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Information support of the system for managing technical assets in railway transportation

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Abstract. Aim. *JSC RZD is one of the largest and most advanced companies in Russia who actively deploys and uses best practices in asset and risk management. In 2010, the railway industry initiated the project for the management of resources, risks and dependability at life-cycle stages of railway facilities (URRAN) that is currently under way. The aims of this paper are to overview the asset management tasks covered by URRAN; examine the marketed IT tools designed to address such problems; present the progress of the URRAN project in terms of process automation implemented by JSC RZD in light of the international best practice and the specificity of the Company.* **Methods.** *The preparation of this paper involved empirical and theoretical research. The authors analysed the URRAN project's package of guidelines and regulations, public information on the globally available software products enabling asset management, as well as the program documentation of the EKP URRAN automated system. They analysed the functionalities and and engineering solutions used in the development of this automated system. The results of the EKP URRAN deployment and practical application by units and branches of JSC RZD were evaluated.* ***Results.*** *Asset management involves using Enterprise Asset Management Systems (EAMS) specially designed to suit the needs of specific companies or mass-produced "out-of-the-box" systems, e.g. SAP ERP, IBM MAXIMO, ABB Ability™ and Simeo™ that are examined in the paper. The EKP URRAN implements a single information space that is a decision support tool for the asset management system as it possesses the required regulatory and procedural resources, hardware and software assets intended for comprehensive management of assets and processes for the purpose of efficient railway service. In the future, the EKP URRAN is to become part of the Digital Platform for Risk and Traffic Safety Management deployed in JSC RZD and will comprise modules that implement dynamic predictive analytics models for the purpose of predicting undesirable events involving infrastructure and rolling stock that may disrupt traffic safety.* **Conclusions.** *Further development of the EKP URRAN will soon provide all levels of company management with an efficient tool that allows, in the context of limited resources, making substantiated managerial decisions and rational investment allocation. The EKP URRAN is an asset of JSC RZD designed to be used by the managers and specialists of various JSC RZD units. It can be implemented as a standalone IT product for the purpose of developing and deploying an asset management system in various railway companies.*

Keywords: *asset management, automated system, dependability, risk, railway transportation.*

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Introduction

JSC RZD is one of the largest and most advanced companies in Russia who actively deploys and uses best practices in asset and risk management [1, 2]. However, it must be understood that a railway system is not only multi-industry, but also multilevel. Each system or service have independent managerial goals and tasks, internal and external connections, which is the reason for the great amount of information and data management flows that circulate both between the system's layers vertically, and horizontally, covering the corresponding geographically distributed entities of the adjacent services and directorates.

Based on the international experience and taking into consideration the specificity of JSC RZD, the project for management of assets, risks and dependability at lifecycle stages (URRAN) was started and is now under way.

In terms of methodology development, the URRAN project started in 2011 and is undergoing continuous improvements by assimilating the obtained experience and taking into account the rapid technological developments.

As part of the project, a process of comprehensive management of operational dependability and safety of railway facilities has been introduced that is composed of three interconnected components:

- risk-based management methodology of railway facility maintenance, structural unit activities, dependability and safety of the transportation process;

- the system's regulatory and procedural framework;

- computerization of data capture and processing, technical asset management, automation of all guidelines and regulations developed as part of the URRAN project.

Fig. 1 shows the key landmarks of the URRAN project development from the concept to a working information system.

The standards and regulations developed as part of the URRAN project include more than 150 regulatory documents covering various aspects of asset management and activities of the branches of JSC RZD. Those include GOST, GOST R, industry standards (STO) and methods. The documents cover:

- infrastructure facilities (track and structures, signalling, electrification and power supply, communications);

- rolling stock (locomotives, EMUs and DMUs, cars and wagons);

- additional functions related to fire, environmental safety and labour protection, train traffic safety.

The methodology and know-how of the URRAN project were repeatedly covered in the Dependability Journal, e.g. [3, 4, 5, 6, 7].

As noted in [1], the introduction of the asset management system is impossible without the deployment of IT tools. Normally, automated systems like EAMS are used for purposes of asset management. Such systems can be either purpose designed for a specific company, or mass-produced "out-of-the-box" solutions. A great number of such systems have been developed worldwide. We will note the main ones that are used in the railway industry.

1. SAP ERP, the best-known enterprise resource planning software developed by SAP SE (Germany). The introduction of SAP ERP includes the development and implementation of the following processes:

– maintenance of reference information (RI);
– overhauls and maintenance;
– annual maintenance planning;
– operational planning;
– work performance and accounting for actual costs;
– maintenance management.

The functional scope of the software includes:

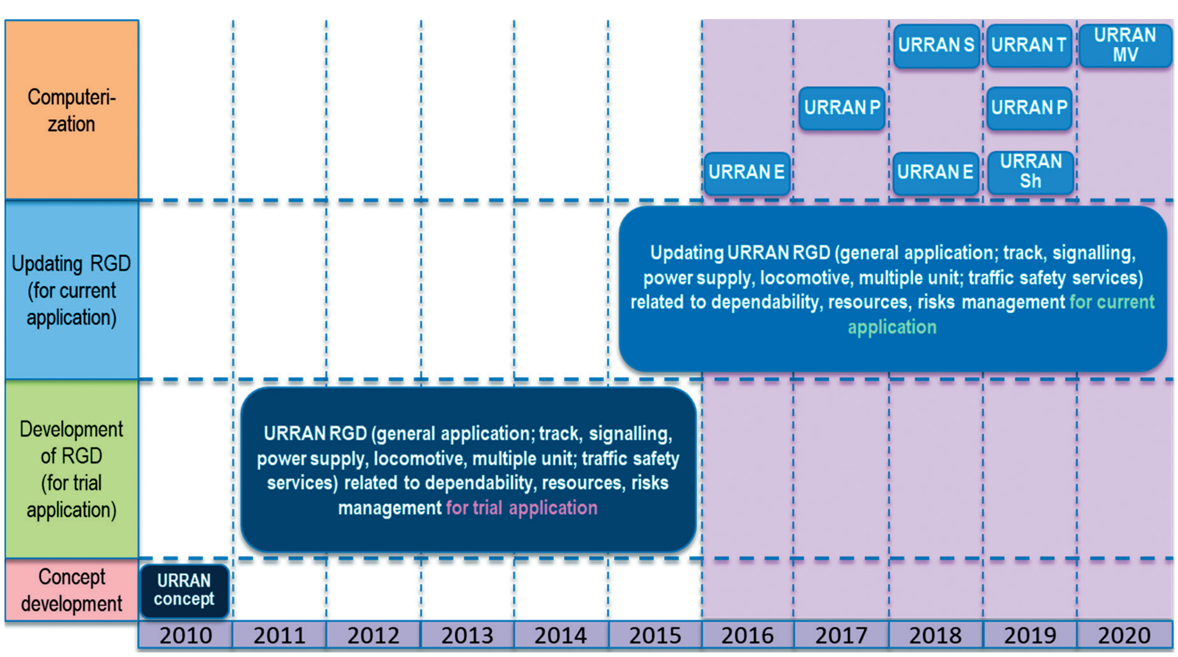


Fig. 1. URRAN project history

– automated equipment data management (functional locations, equipment units, classification, specification of technical facilities, etc.);

– equipment record-keeping;

– maintenance of databases of standards and directories on equipment maintenance and repair (EM&R);

– calculation of required materials, assemblies, spare parts and preparation of purchase requests in the required quantities and ranges;

– record-keeping and performance control of repair activities, including performance control of executed repairs, confirmation of the actual number of hours spent on repairs, release of materials, etc.;

– procurement management (procurement scheduling in order to ensure timely delivery of materials and parts for equipment repair and maintenance);

– planning of manpower and other types of material resources required for EM&R;

– efficient allocation and adjustment of repair costs per selected indicators (business unit, time period).

This software product is used by such railway companies as IrishRail (Ireland) and Infrabel (Belgium).

2. Maximo Asset Management, a software solution by IBM (US) designed for the purpose of managing all types of assets regardless of their location. Within the IBM Maximo, six interconnected functional blocks can be distinguished that enable a complete life cycle of enterprise asset management and maintenance:

– asset management;

– procurement management;

– contract management;

– material management;

– work management;

– service management.

This system is used by Network Rail (UK) and Trafikförvaltningen (Stockholm Public Transport Administration, Sweden).

3. ABB Ability™ (ELLIPSE), AVV's (Switzerland, Sweden) industrial automation software solution that allows optimizing process control, improving energy efficiency and productivity (through reduced operating costs, longer equipment life, better dependability and responsiveness).[1]

This software is also used by Network Rail (UK).

4. The Simeo™ software suite by the Oxand consulting company holds in its database reference information on more than 600 types of assets, analysis of 70000 km of railway infrastructure and more than 40 million m^2 of real estate. The system implements a decision-support module that uses accumulated statistical data on various types of technical assets for the period of 15 years. The primary key indicators for decision-making are the RAMS indicators.

[1] Available at: https://new.abb.com/cpm/production-optimization/eam-enterprise-asset-managment-systems (accessed 17.01.2021)

Yet most railway companies prefer custom-designed asset management software. ADIF (Spain), VAYLA (Finland), ÖBB (Austria), as well as JSC RZD made that choice.

As the vast regulatory framework of the URRAN project implies the collection of a large amounts of statistical data, as well as a lot of calculations involving large volumes of data on various facilities (assets) and structural units of services, JSC RZD is actively automating such standards and regulations using the URRAN Single Corporate Platform (EKP URRAN). As of today, about 35% of all documents have been automated (mainly in the area of dependability analysis, risk assessment and structural unit activities, as well planning of maintenance and lifecycle cost assessment).

1. EKP URRAN architecture

The purpose of the system's development is to implement adaptive management of railway facilities maintenance at the lifecycle stages or a business process based on the compliance with the criteria of dependability, safety and economic efficiency of the operation using the risk-oriented approach.

The primary processes implemented in the EKP URRAN include:

– collection and processing of information on failures, pre-failures and critical parameters of railway facilities;

– assessment of wear, residual operating life and limit state of railway infrastructure facilities;

– standardization of dependability and safety indicators of railway facilities;

– analysis and prediction of actual dependability and safety indicators of railway facilities;

– assessment of risks related to technology dependability, traffic safety disruptions, occupational and fire risks;

– evaluation of railway infrastructure life cycle cost;

– evaluation of JSC RZD business units performance subject to the results of activities aimed at ensuring dependability and safety of operated facilities;

– management decision support, including repair planning, maintenance resource management.

The EKP URRAN contains six functionally complete technical systems (hereinafter referred to as systems) and two enabling systems, namely:

Technical systems:

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Track and Structures (EKP URRAN P);

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Signalling Facilities (EKP URRAN Sh);

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Electrification and Power Supply Facilities (EKP URRAN E);

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Communications Facilities (EKP URRAN S);

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Motive Power Facilities (EKP URRAN T);

– Single Corporate Platform for Management of Resources, Risks and Dependability at Lifecycle Stages of Railway Motor Unit Facilities (EKP URRAN MV).

Enabling systems:

– Single database of calculated indicators of dependability and functional safety, risk assessment for comprehensive assessment of the condition of infrastructure and rolling stock that is a database management system (DBMS) enabling:

a) storage of primary characteristics of railway power supply facilities, track superstructure, telecommunications, signalling, data on locomotives and motor units;

b) storage of data on accidents, failures and incidents that occurred with the facilities of railway power supply, track superstructure, telecommunications, signalling, locomotives and motor units;

c) storage of data on performed repairs obtained from related systems;

d) storage of user-added lifecycle cost data;

e) storage of calculated dependability data (actual and standard);

f) storage of reference information.

– The external automated system interaction modules are intended for the collection and processing of primary information from related systems that calculate the actual and standard dependability indicators, assessment and monitoring of risk levels, residual life assessment, evaluation of professional risks, assessment and monitoring of fire risk, rating service units activities, overhaul planning.

The functional configuration of the EKP URRAN is shown in Fig. 2.

The EKP URRAN contains two load balancing servers (primary and standby), primary and standby servers hosting virtual application servers, as well as virtual database servers. Additionally, the EKP URRAN includes a primary and a standby synchronization servers (see Fig. 2).

The load balancing servers automatically switch requests from one application server to the other if one of them fails.

Each application server is equipped with virtulization tools.

For each application (URRAN E, URRAN P, URRAN S, URRAN T, URRAN Sh, URRAN MV), an Apache Tomcat or Node.js virtual application server is configured.

The database is deployed on separate servers.

Synchronization modules (URRAN E, URRAN P, URRAN S, URRAN T, URRAN Sh, URRAN MV) are configured on individual Apache Tomcat virtual servers.

The application server software is implemented using client/server technologies. User access is through a Web browser.

The user workstation (WS) and administrator WS are a single web application with different access settings designed for managing the System's interaction with administrators and users.

The synchronization modules enable the EKP URRAN's interaction with many of the JSC RZD's primary network-level systems:

1) Automated System for Centralized Reference Information (AS CRI) in terms of retrieval of data from industry-wide directories and classifiers.

2) Integrated Automated System for Technical Failures Tracking, Investigation and Dependability Analysis (KASANT) in terms of retrieval of data on technical failures.

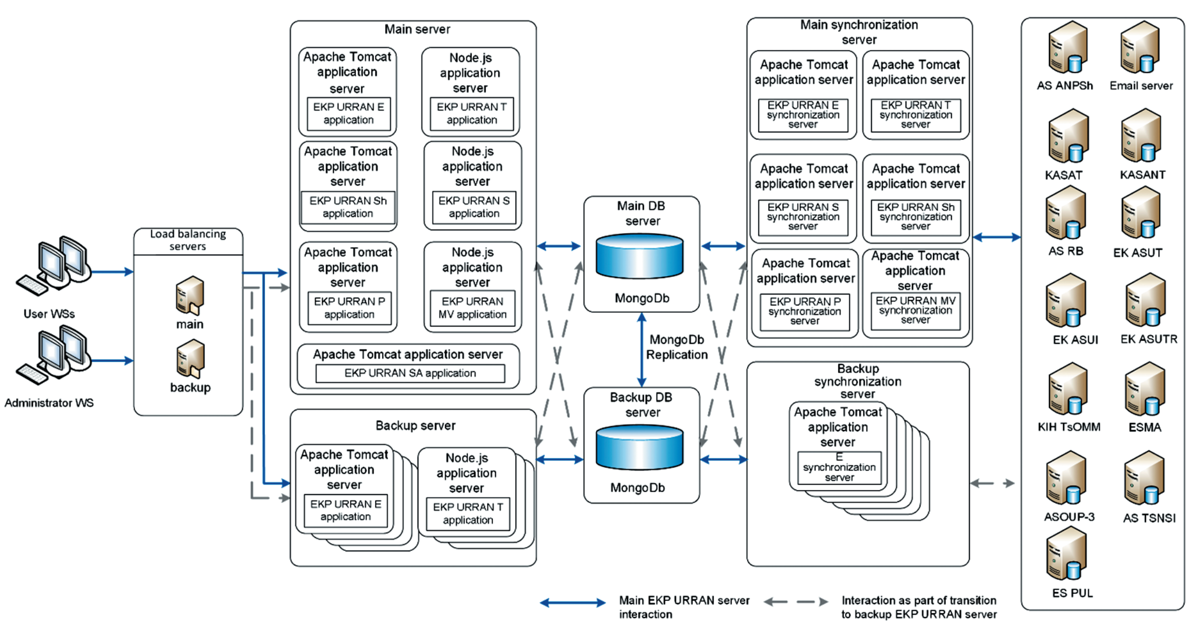


Fig. 2. Functional configuration of the EKP URRAN

3) Integrated Automated System for Recording, Investigation and Analysis of Process Violations (KASAT) in terms of retrieval of data on process violations.

4) Automated Traffic Safety Management System (AS RB) in terms of retrieval of information on traffic safety disturbances.

5) Automated System for Statistical Analysis of Dependability Indicators and Prescriptive Management of Signalling Processes (AS ANPSh) in terms of retrieval of data on railway signalling facilities and their key characteristics.

6) Single Corporate Automated System for Infrastructure Management (EK ASUI) in terms of retrieval of data on electrification and power supply facilities, track and structures, as well as incidents that affect them.

7) JSC RZD's Single System for Monitoring and Administration of Communication Networks (ESMA) in terms of:

a) retrieval of data on railway telecommunications facilities, incident and maintenance sheets;

b) transmission to the ESMA of data on standard and actual dependability indicators of railway telecommunications facilities, risks (risk matrices), integrated assessment of business unit activities.

8) Corporate Data Warehouse of the System for Centralized Processing of Driver's Itinerary List (KIH TsOMM) in terms of retrieval of data on the amount of work performed by locomotiveы and multiple units.

9) Single Corporate Automated System for Motive Power Management (EK ASUT) in terms of retrieval of data on the number of locomotive repairs, activation of barrier functions.

10) New (Third) Generation Automated System for Operational Transportation Process Management (ASOUP-3) in terms of retrieval of data on the number of locomotive and multiple unit repairs, cases of barrier function activation for a motive power depot.

11) Single Corporate Automated System for Workforce Management (EK ASUTR) in terms of retrieval of information on accidents in operating motive power depots and average number of drivers.

12) Single System for Locomotive Number Tracking (ES PUL) in terms of retrieval of data on the inventory multiple unit fleet.

Effectively, the EKP URRAN represents a four-layer architecture. The *lower layer* consists of data sources (KASANT, KASAT, EK ASUI, ASRB, ESMA, AS TsNSI, AS ANPSh, EK ASUT, etc.). The *second layer* is the integration layer containing the data integration modules. The *third layer* is the data warehouses. It includes databases, aggregate functions and computational pipeline for data aggregation. The *fourth layer* is the core layer. This is the analytics layer that implements the URRAN methodology.

2. Technical solutions used as part of the EKP URRAN

The EKP URRAN employs Big Data technology.

The System's data storage layer is based on the MongoDB modern document DBMS.

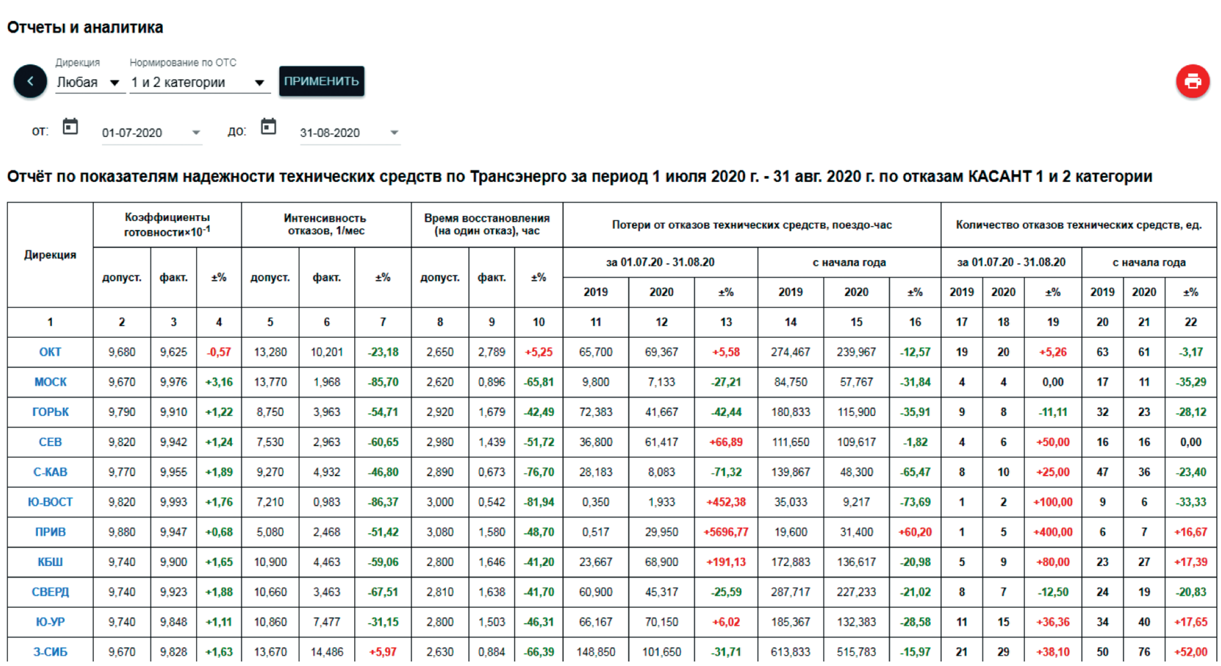
The list and description of the software making part of the EKP URRAN hardware and software architecture is given in Table 1

The System's role model implies the following user categories, as well as the end user rights and privileges:

1) Administrators, including:

– users with the "Administrator" role, who are authorized to add users to the EKP URRAN, as well as all operations at all levels of the organizational hierarchy and have access to all subsystems of the EKP URRAN;

– *technical administrators* who maintain the hardware and software system, install updates.



Отчёт по показателям надежности технических средств по Трансэнерго за период 1 июля 2020 г. - 31 авг. 2020 г. по отказам КАСАНТ 1 и 2 категории

Дирекция	Коэффициенты готовности×10^{-1}			Интенсивность отказов, 1/мес			Время восстановления (на один отказ), час			Потери от отказов технических средств, поездо-час						Количество отказов технических средств, ед.					
	допуст.	факт.	±%	допуст.	факт.	±%	допуст.	факт.	±%	за 01.07.20 - 31.08.20			с начала года			за 01.07.20 - 31.08.20			с начала года		
										2019	2020	±%	2019	2020	±%	2019	2020	±%	2019	2020	±%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ОКТ	9,680	9,625	-0,57	13,280	10,201	-23,18	2,650	2,789	+5,25	65,700	69,367	+5,58	274,467	239,967	-12,57	19	20	+5,26	63	61	-3,17
МОСК	9,670	9,976	+3,16	13,770	1,968	-85,70	2,620	0,896	-65,81	9,800	7,133	-27,21	84,750	57,767	-31,84	4	4	0,00	17	11	-35,29
ГОРЬК	9,790	9,910	+1,22	8,750	3,963	-54,71	2,920	1,679	-42,49	72,383	41,667	-42,44	180,833	115,900	-35,91	9	8	-11,11	32	23	-28,12
СЕВ	9,820	9,942	+1,24	7,530	2,963	-60,65	2,980	1,439	-51,72	36,800	61,417	+66,89	111,650	109,617	-1,82	4	6	+50,00	16	16	0,00
С-КАВ	9,770	9,955	+1,89	9,270	4,932	-46,80	2,890	0,673	-76,70	28,183	8,083	-71,32	139,867	48,300	-65,47	8	10	+25,00	47	36	-23,40
Ю-ВОСТ	9,820	9,993	+1,76	7,210	0,983	-86,37	3,000	0,542	-81,94	0,350	1,933	+452,38	35,033	9,217	-73,69	1	2	+100,00	9	6	-33,33
ПРИВ	9,880	9,947	+0,68	5,080	2,468	-51,42	3,080	1,580	-48,70	0,517	29,950	+5696,77	19,600	31,400	+60,20	1	5	+400,00	6	7	+16,67
КБШ	9,740	9,900	+1,65	10,900	4,463	-59,06	2,800	1,646	-41,20	23,667	68,900	+191,13	172,883	136,617	-20,98	5	9	+80,00	23	27	+17,39
СВЕРД	9,740	9,923	+1,88	10,660	3,463	-67,51	2,810	1,638	-41,70	60,900	45,317	-25,59	287,717	227,233	-21,02	8	7	-12,50	24	19	-20,83
Ю-УР	9,740	9,848	+1,11	10,860	7,477	-31,15	2,800	1,503	-46,31	66,167	70,150	+6,02	185,367	132,383	-28,58	11	15	+36,36	34	40	+17,65
З-СИБ	9,670	9,828	+1,63	13,670	14,486	+5,97	2,630	0,884	-66,39	148,850	101,650	-31,71	613,833	515,783	-15,97	21	29	+38,10	50	76	+52,00

Fig. 3. Report on dependability performance by power supply directorates

Показатели надежности путевого хозяйства за период с 01.12.2020 по 31.12.2020. Сетевой уровень
(Объекты оценки: все объекты; категория ОТС: 1 и 2 категории)

		ОКТ	КЛНГ	МОСК	ГОРЬК	СЕВ	С-КАВ	Ю-ВОСТ	ПРИВ	КБШ	СВЕРД	Ю-УР	З-СИБ	КРАС	В-СИБ	ЗАБ	ДВОСТ	СЕТЬ
Интенсивность отказов, 1/мес	норм.	5,391780	6,945950	5,444340	5,555300	4,345690	4,241300	5,110000	4,807780	4,396060	4,850120	4,252250	4,182170	2,368850	4,072670	4,091650	3,845640	4,561770
	факт.	0,887379	0,000000	0,475090	0,638309	0,453273	0,039252	0,057719	0,245405	0,669371	1,061108	0,654907	0,717565	0,350538	0,492524	1,217215	0,315519	0,568167
	+/-, %	-83,54	-100	-91,27	-88,51	-89,57	-99,07	-98,87	-94,90	-84,77	-78,12	-84,60	-82,84	-85,20	-87,91	-70,25	-91,80	-87,55
Среднее время до восстановления, ч	норм.	2,88	12,32	2,89	3,13	3,2	3,25	3,3	3,38	3,35	3,09	3,37	3,28	3,89	3,5	3,38	2,73	2,28
	факт.	1,07	0,0	1,05	0,97	1,49	2,22	0,6	1,33	0,62	0,93	1,34	0,78	0,69	5,84	1,19	1,02	1,28
	+/-, %	-62,92	-100	-63,70	-69,05	-53,40	-31,74	-81,80	-60,85	-81,38	-69,92	-60,24	-76,30	-82,36	+66,65	-64,66	-62,78	-44,04
Коэффициент готовности	норм.	0,944500	0,934100	0,944200	0,943500	0,951000	0,951600	0,946300	0,948100	0,950700	0,947900	0,951500	0,952000	0,966500	0,952700	0,952600	0,954200	0,949600
	факт.	0,998704	1,000000	0,999318	0,999154	0,999074	0,999881	0,999953	0,999555	0,999428	0,998651	0,998801	0,999237	0,999670	0,996075	0,998014	0,999561	0,999007
	+/-, %	+5,74	+7,05	+5,84	+5,90	+5,06	+5,07	+5,67	+5,43	+5,13	+5,35	+4,97	+4,96	+3,43	+4,55	+4,77	+4,75	+5,20
Интенсивность опасных отказов, 1/мес		0,126622	0,000000	0,031653	0,049061	0,075482	0,039252	0,000000	0,000000	0,044600	0,000000	0,046728	0,113218	0,140187	0,098138	0,233710	0,000000	0,065608
Количество ОТС		28	0	15	13	12	1	1	4	15	27	14	19	5	10	26	9	199
Потери от ОТС, поездо-час		69,87	0,00	30,30	15,82	70,18	0,00	0,22	6,35	12,60	69,32	27,33	19,77	4,52	74,73	230,73	61,03	692,77
Структурные подразделения (СП)	СП в "красной зоне"	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	СП в "оранжевой зоне"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
	СП в "жёлтой зоне"	13	0	10	11	9	1	1	4	8	15	9	13	5	8	10	6	123
	СП в "зелёной зоне"	18	1	21	9	17	24	16	12	14	10	12	13	9	10	9	22	217

СП в "красной зоне" - 3 показателя надежности хуже нормативного
СП в "оранжевой зоне" - 2 показателя надежности из 3 хуже нормативного
СП в "желтой зоне" - 1 показатель надежности из 3 хуже нормативного
СП в "зеленой зоне" - нет показателей надежности хуже нормативного

Fig. 4. Evaluation of dependability indicators in the track and structures services of Infrastructure Directorates

Table 1 EKP URRAN software

Name	Purpose
CentOS	Operating system
VMware	Virtualization tool
MongoDB	DBMS
Apache Tomcat 8.5/ Node.js 12	Application server
Keepalived	Server health monitoring and failover
Haproxy	Load balancing for TCP and HTTP applications by distributing incoming requests to multiple servers

2) Technical users, including:

– users with the *"RI editor"* role can perform all operations at all levels of the organizational hierarchy and have access to all sections of the EKP URRAN except "Administration";

– users with the *"Information user"* role are authorized to, depending on the access level, generate calculation parameters in all subsystems, generate and print reports, view RI.

– users with the *"Technical user"* role are authorized to, depending on the access level, generate calculation parameters in all subsystems, generate and print reports, view RI.

– users with the *"Unit manager"* role are authorized to agree and approve reports, as well as generate calculation parameters in all subsystems, generate and print reports.

3. Using EKP URRAN

We must note the wide application of the EKP URRAN functionality in the business activities of the branches and divisions of JSC RZD. Thus, the EKP URRAN is supporting activities aimed at improving technical facilities depend-

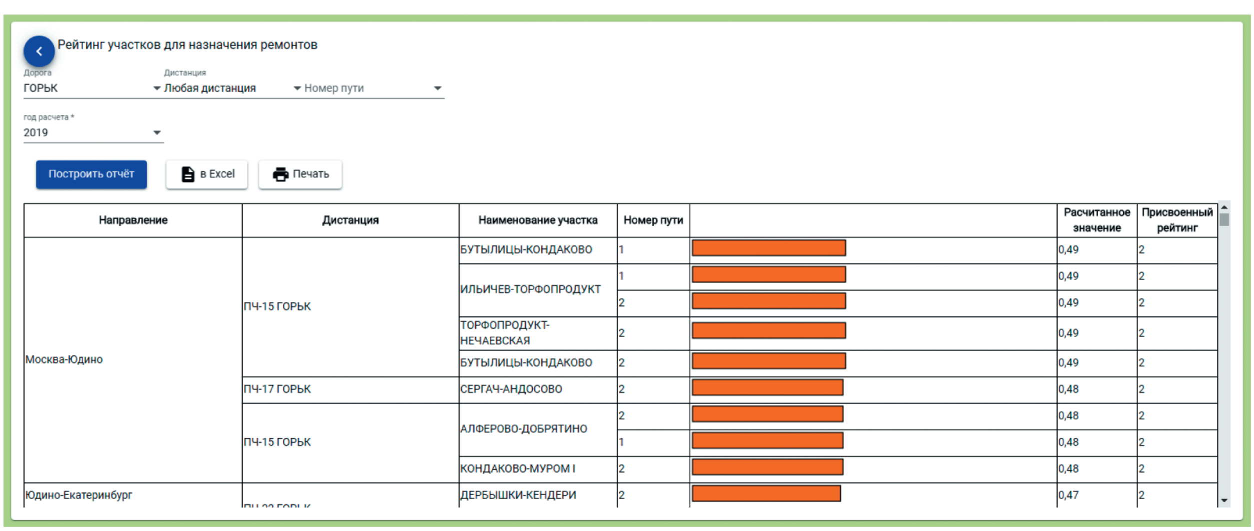


Fig. 5. Line section ranking for overhauls

Ведомость оценки интегрального показателя устойчивости функционирования железнодорожной электросвязи

Наименование подразделения	Показатель неготовности объектов железнодорожной электросвязи	Показатель интенсивности отказов объектов железнодорожной электросвязи	Показатель интенсивности предотказов объектов железнодорожной электросвязи	Показатель среднего времени до восстановления объектов железнодорожной электросвязи	Балльная оценка интегрального показателя устойчивости функционирования железнодорожной электросвязи
	K11	K121	K122	K13	B1
По дирекции	20.004375	59.478027	100	81.429565	52
РЦС-1	0.89099985	28.567501	100	1.5256927	54
РЦС-2	41.140522	69.56835	100	100	53
РЦС-3	12.53277	40.315468	68.69776	51.3834	38
РЦС-4	3.1610045	82.8538	96.13721	3.1373253	49
РЦС-5	13.087995	17.127426	100	98.32765	46
РЦС-6	15.977224	32.91246	100	69.13891	53

Ведомость оценки интегрального показателя влияния функционирования железнодорожной электросвязи на перевозочный процесс

Наименование подразделения	Показатель неготовности услуг железнодорожной электросвязи, отказы которых привели к задержкам поездов	Показатель интенсивности отказов услуг железнодорожной электросвязи, приведших к задержкам поездов	Показатель среднего времени до восстановления услуг железнодорожной электросвязи, отказы которых привели к задержкам поездов	Балльная оценка интегрального показателя влияния функционирования железнодорожной электросвязи на перевозочный процесс
	K21	K22	K23	B2
По дирекции	25.030964	8.716195	100	52
РЦС-1	0	0	0	0
РЦС-2	16.518341	2.9053981	100	53
РЦС-3	1.9730561	2.9053981	10.712373	5
РЦС-4	0	0	0	0
РЦС-5	13.665926	2.9053981	100	46
РЦС-6	0	0	0	0

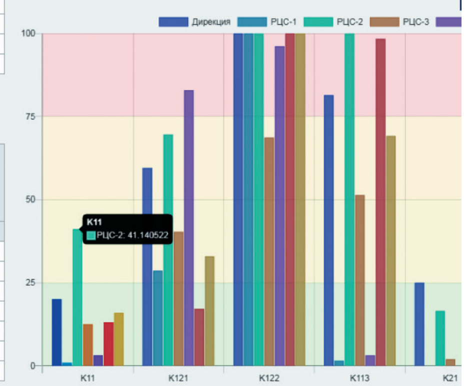


Fig. 6. Evaluation of the impact of business units on the transportation process in the communications service

Рейтинг структурных подразделений путевого хозяйства

Дорога: ГОРЬК | Дистанция: Любая дистанция | год расчета *: 2020 | период расчета *: год

- Выбрать все
- Балльная оценка безопасности движения поездов (БДД)
- Балльная оценка надёжности в целом (БН)
  - Балльная оценка качества технического содержания ($Б_λ$)
  - Балльная оценка оперативности устранения отказов объектов ВСП ($Б_в$)
  - Балльная оценка влияния на перевозочный процесс ($Б_п$)
- Балльная оценка компетентности персонала (БЧ)

Построить отчёт | в Excel | Печать

№ рейтинга	Период оценки с 01.2020 по 12.2020								
Наименование структурного подразделения	Интегральная балльная оценка, $Б^И$		Балльная оценка безопасности движения поездов, $Б^Д$		Балльная оценка надёжности, $Б^Н$		Балльная оценка компетентности персонала, $Б^Ч$		Место
	кол-во баллов	оценка	кол-во баллов	оценка	кол-во баллов	оценка	кол-во баллов	оценка	
ГОРЬКОВСКАЯ									
ИЧ-4 КАНАШ П ГОРЬК	11,05	ОТЛИЧНО	0	ОТЛИЧНО	36,84	ХОРОШО	0	ОТЛИЧНО	1
ПЧ-13 ГОРЬК	11,17	ОТЛИЧНО	0	ОТЛИЧНО	37,22	ХОРОШО	0	ОТЛИЧНО	2
ПЧ-10 ГОРЬК	12,64	ОТЛИЧНО	0	ОТЛИЧНО	42,15	ХОРОШО	0	ОТЛИЧНО	3
ИЧ-2 НИЖНИЙ НОВГОРОД П ГОРЬК	12,71	ОТЛИЧНО	0	ОТЛИЧНО	42,38	ХОРОШО	0	ОТЛИЧНО	4
ИЧ-3 МУРАШИ П ГОРЬК	13,14	ОТЛИЧНО	0	ОТЛИЧНО	43,79	ХОРОШО	0	ОТЛИЧНО	5
ИЧ-5 ИЖЕВСК П ГОРЬК	13,27	ОТЛИЧНО	0	ОТЛИЧНО	44,24	ХОРОШО	0	ОТЛИЧНО	6
ПЧ-1 ГОРЬК	13,71	ОТЛИЧНО	0	ОТЛИЧНО	45,72	ХОРОШО	0	ОТЛИЧНО	7
ПЧ-4 ГОРЬК	13,83	ОТЛИЧНО	0	ОТЛИЧНО	46,11	ХОРОШО	0	ОТЛИЧНО	8
ПЧ-30 ГОРЬК	14,07	ОТЛИЧНО	0	ОТЛИЧНО	46,91	ХОРОШО	0	ОТЛИЧНО	9
ПЧ-6 ГОРЬК	14,15	ОТЛИЧНО	0	ОТЛИЧНО	47,18	ХОРОШО	0	ОТЛИЧНО	10
ПЧ-25 ГОРЬК	14,72	ОТЛИЧНО	0	ОТЛИЧНО	49,06	ХОРОШО	0	ОТЛИЧНО	11
ПЧ-22 ГОРЬК	15,16	ОТЛИЧНО	0	ОТЛИЧНО	50,52	УДОВЛЕТВОРИТЕЛЬНО	0	ОТЛИЧНО	12
ПЧ-9 ГОРЬК	15,5	ОТЛИЧНО	0	ОТЛИЧНО	51,68	УДОВЛЕТВОРИТЕЛЬНО	0	ОТЛИЧНО	13

Fig. 7. Comparative rating of the activities of business units of the track and structures service in terms of operational dependability and safety indicators

ability on the basis of target indicators calculated by means of URRAN-based rating for the purpose of optimizing the resource allocation as part of planning dependability improvement activities.

Standard dependability indicators are calculated yearly according to the URRAN methodology, their standard values, according to an established procedure, are approved in the 4 quarter of the reporting year as targets for the next year.

Based on the results of the reporting year, the URRAN-rated dependability indicators approved as targets for the following year are updated in the first quarter of the following year.

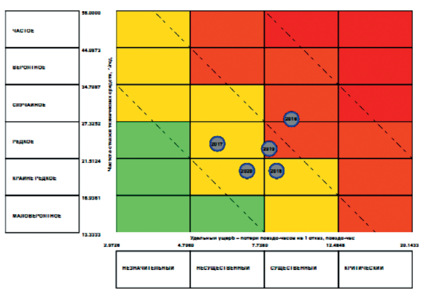
Standard target dependability indicators calculated in the EKP URRAN, are associated with the effectiveness of the performed activities aimed at improving the dependability of technical facilities and guide the planning of preventive measures subject to optimization of resource allocation.

Fig. 3 and 4 show examples of output forms for evaluating the compliance with the established standard dependability indicators of electrification and power supply facilities.

The EKP URRAN also enables detailed analysis of operational dependability of line-level units in general (track maintenance divisions, power supply divisions, etc.) and

Наименование риска	Год наблюдения	Количество отказов	Суммарные потери, поездо-часы	Суммарные потери, тыс.руб	Частота возникновения отказов технических средств, 1/год	Величина удельного ущерба (последствий) на один отказ
Задержка поездов	2016	28	259,7833	0,0000	28,0000	9,2780
	2017	24	137,9333	492,8670	24,0000	5,7472
	2018	20	168,7667	600,0767	20,0000	8,4383
	2019	23	184,1500	591,8863	23,0000	8,0065
	2020	20	139,4833	428,7886	20,0000	6,9742

Задержка поездов, Северная дорога, Все дистанции



- 2016 — **Уровень риска для участка в целом на 2016 год:** 259,78 поездо-час/год
  Характеристика риска: риск имеет категорию «нежелательный».
  Рекомендации по принимаемым решениям при управлении техническим содержанием: снижение риска с данным уровнем рекомендуется, но может не выполняться по усмотрению владельца риска, если затраты на снижение риска являются существенными по сравнению с денежным эквивалентом его последствий. Риск может быть снижен путем снижения частоты событий и/или путем снижения удельного уровня последствий. Выполнить анализ отказов. Выполнить анализ работ текущего содержания в рамках ППР.
- 2017 — **Уровень риска для участка в целом на 2017 год:** 137,93 поездо-час/год

Fig. 8. Risk matrix

individual assets (track sections, contact network, etc.) of business units.

Depending on the level of management targeted by the dependability and safety performance analysis, both individually, and along with the risk assessment, it is used for:

1) identification of the most frequently failed facilities over a period of time (operation life);

2) ranking of facilities (assets) for inclusion into renovation and repair plans (see Fig. 5). Here, along with the dependability indicators, the residual life of a facility and risk assessment are used for confirming the need for repairs. The system will also prioritize the track sections to be repaired first.

3) identification of facilities of a certain type with the least time to/between failure (active, put into operation, upgraded).

4) estimation of the impact of facility failures and their timely elimination on the transportation process, both in tabular form, and graphic form (see Fig. 6).

5) comparative evaluation of the performance of the business units (see Fig. 7).

In the EKP URRAN, risk assessment is based on the principles set out in [4, 8] and results in a matrix for the selected risk type and the selected assessed facility (see Fig. 8). It can be presented both for the selected year, and a number of years.

In general, the EKP URRAN, along with the risk matrix, provides a risk assessment in the form of recommendations

Table 2. Decision-making scenarios as part of risk assessment

Coefficient comparison	Characteristic	Recommendations
$R > R_{o.al}$	The risk is higher than allowed	Risk reduction is required. The risk can be reduced by reducing the frequency of events and/or by reducing the specific level of consequences
$\frac{R_{o.al}}{K} < R \le R_{o.al}$	The risk is within the ALARP region, classified as “undesirable”	Reduction of such risk is recommended, but is left to the discretion of the risk owner, if the cost of risk reduction is substantial compared to the money equivalent of its consequences. The risk can be reduced by reducing the frequency of events and/or by reducing the specific level of consequences
$\frac{R_{o.al}}{K^2} < R \le \frac{R_{o.al}}{K}$	The risk is within the ALARP region, classified as “acceptable”	Reduction of such risk is not recommended, but can be done at the discretion of the risk owner, if the cost of risk reduction is not substantial compared to the money equivalent of its consequences. The risk can be reduced by reducing the frequency of events and/or by reducing the specific level of consequences
$R \le \frac{R_{o.al}}{K^2}$	The level of risk is negligible	No risk reduction is required. The risk is to be routinely monitored

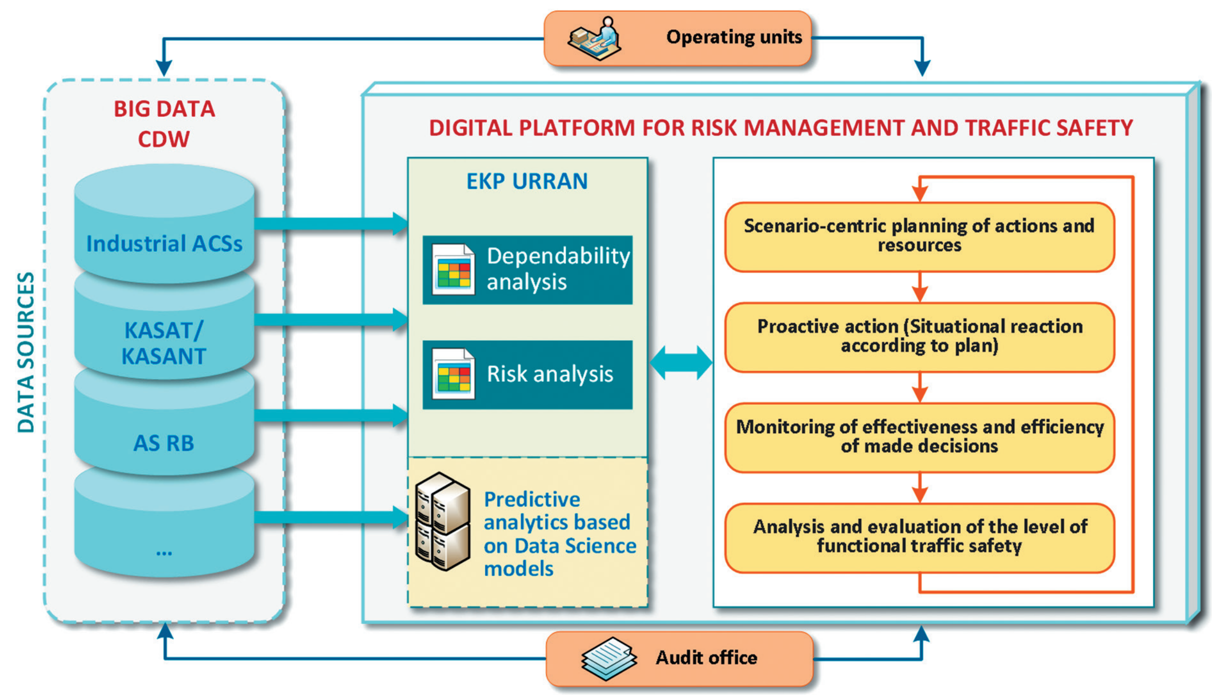


Fig. 9. Digital platform for risk management and traffic safety

for one of the scenarios of Table 2, where $K = 3\ldots15$ is the scaling coefficient of the adopted risk score.

4. Future development of EKP URRAN

As noted in [6, 7], the future development of the URRAN project will focus on the Data Science-based data mining system in terms of construction of predictive dynamic models of infrastructure and rolling stock condition.

Data Science technology combines the management of large amounts of input data for simulation (i.e., Big Data) and training of models using an array of data [9, 10, 11]. Such simulated results will be employed in flexible resource management by operating branches for the purpose of facility maintenance, as well as in the preparation by the JSC RZD Situation Center of procedures aimed at preventing undesirable events. Thus, in the future, the EKP URRAN will contain modules that implement dynamic predictive analytics models for the purpose of predicting undesirable events involving infrastructure and rolling stock that may disrupt traffic safety.

This feature of the EKP URRAN is to become a component of the Digital Platform for Risk and Traffic Safety Management deployed in JSC RZD (see Fig. 9).

Conclusions

The EKP URRAN implements a single information space that supports decision-making as part of the asset management system, as it possesses the required regulatory and procedural resources, hardware and software assets intended for comprehensive management of assets and processes for the purpose of efficient railway service.

Further development of the EKP URRAN will soon provide all levels of company management with an efficient tool that allows, in the context of limited resources, making substantiated managerial decisions and rational investment allocation.

The EKP URRAN is an asset of JSC RZD designed to be used by the managers and specialists of various JSC RZD units. It can be implemented as a standalone IT product for the purpose of developing and deploying an asset management system in various railway companies.

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The authors' contribution

Bublikova M.A. analysed the URRAN project and its potential future developments, along with open information sources on the existing asset management software products.

Khokhlov I.P. analysed the functionality and technical solutions of the URRAN system, its applicability as part of various JSC RZD activities.

Conflict of interests

The authors declare the absence of a conflict of interests.