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SUBWAY AND URBAN TRANSPORT DIAGNOSTICS

www.tvema.com
TVEMA is one of the world leaders in the development and implementation of the railway infrastructure diagnostic systems for the network of railways, subways, industrial enterprises and urban rail transport.

Nowadays, dozens of railway companies and subways worldwide operate approximately 390 mobile and over 4,000 hand-held and portable diagnostic tools manufactured by TVEMA. For three decades, our innovative products and technologies found their use in more than 30 countries on 5 continents.

Nowadays, our products are in great demand in Moscow, St. Petersburg, Novosibirsk, Yekaterinburg, Nizhny Novgorod, Minsk, Almaty, Baku and Beijing subways, carrying out a wide range of test, measuring and diagnostic procedures for rail flaw detection and measurement of their geometric parameters, infrastructure video monitoring and spatial scanning, measurement of contact rail parameters and temperature, thermal imaging monitoring and hyperspectral diagnostics, rolling stock location positioning and more. All our developments are universal in application and allow to carry out rapid monitoring of infrastructure facilities of the network of railways, subways, industrial enterprises and urban rail transport. Due to their integration and inter-changeability, our products can be used individually and in combination with each other, for one or several types of monitoring of different facilities. The modular design of systems and solutions allows to install them in any combination and configuration on various assets. In addition, all our products are united by all-weather and all-season operability, and the data obtained with them are synchronized within a software solution with combinatorial analysis and processing.

TVEMA actively participates in the joint international project implementation. For example, a unique diagnostic railcar Railway LAB Ultrasonic Test TVEMA 70 was created in partnership with the Chinese railway corporation CRRC, now it is used to monitor 80% of the Beijing subway infrastructure.
# TABLE OF CONTENTS

## COMPANY PRODUCTS FOR SUBWAYS.
### INFRASTRUCTURE INSPECTION AND DIAGNOSTIC SYSTEMS
- High-speed ultrasonic flaw detection ................................................................. 6
- SOKOL automated system for inspection and assessment of the track geometric parameters ................................................................. 8
- SOKOL-2.3 high-speed rail profile and track geometry measurement system ........ 10
- Rail corrugation measurement system ............................................................... 12
- SVOD surveillance system ................................................................................ 14
- SVOD-2 visual flaw detection system ................................................................. 16
- GABARIT-M high-speed spatial scanning system for the railway infrastructure facilities ................................................................. 18
- Contact rail position and temperature inspection system ................................. 20
- YANTAR system for non-contact track coordinate correction and railway vehicle positioning ................................................................. 22
- Thermal imaging inspection system ................................................................. 24
- Hyperspectral diagnostic system .................................................................... 26
- AKSIOMA system for inspection of the track infrastructure condition and passenger travel comfort ................................................................. 28

## MOBILE INFRASTRUCTURE DIAGNOSTIC AND MAINTENANCE TOOLS
- Flaw detection cars.......................................................................................... 32
- Track measuring cars ..................................................................................... 34
- Rapid diagnostic systems for inspection of the subway infrastructure of the SYNERGY project ................................................................. 36
- Diagnostic software and hardware ................................................................ 38

## COMPANY PRODUCTS FOR ABOVE-GROUND URBAN RAIL TRANSPORT AND SUBWAYS
- Infrastructure diagnostic and maintenance solutions based on road-rail vehicles ................................................................. 42
- SPRUT-2 flaw detection trolleys ...................................................................... 48
- SKAT-2 and SOM single-rail flaw detectors ..................................................... 50
- PT-10 track measuring trolleys ...................................................................... 52
- PT-12M and PT-12-01 manual diagnostic solutions ......................................... 54
- Digital track gauge ....................................................................................... 56
- DRED series self-propelled electric railway inspection cars ......................... 58
- Specifications of diagnostic systems produced by AO «Firma TVEMA» ............ 62
The subway is an off-street electric transport, characterized by high carrying capacity and providing fast, safe and comfortable commute. The subway carrying capacity sometimes reaches 40-50 thousand passengers per hour in one direction. Subways are divided into underground, above-ground and overground. By capital investment, the subway is the most expensive form of transport, and therefore it is built only in the largest cities with a population of more than 1 million inhabitants in directions with very dense and stable passenger traffic flows. The subway solves the problem of mass rapid passenger transportation, which is beyond the power of street rail transport.

Ensuring traffic safety in the subway is of utmost importance. Not only does the subway transport millions of passengers every day, but also the underground rail track location increases the risk degree. A variety of measuring and diagnostic equipment is used for the right time detection, prevention and elimination of various flaws and disorders of the subway “carriageway”, the tasks and functions of this equipment become more complicated as the subway develops.
The software implements the inspection data presentation in accordance with customer requirements. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track.

**SOFTWARE**

The software provides rail flaw detection and recording by the ultrasonic non-destructive testing method in the speed range from 0 to 140 km/h without reducing the inspection reliability.

The solution' mechanical component is located directly on the bogie of most types of cars between wheelsets and consists of a contactless magnetic centering system; detection system; pneumatic system and couplant supply system. The device is based on the approach of modularity, which simplifies the installation of a vehicle and the replacement of its components during their modernization.

The contactless centering system ensures accurate positioning of detection systems against the rail axis due to the interaction of its permanent magnet magnetic fields with the rail field.

The sliding detection system consists of probe units, the design of which allows to implement any probe configuration. The unit transducers emit ultrasonic waves with different turning angles towards rail head gauge and field faces, which allows to implement inspection without dead zones.

The couplant supply system provides an uninterrupted supply of water that can be heated, to carry out the inspection even at low temperatures.

**ADVANTAGES**

- Inspection speed up to 140 km/h.
- Use of sliding detection systems.
- Simple design.
- High reliability level exceeding 95%.
- Unobstructed passage of any turnouts.
SOKOL AUTOMATED SYSTEM FOR INSPECTION AND ASSESSMENT OF THE TRACK GEOMETRIC PARAMETERS

The system uses a mechanical chord scheme, allowing to perform the measurement at any time of the day in any weather and climatic conditions. SOKOL features: high accuracy, reliability, high maintainability, ease of maintenance and operation, no need of high requirements for the staff qualification.

PRODUCT PURPOSE AND COMPOSITION

SOKOL allows to monitor and assess the rail track geometry parameters at the main and secondary railway track sections and identify deviations from the maintenance standards. At the same time, the condition of the studied area facilities is recorded: artificial structures, level crossings, turnouts, etc. The system track measuring equipment is a set of sensors located on three or four mechanical measuring bogies, which are installed on the car body and frames of driving bogies. This design allows to read the data and make accurate measurements at speeds up to 100 km/h.

SOFTWARE

The data obtained during the travel goes to the on-board control and computing system, which converts the measuring mechanism movements into electrical signals and, based on their analysis, identifies the main and additional track geometry parameters. Simultaneously, additional information is collected on travel speed and time, on turnouts, etc. Processing the main and additional information, the control and computing system reveals deviations of the track geometry parameters from the maintenance standards. Then, any deviation receives both quantitative and qualitative assessment and is bound to specific coordinates. All received information is processed in real time.

SCOPE OF APPLICATION

The network of railways and subways.

ADVANTAGES

— Inspection speed up to 100 km/h.
— Low cost.
— High reliability level.
SOKOL-2.3 HIGH-SPEED RAIL PROFILE AND TRACK GEOMETRY MEASUREMENT SYSTEM

The main and additional track geometry parameter measurement system SOKOL-2.3 uses optical triangulation sensors in combination with the strapdown inertial navigation system (IMU). Such a combination of measurement equipment made it possible to build a system that can be installed on almost any diagnostic tool, including hybrid road-rail vehicles and even trolleys, and is able to operate in one section, unlike chord systems, and also make high-precision measurements at speeds up to 250 km/h, since there is no contact with the measured facility — the rail.

PRODUCT PURPOSE AND COMPOSITION

An installation scheme of double triangulation units per rail is used to obtain a complete rail head profile. Due to the three-dimensional cameras monitoring the rail external side, it is possible to assess its wear and all the necessary additional parameters from a non-gauge face. The installation of dual triangulation units provides a single line of illumination by the main and additional lasers, which allows to increase the power, intensity and quality of their radiation and provides an automated analysis of the track superstructure elements from the gauge and field rail side. Equivalent conicity monitoring with a full rail profile inspection system allows maintaining the proper level of traffic safety at high-speed railway sections.

The SOKOL-2.3 system uses double laser illumination on both sides of the rail, which makes it possible to increase the intensity of the reflected laser radiation into the measuring chamber. To combat rain, snow, dust, etc., pre-cleaned air is supplied in front of the optical profilometer glass under pressure.

SOFTWARE

The modular INTEGRAL software collects, displays and analyzes data and forms output lists. It has a distributed architecture, which allows you to physically and/or logically separate the client and server parts, group measurement systems in any configuration and flexibly configure the automated workstations of operators in terms of the displayed data.

SCOPE OF APPLICATION

The network of railways and subways.

ADVANTAGES

— High inspection speed (up to 250 km/h).
— Compact, lightweight and simple design.
The rail corrugation, manifested in the form of periodic irregularities on the rail head, leads to intense noise, impairs the train movement smoothness and reduces the track superstructure and rolling stock element service life. To determine this flaw, in 2018, we created a system for the rail corrugation measurement. Having several integration interfaces, it, if necessary, can be integrated into the existing mobile unit measuring system.

**RAIL CORRUGATION MEASUREMENT SYSTEM**

The device is designed to collect data on the rail head corrugation depth and length during the movement along the surveyed track section. The system includes measuring modules for high-precision measurement at a wide range of speeds. The modules are installed on a car bogie, one on each side. Their centering is carried out with permanent magnets, which direct the whole system and position the sensors to ensure measurement accuracy. Compressed air is used to protect the system optical windows from dirt and dust. Computer equipment is installed in a telecommunication rack inside a mobile unit.

**PRODUCT PURPOSE AND COMPOSITION**

**SOFTWARE**

All obtained information on the parameters of the identified deviations from the maintenance standards is processed in real time, recorded and documented for further analysis and planning of works on the routine track maintenance and repair. The software generates output forms in tabular and graphical displays for all parameters and issues customizable measurement reports. For irregularities in each of the measured ranges, the number of threshold value excesses for the selected profile, the average RMS amplitude value and the average RMS error amplitude value are calculated. The percentage excess ratio for these values is also calculated.

**SCOPE OF APPLICATION**

The network of railways and subways.

**ADVANTAGES**

- Performing direct irregularity measurements.
- High accuracy and speed of measurements (up to 160 km/h) according to the standards of both the Russian Federation and EN in the wavelength range from 0.15 m to 3.5 m.
- Non-contact magnetic tracking system.
- Ability to integrate into the existing measuring system of a mobile unit.
In order to automate the process and eliminate the “human factor” influence on the results of periodic rounds and inspections of infrastructure sections, we have created the SVOD video surveillance system. It is a hardware and software solution for inspection of railway infrastructure with the ability to output and store video recordings of the received image in special software.

**PRODUCT PURPOSE AND COMPOSITION**

The SVOD system is designed for railway infrastructure inspection and control during the measuring train movement and allows the operator to locate places where an emergency can occur due to the damage or lack of any element.

The system can be installed on any mobile unit and allows to perform:

- continuous inspection and visual control of all railway infrastructure facilities;
- recording and processing of high-resolution images from cameras placed on a mobile unit.

The equipment design allows to place it both on the car body, and on various types of carriage bogies. For more efficient operation, SVOD can be equipped with systems for heating, dust extraction, mechanical cleaning and washers for external glazing. All received video data is precisely bound to the track and geographic coordinates.

**SOFTWARE**

The software implements the inspection data presentation in accordance with customer requirements. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track. It is also possible to compare the obtained data with the data of other diagnostic systems installed on the mobile unit.

**ADVANTAGES**

- High inspection speed.
- Automatic switching of day/night modes.
- High photosensitivity.
- Operation in a wide range of temperatures.
- Efficient lighting system that guarantees the sharp image at very short shutter speeds of the camera.
- Compact, lightweight and simple design.

**SCOPE OF APPLICATION**

The network of railways and subways.
In order to improve the quality and optimize the railway track superstructure element inspection by increasing the operating speeds, we have created the SVOD-2 visual flaw detection system.

**PRODUCT PURPOSE AND COMPOSITION**

The system is designed for automated visual inspection of the track superstructure element condition and real-time post-processing of the obtained data. One of the system main components are high-speed linear cameras capable of high-resolution shooting in the speed range from 0 to 250 km/h.

The system operating approach is based on the visual detection of the track superstructure element surface flaws with linear cameras. The resulting image is digitized and transmitted via a high-speed interface to the server, where data is recorded for later evaluation. SVOD-2 allows real-time and post-processing inspection of missing bolts, fishplate condition, joint gaps, bond flaws, rail bond and sleeper condition, surface rail flaws, rail bar displacement against the guide sleepers. The equipment design allows to place it on the car bogie and survey the track superstructure elements within the assembled rails and sleepers. For more efficient operation, SVOD-2 is equipped with a blowing system using compressed air. All received video data is precisely bound to the track and geographic coordinates.

**SOFTWARE**

Analytical software allows to solve a number of problems in identifying flaws in infrastructure, depending on the customer needs. The data recording and analysis system provides real-time lossless image compression, increasing the autonomous session period without data archiving. It is possible to compare the obtained data with the data of other diagnostic systems installed on the mobile unit.

**SCOPE OF APPLICATION**

The network of railways and subways.

**ADVANTAGES**

- Automated analysis of the track superstructure element flaws with up to 95% reliability.
- High speed inspection in real time.
- Track inspection for several parameters simultaneously.
- Operation in a wide range of temperatures.
- Compact, lightweight and simple design.
- Advanced identification of places with a possible threat to traffic safety.
GABARIT-M HIGH-SPEED SPATIAL SCANNING SYSTEM FOR THE RAILWAY INFRASTRUCTURE FACILITIES

One of the most laborious tasks in the conditions of growing speeds and volumes of cargo transportation is the maintenance of tunnels and artificial structures. To facilitate the fulfillment of the tasks of diagnosing these facilities, we have developed the high-speed spatial scanning system GABARIT-M.

PRODUCT PURPOSE AND COMPOSITION

The system combines from 1 to 6 high-speed laser scanners that provide impressive results and a minimum distance between the survey cross-sections while maintaining a high point cloud resolution. Due to the system, it is possible to measure infrastructure facilities at speeds from 0 to 250 km/h year-round. High equipment accuracy and manufacturing quality make it possible to achieve at high speeds the minimum measurement error in the entire operating range. The system integration capabilities provide the sharing of scan data and information from video inspection and track measuring tools. GABARIT-M can be used on high-speed rail lines without track time allocation for infrastructure inspection.

SOFTWARE

The innovative filtration and compression system allows to use only the really necessary information, and smart data analysis algorithms and modules of integration with customer information systems allow to quickly integrate our measuring systems into the diagnostic technology used by the customer. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track. The program modules form analytical and reporting data on the violations of obstruction clearance, width of distances between tracks, outlines of the ballast section and the roadbed, oversized railway platforms.

ADVANTAGES

- High inspection speed.
- Unique software that has no equivalent in the world.
- Operation in a wide range of temperatures.
- Compact, lightweight and simple design.

SCOPE OF APPLICATION

The network of railways and subways.
CONTACT RAIL POSITION AND TEMPERATURE INSPECTION SYSTEM

The contact rail position and temperature inspection system was developed by TVEMA exclusively for the subway and was first used at the SYNERGY-1 diagnostic solution in the Moscow subway.

PRODUCT PURPOSE AND COMPOSITION

The system is designed to identify the spatial position (horizontal and vertical) of the contact rail and perform video inspection of its condition, including the condition of its nodes, brackets and boxes, and identify its temperature.

The system uses two types of optical triangulation sensors to monitor the contact rail position against the running rail. Due to this, the system does not have contact with the measured facility (contact rail) and it can work while the train is moving at a set speed, when the contact rail is energized. Since the subway equipment clearance allows to place only a rather compact object, the contact rail optical unit uses a system of mirrors to rotate the laser beam and image (the camera and the laser are located in this unit at an angle of approximately 90 degrees to the contact rail). The system compact design makes it possible to install it on almost any mobile unit by maximum two people. To combat precipitation and dust, pre-cleaned air is supplied in front of the optical profilometer glass under pressure.

SOFTWARE

The modular INTEGRAL software collects, displays and analyzes data and forms output lists. It has a distributed architecture, which allows you to physically and/or logically separate the client and server parts, group measurement systems in any configuration and flexibly configure the automated workstations of operators in terms of the displayed data.

SCOPE OF APPLICATION

The network of subways. Applied on diagnostic solutions of the SYNERGY project in the Moscow and Baku subways.

ADVANTAGES

— High inspection speed.
— Unique software.
— Operation in a wide range of temperatures.
— Compact and lightweight design.
YANTAR SYSTEM FOR NON-CONTACT TRACK COORDINATE CORRECTION AND RAILWAY VEHICLE POSITIONING

The YANTAR system was first used in the Moscow subway.

PRODUCT PURPOSE AND COMPOSITION

The system allows to position vehicle in the subway by reading information located directly in the sleeper (label) and transmitting it to the vehicle.

System components:
— passive floor label (positioning sensor) located directly in the sleepers of all types;
— data reading and writing device located directly in the vehicle body;
— antenna (possibly several), located under the vehicle body.

Using the method of non-contact data search, identification and reading, the system solves the following tasks:
— automation and improvement of accuracy of the vehicle track coordinate identification;
— elimination of the “human factor” influence on obtaining reliable information about the vehicle or hand-held diagnostic tool location;
— increase of the reliability and efficiency of data transfer from a diagnostic vehicle to a track repair tool;
— acceleration of the track maintenance and routine repair tool search and precise positioning on the track section;
— recording and storing of data on the track data sheet;
— specifying of turnouts, bridges, tunnels, level crossings for track diagnostic, maintenance and routine repair tools;
— recording of the service information.

SOFTWARE

The software is fully integrated into the INTEGRAL solution, for which the YANTAR system is a data provider. Any available protocols can be used for data transmission.

ADVANTAGES

— High inspection speed.
— Ability to integrate into existing software.
— Operation in a wide range of temperatures.

SCOPE OF APPLICATION

The network of subways.
THERMAL IMAGING INSPECTION SYSTEM

It is very important to monitor the temperature of facilities, improper maintenance or damage of which can affect the subway traffic safety.

PRODUCT PURPOSE AND COMPOSITION

The system was first used in the Moscow subway at the SYNERGY-2 diagnostic solution. It is designed to identify flaws in various types of the subway communications (electrical equipment, water supply, etc.) using the thermographic imaging method. The system is ideal for real-time flaw detection in jumpers, cable lines, secondary winding connections, etc.

The inspection is carried out with thermographs, the readings of which are processed and analyzed by special software. The greatest efficiency can be achieved when inspecting a large number of the same type facilities.

System components:
1. Thermal imaging cameras.
2. Computer.
3. Software package for real-time operation.
4. Software package for post-processing data.

The system functional purpose:
— inspection of the subway artificial structures (tunnels) by the level of thermal radiation;
— assessment of condition of the water supply communications in the tunnel;
— prompt analysis of temperature fields in specified areas.

SOFTWARE

Various thermogram settings allow to select various types of facilities and carry out control as efficiently as possible with a minimum probability of a flaw missing. It has a distributed architecture, which allows to flexibly configure the automated operator workstations in terms of displayed data.

SCOPE OF APPLICATION

The network of subways.

ADVANTAGES

— Prompt inspection and flaw detection.
— Low cost of the inspection.
— Online data export.
— Automation of the diagnostic process.
— Ability to track and predict changes in the technical condition parameters over time.
— Wide range of functional thermographic equipment with various accuracy and speed characteristics.
The software solution is built into the INTEGRAL software, for which the hyperspectral diagnostic system is a provider of data on leakage parameters. Any available protocols can be used for data transmission.

---

**ADVANTAGES**

- Innovative and high-tech approach to diagnostics.
- Automatic measurement of damage parameters in various structures (leaks, mold, etc.).
- Full synchronization with video systems to improve the quality of diagnostics.
- Possibility of installation on any vehicle, including common rolling stock.

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**SOFTWARE**

The software solution is built into the INTEGRAL software, for which the hyperspectral diagnostic system is a provider of data on leakage parameters. Any available protocols can be used for data transmission.

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**SCOPE OF APPLICATION**

The network of subways.
AKSIOMA SYSTEM FOR INSPECTION OF THE TRACK INFRASTRUCTURE CONDITION AND PASSENGER TRAVEL COMFORT

Monitoring is a system of inspection, assessment and forecasting of the current railway infrastructure maintenance quality. Inspection can be carried out both visually and with special instrumentation and systems.

PRODUCT PURPOSE AND COMPOSITION

The AKSIOMA inspection system is designed to obtain data on the track infrastructure condition, and data on the vehicle running smoothness and the passenger travel comfort assessment.

System components:
- Autonomous measuring unit for obtained data processing and binding. The unit is installed on a surface rigidly connected to the vehicle, while the "X" axis on the housing should be oriented along the movement direction.
- Charger.
- Antenna, located in a place that provides reliable signal reception (as close as possible to the window or on the roof). With antenna, the autonomous measuring unit controller carries out automatic data binding for subsequent synchronization with the track coordinate.
- Measuring unit, binding the data to the current geographical coordinate, writes the data to the SD card. Further data processing, visualization and storage is carried out on the workstation computer located on the mobile unit.

SOFTWARE

The TRACK ICAR software monitors the track infrastructure condition and records data on the assessment of the mobile unit running smoothness and the passenger travel comfort.

The software consists of two parts. The first, designed for measurements, is installed in the form of microcontroller firmware.

The second is designed to process, visualize and store data on a computer. The processed measurement results are displayed in the form of graphs on the computer monitor and are archived on the hard disk or external media.

SCOPE OF APPLICATION

The network of railways and subways.

ADVANTAGES

- Compact, lightweight and simple design.
- Does not require special staff training.
- Standard equipment is used for data processing.
Since the 1990s, the aging rate of measuring and diagnostic equipment in domestic subways began to exceed the rate of its renewal, which caused an urgent need to develop and implement inspection tools and software that meet modern requirements.

In the early 2000s, at the request of the Moscow subway management, TVEMA began to develop a new generation of mobile diagnostic tools based on innovative digital technologies. During these years, laboratory cars for flaw detection, track measuring and technical diagnostics of railway automation, telemechanics and communication devices, as well as SYNERGY-1 and SYNERGY-2 diagnostic solutions — the subway counterparts of the INTEGRAL and SPRINTER-INTEGRAL infrastructure diagnostic solutions operated on the country’s railways — were created for the subways in Moscow and St. Petersburg, Beijing and Baku. Today, the Moscow subway operates two high-speed flaw detection cars, one track measuring car and two diagnostic solutions of the SYNERGY project, which makes up 90% of the fleet of all mobile diagnostic tools of the Moscow subway.
FLAW DETECTION CARS

Regular track flaw detection is an integral part of ensuring traffic safety in the subway. Track flaw detection allows to identify any kind of track heterogeneity and microcracks even at the stage of their formation, thereby preventing accidents.

PRODUCT PURPOSE AND COMPOSITION

Flaw detection cars are designed for daily high-speed inspection of the subway station tracks and hauls, providing for the rail flaw detection and recording by the ultrasonic method without reducing the inspection reliability. A flaw detection car based on a regular subway car is equipped with a high-speed ultrasonic rail inspection solution.

The solution’s mechanical component is located directly on the bogie of most types of cars between wheelsets and consists of a non-contact magnetic centering system; detection system; pneumatic system and couplant supply system. The device is based on the approach of modularity, which simplifies the equipment installation on a vehicle and the replacement of its components during their modernization.

The contactless centering system ensures accurate positioning of detection systems against the rail axis due to the interaction of its permanent magnet magnetic fields with the rail field.

The sliding detection system consists of probe unit, the design of which allows to implement any probe configuration. The unit transducers emit ultrasonic waves with different turning angles to the rail head gauge and non-gauge faces, which allows to implement inspection without dead zones.

The couplant supply system provides an uninterrupted supply of water, that can be heated, to carry out the inspection even at low temperatures.

Flaw detection solution ECHO-COMPLEX-3. Distinctive features of the solution are: an increased number of ultrasonic channels, the use of the latest solutions in the field of circuitry and an expanded range of control software functions, which makes it possible to use a new inspection technologies that allows to overcome the previously unattainable for ultrasound speed barrier.

SOFTWARE

The INTEGRAL software and the recording solution synchronize the actions of all diagnostic systems and solutions, while simultaneously recording, processing and analyzing signals and data from various inspection tools. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track.

ADVANTAGES

— Allows to perform rapid infrastructure flaw detection.
— All systems are united by a single software.
— Allows to predict the pre-failure rail condition.
— Operation in a wide range of temperatures.

SCOPE OF APPLICATION

The network of subways.
The data obtained during the travel goes to the on-board control and computing system, which converts the measuring mechanism movements into electrical signals and, based on their analysis, identifies the main (standardized) and additional (non-standardized) rail track gauge geometric parameters. Simultaneously, additional information is collected on travel speed and time, on turnouts, etc. By processing the main and additional information, the control and computing system reveals deviations from the maintenance standards. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track.

The track measuring car allows to monitor and assess the track geometry parameters at the main and minor railway track sections and identify deviations from the maintenance standards. The car is equipped with a SOKOL rapid contact track measuring system. The system track measuring equipment is a set of sensors located on three or four mechanical measuring bogies, which are installed on the car body and frames of driving bogies. This design makes possible to read data at speeds up to 100 km/h and accurately identify the track geometry. Also, during movement, the parameters of the following inspected track section facilities are recorded: km posts, artificial structures, turnouts, etc.

TVEMA track measuring cars with an automated assessment system are a solution for technological inspection of the rail track geometry parameters on the base of standard passenger subway car.

**PRODUCT PURPOSE AND COMPOSITION**

**SOFTWARE**

The data obtained during the travel goes to the on-board control and computing system, which converts the measuring mechanism movements into electrical signals and, based on their analysis, identifies the main (standardized) and additional (non-standardized) rail track gauge geometric parameters. Simultaneously, additional information is collected on travel speed and time, on turnouts, etc. By processing the main and additional information, the control and computing system reveals deviations from the maintenance standards. All received information is processed in real time, recorded and documented for further analysis and planning of works on the routine maintenance and repair of the track.

**SCOPE OF APPLICATION**

The network of subways.

**ADVANTAGES**

- Allows to perform rapid infrastructure diagnostics.
- All systems are united by a single software.
- High reliability level.
- Ability to use technological systems.
Today, the main trend in the development of the subway infrastructure diagnostic and inspection system is aimed at its automation and comprehensive inspection at high speeds. One of the main directions in the innovative technology development is the creation of multifunctional tools that can provide comprehensive diagnostics of the entire subway infrastructure at high speeds in one run.

**PRODUCT PURPOSE AND COMPOSITION**

For the first time in Russia, a unique rapid diagnostic solution was created in 2013 by order of the Moscow subway to monitor the SYNERGY project railway infrastructure. It is based on the standard subway passenger car and is designed for a comprehensive inspection and assessment of the subway railway technical facility condition at high speeds. Many of the solution devices have no equivalents in the world. The solution uniqueness lies in the fact that it combines many different inspection subsystems, allowing to measure and process more than one hundred condition parameters of almost all of the subway railway infrastructure facilities at a high speed and in one run. All obtained data is synchronized by a single track coordinate. On its “board” the solution has various diagnostic and inspection systems manufactured by TVEMA that proved themselves “on the earth surface” (high-speed rail flaw detection, track geometry parameter inspection; track superstructure visual inspection; maximum moving dimensions scanning, RAT and communication device inspection, passenger travel comfort inspection), and the systems specially developed for subways: for recognition of binding to electronic road marking, measurement of contact rail parameters and temperature, thermal imaging inspection and hyperspectral diagnostics.

Through the subway tunnel, SYNERGY moves in the same stream as the passenger trains, without violating their schedule. The instrumentation accuracy allows to carry out all the necessary measurements without the travel speed reduction. Nevertheless, even one vehicle manages to carefully examine each line of the Moscow subway twice each month, while it is one of the longest and busiest subways in the world.

**SOFTWARE**

All of the diagnostic vehicle components are integrated by the INTEGRAL software into a single on-board control and computing solution that receives and processes measurement and video data in real time. Based on them, the quality indicators of all of the subway railway infrastructure facilities are determined and both the schedule for their inspection with mobile diagnostic tools and plans for the routine maintenance and repair of these facilities are optimized. Correspondingly, the costs on diagnostic tool servicing personnel are also reduced.

**ADVANTAGES**

— Does not violate the subway schedule.
— Cost effective.
— Each diagnostic vehicle is able to inspect over 8 thousand km of subway tracks annually.

**SCOPE OF APPLICATION**

The network of subways.
DIAGNOSTIC SOFTWARE AND HARDWARE

One of the ways to increase the economic efficiency of applied inspection and diagnostic tools is to merge existing separate software and products into a single integrated solution.

PRODUCT PURPOSE AND COMPOSITION

INTEGRAL software

Various inspection and diagnostic systems are used to monitor the track condition; they use their own algorithms for data collecting, processing and displaying. Reducing such informational variety to a single generally understandable form is also solved by the INTEGRAL software for railroad track infrastructure analysis. It manages all diagnostic systems and is a unique tool for carrying out effective measurements and data processing. The software allows to centrally monitor and manage the work of all jointly operating subsystems. Such unparalleled methodology provides a high degree of coordination and integration of actions of all inspection elements.

Software consists of a server part and automated operator workstations (WKS) with equal rights, the quantity of workstations is determined only by the convenience of use and the needs of the operating organization.

The server part consists of different, but coordinately operating, modules for data recording and processing. Such a scheme allows to expand the package functionality as much as you like by simply adding new modules. The package is installed on all mobile diagnostic tools manufactured by AO «Firma TVEMA».

Integrated automated system for combinatorial data analysis CASCADE

CASCADE allows comprehensive monitoring, analysis and forecasting of the railway infrastructure condition, joint processing of basic and additional data received from various diagnostic systems of automated monitoring. The return on the CASCADE system implementation is mainly related to the technically justified planning of the railway infrastructure repair and maintenance and the efficient distribution of the necessary resources. Thus, CASCADE allows to switch from a planned preventive maintenance system to a system of repairs according to the actual infrastructure condition.

Module for automated evaluation of data from flaw detection tools ASTRA

The ASTRA module is designed for automated evaluation of measurement data coming from various NDT and TD tools. Using the ASTRA module as part of the INTEGRAL software allows to optimize the inspection frequency and reduce the costs of the rail bed repairs associated with rail breaks due to a flaw being skipped by the operator and evaluator. The ASTRA module has successfully passed acceptance tests at Russian Railways and is recommended for implementation on the railway network.

SCOPE OF APPLICATION

The network of railways and subways.
Above-ground rail transport is an important element of the transport system of any major city. Nowadays, it is presented in many cities of Russia, although not everywhere it operates efficiently. The primary measure to create an efficient transport system is the development of high-speed and accelerated tram line network that ensure the greatest possible regularity of traffic. It is scientifically substantiated that this development must be carried out on the basis of the existing tram network, with the individual section reconstruction and the new line construction. From the whole set of routes of the distributed urban tram track network, it is necessary to determine those that are primarily in need of restoration and repair work. This is facilitated by various diagnostic tools that allow to solve a whole range of the urban transport infrastructure safety problems.

COMPANY PRODUCTS FOR ABOVE-GROUND URBAN RAIL TRANSPORT AND SUBWAYS

Above-ground rail transport is an important element of the transport system of any major city. Nowadays, it is presented in many cities of Russia, although not everywhere it operates efficiently. The primary measure to create an efficient transport system is the development of high-speed and accelerated tram line network that ensure the greatest possible regularity of traffic. It is scientifically substantiated that this development must be carried out on the basis of the existing tram network, with the individual section reconstruction and the new line construction. From the whole set of routes of the distributed urban tram track network, it is necessary to determine those that are primarily in need of restoration and repair work. This is facilitated by various diagnostic tools that allow to solve a whole range of the urban transport infrastructure safety problems.
INFRASTRUCTURE DIAGNOSTIC AND MAINTENANCE SOLUTIONS BASED ON ROAD-RAIL VEHICLES

To solve the problems of inspection and maintenance of the small railway track sections in the early 2000s, TVEMA has mastered the production of a whole series of special hybrid road-rail track maintenance vehicles based on off-road and all-terrain vehicles of domestic and foreign production.

PRODUCT PURPOSE AND COMPOSITION

These vehicles allow to perform a whole range of the small tramway section inspection and diagnostics at low speeds, perform shunting work, promptly deliver repair crews with the necessary equipment to the failure detection sites and perform the rail lubrication.

Due to the hybrid road-rail system, the vehicles can move both on motorways or off-road and on a railway track.

The hybrid road-rail system of these vehicles is controlled by:

— pneumatic circuit that provides air supply to the suspension cylinders;
— hydraulic circuit that provides oil supply to the suspension cylinders.

Especially for such vehicles, we have developed the following unique equipment:

— universal ramps for quick setting and removing them from the railway track with any type of sleepers;
— coupling device for towing them in case of emergency stop on the haul.

The vehicles have a unique traffic safety system. It is equipped with train-stop braking and navigation in GLONASS/GPS coordinates and provides continuous vehicle movement monitoring.

ADVANTAGES

— Independence in the work performance from the railway (tramway) track load and traffic schedules due to coming to the work site and back by road.
— Multiple reduction of operating costs.
— Possibility of using standard inspection and diagnostic systems.
— Possibility of using as a fully functional vehicle.
— Replacement for expensive shunting rolling stock.
— Traffic safety systems.

SCOPE OF APPLICATION

The network of railways, industrial enterprises, urban rail transport and subways.
The device is made on the basis of a cross-country shunting locomobile Mercedes-Benz Unimog. The laboratory is designed for continuous railway infrastructure facility diagnostics using data processing systems with an operating speed up to 40 km/h. The device can be fully used for the urban electric transport infrastructure diagnostics.

**Vehicle modifications**

**LDM SERIES DIAGNOSTIC LABORATORY**

The device is made on the basis of the UAZ PATRIOT SUV and is designed to conduct continuous non-stop rail diagnostics, including:

— rail flaw detection using the ECHO-COMPLEX flaw detector;
— track geometry parameter inspection using the SOKOL-2 non-contact system;
— building and intertrack clearance inspection using the GABARIT-M three-dimensional scanning solution;
— automated track superstructure element video inspection using the SVO-D-2 system.

During its movement, the laboratory clarifies the inspected rail (tram) track section parameters (coordinates of crossings, turnouts, etc.), generates and transmits in real-time track condition data to the relevant service units.

The improved guidance system design provides a more accurate positioning of the detection system on the rail head, reduces the likelihood of damage when passing the turnout, and also allows to increase the inspection speed. The laboratory is capable to perform inspection in the speed range from 0 to 40 km/h and is equipped with a train radio.

**SOFTWARE**

The modular INTEGRAL software collects, displays and analyzes data and forms output lists. Presence of special software with a high level of data processing automation increases the crew work efficiency and reduces labor costs.

**Vehicle modifications**

**DIAGNOSTIC LABORATORY BASED ON MERCEDES-BENZ UNIMOG**

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SHUNTING VEHICLE

The device is based on the UAZ 2363 pick-up SUV and is designed for lubrication of turnouts, frogs, rails in the station (tram) and low-density railway track curves and is a cost effective and efficient alternative to rail lubrication cars. This device was first used at the beginning of 2015 to lubricate station tracks in the Almaty subway.

The vehicle has a unique, previously only car mounted, high-tech rail lubrication system of a new generation. The highest unit efficiency factor, based on smart control, can significantly save material and human resources, and time for rail lubrication — the most important procedure for increasing the service life of car wheels and railway (tramway) bed and ensuring safe traffic on it. Another difference between this device and other used lubrication means is its almost safe impact on the environment.

Vehicle modifications

AVL SERIES EMERGENCY RESPONSE AND RESTORATION LABORATORIES

The AVL-P track emergency response and restoration laboratories, designed specifically for the prompt railway (tram) track, allow quick repair crew delivery to the problem area.

The device is based on GAZ-3284 truck. The AVL-P is able to take on board a repair crew of up to 10 people who can quickly carry out such work as: surfacing, tamping, alignment, urgent replacement of defective rails, etc. For conducting track work, the laboratory can be equipped with various tools, including electric.

The tools can be powered by portable gasoline power generators. Using the emergency response and restoration laboratory, it is also possible to carry out preventive and repair work on the urban electric transport overhead — the corresponding AVL-K modification has been developed for this.

MRK SERIES MOBILE RAIL LUBRICATOR

The device is made on the basis of the UAZ PATRIOT SUV and is designed for lubrication of turnouts, frogs, rails in the station (tram) and low-density railway track curves and is a cost effective and efficient alternative to rail lubrication cars. This device was first used at the beginning of 2015 to lubricate station tracks in the Almaty subway.

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Vehicle modifications

AVL SERIES EMERGENCY RESPONSE AND RESTORATION LABORATORIES

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Vehicle modifications

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The SPRUT-2 ultrasonic two-way flaw detector is an improved modification of the SPRUT flaw detection trolley.

**PRODUCT PURPOSE AND COMPOSITION**

SPRUT-2 is designed for continuous and local (secondary) inspection of rails, welded joints and turnout elements and for the flaw depth determination. The flaw detector uses innovative ultrasonic rail testing technologies with an adaptive threshold for automatic channel sensitivity adjustment and the inspection results evaluation. In its operation, the flaw detector implements an echo-pulse, echo-shadow and echo-mirror inspection methods.

The flaw detector has a built-in geolocation and cellular communication module (LTE/GPS/GLONASS/BEIDOU) for transmitting data to the diagnostic center and a color Touchscreen display with 16,000,000 colors. The product has optimal mass-dimensional characteristics and the trolley design, ensuring an unobstructed passage of any turnouts.

The flaw detector has the following functions:

- manual coordinate adjustment by kilometers and railway milestones;
- data visualization in various forms — A-scan and B-scan;
- data rewind during the inspection process with the scaling function;
- data presentation in the form of ultrasonic beam travel inside a three-dimensional rail model;
- sound alarms when the permissible inspection speed is exceeded, the acoustic contact is lost, etc.
- ability to remotely monitor the operator work in real time with the screenshot receipt at the controlling party initiative.

The SPRUT-2 flaw detection trolley should be serviced by an operator who has undergone special training to work with it. When working on the line, the operator should be accompanied by track supervisor or track foreman.

**SOFTWARE**

The software contains various modules, including a module for automated configuration and a web service in the form of an encrypted cloud Internet server, accessible to authorized users from anywhere in the world. With it, the monitoring of the current flaw detector positions and routes on the map, express decryption of data and download of session files are carried out.

**SCOPE OF APPLICATION**

The network of railways, subways, urban transport and industrial enterprises.

**ADVANTAGES**

- Use of advanced scanning pattern.
- Presence of a control panel with the output of information about the current operation modes.
- Sound and light indication.
- Use of the global positioning system GLONASS/GPS.
- Use of color matrix indicator.
- Data transfer with USB flash drive and via wireless mobile Internet.
SKAT-2 AND SOM SINGLE-RAIL FLAW DETECTORS

New single-rail flaw detectors SKAT-2 and SOM developed by TVEMA differ in their functional and operational parameters from similar products of other manufacturers and have a number of advantages.

PRODUCT PURPOSE AND COMPOSITION

The single-rail flaw detectors are designed for detection, recording and evaluation of signals from flaws in rails of the sections where testing is difficult or unsafe if conducted on both rails simultaneously (rails located in tunnels, on bridges, near passenger platforms and in places with intensive train traffic). SKAT and SOM allow to perform inspection using the echo-pulse and echo-shadow methods both with transducer units and separate manual transducers. The flaw detectors have 14 acoustic channels for continuous inspection and 2 channels for local (manual) inspection, including low-frequency channels. The use of innovative ultrasonic rail testing technology with an adaptive threshold for automatic flaw detector channel sensitivity adjustment and automated inspection result evaluation eliminates the “human factor” influence on the inspection accuracy and results.

The flaw detectors have a built-in geolocation and cellular communication module (LTE/GPS/GLONASS/BEIDOU) for transmitting data to the diagnostic center and a color touchscreen display with 16,000,000 colors. The products operate without occupying the haul. The products are carried manually by one person.

SOFTWARE

The software has an intuitive menu, user-friendly interface and extended functionality. The software has an encrypted cloud server, accessible to authorized users from anywhere. With it, the monitoring of the current flaw detector positions and routes on the map, express evaluation of data and download of session files are carried out.

SCOPE OF APPLICATION

The network of railways, subways, urban transport and industrial enterprises.

ADVANTAGES

— Mobility.
— Sound and light alarms.
— Availability of the automated piezoelectric transducer parameter setting.
— Prompt inspection data transmission via the Internet.
— Use of the global positioning system GLONASS/GPS.
— Use of color matrix indicator.
— Display of the rail inspection results on the 3D model.
— Data transfer with USB flash drive and via wireless mobile Internet.
**PT-10 TRACK MEASURING TROLLEYS**

Trolleys PT-10 are an improved version of PT-7MK and AKNOP trolleys that, for their long production history, have proven to be reliable assistants to middle-level railway specialists, established a certain standard for the same segment products from other manufacturers and became a basis for development of a number of prospecting systems for railway track inspection and diagnostics.

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**PRODUCT PURPOSE AND COMPOSITION**

Computerized track measuring trolley of PT series are designed for inspection, recording and digital indication of the current track coordinate values, track gauge width and the mutual level exceeding of one rail against the other during the track infrastructure construction, operation and repairs. The trolleys measure the track geometry parameters and process the information in the same format as the track measuring cars, they also allow to perform a full-scale analysis of the current track condition and predict its future condition and possible deterioration. Due to the exhaustive hardware and flexible software, reliable and simple design, allowing to operate them in any climatic conditions, these trolleys are in high demand among railway workers in Russia, CIS countries and abroad. PT-10 trolleys are produced with a modified touchscreen display and a microprocessor, which uses modern innovative technologies that provide more comfortable working conditions for the operator. The trolleys can be used at the railway sections both with and without automatic block signaling system.

The PT-10 track measuring trolley should be serviced by an operator who has undergone special training to work with it. When working on the line, the operator should be accompanied by track supervisor or track foreman. The product works without occupying the haul. The product is carried manually by one person.

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**SOFTWARE**

The software allows data processing to identify the measured parameter deviation from the maintenance standards, received data storing with a qualitative assessment of the track facility condition, forming and exporting the output report forms to the analytical center or service units.

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**ADVANTAGES**

— Simple design.
— Portable.
— Modular design.
— Unique mass-dimensional characteristics.
— Export of received data to operational units.
— Use of the global positioning system GLONASS/GPS.
— Use of color matrix indicator.
— Operation in a wide range of temperatures.

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**SCOPE OF APPLICATION**

The network of railways, subways, urban transport and industrial enterprises. Computerized track measuring trolleys of the PT series are one of the most popular and high-demand TVEMA products.
The software collects and processes data on the track geometry parameter condition to identify deviations from maintenance standards with their quantitative and qualitative assessment, stores the received data, generates and exports the output report forms to the analytical center or service units.

Using INTEGRAL software, additional data (spatial scanning of railway infrastructure facilities and integrated video surveillance of the track condition) are processed.

The network of railways, subways, urban transport and industrial enterprises.

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**PRODUCT PURPOSE AND COMPOSITION**

In addition to measuring the track gauge, the relative position of both rails by height (level) and the length of the path traveled, the PT-12M and PT-12-01 solutions can additionally measure:

- bend of each rail in a vertical plane (vertical alignment or sag);
- bend of each rail in a horizontal plane (horizontal alignment);
- short irregularities on the rail running surface (corrugations);
- long irregularities in the plane and profile;
- longitudinal track profile;
- longitudinal track profile angle;
- track condition in the plane (curve cards).

The solutions are used at the rail track sections both with and without automatic block signal system. The device is carried manually by two people.

The solutions are capable to:

- perform a three-dimensional scanning of the railway infrastructure facilities (bridges, tunnels, platforms, etc.);
- perform an automated assessment of the contact rail geometric position (vertical and horizontal);
- perform integrated video surveillance of the track condition;
- monitor lateral and vertical wear, canting, tilt of the rolling surface;
- perform binding to the track coordinates by kilometer and/or milestones.

* these functions are implemented only in the PT-12M trolley.

Product components:
- trolley frame;
- data acquisition and preprocessing system;
- software and hardware unit;
- workstation with application software;
- power module and charger.

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**SOFTWARE**

The software collects and processes data on the track geometry parameter condition to identify deviations from the maintenance standards with their quantitative and qualitative assessment, stores the received data, generates and exports the output report forms to the analytical center or service units. Using INTEGRAL software, additional data (spatial scanning of railway infrastructure facilities and integrated video surveillance of the track condition) are processed.

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**ADVANTAGES**

- Wide range of monitored parameters.
- Simple design.
- Mobility.
- Large operating life of the measuring equipment.
- Data export to the analytical center and service units.
- Use of the global positioning system GLONASS/GPS.
- Operation in a wide range of temperatures.

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**SCOPE OF APPLICATION**

The network of railways, subways, urban transport and industrial enterprises.
Digital technologies are being increasingly introduced on the railways. In particular, the common track gauge, a tool for measuring the track geometry and turnout parameters, has changed dramatically.

**PRODUCT PURPOSE AND COMPOSITION**

Digital track gauges are designed to measure, visualize and transmit data for further processing of the railway track and turnout geometrical parameters, as well as to verify and calibrate the measuring channels of vehicular track-measuring infrastructure diagnostic tools.

The product is used on the tracks and turnouts of all classes, both in operation and under construction.

Product components:

- rod made of aluminum or modern composite materials, equipped with a handle to carry and abut, as well as to ensure perpendicularity when installing the gauge on the rails;
- sensors for track geometry parameter measuring;
- temperature sensors;
- electronic unit with non-volatile memory and an interface for data managing, visualizing, storing, processing and transmitting. To determine the measurement location, the electronic unit is equipped with the GLONASS/GPS system.

If it is necessary to transfer the measurement results to a remote computer, the tool can be supplemented with a smartphone.

The product operates without occupying the haul. The product is carried manually by one person.

**SOFTWARE**

The software consists of two parts: one is installed as a firmware on the electronic unit, the second is installed on a smartphone.

The first, installed directly on the gauge, receives, preprocesses and visualizes the data from the electronic unit. The second, installed on the smartphone, ensures the data reception from the gauge’s electronic unit, their primary processing and storage, visualization, initial filling of the established document forms, as well as the Internet transmission of results to the railway infrastructure management system.

**SCOPE OF APPLICATION**

The network of railways, subways, urban transport and industrial enterprises.

**ADVANTAGES**

- Wide range of monitored parameters of the turnouts and track sections.
- Simple design.
- Simple interface.
- Mobility.
- Small weight.
- Ability to perform diagnostics of the track with different track gauge width.
DRED SERIES SELF-PROPELLED ELECTRIC RAILWAY INSPECTION CARS

The newest product of the company, designed to monitor and diagnose the infrastructure of low-density sections of railways, subways, urban rail transport, as well as access tracks of industrial enterprises.

PRODUCT PURPOSE AND COMPOSITION

Mobile infrastructure diagnostic car DRED

Infrastructure diagnostic car DRED allows to test the railway track sections in the range of operating speeds from 0 to 20 km/h and is a self-propelled trolley on an accumulator battery drive equipped with various inspection and diagnostic systems.

At the customer request, DRED can be equipped with diagnostic systems for:
- ultrasonic rail testing;
- track geometry parameter inspection;
- railway infrastructure condition visual inspection;
- railway infrastructure facility three-dimensional scanning.

The solution has design versions for various track gauge widths and can be operated in a wide range of climatic conditions.

Depending on the modification, the DRED series railway inspection cars are also capable of solving the following problems:
- ballast section herbicide treatment;
- prompt delivery of track crews and necessary maintenance equipment to the scheduled and urgent work location. The railway inspection car may be additionally equipped with a trailer, almost doubling the loading capacity (up to 1000 kg in total).

SOFTWARE

It is a smart automated system that ensures recording of primary data on detected faults, its real-time processing, long-term storage and documentation for subsequent analysis.

SCOPE OF APPLICATION

The network of railways, subways, urban rail transport and industrial enterprise railways.

ADVANTAGES

- Compact design.
- Small weight.
- Versatility, depending on the tasks.
- Mobility.
- Environmentally friendly.