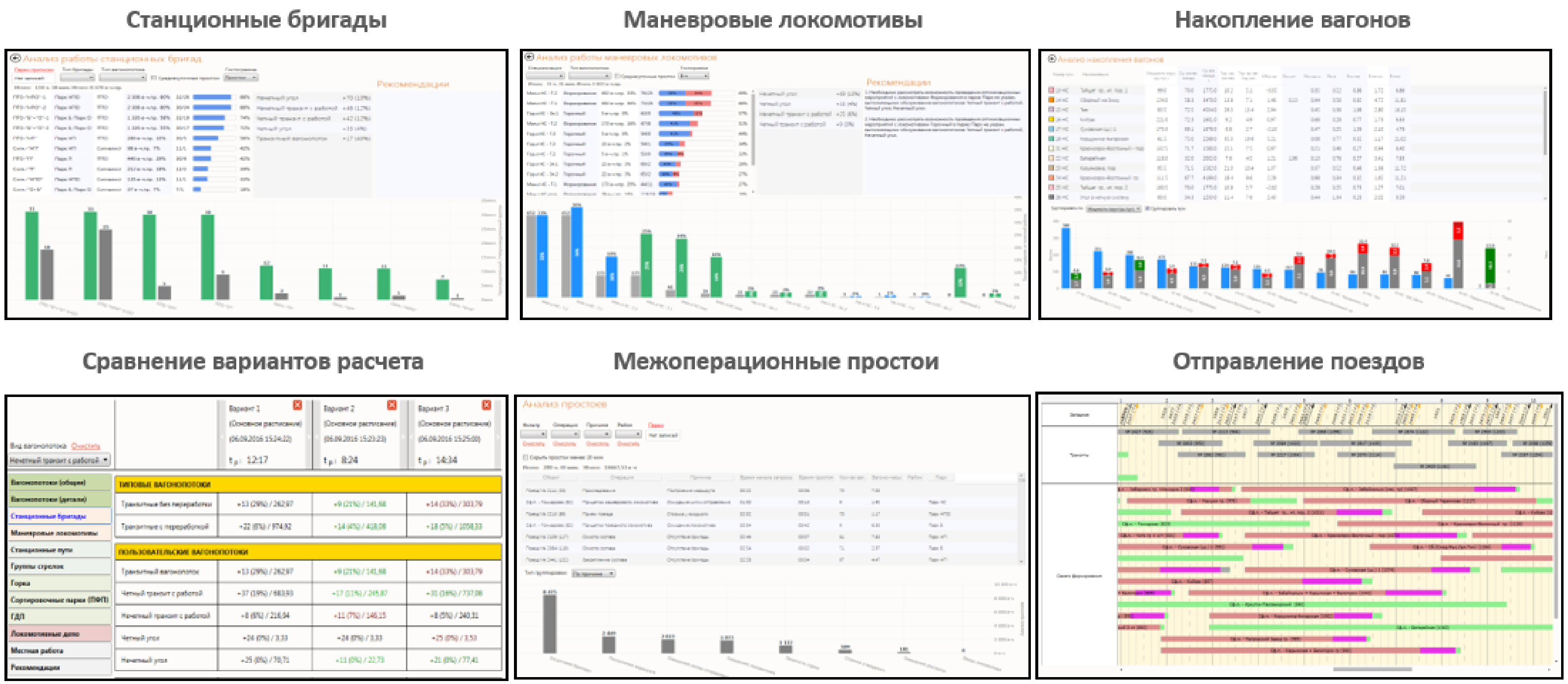


Figure 15. **Analytical reporting**



On this basis, statistical reports on the activities of marshalling yards are generated automatically. We will thus have reliable and timely statistical reports and the necessary tools to effectively manage transport processes and other workflows.

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