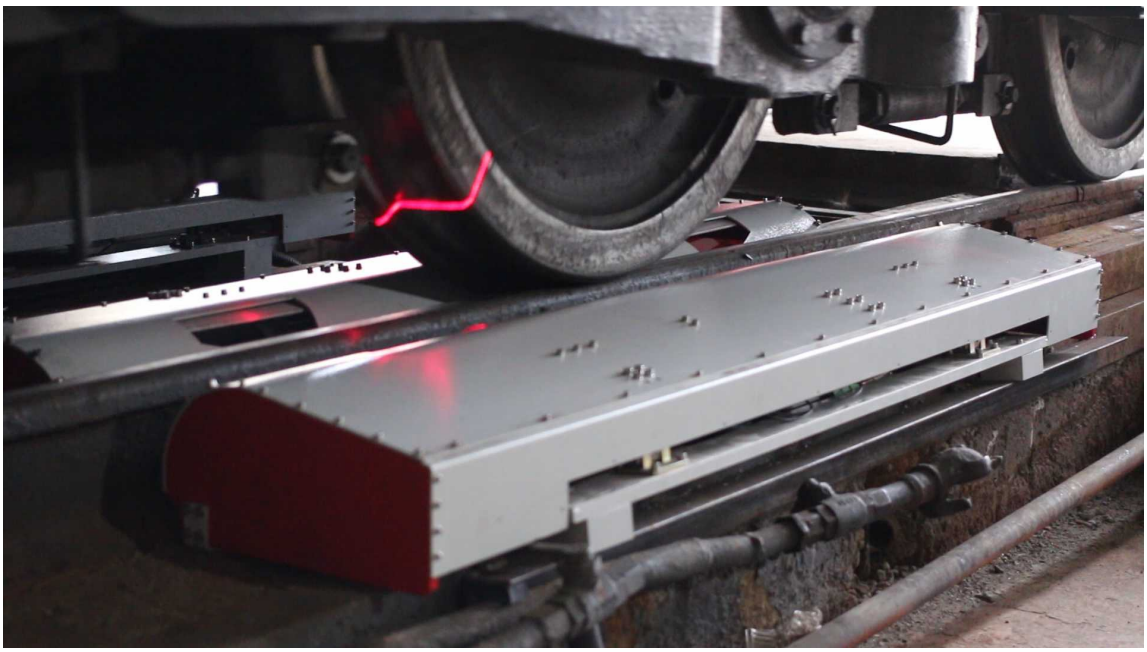
RIFTEK
Sensors & Instruments



REAL TIME WHEELS GEOMETRY MEASUREMENT SYSTEM

3DWheel Series

User's manual

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Contents

1. Safety precautions and measurement conditions

- Use supply voltage and interfaces indicated in the system specifications.
- In connection/disconnection of cables, the system power must be switched off.
- The system must be grounded. All power cables must be shielded.

2. CE Compliance

The system has been developed for use in industry and meets the requirements of the following Directives:

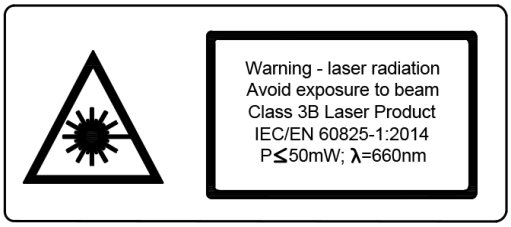
- EU directive 2014/30/EU (Electromagnetic compatibility).

3. Laser safety

The 3DWheel system includes laser scanners RF627, which correspond to the 2M or 3B safety classes according to IEC/EN 60825-1:2014.

3.1. Class 3B scanners

The scanners make use of a c.w. 660 nm wavelength semiconductor laser. Maximum output power is 50 mW. The scanners belong to the 3B laser safety class. The following warning label is placed on the scanner body:

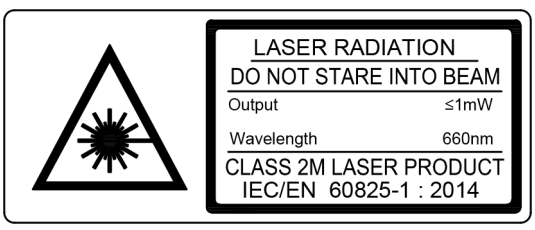


The following safety measures should be taken while operating the scanners:

- Do not target the laser beam to humans.
- Avoid staring into the laser beam through optical instruments.
- Mount the scanner so that the laser beam is positioned above or below the eyes level.
- Mount the scanner so that the laser beam does not fall onto a mirror surface.
- Use protective goggles while operating the scanner.
- Avoid staring at the laser beam going out of the scanner and the beam reflected from a mirror surface.
- Do not disassemble the scanner.
- Use the laser deactivation function in emergency.

3.2. Class 2M scanners

The scanners make use of an c.w. 660 nm or 405 wavelength semiconductor laser. Maximum output power is 1 mW. The sensors belong to the 2M laser safety class. The following warning label is placed on the scanner body:



The following safety measures should be taken while operating the scanners:

- Do not target the laser beam to humans.
- Do not disassemble the scanner.
- Avoid staring into the laser beam.

4. General information

The 3DWheel system is designed for non-contact automatic measurement of geometrical parameters of wheelsets. The system uses a combination of 2D laser scanners RF627 Series mounted wayside in the track area and calibrated into one common coordinate system. All measurements are performed in the real-time mode.

The main advantages of the system are as follows:

- Measurements are performed on moving trains.
- A modular structure allows to configure the system to customer's requirements (landscape, climatic and technical conditions).
- Automatic recognition of the train number and automatic start of the measurement process.
- Non-contact measurement method.
- Taking a full profile of the wheel rolling surface.
- Control of geometrical parameters of railway wheels:
  - Wheel profile
  - Flange height
  - Flange thickness
  - Flange slope
  - Root wear
  - Wheel tread hollow
  - Wheel rim thickness
  - Flange rollover
  - Tread rollover
  - Wheel diameter
  - Wheel width
  - Back-to-back distance
- Generating reports in CSV format with the ability to export data to other systems (integration into existing infrastructure).
- Ability to receive data by email or SMS.
- Electronic database of the railway wheels wear.
- Autonomous operation - there is no need to control the measurement process.
- The system is very easy to install due to a modular structure.
- The system has protection against climatic and technogenic factors such as rain, snow, dust, lubricating fluid.

5. Basic technical data

Measurement range	
Parameter	**Value**
Flange height, mm	20...45
Flange thickness, mm	20...50
Flange slope, mm	1...15
Rim thickness, mm	30...100
Tire width, mm	20...120
Wheel diameter, mm	400...1400
Back-to-back distance, mm	according to the track width
Measurement error	
Parameter	**Value**
Flange height, mm	± 0.5
Flange thickness, mm	± 0.5
Flange slope / qR factor, mm	± 0.5
Root wear, mm	± 0.5
Wheel tread hollow, mm	± 0.5
Wheel rim thickness, mm	± 1.0
Flange rollover, mm	± 0.5
Tread rollover, mm	± 0.5
Wheel width, mm	± 1.0
Back-to-back distance, mm	± 1.0
Other technical data	
Parameter	**Value**
Power supply (control cabinet), V	220 (AC)
Power supply (air conditioning system), V	380 (AC)
Power consumption (control cabinet), kW	1 (voltage 220, 50 Hz)
Power consumption (air conditioning system), kW	summer: 3 (voltage 380) winter: up to 16 (voltage 380)
Operating temperature, °C	0…+50
Relative humidity, %	5-95 (no condensation)
Enclosure rating	IP67

6. Structure and operating principle

The 3DWheel system has a modular and open configuration, which makes it possible to adapt it to any types of railroad tracks and railway wheels, and to reduce the technical maintenance to a minimum.

A functional diagram of the system is shown in Figure 1.

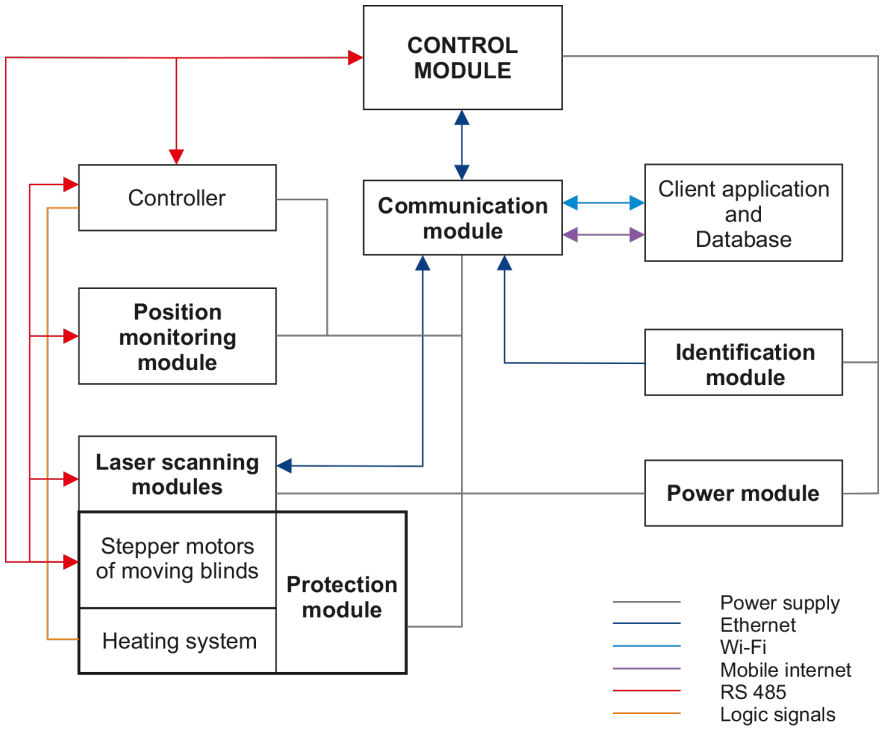


Figure 1

The main modules of the 3DWheel system are as follows:

1) **Laser scanning modules**. These modules are intended for scanning of the wheelset. They contain 2D laser scanners RF627 Series mounted wayside in the track area and calibrated into one common coordinate system.

2) **Air conditioning and protection module**. It is intended to maintain a stable temperature inside laser scanning modules, and for mechanical protection of laser scanners against any possible damage and contamination.

3) **Position monitoring module**. It is intended to monitor the position of the wheel relative to the laser scanning modules. This module contains inductive sensors mounted wayside in the track area, which run the scanning process when the wheelset is detected.

4) **Identification module**. It is intended to identify the train number. The module contains the RFID registration system.

5) **Control module**. It is intended to coordinate the operation of all modules of the system, to gather data, to create a mathematical model of the wheel profile, to calculate required geometrical parameters, and to generate reports to send to the operator.

6) **Communication module**. It is intended for remote access to the 3DWheel system in order to test it, to change settings, and to transmit data to a depot.

7) **Power module**. It is intended to provide a stable power supply of all 3DWheel modules. It guarantees the uninterruptible power supply for 60 minutes in a case when an external mains voltage is lost.

The 3DWheel system also includes a controller of RF700 series (see Annex 1). It controls the air conditioning cabinet, the power of the laser scanning modules and HTC boards in scanners, as well as the power of the moving blinds. It processes signals from four inductive sensors and generates sync pulses for scanners.

The 3DWheel system operates as follows.

The **Position monitoring module** detects the rolling stock. When the rolling stock is detected, the **Control module** turns on the **Laser scanning modules** and opens the protective blinds. The **Identification module** recognizes the train number. The **Position monitoring module** detects the wheels, and the **Laser scanning modules** start the scanning process. The **Laser scanning modules** are taking the wheel profiles when the wheelset is going through the control area. Data gathered from all scanners are transmitted to the **Control module** for calculation of geometrical parameters of the wheels. The received data are grouped and the **Communication module** sends them to the client application and to the database.

6.1. Laser scanning modules

Laser scanning modules consist of a combination of 2D laser scanners RF627 Series mounted wayside in the track area and calibrated into one common coordinate system. These modules scan the wheel surface and then transmit data to the **Control module** for calculating geometrical parameters of the wheels.

Operation of the scanners is based on the principle of optical triangulation (see Figure 2).

Radiation of a semiconductor laser is formed by a lens in a line and projected to an object. Radiation scattered from the object is collected by the lens and directed to a two-dimensional CMOS image sensor. The image of object outline thus formed is analyzed by a FPGA and signal processor, which calculates the distance to the object (Z-coordinate) for each point of the set along the laser line on the object (X-coordinate). Scanners are characterized by the beginning of the range (SMR) for Z-coordinate, measuring range (MR) for Z-coordinate, measuring range for X-coordinate at the beginning of Z (Xsmr) and measuring range for X-coordinate at the end of Z (Xemr).

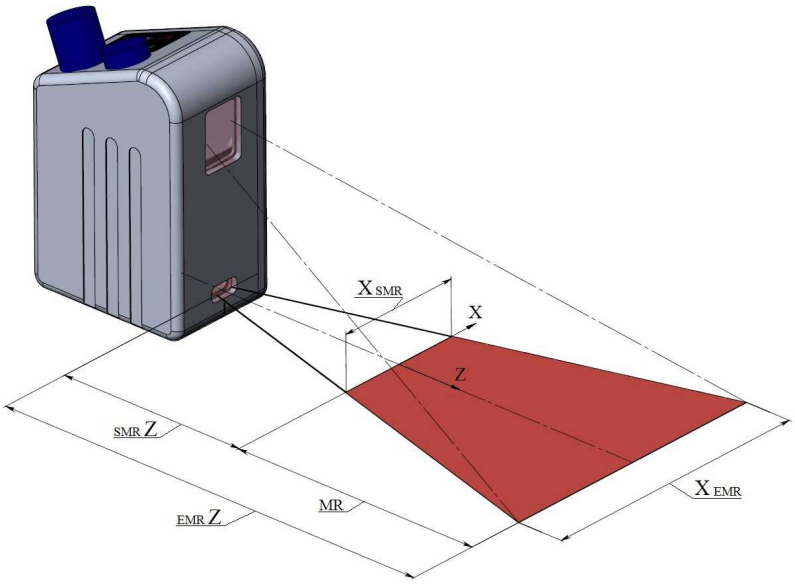
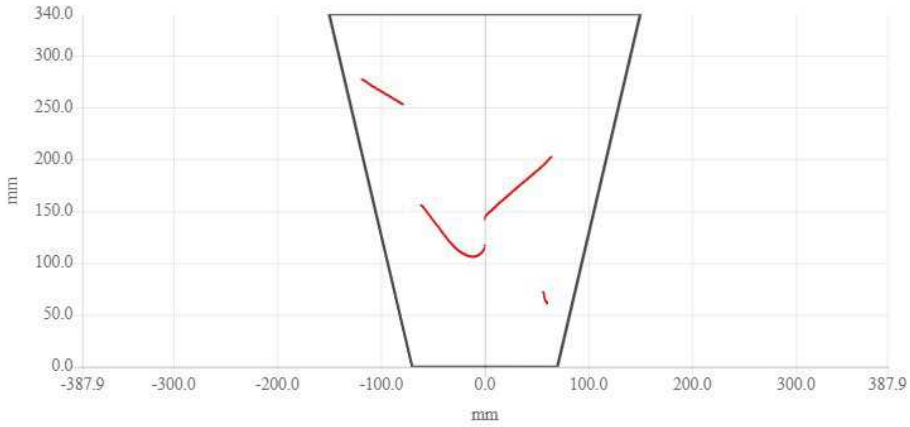


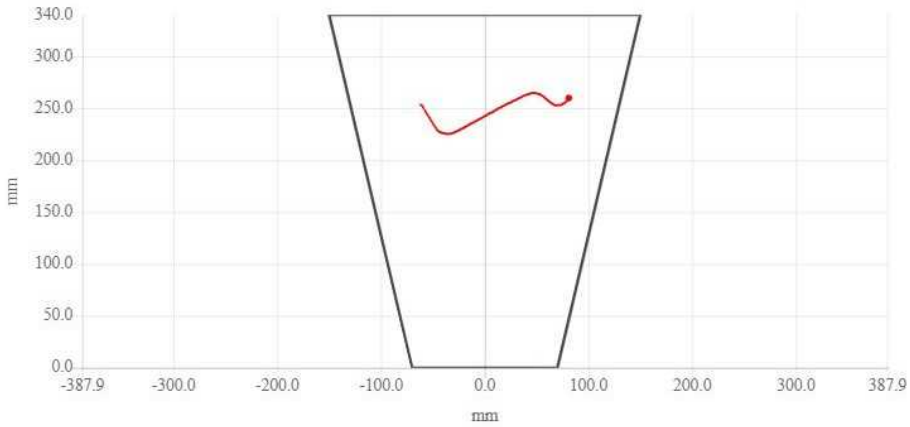
Figure 2

Below are the wheel profiles obtained by the scanners when measuring the wheelsets. The first profile is obtained by the scanner from the inner side of the rail, the second profile is obtained from the outer side of the rail. The obtained profiles are sent to the **Control module** for further calculations.

Inner side:



Outer side:



Modules containing two scanners are placed on the outer side of the rail. Modules containing three scanners are placed on the inner side of the rail. In order to avoid mutual influence on each other, scanners located on the opposite sides of the rail have lasers of different wavelengths (RED and IR).

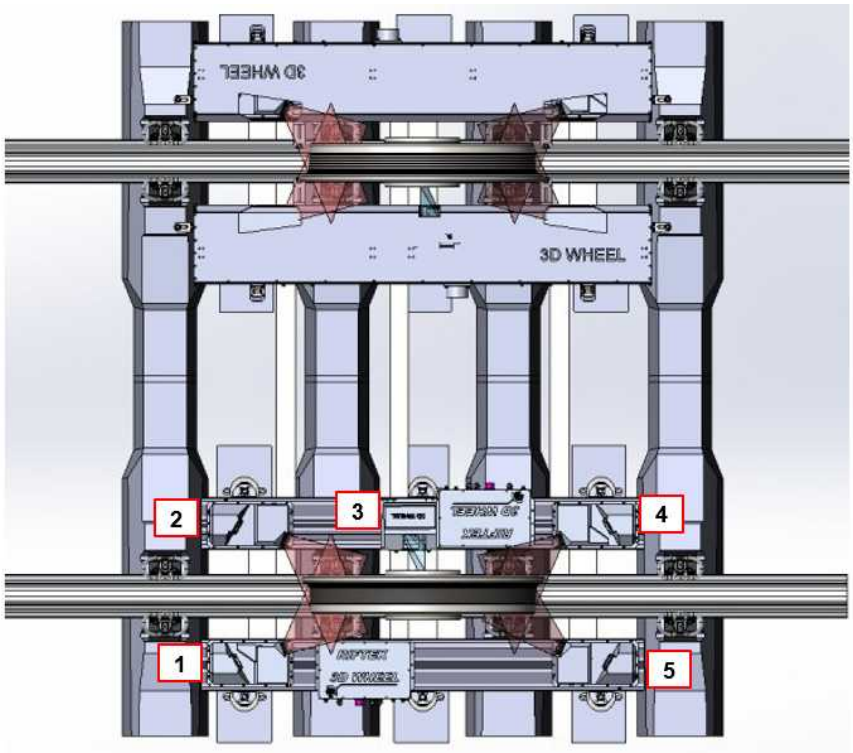


Figure 3

After detecting the wheelset, the laser scanning modules are activated and scan the wheelsets when the rolling stock is passing through the control area. Upon completion of the scanning process, laser scanning modules will be turned off.

Three scanners (#2, #3 and #4 - see Figure 3) are used to measure the wheel diameter. In the calculations, a three-point method is used to determine the position and diameter of the wheel, as well as the method of averaging by measuring in several positions of the wheel while passing through the control area.

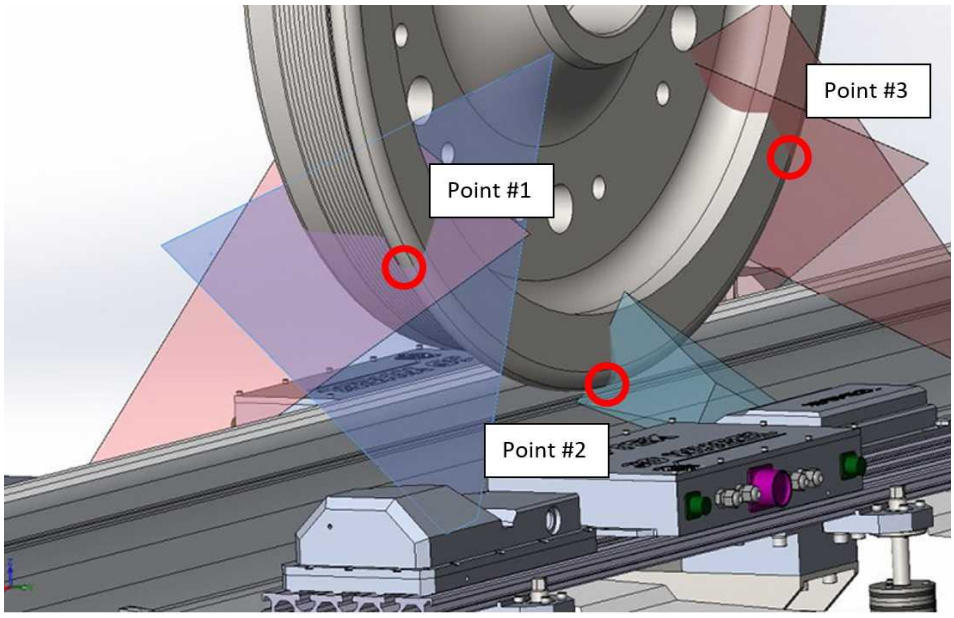
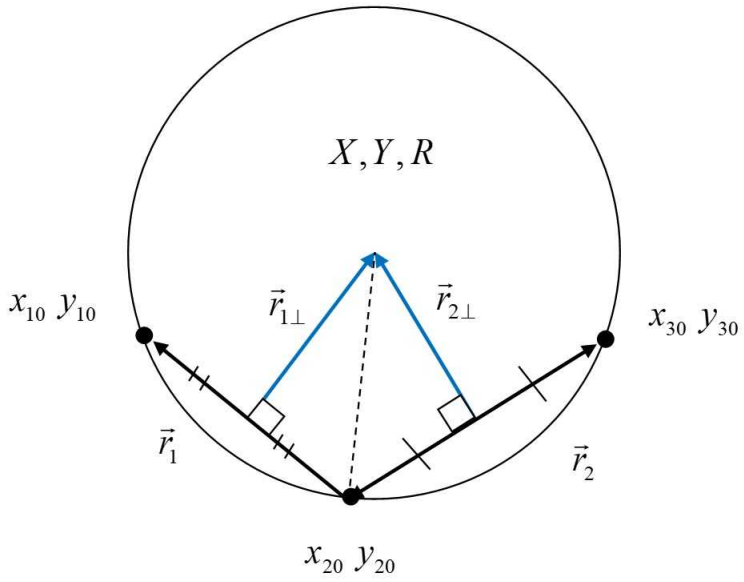


Figure 4

Three-point method

Calculation of the wheel center coordinates and the wheel radius:



Geometric way to find the center of a circle:

1) Three points are randomly selected on the arc.
2) The selected points are connected with segments (chords).
3) Perpendiculars are specified to the segments through their midpoints.
4) The intersection point of the perpendiculars defines the position of the circle center.

Calculations

The coordinates of the vectors perpendicular to the chords of the circle:

$$\vec{r}_{1\perp} = (X - (x_2 + \frac{x_1 - x_2}{2}), Y - (y_2 + \frac{y_1 - y_2}{2}))$$

$$\vec{r}_{2\perp} = (X - (x_2 + \frac{x_3 - x_2}{2}), Y - (y_2 + \frac{y_3 - y_2}{2}))$$

The condition of orthogonality of vectors $\vec{r}_1$ and $\vec{r}_{1\perp}$, $\vec{r}_2$ and $\vec{r}_{2\perp}$ according to which the scalar product of vectors is equal to zero:

$$(X - (x_2 + \frac{x_1 - x_2}{2})(x_1 - x_2) + (Y - (y_2 + \frac{y_1 - y_2}{2}))(y_1 - y_2) = 0$$

$$(X - (x_2 + \frac{x_3 - x_2}{2})(x_3 - x_2) + (Y - (y_2 + \frac{y_3 - y_2}{2}))(y_3 - y_2) = 0$$

Thus, we obtain a system of linear equations with two unknowns X and Y.

Solution

$$X = \frac{1}{2(x_1 - x_2)}(x_1^2 - x_2^2 + y_1^2 - y_2^2 - 2Y(y_1 - y_2))$$

$$Y = \frac{1}{2(y_3 - y_2)}(x_1^2 - x_2^2 + y_1^2 - y_2^2 - \frac{(x_3^2 - x_2^2 + y_3^2 - y_2^2)(x_3 - x_2)}{(x_1 - x_2)})$$

Circle radius

$$R = \sqrt{(X - x_2)^2 + (Y - y_2)^2}$$

The wheel profile is assembled by two pairs of scanners: #1-2 and #4-5.

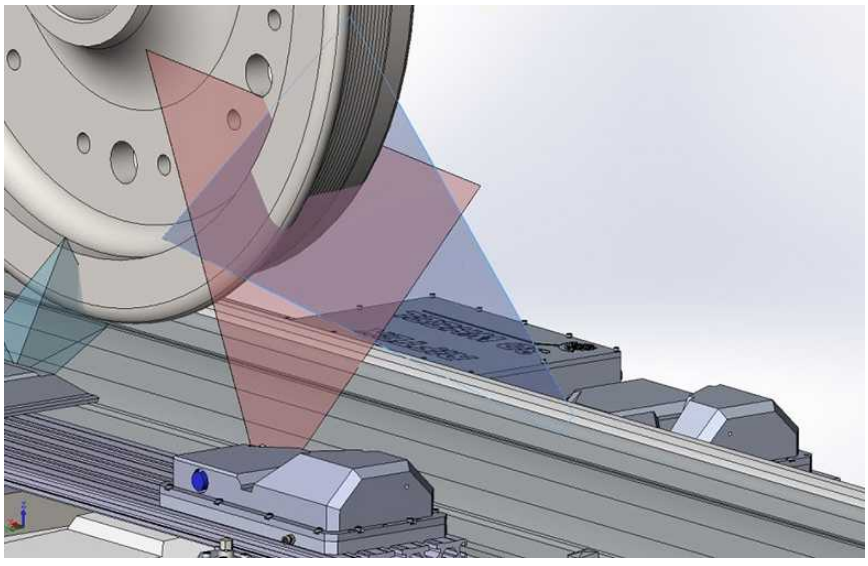


Figure 5

In this case, an undistorted profile is calculated by mathematical transformations, and this undistorted profile is used for further calculations of all necessary parameters of the wheel profile, such as the flange thickness and height, the rim thickness and so on.

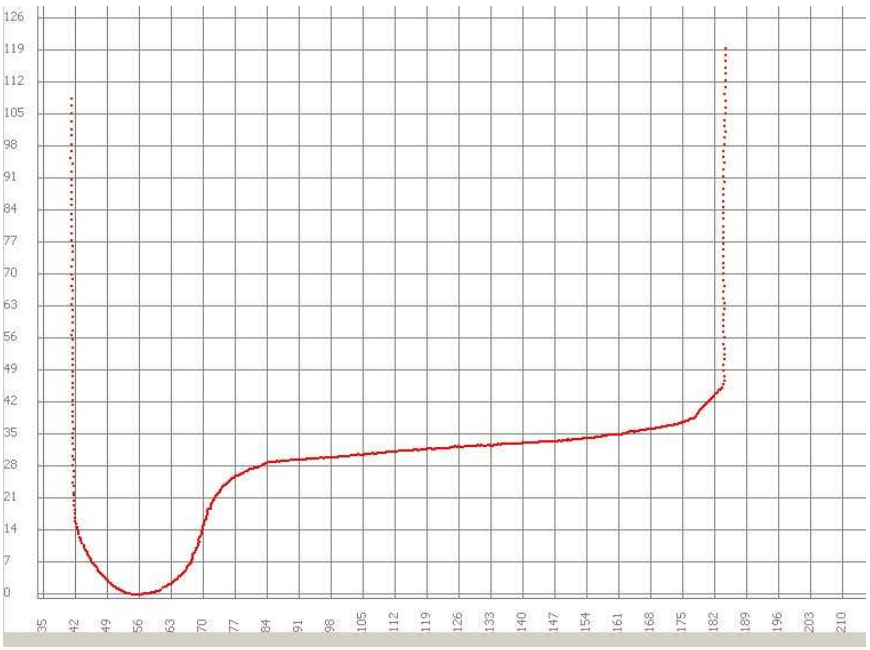


Figure 6

The back-to-back distance is measured at three points on the wheel and averaged. Figure 7 shows three pairs of scanners whose measurements are used for calculations.

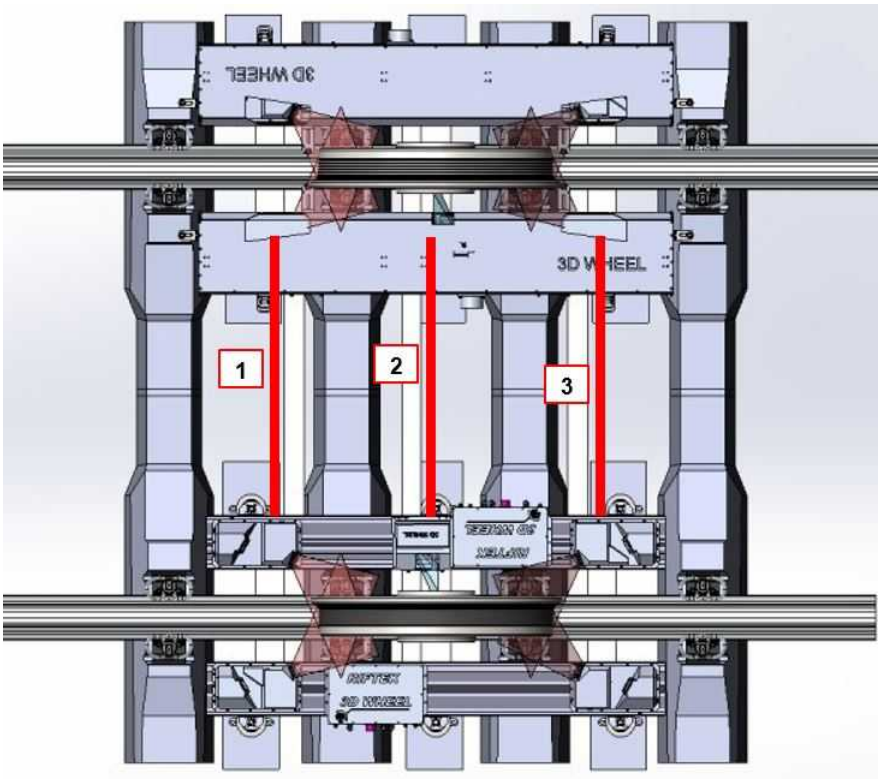


Figure 7

Laser scanning modules come with the special protective housings equipped with the air conditioning system. To eliminate the influence of vibrations and shocks, laser scanning modules are equipped with shock-absorbing supports.

Overall and mounting dimensions of laser scanning modules are shown in Figure 8.

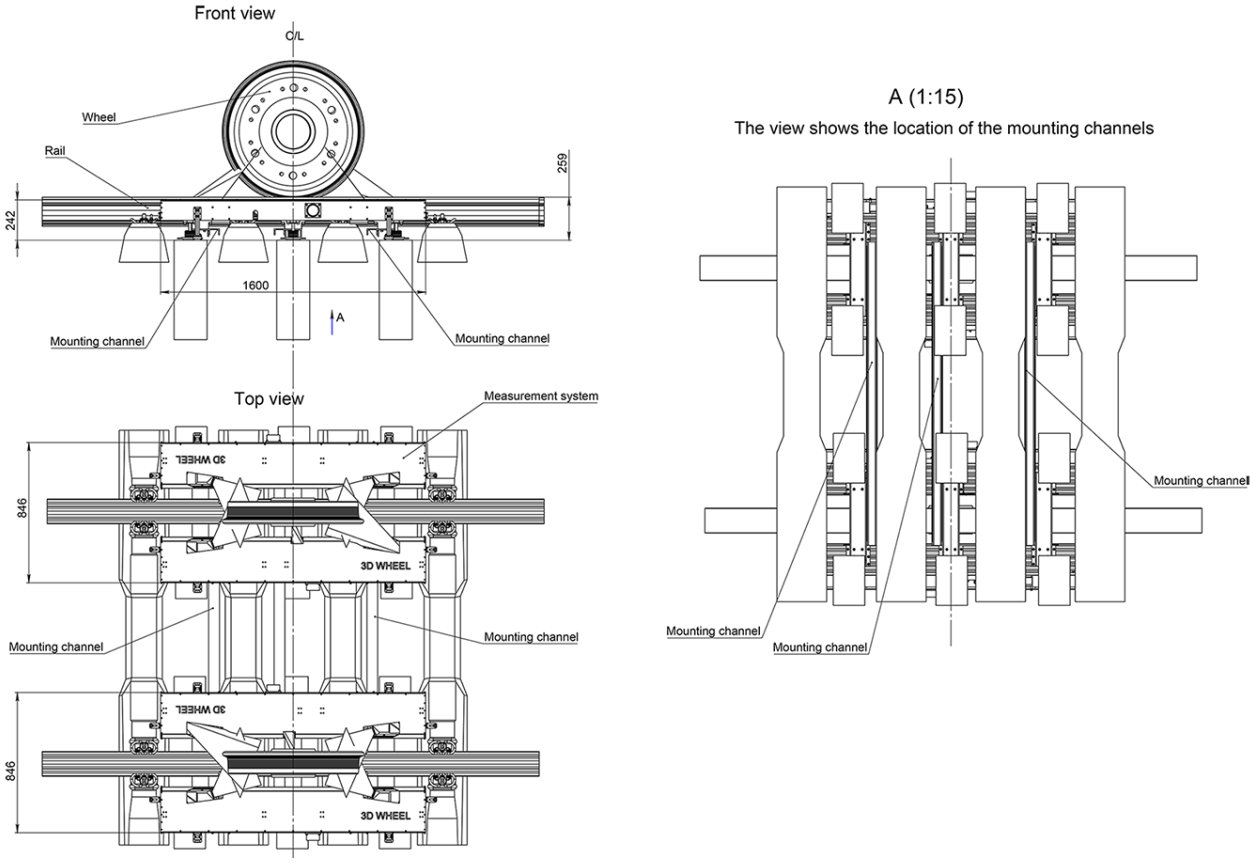


Figure 8

6.2. Air conditioning and protection module

The **Air conditioning and protection module** is designed to maintain a stable temperature inside the laser scanning modules, as well as to protect the laser scanners against mechanical damage.

The heating system is activated when the thermostat inside the protective housing registers a temperature below +15°C. The air is heated by built-in heaters, the warm air circulation is provided by built-in fans. The cooling system is activated when the thermostat inside the protective housing registers a temperature above +24°C.

The mechanical protection system opens the special protective shutters when the rolling stock is detected by the first inductive sensor. Upon completion of the scanning process, the mechanical protection system will close the protective shutters.

6.3. Position monitoring module

The **Position monitoring module** contains three (four for reverse traffic) inductive sensors. Inductive sensors are placed on the railway track as shown schematically in Figure 9.

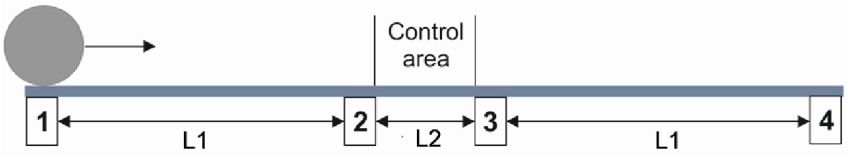


Figure 9

"L1" is the minimum distance between the 1st (or 4th) inductive sensor and the beginning of the control area. It is calculated by the following formula:

L1 = max speed (km/h) * 3 / 3.6

max speed (km/h) | L1 (m)
10 | 8.5
30 | 25
40 | 33.5
50 | 42

The minimum train speed is calculated by the following formula:

SpeedMin = L1 / measurement timeout

When the wheelset is detected by the first inductive sensor (1), the Control module opens the moving blinds on the protective housings and switches the Laser scanning modules to the data acquisition mode.

When the wheel is detected by the next inductive sensor (2) placed directly in front of the Laser scanning modules, the Control module turns on the lasers of the laser scanners, and the scanning process begins.

When the wheel is detected by the third inductive sensor (3), the Control module turns off the lasers and stops data acquisition.

After measuring the last wheel, the system waits for timeout, and then closes the moving blinds on the protective housings. The system goes into standby mode.

The fourth inductive sensor (4) is used only when the train moves in the opposite direction. In this case, it functions as the first inductive sensor, the third sensor functions as the second, and the second sensor functions as the third.

Figure 10 illustrates the operating principle of inductive sensors:

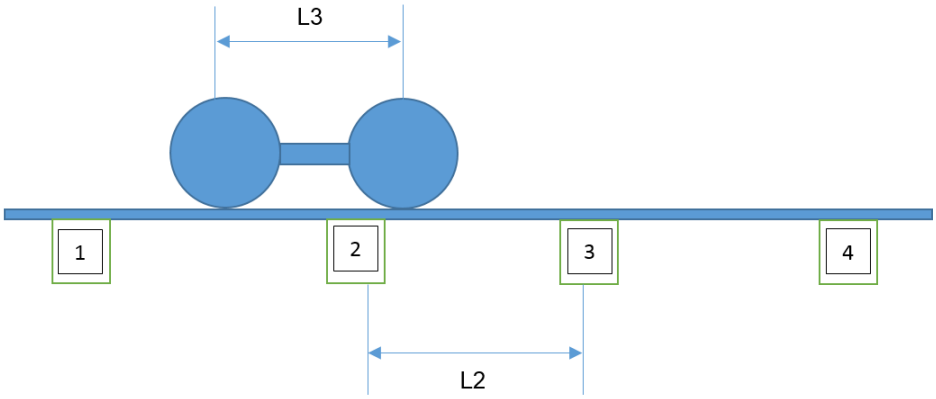


Figure 10

"L2" is a distance between the 2nd and 3rd inductive sensors.

"L3" is the minimum distance between the wheelsets.

IMPORTANT: The minimum distance between the wheelsets must be greater than the distance between the 2nd and 3rd inductive sensors. Otherwise, the first wheelset will not have time to turn off the measurements by passing near sensor #3. This will be done by the second wheelset and the measurement sequence will be disrupted.

6.4. Identification module

The RFID identification module is used to recognize the train number. A particular RFID tag, in which the train number is embedded, will be fitted on the train body. Once the train comes near the system, the RFID readers detect the RFID tags, give a signal to the system and display the train number. After the train has been identified, the number of wheelsets of that particular identified train will be counted by inductive sensors installed nearby the system. The number of wheelsets will be displayed next to the train number.

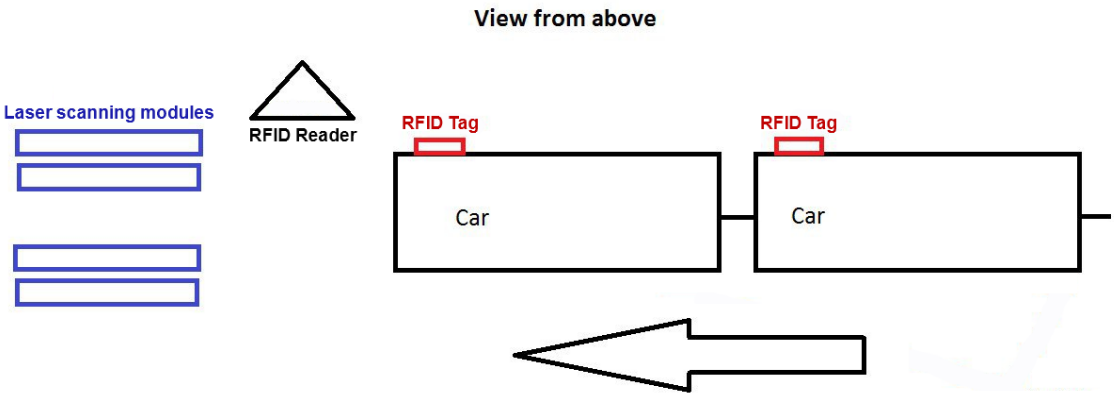


Figure 11

RFID reader:

Figure 12

6.5. Control, communication and power module

The **Control module** is a server computer. It is designed to coordinate the operation of all other modules, gather data from laser scanners, create a mathematical model of the wheel profile and calculate geometric parameters.

The **Communication module** is intended for remote access to the 3DWheel system for testing, parameterization and data transfer.

The **Communication module** includes:

- Network switch.
- Wi-Fi modem.
- 3G modem.

The **Power module** is intended to maintain a stable power supply for the 3DWheel system. It provides 60 minutes of uninterrupted power supply when the mains voltage is lost.

The **Power module** includes:

- Uninterruptible power supply (UPS).
- Power supply unit (2 pcs.): for laser scanning modules and for the heating system.

These three modules are located in the control cabinet, the components of which are described in the next paragraph.

6.5.1. Control cabinet

General view of the control cabinet:

Figure 13

Circuit breakers:

Figure 14

NOTE. The pink circuit breaker is not used.

IMPORTANT! For all circuit breakers, the top position is "On" and the bottom position is "Off".

Designations in Figure 14:

1) General power supply of the control cabinet.
2) The black switch has three positions: top position - the system is powered on (not from the UPS), middle position - the system is powered off, down position - the system is powered by the UPS.
3) Main power supply (measuring modules and peripherals).
4) Power supply for heating and blowing systems.
5) Low voltage power supply 24 V (measuring modules and peripherals).
6) Low voltage power supply 24 V (heating and blowing glass inside the scanners).
7) Power supply for wheel sensors (supplied directly without the controller).
8) Controller power supply.
9) Power supply for scanners (controlled by the controller).
10) Power supply for protective shutters (controlled by the controller).
11) Power supply for heating and blowing systems (controlled by the controller).
12) Power supply for controller outputs (controlled by the controller).
13) RFID power supply.

Computer indication:

Figure 15

The power button (1) glows blue when the computer is turned on. If the button is red, the computer is turned off.

Main controller indication:

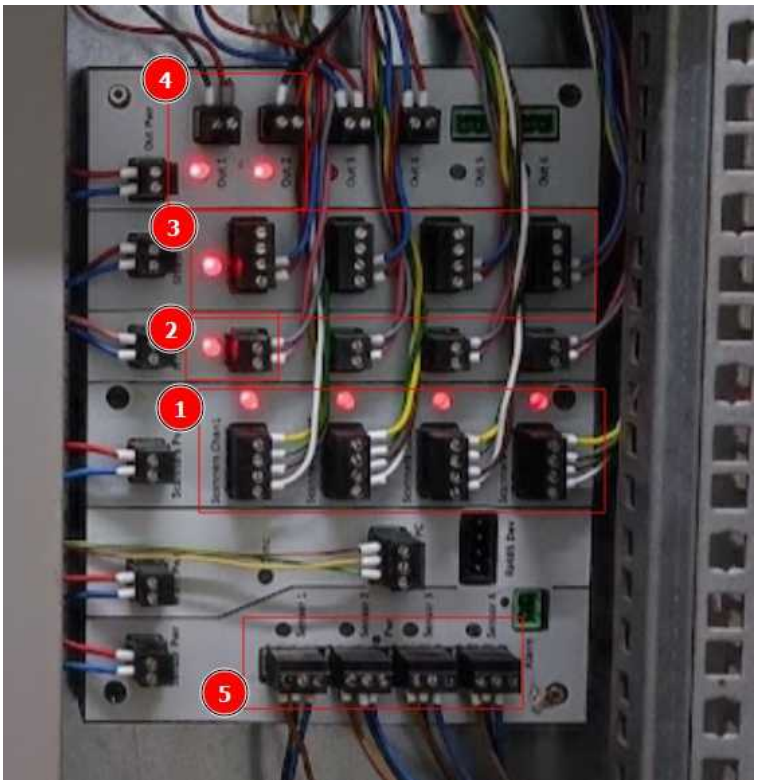


Figure 16

Designations:

1) If the LEDs are lit, power is supplied to all scanners of all four measuring modules.
2) Power is supplied to the temperature and humidity sensors. Power is also supplied to the heating system, but it only turns on when the temperature is below 15°C.
3) Power is supplied to all protective shutters.
4) Power is supplied to two RFID readers.
5) Indication of four wheel sensors. The indicators light up only if there is a massive metal object (wheel) above the sensor.

Other components of the control cabinet:

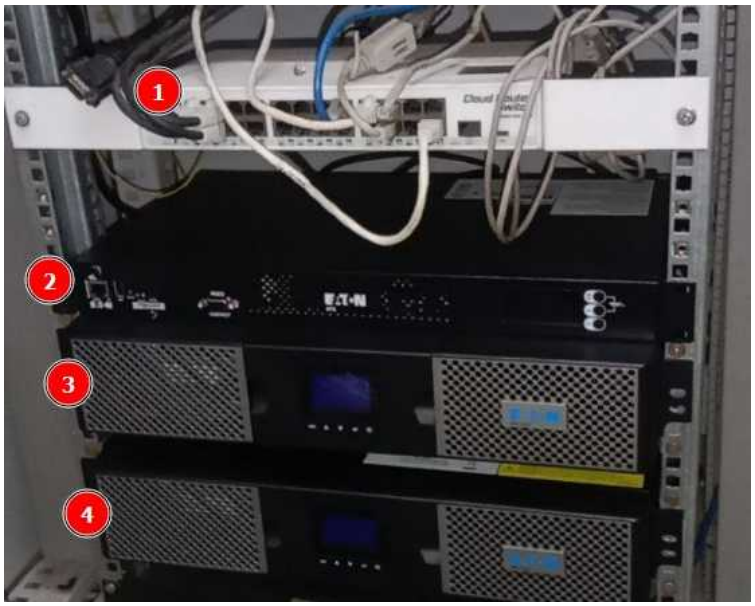


Figure 17

Designations:
1) Network switch:
   a. Ports 1-4 – for connecting the measuring modules.
   b. Port 16 – for connecting the Internet cable to the local network.
   c. Port 17 – for connecting the UPS controller.
   d. Port 18 – for connecting a computer to the local network of the system.
   e. Port 19 – for connecting the Wi-Fi router.
   f. Port 20 – for connecting the surveillance camera.
   g. Port 21 – for connecting UPS 1.
   h. Port 23 – for connecting a computer to the measuring modules.
2) UPS controller. It is used to control two UPS of the system.
3) UPS 1.
4) UPS 2.

7. Geometric parameters of the wheel under control

Geometric parameters of the wheelset are calculated automatically after laser scanning of wheels is completed. To calculate geometric parameters of the profile, use is made of reference points on the wheel profile. Location of the reference points is defined by L- and P-parameters.

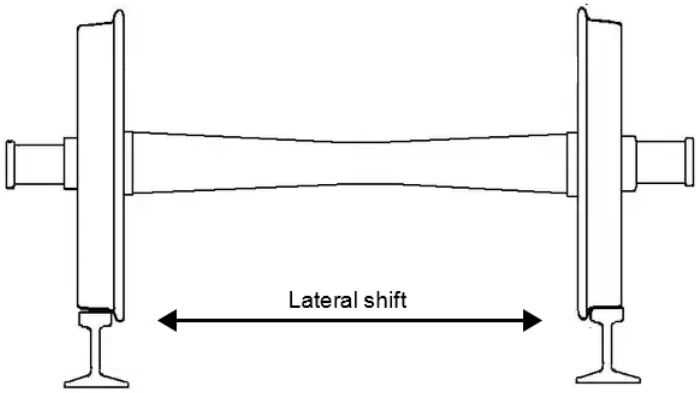
7.1. Measurement constraints

7.1.1. Longitudinal shift

Longitudinal shift is a shift along the rails. This shift is not limited, only the maximum speed of the train is limited. If the train speed exceeds the maximum permissible speed, the wheels will not be measured.

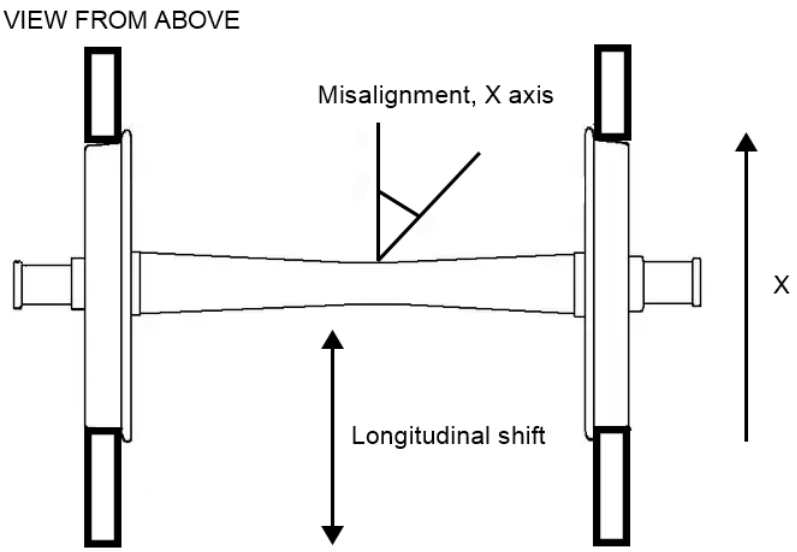
7.1.2. Lateral shift

Lateral shift is a shift across the rails. The maximum shift across the rails is 20 mm from the center position of the wheelset.



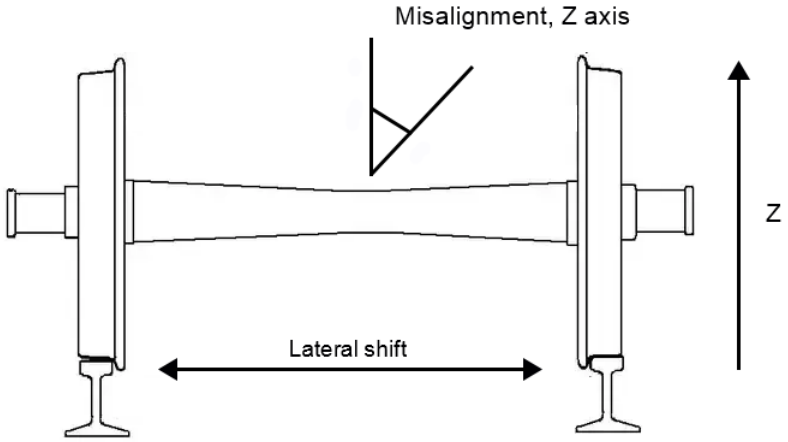
7.1.3. Misalignment, X axis

Misalignment, X axis (axis along the rails) – the maximum angle of rotation of the wheel along the rail (0.12 radians).



7.1.4. Misalignment, Z axis

Misalignment, Z axis (vertical axis) – the maximum angle of inclination of the wheel relative to the vertical axis (0.06 radians).

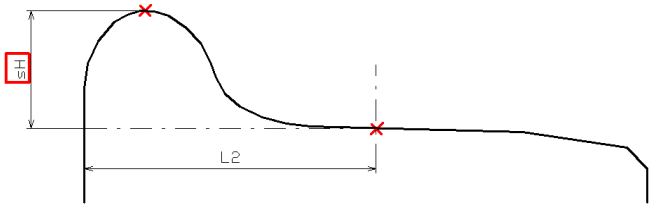


7.2. Measured parameters

7.2.1. Flange height, sH

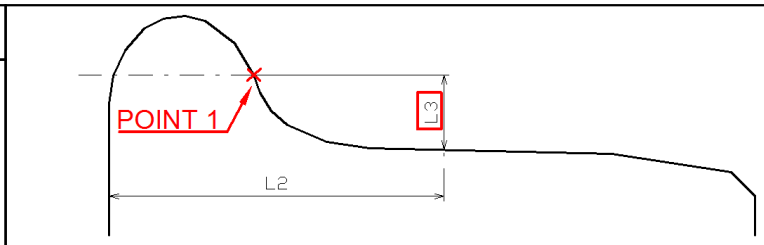
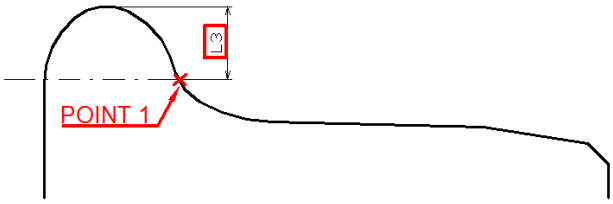
Calculation of the flange height is determined by parameter L2.

The flange height is calculated as a distance measured vertically between the flange top and the point of wheel rolling surface at any preselected distance (L2) away from the inner face of the wheel tire.



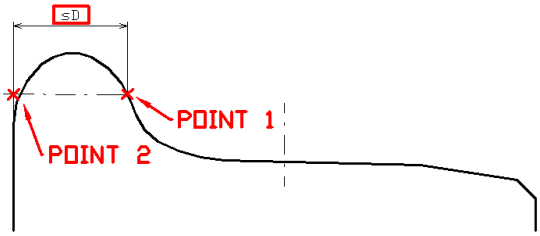
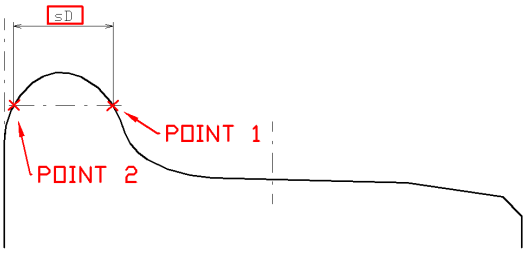
7.2.2. Flange thickness, sD

Calculation of the flange thickness is determined by parameter L3 that specifies Point 1 on the flange surface. There are two ways to specify the parameter:

Method 1 Height L3 is measured vertically upward from a point of the wheel rolling surface, the position of which is defined by parameter L2.	
Method 2 Height L3 is measured vertically downward from the flange top.	

The flange thickness is calculated as a distance measured horizontally at any preselected height (L3) between two points (Point 1 and Point 2) lying on the opposite sides of the flange top.

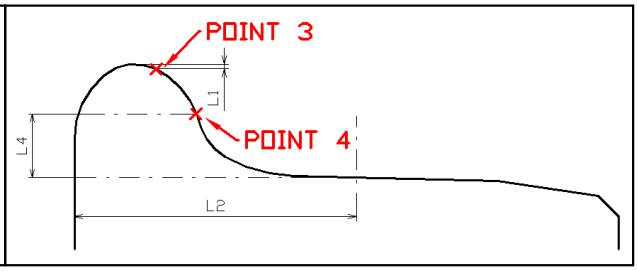
There are two ways to calculate the flange thickness:

Method 1 Point 1 is defined by parameter L3. Point 2 is the intersection point of a horizontal line and a line lying on the internal face of the wheel.	
Method 2 Point 1 is defined by parameter L3. Point 2 is the intersection point of a horizontal line and the flange surface.	

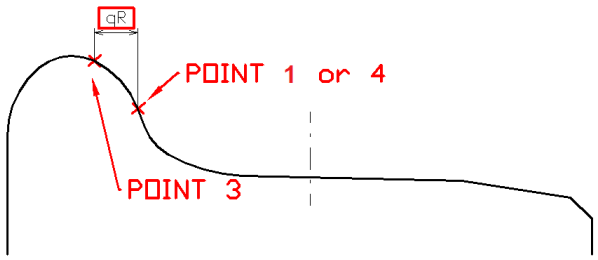
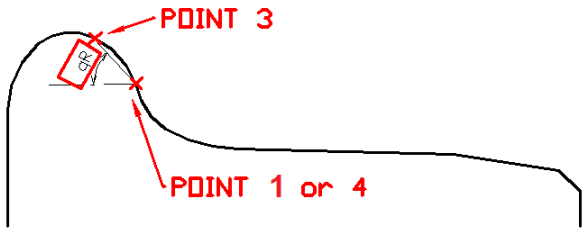
Note: Both calculation methods can be performed simultaneously.

7.2.3. Flange slope, qR

Calculation of the flange slope is determined by parameters L1 and L3 (or L4).

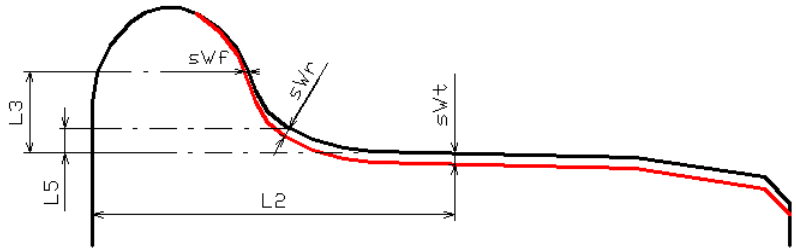
Height L1 is measured vertically downward from the flange top and determines Point 3 on the flange surface. Height L4 is measured vertically upward from a point of the wheel rolling surface, the position of which is defined by parameter L2 (wheel rolling circle), and determines Point 4 on the flange surface.	

There are three ways to calculate/display the flange slope:

Method 1 **Calculation in millimeters** The flange slope is calculated as a distance measured horizontally between Point 3 and Point 1 (or 4).	
Method 2 **Calculation in degrees** The slope is calculated as the inclination angle of a straight line passing through Point 1 or 4.	
Method 3 **Pass/Fail** The calculation is performed according to Method 1. The software displays information only about whether the measured slope meets the tolerance conditions or not.	

7.2.4. Root wear, sWr

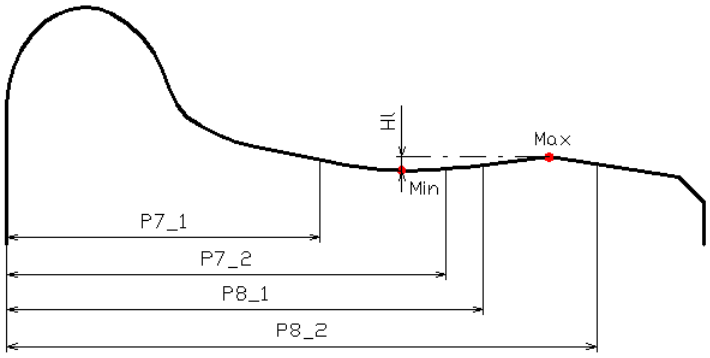
Root wear	sWr	is calculated as a distance along the normal to the tangent at the point at height L5 from the wheel rolling circle of the measured profile and the selected reference.



* Red color indicates the worn profile

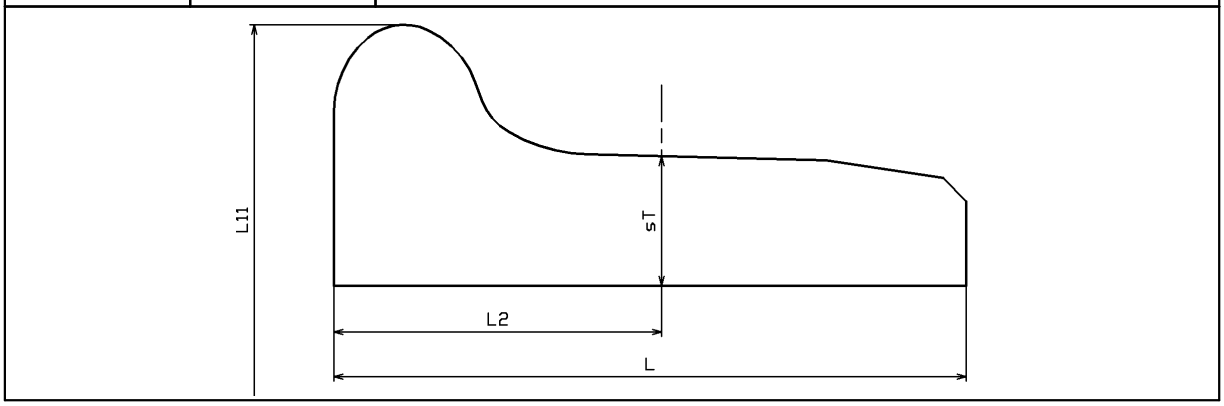
7.2.5. Wheel tread hollow, Hl

Wheel tread hollow	Hl	is calculated as a difference between the maximum and minimum values within the specified limits. The search limits: - parameters of the minimum value [P7_1..P7_2]; - parameters of the maximum value [P8_1..P8_2].



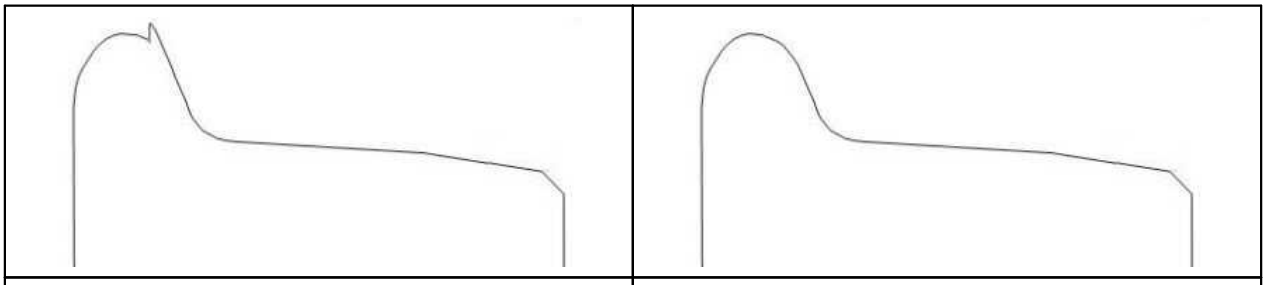
7.2.6. Wheel rim thickness, sT

Wheel rim thickness	sT	is calculated as a distance measured vertically between the internal rim diameter and a point on the wheel rolling circle located on any preset distance L2 away from the wheel face.
		L11 is an external wheel diameter.



7.2.7. Flange rollover, sA

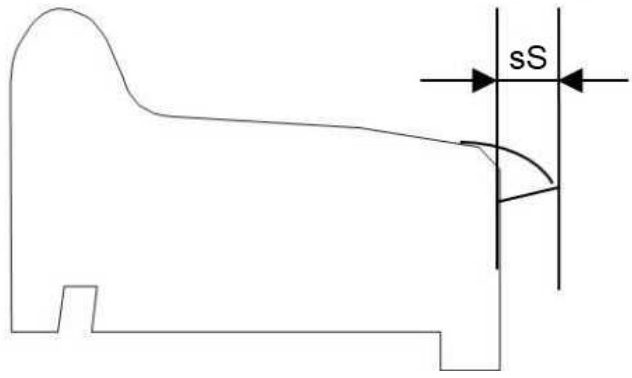
The flange rollover is a protrusion resulting from the deformation of the surface layers of the flange metal toward its apex.



Flange rollover	Normal wheel

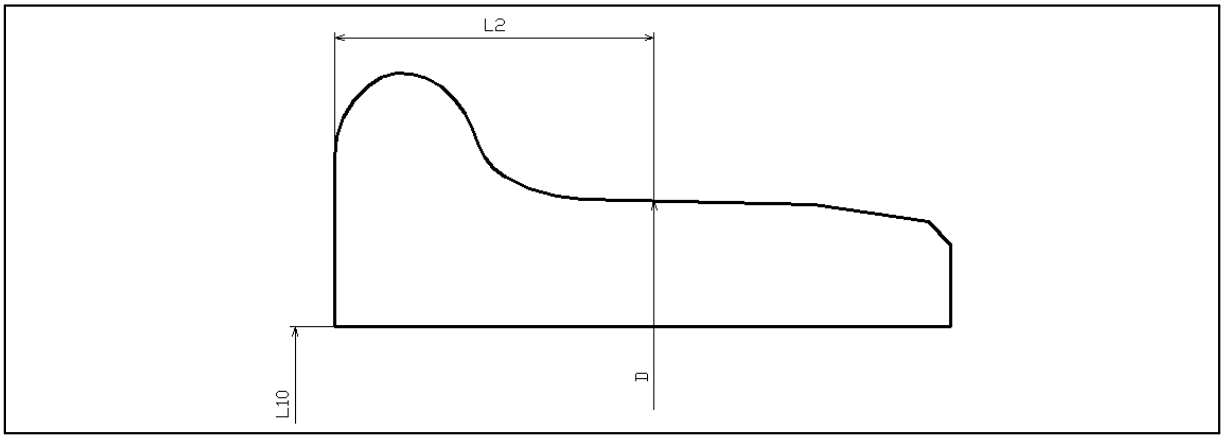
7.2.8. Tread rollover, sS

The displacement of the metal from the rolling surface to the chamfer and then to the outer edge of the rim. The distance from the outer edge of the rim to the most protruding part.



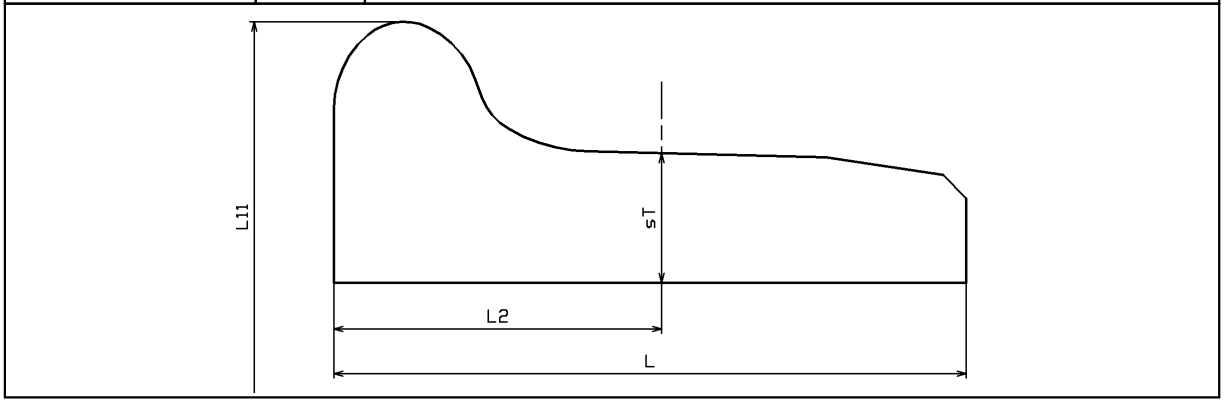
7.2.9. Wheel diameter, D

Wheel diameter	D	is calculated by the formula: **D = 2*T+L10** T – rim thickness; L10 – diameter of wheel center



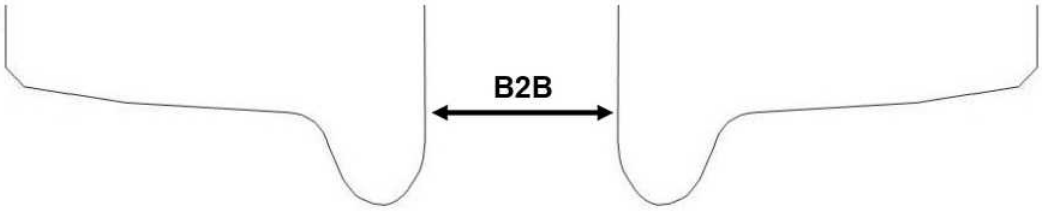
7.2.10. Wheel width, L

Wheel width	L	is calculated as the distance measured vertically between the inner and outer surfaces of the wheel.



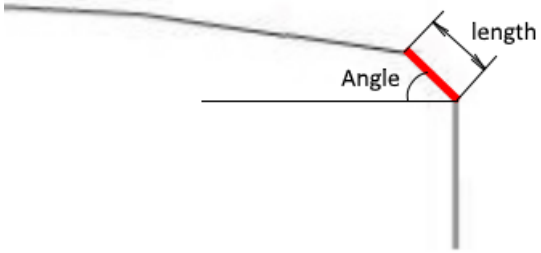
7.2.11. Back-to-back distance, B2B

The back-to-back distance is a distance between the inner surfaces of the wheels in a wheelset.



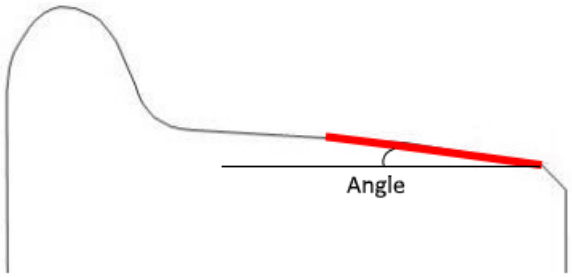
7.2.12. Wheel chamfer, f

The wheel chamfer is measured by the inclination angle and length.



7.2.13. Tread taper, Tt

The tread taper is measured as the inclination angle of the tread surface between the tread point (63.5 mm from the inner face of the wheelset) and the wheel chamfer.



8. Intended use

In order to use the system properly, it is necessary to read this User's Manual and to follow all instructions.

The specialists, which will work with the system, must have the appropriate qualifications, and must receive the training conducted by the Manufacturer. The specialists must know about all system components, risks associated with the system installation, permissible actions and how to handle emergency situations.

All repair works must be performed in consultation with the Manufacturer in order to avoid critical damage to the equipment.

8.1. Preparation for use

The preparation involves the following steps:

- Visual inspection.
- System installation.
- Switching on the system.
- Calibration.

8.1.1. Visual inspection

- Check the equipment for completeness and absence of damage.
- Check the cables and ground wires.
- Check the windows of laser scanners and, if necessary, clean them with a soft, lint-free cloth and non-streaking glass cleaner or 20% alcohol.

8.1.2. System installation

8.1.2.1. Mounting place

The 3DWheel system must be installed in accordance with the documentation and in consultation with the Manufacturer.

The mounting place must be prepared for the system installation - all preparation work must be performed under control of the Manufacturer's specialists.

Make sure that the mounting place meets the following conditions:

- The railway track, where the system will be installed, must not have the angle of inclination greater than 5°.
- There must be enough space to install the inductive sensors onto the lower face of the rail.

8.1.2.2. Equipment installation

The system is supplied as a set of modules ready to install. The specialists responsible for the system installation must have the appropriate qualifications.

Safety precautions:

- Lift and move the equipment carefully, without sudden movements. The modules weighing more than 10 kg must be transported using the special equipment (trolley or forklift).
- The equipment for transporting the modules must be certified, and its maximum workload must be greater than the cargo weight.
- Only people working on the system installation are allowed to be in the installation area.

ATTENTION!

- The system must be grounded – static electricity may cause the failure of electronic components.
- All power cables must be shielded.

8.1.3. Calibration

ATTENTION!
During the first month after the system is put in operation, it is necessary to compare the 3DWheel measurements with those of certified instruments every week and, if necessary, calibrate the system. Thereafter, the system should be calibrated once every six months.

There are two methods to calibrate the system:

1. Calibration using a calibration bogie (see par. 9.2.2).
2. Calibration using a wheel (see par. 9.2.3).

8.2. Turning on the system

To turn on the system, follow these steps:

1. Turn on the general power supply (see Fig. 14, par. 6.5.1).
2. Turn on the UPS (2 pcs.). To do this, press the power button:

3. Turn on low voltage power circuit breakers (2 pcs., 24V, see Fig. 14 in par. 6.5.1).

NOTE. The industrial computer turns on automatically after powering up the system. But this will not happen if the industrial computer has been turned off manually. Therefore, if the power button (see Fig. 15, par. 6.5.1) remains red after power is applied, you need to press it to turn on the computer. The blue glow of the power button indicates that the computer is on.

8.3. Operating the system

When all preparation work is done and the system is powered on, it is completely ready to operate.

The measurement process starts automatically when an inductive sensor detects the wheel. Wheel profiles are taken when the rolling stock goes through the control area. The maximum train speed is 120 km/hour.

Data collected from all scanners is transmitted to a server computer via Ethernet to calculate the geometric parameters. The calculated parameters are sent to the database and the client application.

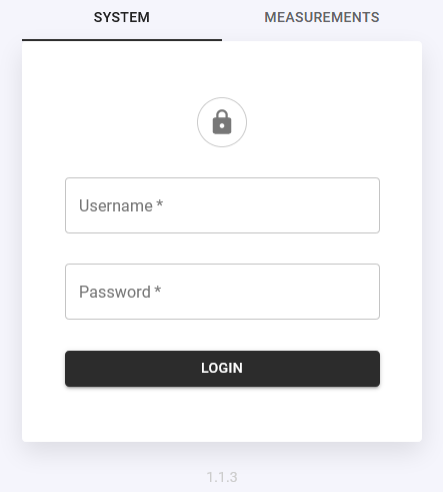
8.4. Turning off the system

To turn off the system, follow these steps:

1. Turn off the industrial computer by pressing the power button on the housing (see Fig. 15, par. 6.5.1). When the industrial computer is turned off, the power button glows red.
2. Turn off low voltage power circuit breakers (2 pcs., 24V, see Fig. 14 in par. 6.5.1).
3. Turn off the UPS (2 pcs.). To do this, press and hold the power button until the display turns off.
4. Turn off the general power supply (see Fig. 14, par. 6.5.1).

9. Web interface

9.1. Logging in to the Control Panel

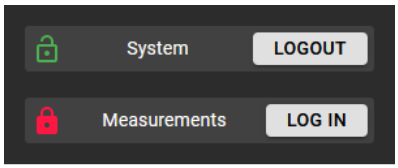


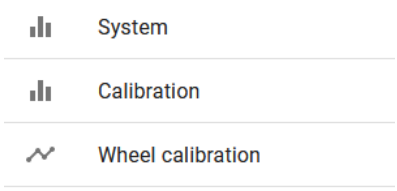
- **SYSTEM** tab – Authorize the user to control/calibrate the system, view the last measurements.
- **MEASUREMENTS** tab – Authorize the user to make measurements, read/edit the database.

For authorization, select the tab you need, enter the username and password, and click **LOGIN**.

9.2. "System" authorization

View of the web interface after authorization:

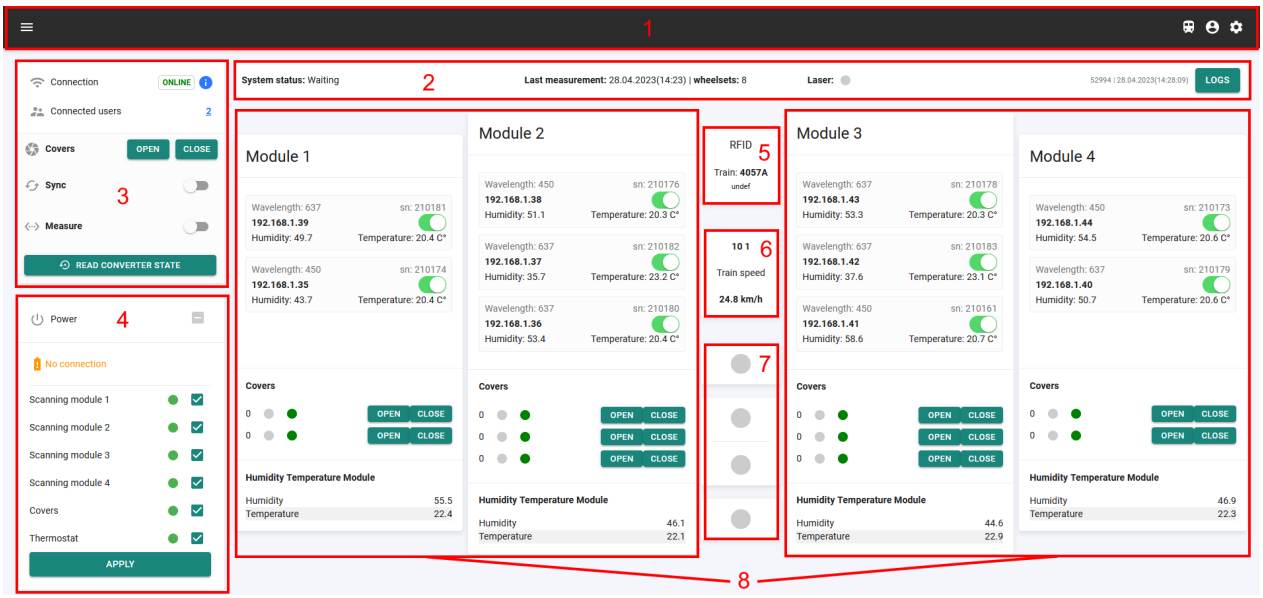


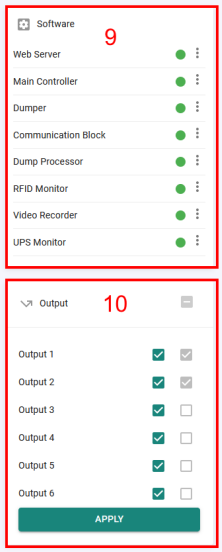


After authorization, the following menu items will become available:

- System
- Calibration
- Wheel calibration

9.2.1. "System" page



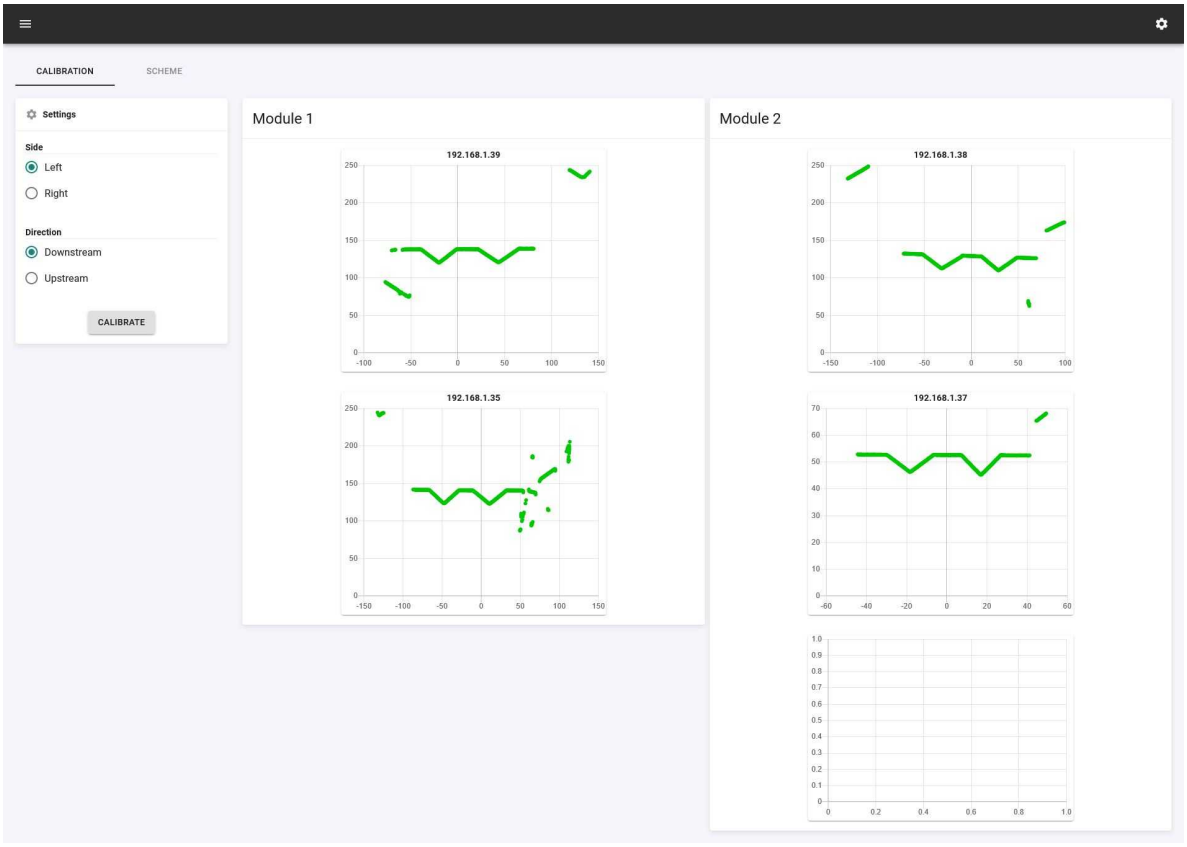


The elements of the System page are described in the table:

Element	Description
Area 1	
	Expand the Menu panel. See par. 9.2.
	Go to the Passages page. See par. 9.3.1.
	Go to the Profile page. See par. 9.4.
	Open the Settings panel. See par. 9.5.
Area 2	
System status	System status: on/off.
Last measurement	Date and time of the last measurement.
Wheelsets	Number of wheelsets.
Laser	Laser state indicator: green - on, gray - off.
LOGS	Open the log.
Area 3	
Connection	System connection status: online/offline.
Connected users	Number of connected users. Hovering over a number will display the names of connected users and their ip addresses.
Covers	Open/close all covers of laser scanning modules.
Sync	Start measuring (all lasers light up).
Measure	Switch to measurement mode.
READ CONVERTER STATE	Clicking this button refreshes the information displayed on the Module panels.
Area 4	
Power	System power indicator.
Scanning module 1-4	Power supply for laser scanning modules.
Covers	Power supply for covers.
Thermostat	Power supply for the thermostat.
NOTE: Indicators ● show the state: green color means the power is on, gray color - off. Checkboxes ☑ are intended to write data to the controller. After making changes, it is necessary to click APPLY.	
Area 5	
RFID	Train number.
Area 6	
Train speed	Train speed (km/h) and timeout value (sec).

Element	Description
Area 7	
Inductive sensors	Indicators show which sensor has detected a wheel. When the sensor detects the wheel, the indicator turns green.
Area 8	
Module 1-4	Laser scanning modules 1-4.
Scanners	Information about laser scanners: wavelength, IP address, serial number, humidity and temperature. To power on/off the scanners, use the toggle switch - .
Covers	Buttons are used to open / close the covers. Indicators show the current state: green means the cover is opened, gray - closed. The number next to the indicators is the alarm code (in bytes).
Humidity Temperature Module	Current humidity and temperature inside the module.
Area 9	
Software	Indicators show the current state of the software and controllers: green color means it is running, gray color means it is not.
Area 10	
Output	Digital outputs of the main controller.

9.2.2. "Calibration" page



Calibration is carried out using a special calibration bogie supplied with the system.

To perform the calibration, follow the steps below:

1. Install the calibration bogie.

2. Select the side (**Left** / **Right**) of the laser scanning module.
3. Select the direction of scanners (**Downstream** / **Upstream**).

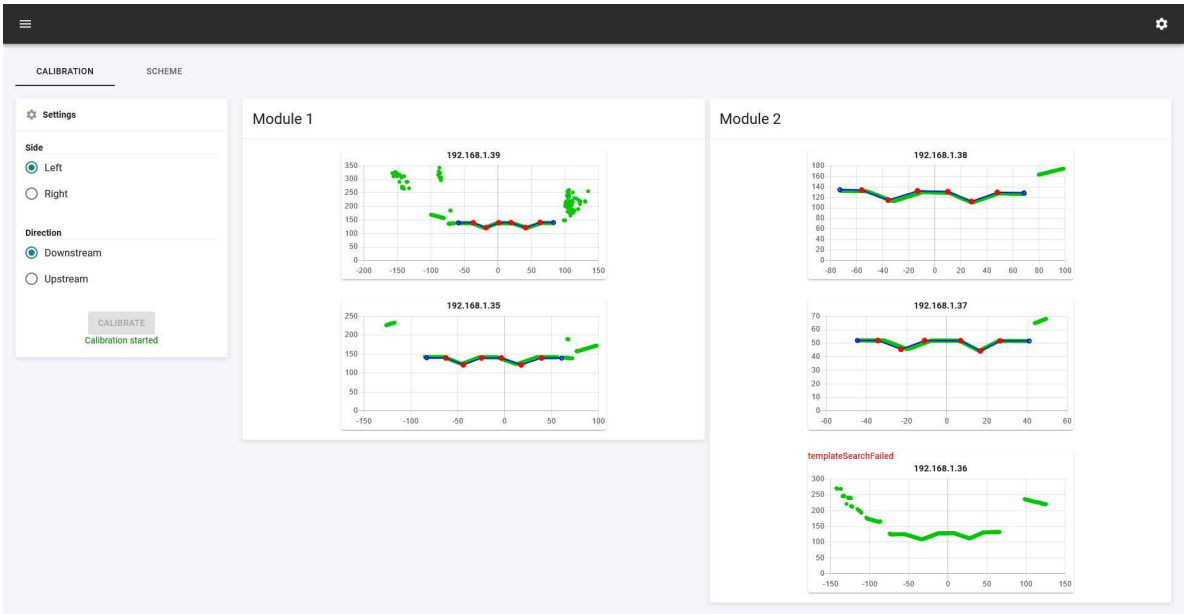
NOTE. Five of the scanners are calibrated together (scanners of the left or right laser scanning module).

The calibration can be done using both sides of the calibration bogie. If you calibrate the scanners of the *right* scanning module using the *right* side of the calibration bogie, you need to select **Downstream**. If, for example, you calibrate the scanners of the *right* scanning module using the *left* side of the calibration bogie, select **Upstream**.

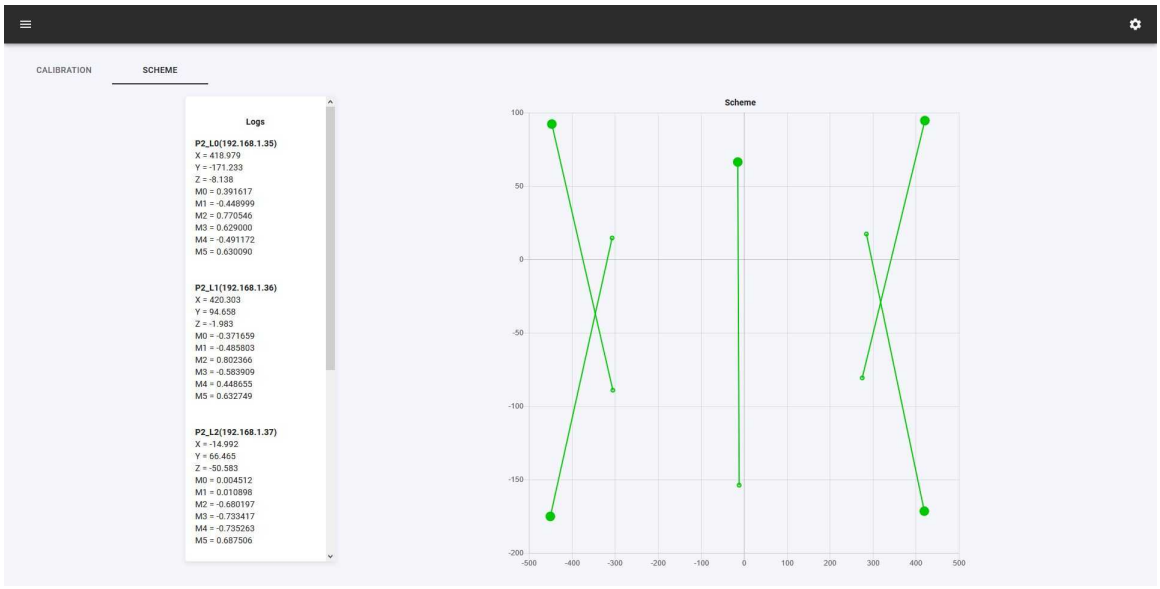
IMPORTANT! All scanners must see the full profile of the calibration plate. If any scanner sees an incomplete profile or a profile with gaps, move the calibration bogie until a profile is good.

4. Click **CALIBRATE** to calibrate the scanners.

If the calibration has failed, a corresponding message appears:



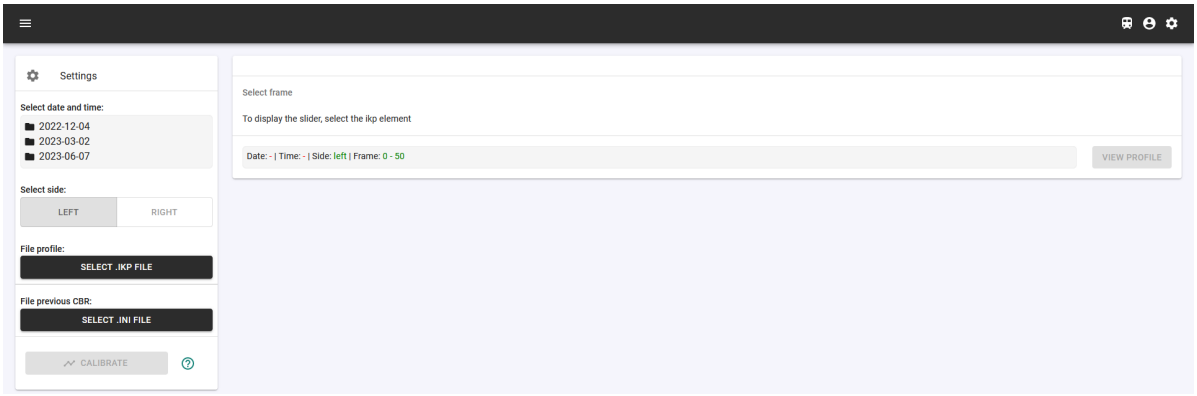
If the calibration was successful, the **SCHEME** tab will become available:



This tab displays the scheme of the scanners, their direction and log information.

5. Repeat steps 2-4 for another laser scanning module.

9.2.3. "Wheel calibration" page



During the calibration process, it is necessary to compare measurements obtained by the 3DWheel system with measurements made by other certified instruments.

To perform the calibration, follow the steps below:

1. Select wheels.

IMPORTANT!
Wheels must meet the following requirements:
1. No defects.
2. No wear.
3. Not shiny, more than 2 days after turning.
4. Maximum possible difference in diameters. It is necessary to use measurements of two wheelsets (minimum diameter and maximum diameter). For example, if the maximum wheelset diameter is 850 mm and the minimum diameter is 840 mm, then these should be used for calibration. The measurements of the other wheelsets are used to control the success of the calibration.

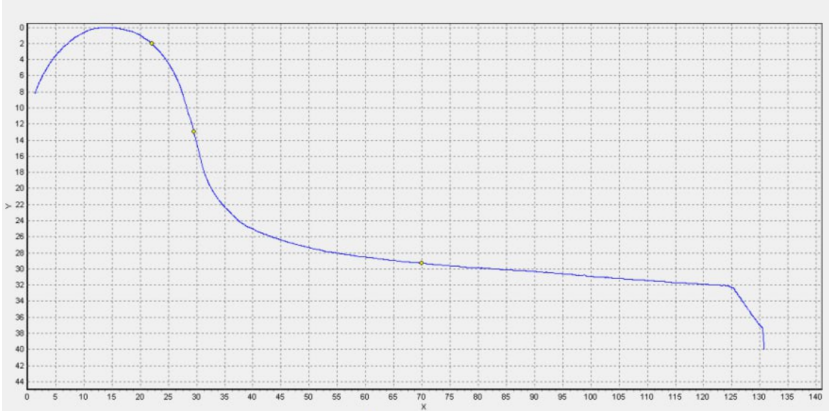
2. Make measurements using the 3DWheel system.

The following parameters must be measured:

- Wheel profile
- Wheel diameter
- Wheel width
- Back-to-back distance

It is necessary to make measurements of two wheelsets.

The wheel profile must have a resolution of at least 0.2 mm and an accuracy of at least ±0.1 mm. Wheel profile example:



The diameter measurement accuracy must be at least ±0.3 mm.

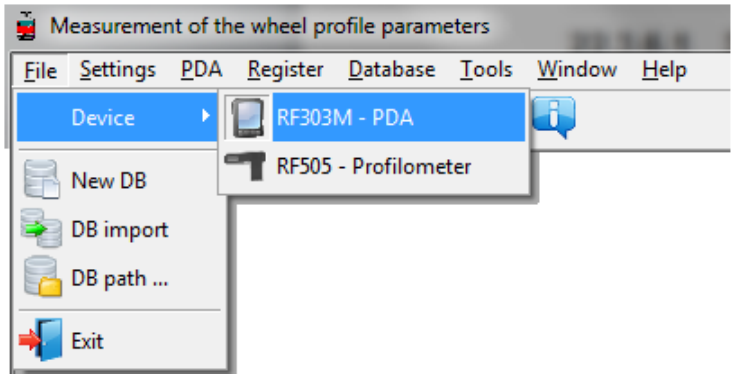
The wheel width measurement accuracy must be at least ±0.2 mm.

The back-to-back distance measurement accuracy must be at least ±0.3 mm.

3. Make measurements using special instructions.

- Railway Wheel Profile Gauge IKP Series: https://riftek.com/upload/iblock/6c6/Railway_wheel_profile_gauge_IKP_Series_Model_2017_eng.pdf
- Wheel Diameter Measuring Gauge IDK Series: https://riftek.com/upload/iblock/acd/Wheel_Diameter_Measuring_Gauge_eng.pdf
- Back-to-Back Distance Measuring Gauge IMR Series: https://riftek.com/upload/iblock/eae/Back_to_Back_Distance_Measuring_Gauge_eng.pdf

4. Download measurements from PDA. To do this, start the **ikp5_DB** software on your PC and select the device: **File > Device > RF303M-PDA**.

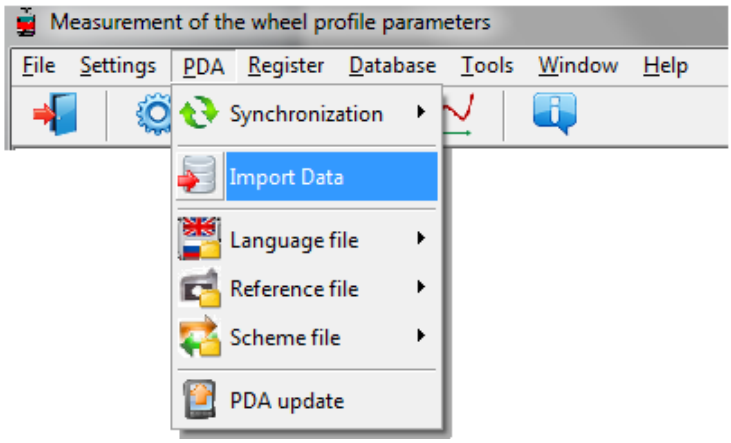


Data exchange between PC and PDA is carried out by direct connection of the PDA to the USB port of the PC (special cable RF505.42 is supplied).

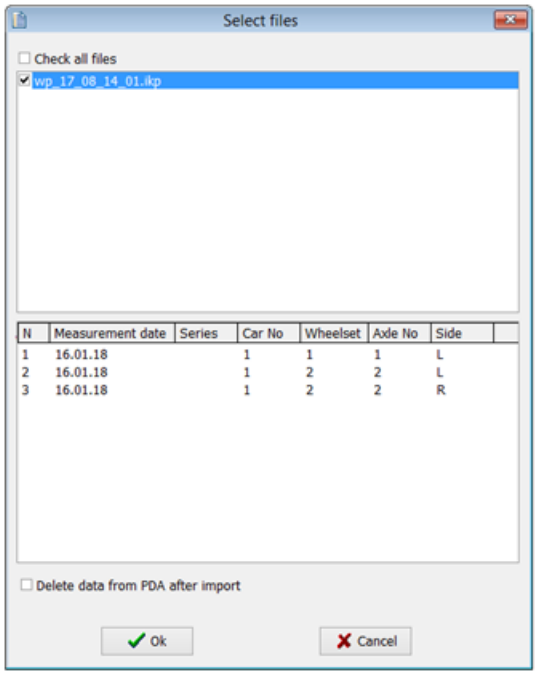
There are two ways of synchronization via USB cable: ActiveSync and Mass Storage.

ActiveSync synchronization. To transfer the database file from PDA to PC, do the following:

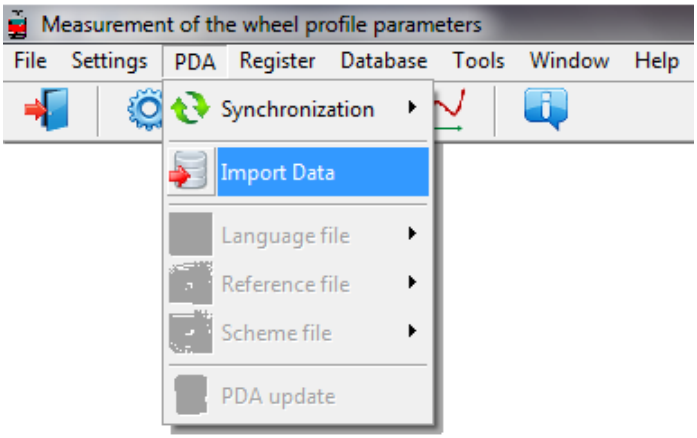
- Select **PDA > Import Data**.



- Select files and click **OK**.

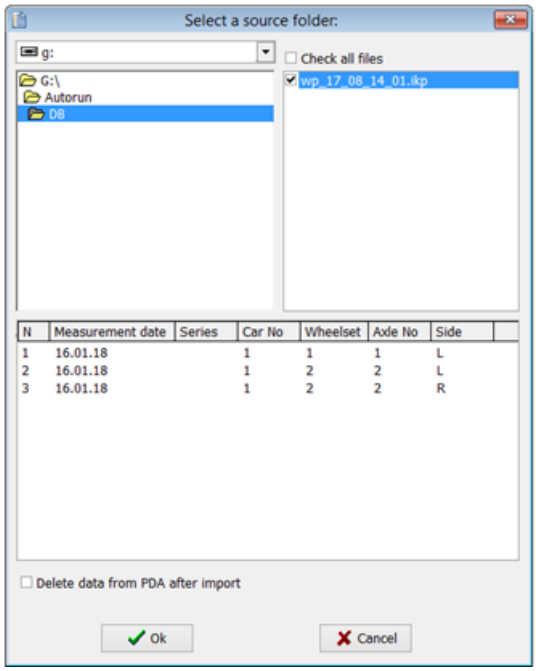


Mass Storage synchronization. When this type of synchronization is selected, PDA is detected as an external storage device. Therefore, only the **Import Data** item is active.



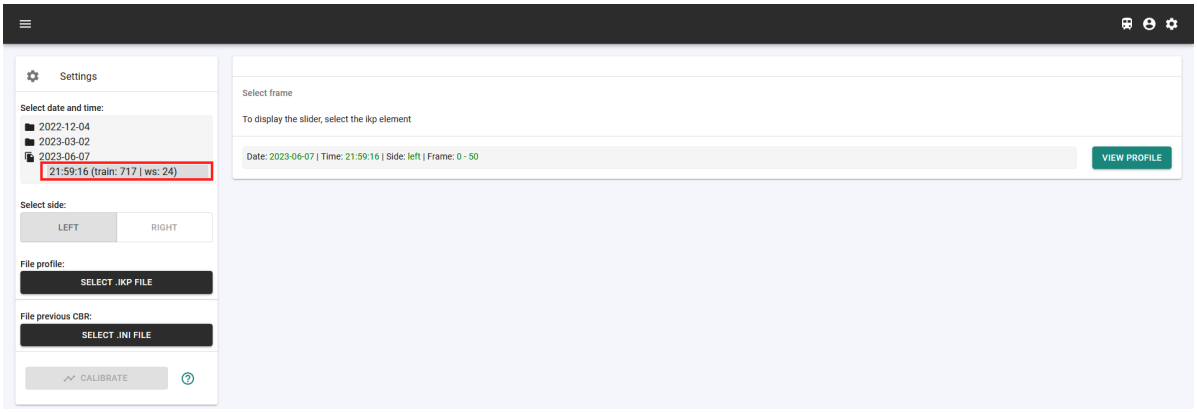
To transfer the database file from PDA to PC, do the following:

- Select **PDA > Import Data**.
- Specify the path to the database on PDA (by default, **SDMMC\Autorun\DB**).



- Select files and click **OK**.

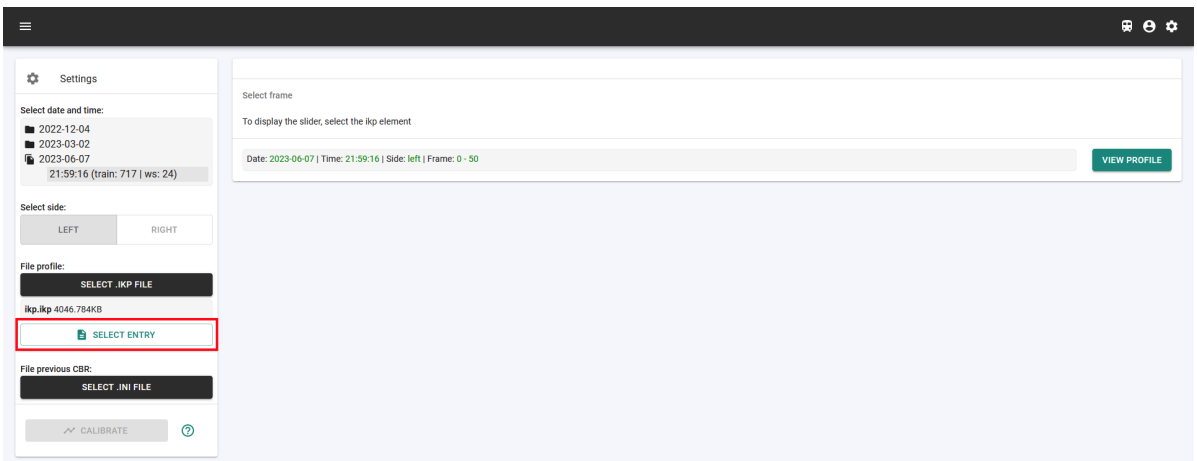
5. Select measurements taken by the 3DWheel system.



6. Upload a file with measurements taken with special instruments. To do this, click the **SELECT .IKP FILE** button and select the file (*.ikp). The name of the selected file will be displayed under the **SELECT .IKP FILE** button.

7. Select the side to be calibrated (**LEFT** or **RIGHT**).

8. Click the **SELECT ENTRY** button.

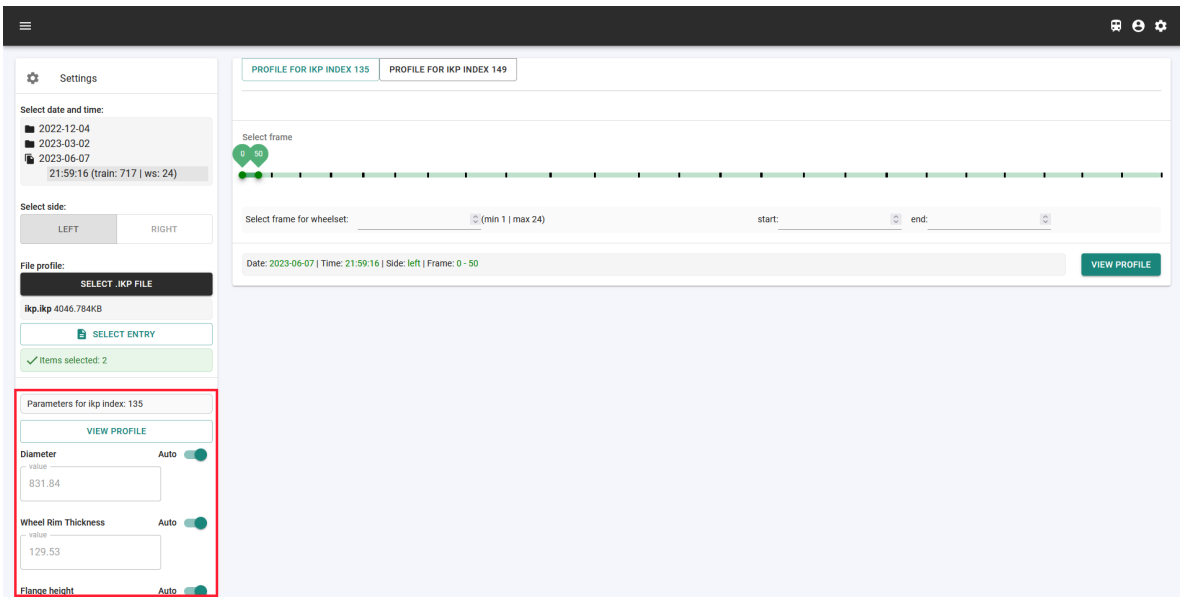


You will see a list of measurements from the uploaded *.ikp file. Select two wheels with the maximum difference in diameters.

NOTE. It is necessary to select the left wheels when you calibrate the left side, and the right wheels when you calibrate the right side.

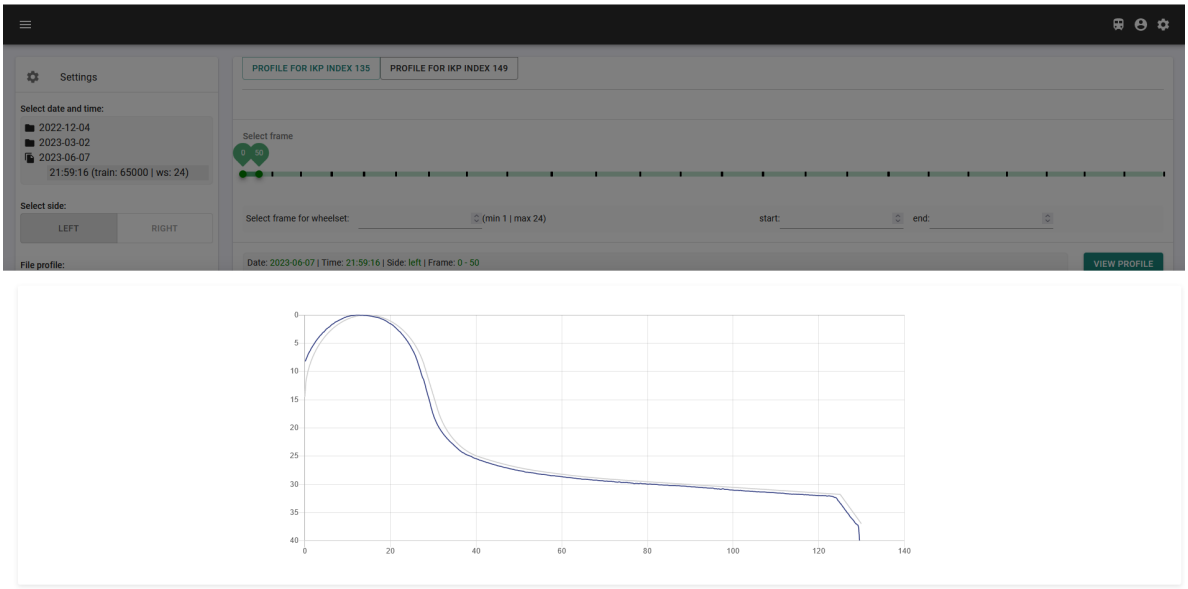
Index	Date/Time	Series	Number	Axle	Side	D	sH	L	
135	2023-02-21 | 12:30:26	717	2	4	Left	831.84	28.82	129.53	UNSELECT
136	2023-02-21 | 12:31:01	717	3	1	Right	838.52	28.6	129.69	SELECT
137	2023-02-21 | 12:31:35	717	3	1	Left	837.57	28.74	129.81	SELECT
138	2023-02-21 | 12:32:18	717	3	2	Right	837.06	28.68	129.66	SELECT
139	2023-02-21 | 12:32:55	717	3	2	Left	836.85	28.61	129.53	SELECT
140	2023-02-21 | 12:33:36	717	3	3	Right	839.11	28.57	129.78	SELECT
141	2023-02-21 | 12:33:59	717	3	3	Left	838.5	28.82	129.81	SELECT
142	2023-02-21 | 12:34:48	717	3	4	Right	839.01	28.84	129.5	SELECT
143	2023-02-21 | 12:35:07	717	3	4	Left	838.33	28.94	129.53	SELECT
144	2023-02-21 | 12:35:43	717	4	1	Right	837.28	28.58	129.5	SELECT
145	2023-02-21 | 12:36:06	717	4	1	Left	836.23	28.83	129.66	SELECT
146	2023-02-21 | 12:36:34	717	4	2	Right	837.13	28.61	129.47	SELECT
147	2023-02-21 | 12:36:58	717	4	2	Left	836.54	28.73	129.47	SELECT
148	2023-02-21 | 12:37:50	717	4	3	Right	840.2	28.71	129.66	SELECT
149	2023-02-21 | 12:38:18	717	4	3	Left	839.72	28.62	129.69	UNSELECT
150	2023-02-21 | 12:38:49	717	4	4	Right	838.94	28.74	129.72	SELECT
151	2023-02-21 | 12:39:13	717	4	4	Left	838.24	28.68	129.5	SELECT

To close this window, scroll to the top of the list and click the **CLOSE** button.
The parameters of the selected wheels will be displayed on the left panel.



If any value is missing or incorrect, you can turn off the **Auto** option and enter the value manually.

To view the wheel profile, click the **VIEW PROFILE** button on the left panel.

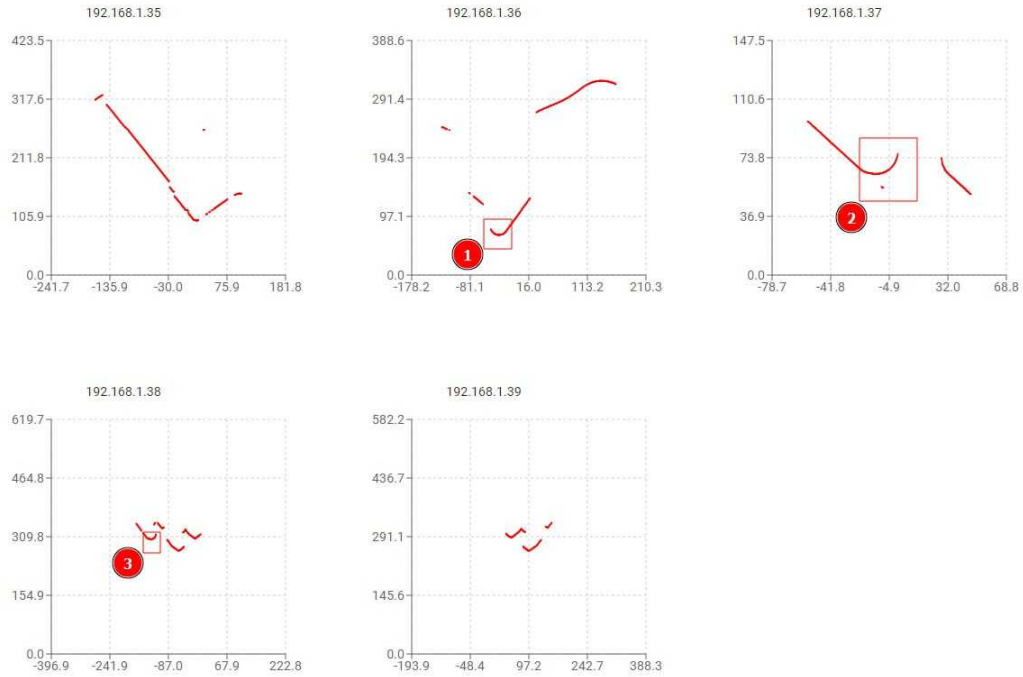


9. For each of the two profiles from the *.ikp file, select the corresponding profile from the 3DWheel measurements. To do this:

- Select the wheel profile from the *.ikp file:

- Select the corresponding profile from the 3DWheel measurements.

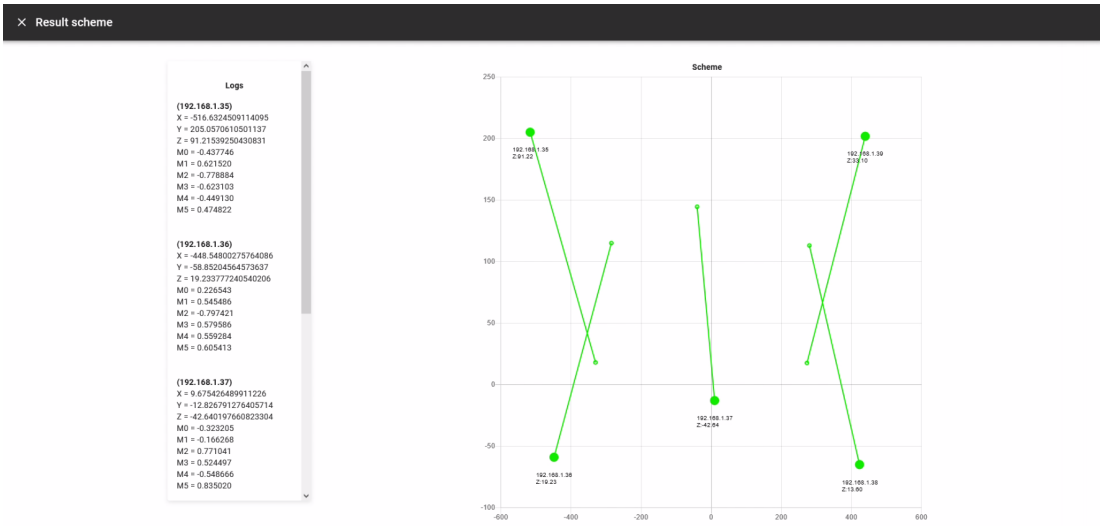
Profiles can be selected on the scale using the sliders, or you can enter values in the fields below the scale. When selecting the boundaries of the wheel (**start**/**end**), the wheel flange should be visible (see the screenshot below - 1, 2, 3).



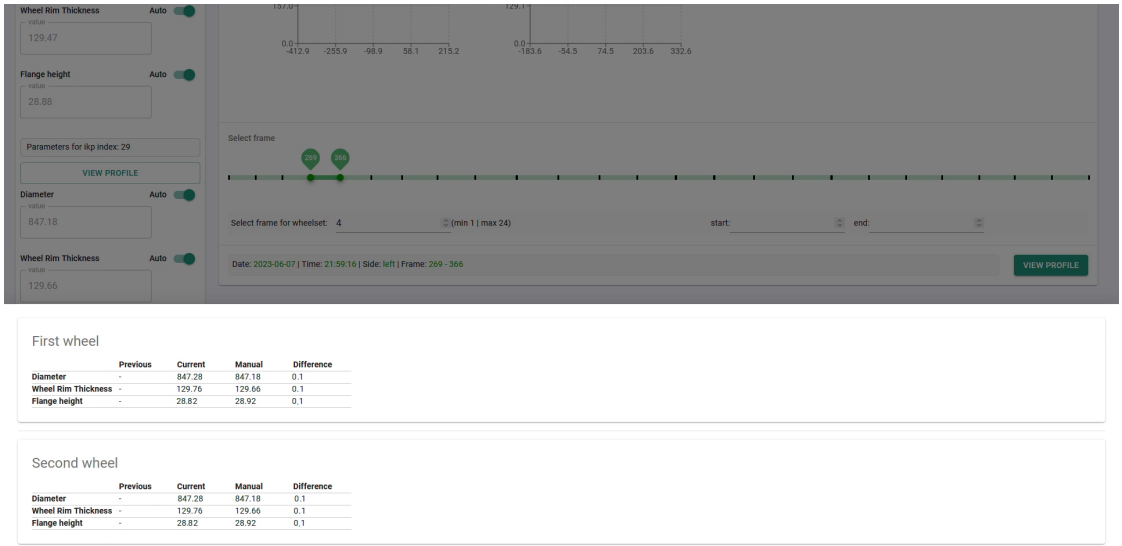
To view the wheel profile, click the **VIEW PROFILE** button in the right part of the window.

10. Click the **CALIBRATE** button. After the calibration is completed, the new buttons will appear on the left panel:

To view the calibration results, click the **VIEW RESULT** button.



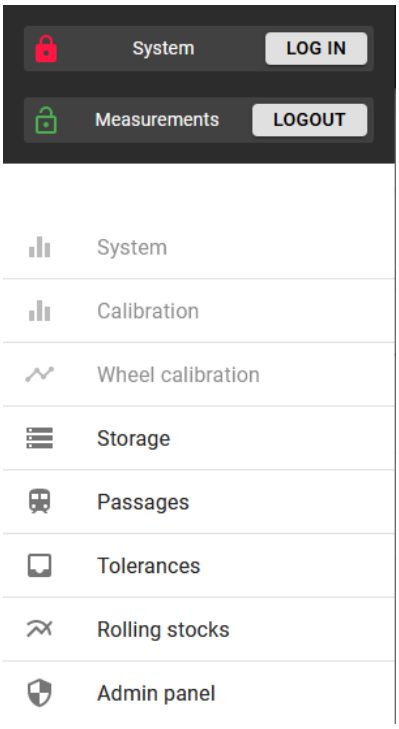
To compare the results, click the **TABLE WITH RESULTS** button.



11. Click the **APPLY** button to apply the calibration results.
12. Repeat steps 7-11 for the other side.

9.3. "Measurements" authorization

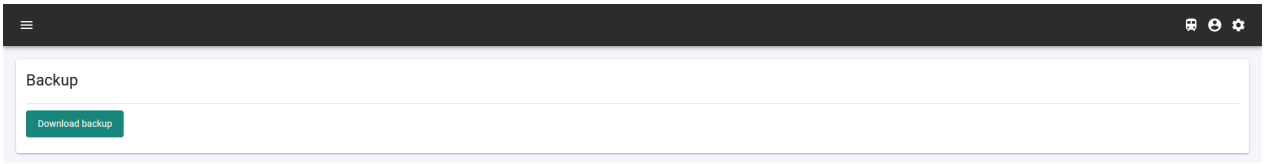
View of the web interface after authorization:



After authorization, the following menu items will become available:

1. Storage
2. Passages
3. Tolerances
4. Rolling stocks
5. Admin panel (if the user has access)

9.3.1. "Storage" page

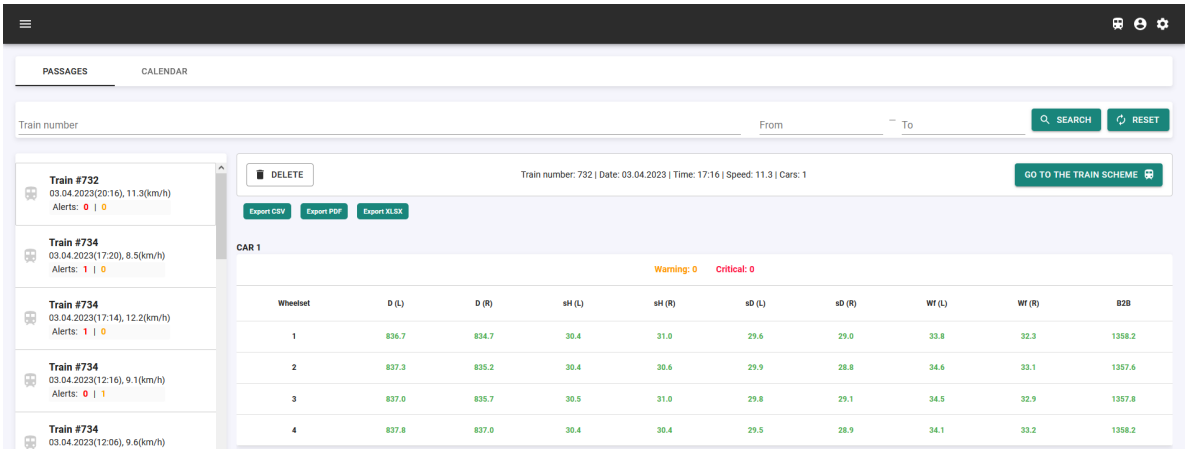


This page contains the **Download backup** button, which is used to download the archive with measurements.

9.3.2. "Passages" page

The **Passages** page contains two tabs: **Passages** and **Calendar**.

The **Passages** tab:



On the left side of the page there is a list of passages, on the right side there is a table with the measurement results.

To view the measurement results, select a passage from the list.

NOTE. If you enter the train number in the search bar and click the **SEARCH** button, only the passages of that train will be displayed on the panel. To reset the filter, click the **RESET** button.

Measurement results are colored depending on compliance with the specified tolerances:

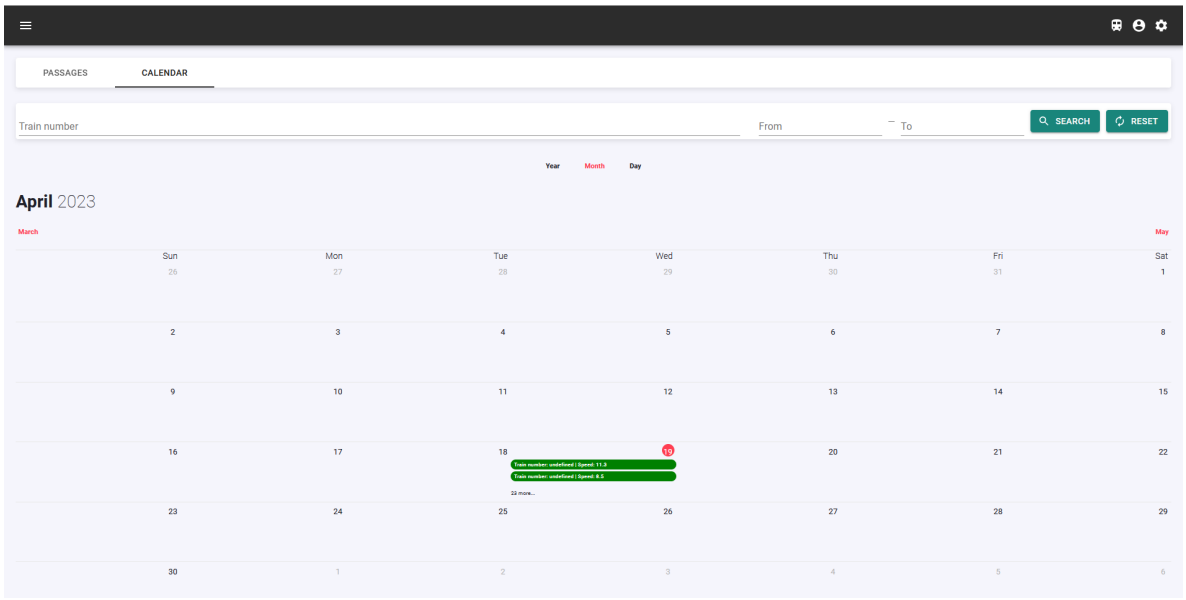
- **Green** – results are within tolerances.
- **Orange** – results are approaching critical values.
- **Red** – results are out of tolerances.

Measurement results can be exported in three formats: CSV, PDF, XLSX. To export to the desired format, click the appropriate button.

The passages can be removed from the list only by a user with administrator rights (the **DELETE** button).

To go to the train scheme, click the **GO TO THE TRAIN SCHEME** button (for details, see par. 9.3.4).

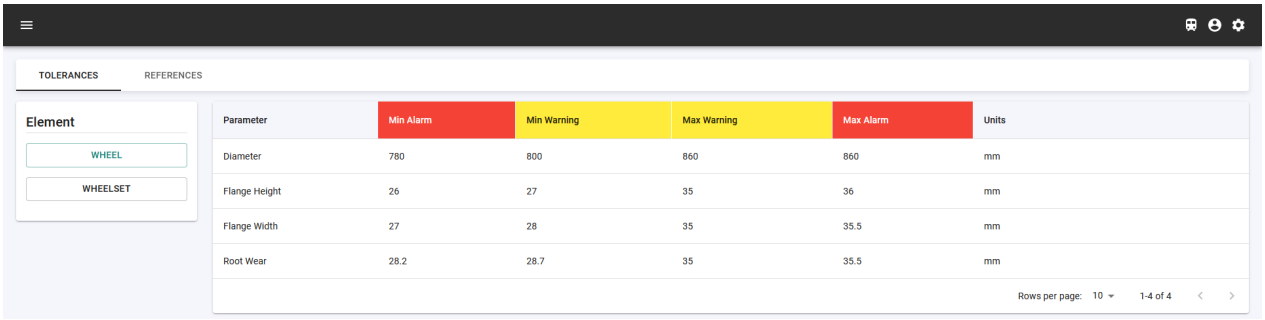
The **Calendar** tab:



With this calendar, the user can view passages for a specific date.

9.3.3. "Tolerances" page

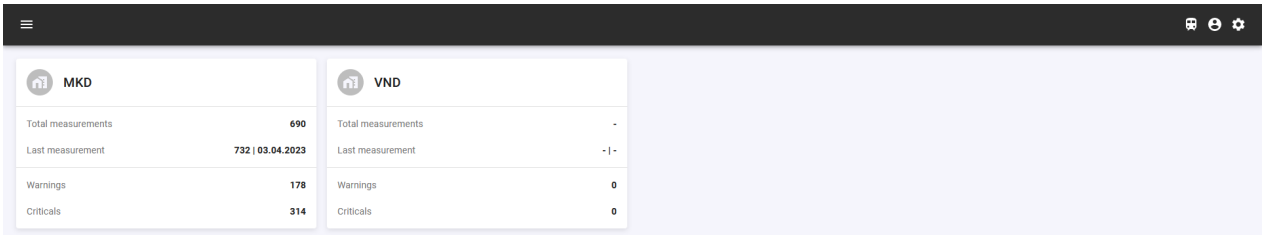
This page contains two tabs: **Tolerances** and **References** (currently not used). The **Tolerances** tab:



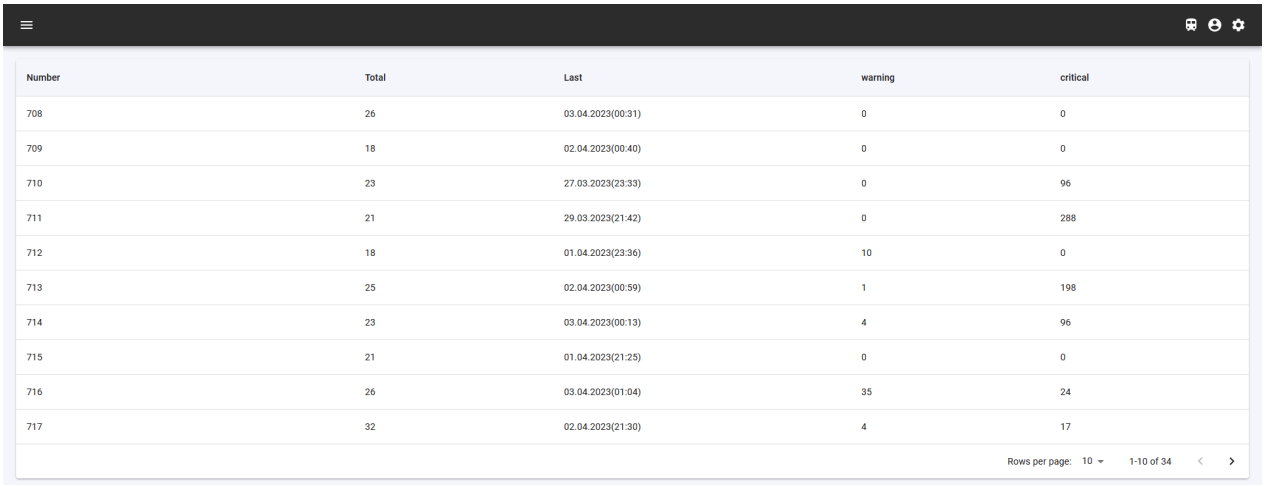
On this tab, the user can view the tolerances for the wheel and wheelset. Tolerances are set and edited on the **Admin panel** page (see par. 9.3.5.4).

9.3.4. "Rolling stocks" page

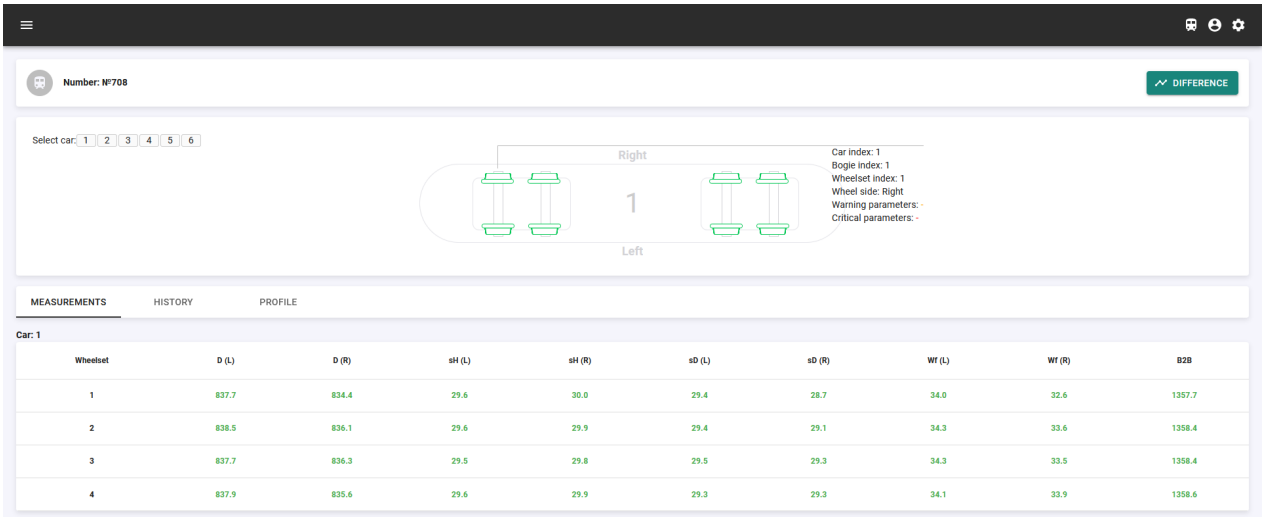
Select a depot by clicking on the panel with its name:



After clicking, a list of trains belonging to this depot will appear. To go to the train scheme, click on the train number in the list.

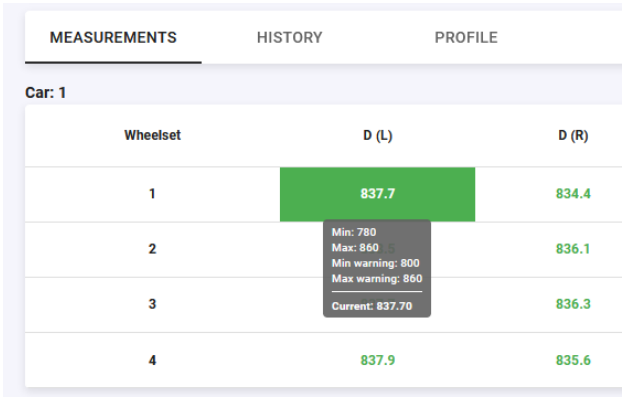


The train scheme:

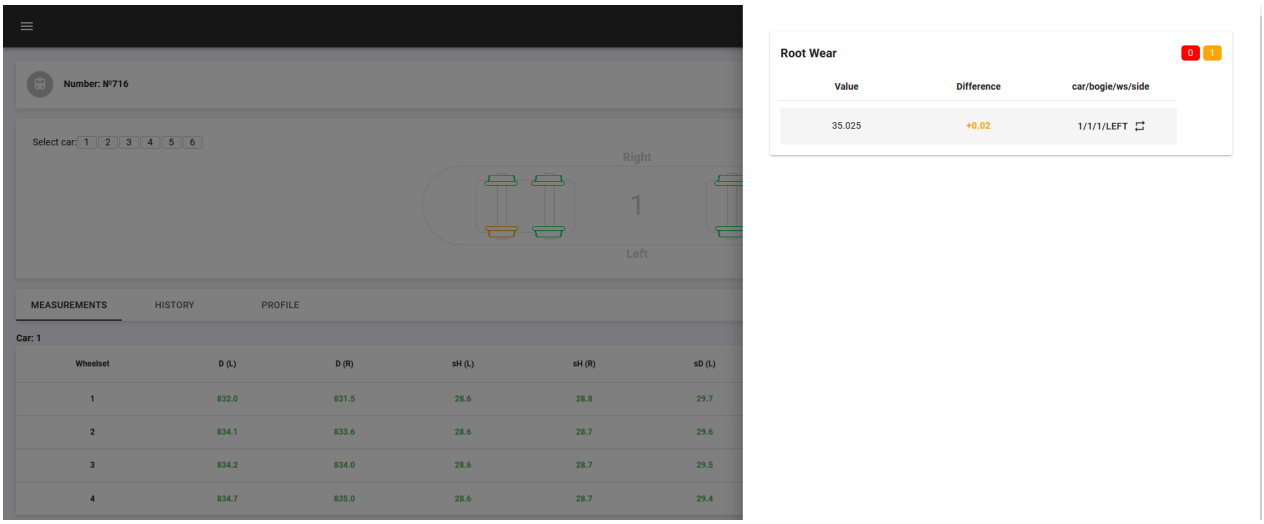


This panel contains three tabs: **Measurements**, **History**, and **Profile**.

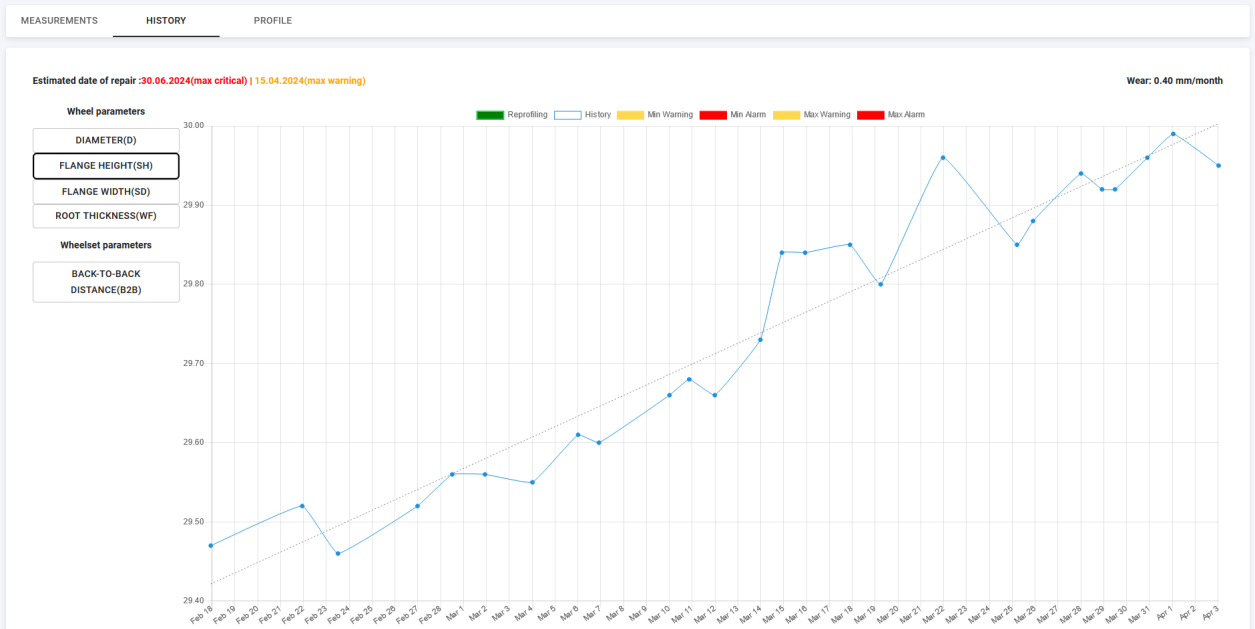
The **Measurements** tab (shown above) displays the measured parameters of the wheelsets of the selected car. When you hover the pointer over a value in the table, a tooltip appears with the tolerances for that parameter and the current measured value:



If there are values in the measurement results that are close to critical or out of tolerances (shown in orange and red respectively), then you can click the **DIFFERENCE** button to see the deviation in millimeters.



The **History** tab:

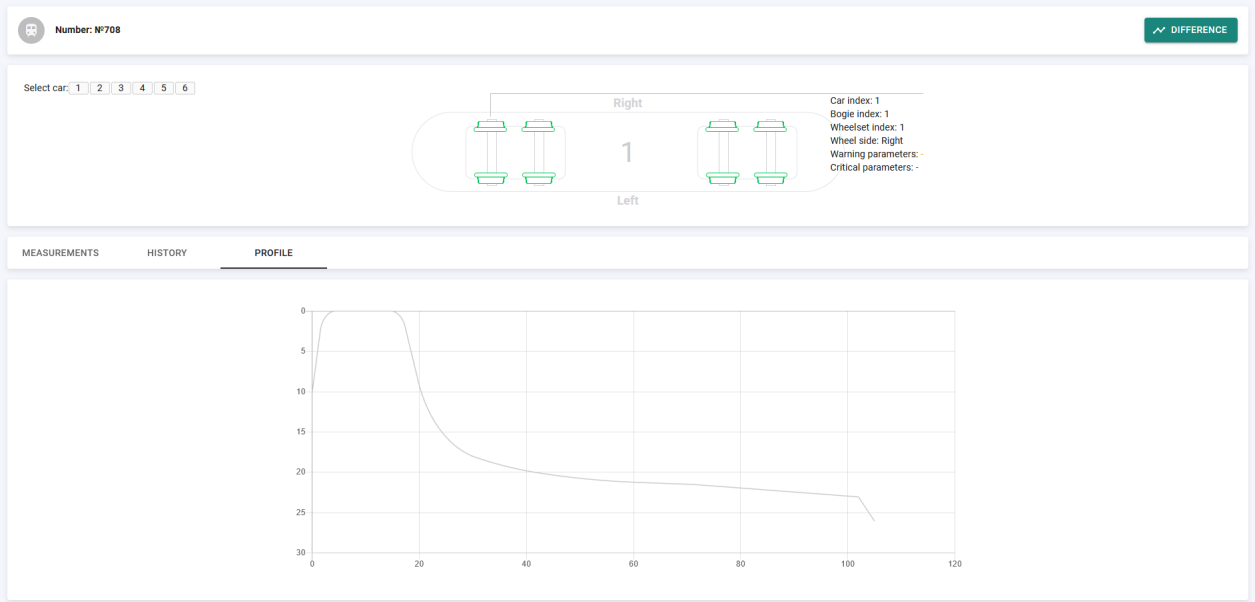


The graph in the **History** tab shows the measured values for the entire observation period. You need to select a car and a wheel on the train scheme and a parameter in the panel on the left. To select a wheel, left-click on it in the scheme.

Estimated dates of repair are displayed to the left of the graph. The orange color shows the date when the parameter is expected to approach critical values, and the red color shows the date when it goes beyond the specified tolerances.

To the right of the graph is the calculated wear rate in millimeters per month.

The **Profile** tab:

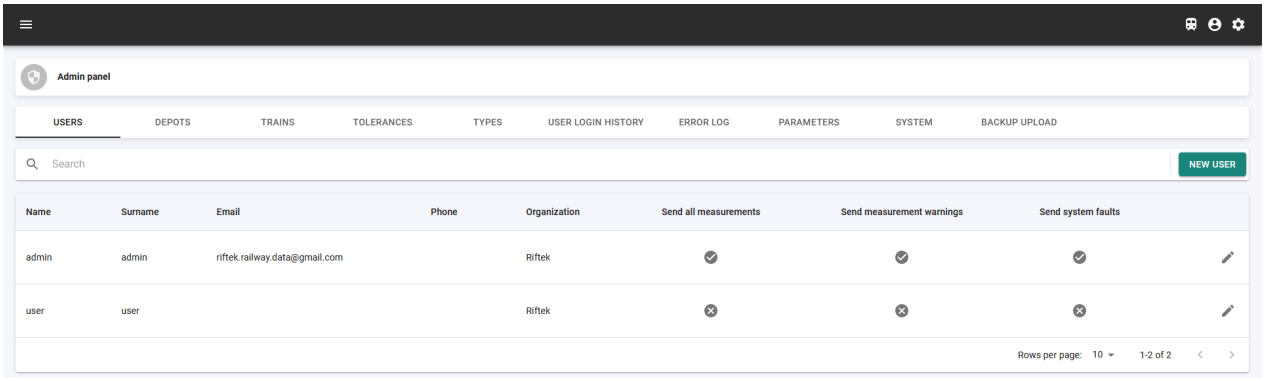


The **Profile** tab displays the profile of the wheel selected in the train scheme.

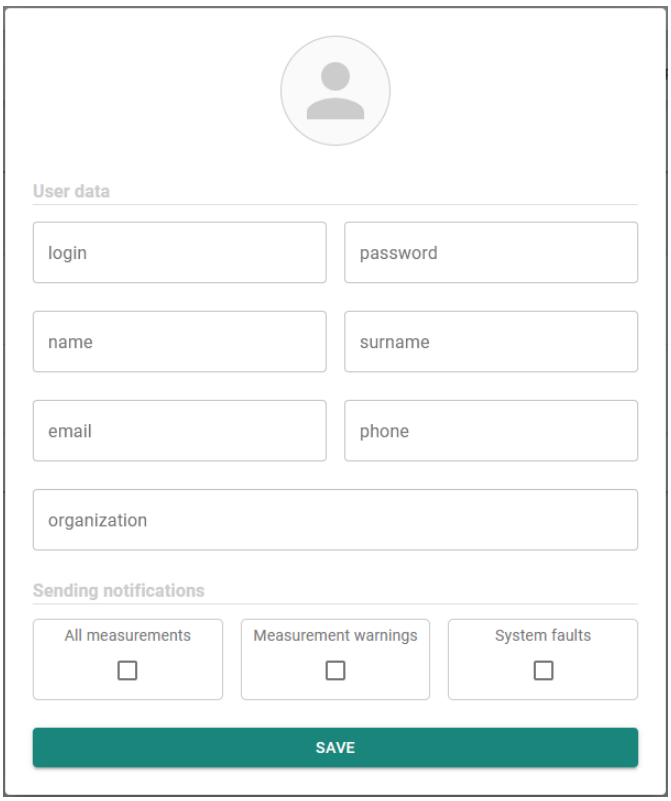
9.3.5. "Admin panel" page

The **Admin panel** page allows the user to view and manage the database.

9.3.5.1. "USERS" tab

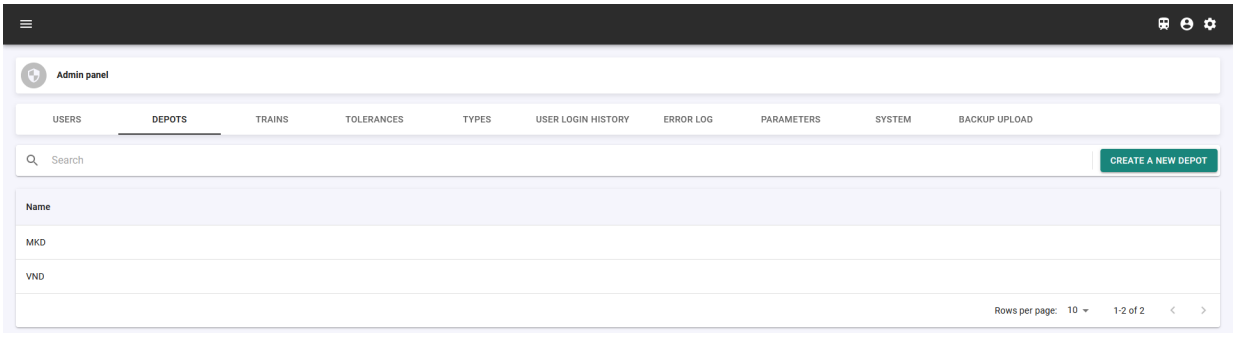


This tab contains a list of users.
To create a new user profile, click the **NEW USER** button.

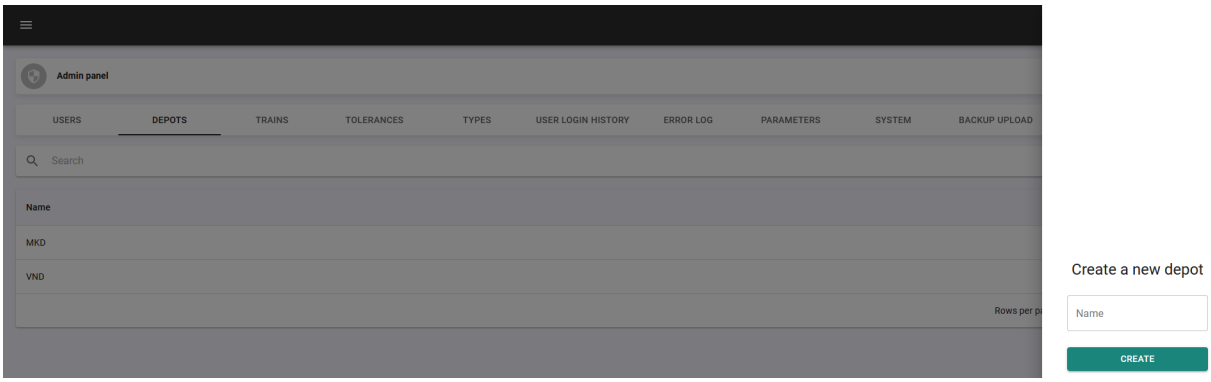


Fill in the details, select notifications (see par. 9.6), and click **SAVE**.
To edit the user profile, click ✎, make changes, and click **SAVE**.

9.3.5.2. "DEPOTS" tab

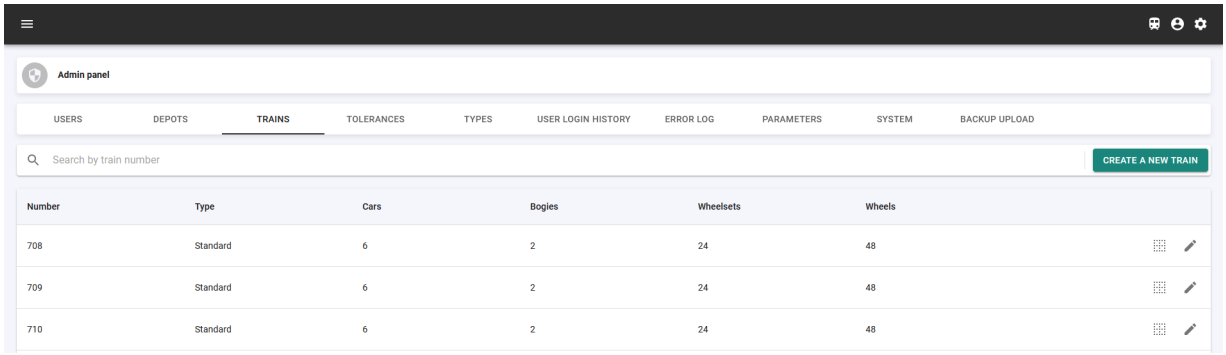


The **DEPOTS** tab contains a list of depots.
To find a specific depot, enter its name in the **Search** bar.
To create a new depot, click the **CREATE A NEW DEPOT** button.

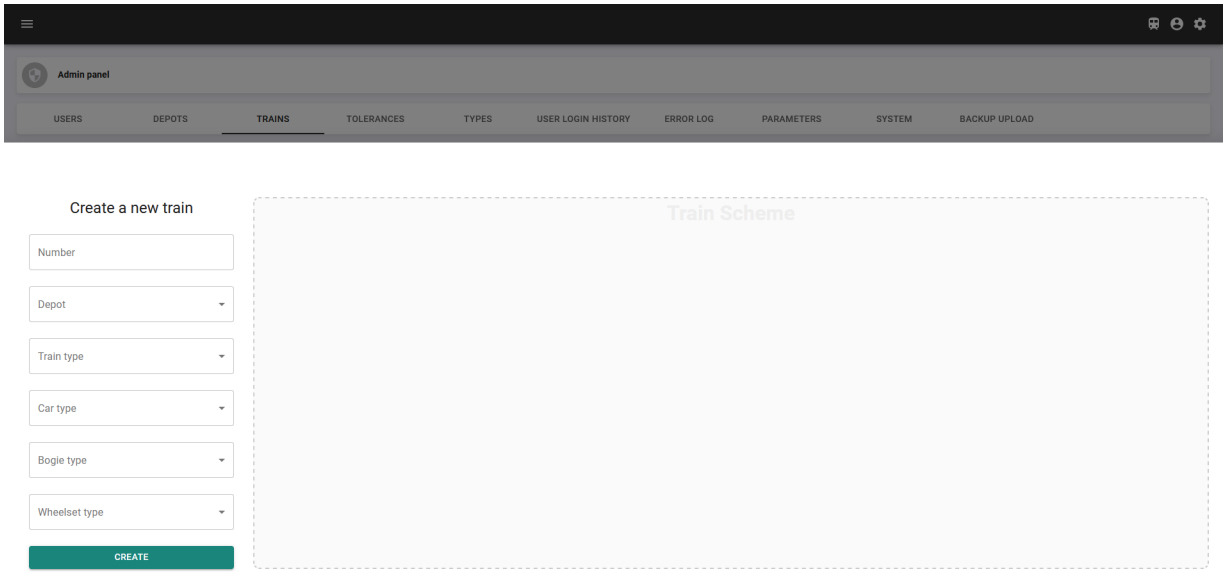


Enter a name and click **CREATE**.

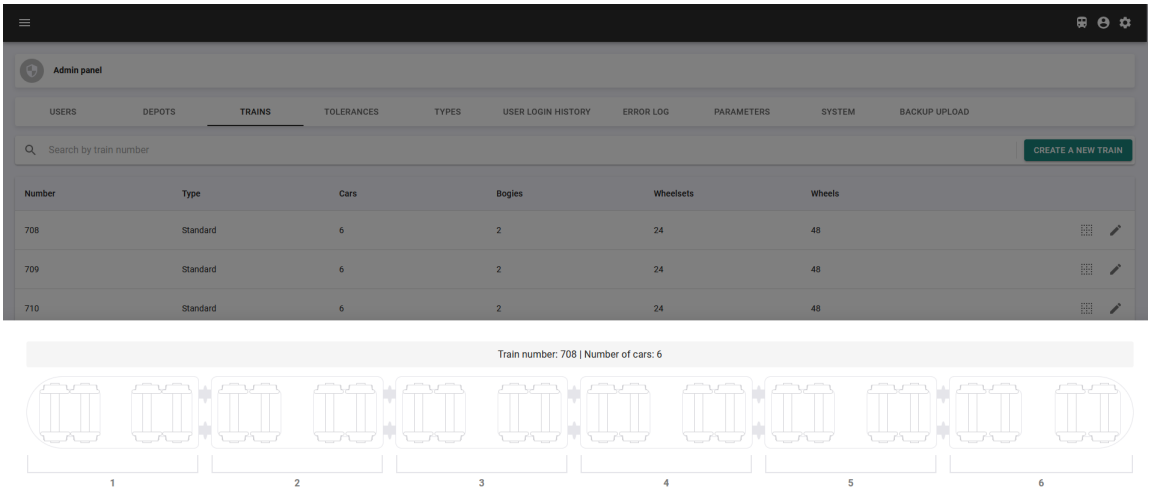
9.3.5.3. "TRAINS" tab



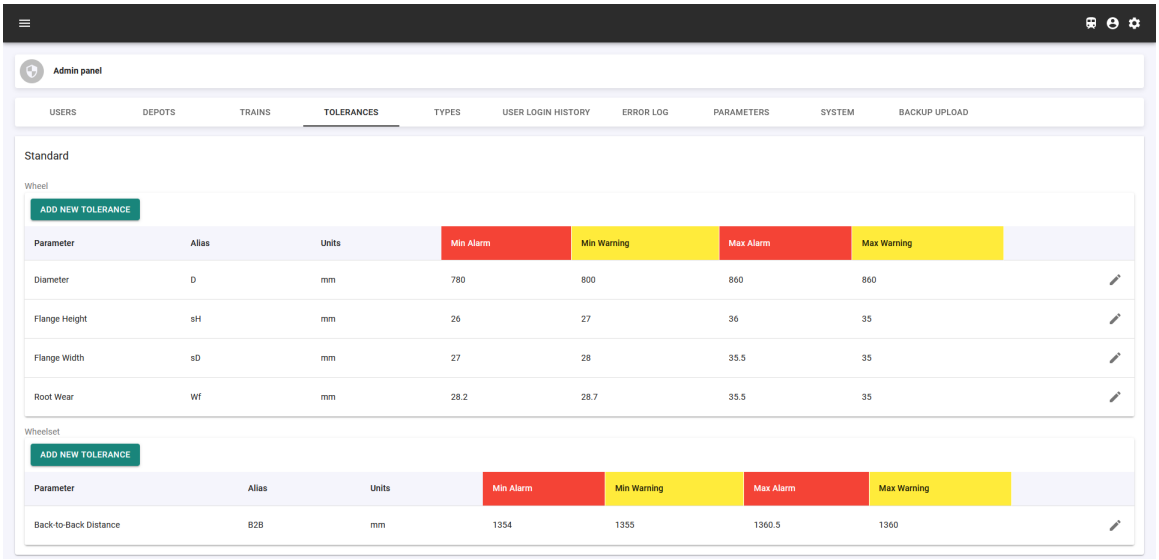
The **TRAINS** tab contains a list of trains.
To find a specific train, enter its number in the **Search** bar.
To edit a train, click ✎.
To create a new train, click the **CREATE A NEW TRAIN** button.



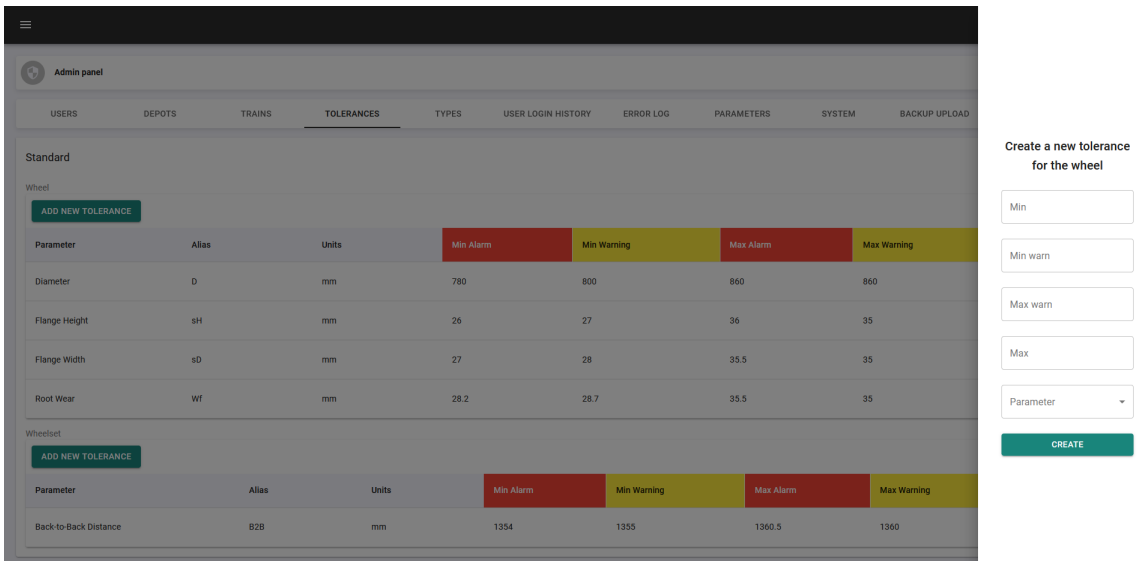
Specify the parameters and click **CREATE**.
Clicking on ⁘ opens the train scheme.



9.3.5.4. "TOLERANCES" tab



The **TOLERANCES** tab allows the user to add/edit the tolerances.
To edit a tolerance, click .
To add a new tolerance, click the **ADD NEW TOLERANCE** button.

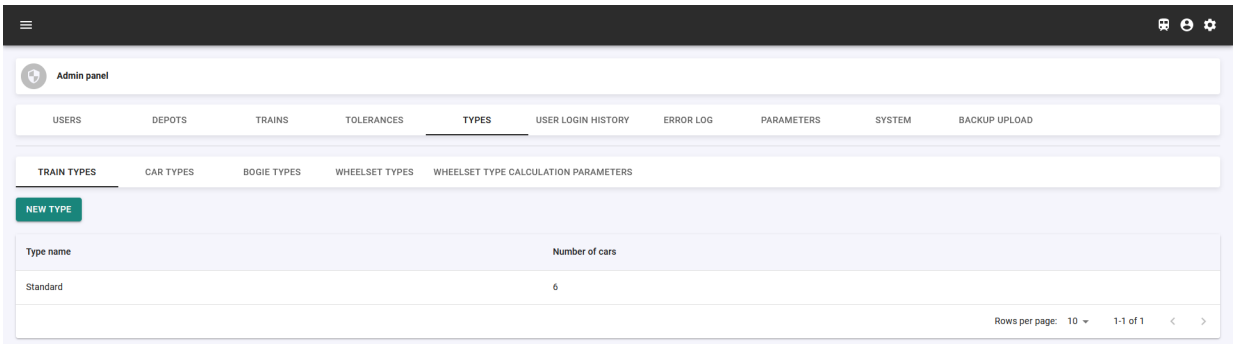


Enter the values, select a parameter from the drop-down list and click **CREATE**.

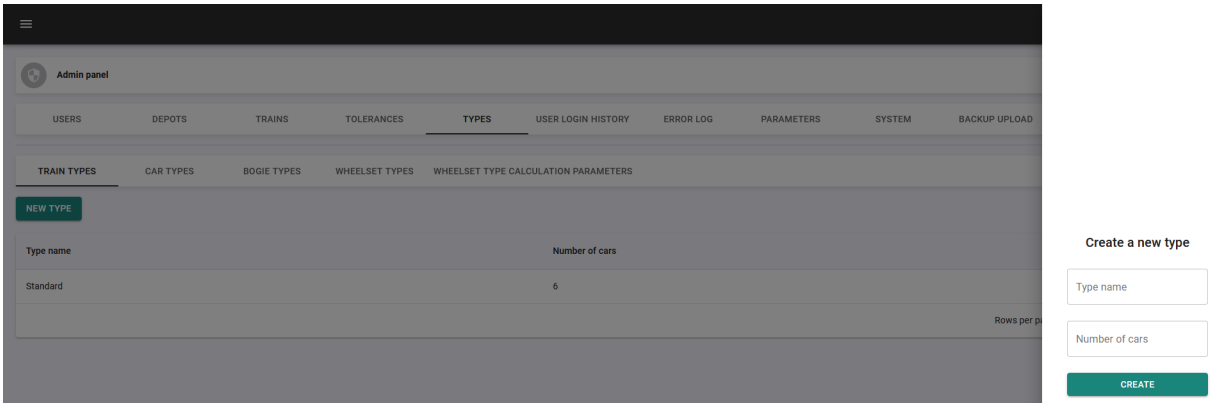
9.3.5.5. "TYPES" tab

9.3.5.5.1. "Train types" tab

This tab contains a list of train types.



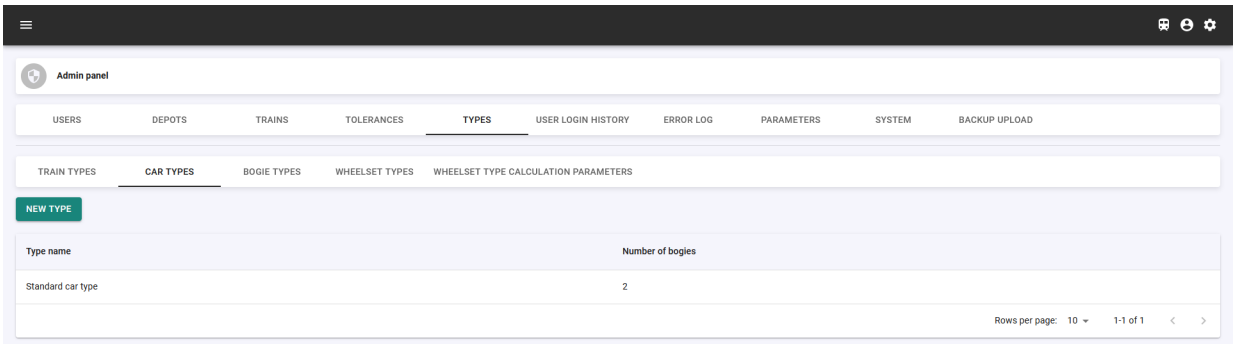
To add a new type, click the **NEW TYPE** button.



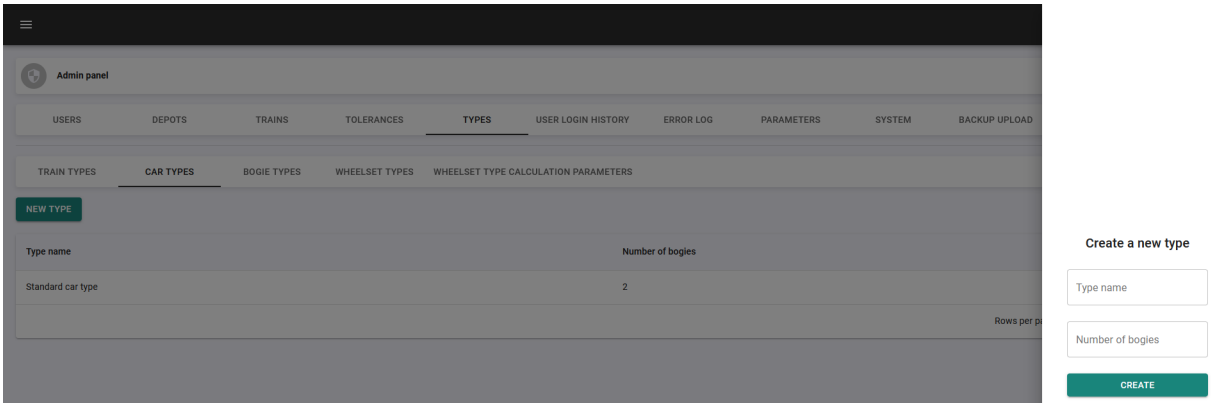
Enter the name of the train type, the number of cars and click the **CREATE** button.

9.3.5.5.2. "Car types" tab

This tab contains a list of car types.



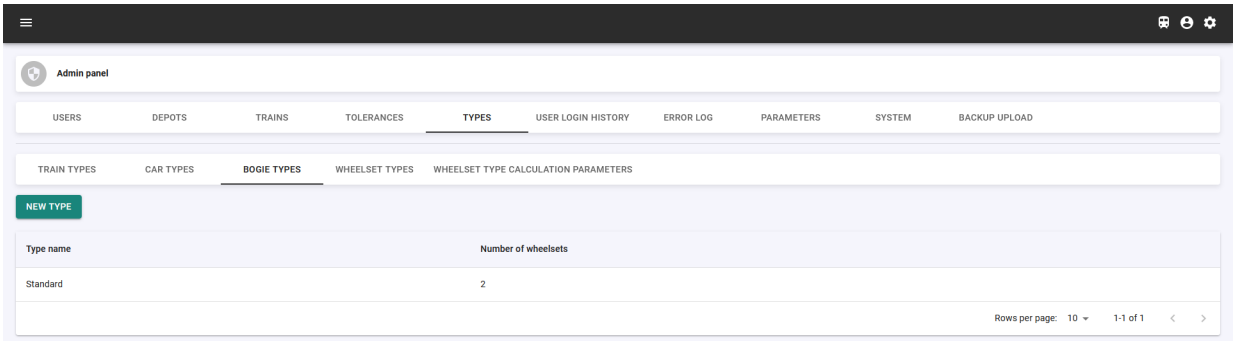
To add a new type, click the **NEW TYPE** button.



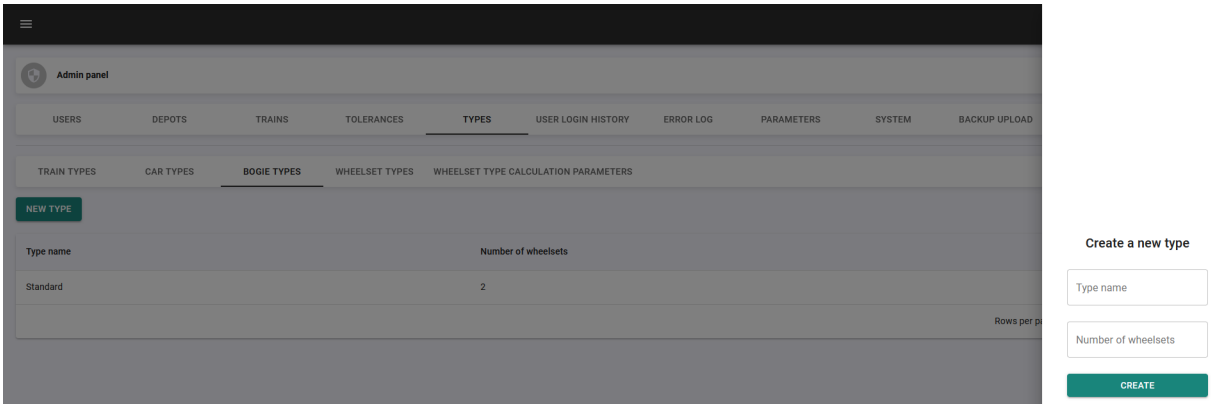
Enter the name of the car type, the number of bogies and click the **CREATE** button.

9.3.5.5.3. "Bogie types" tab

This tab contains a list of bogie types.



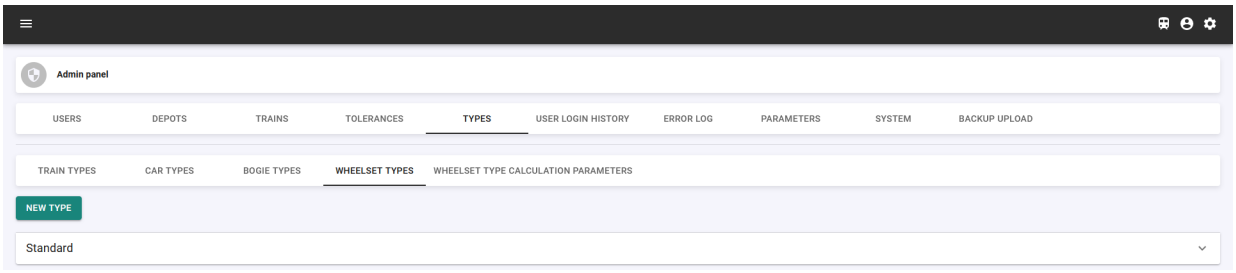
To add a new type, click the **NEW TYPE** button.



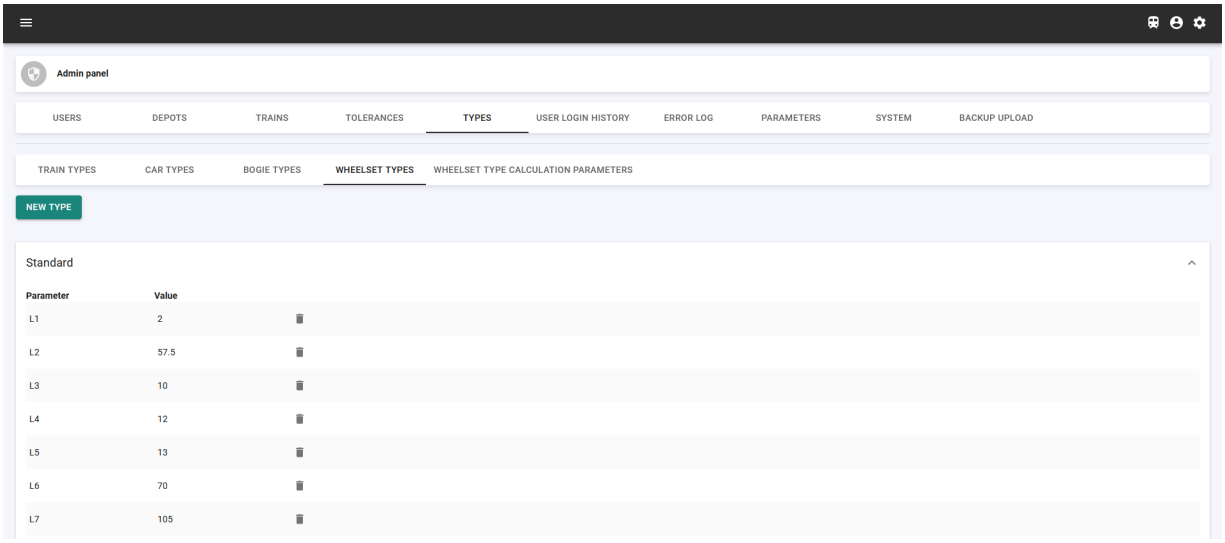
Enter the name of the bogie type, the number of wheelsets and click the **CREATE** button.

9.3.5.5.4. "Wheelset types" tab

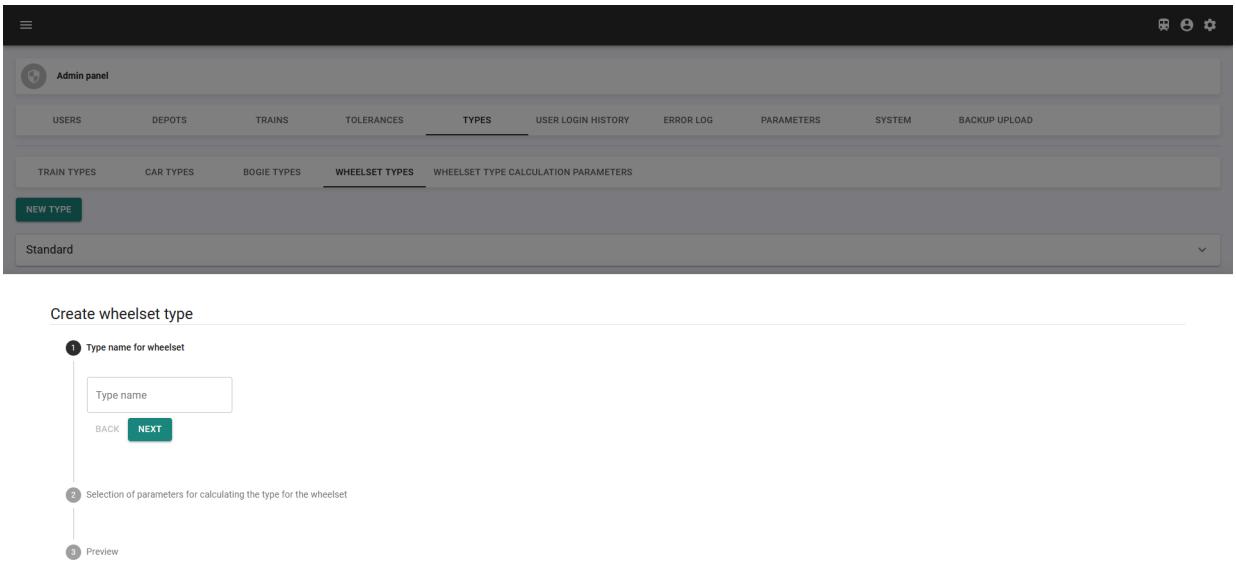
This tab contains a list of wheelset types.



To view the parameters, click ⌄.



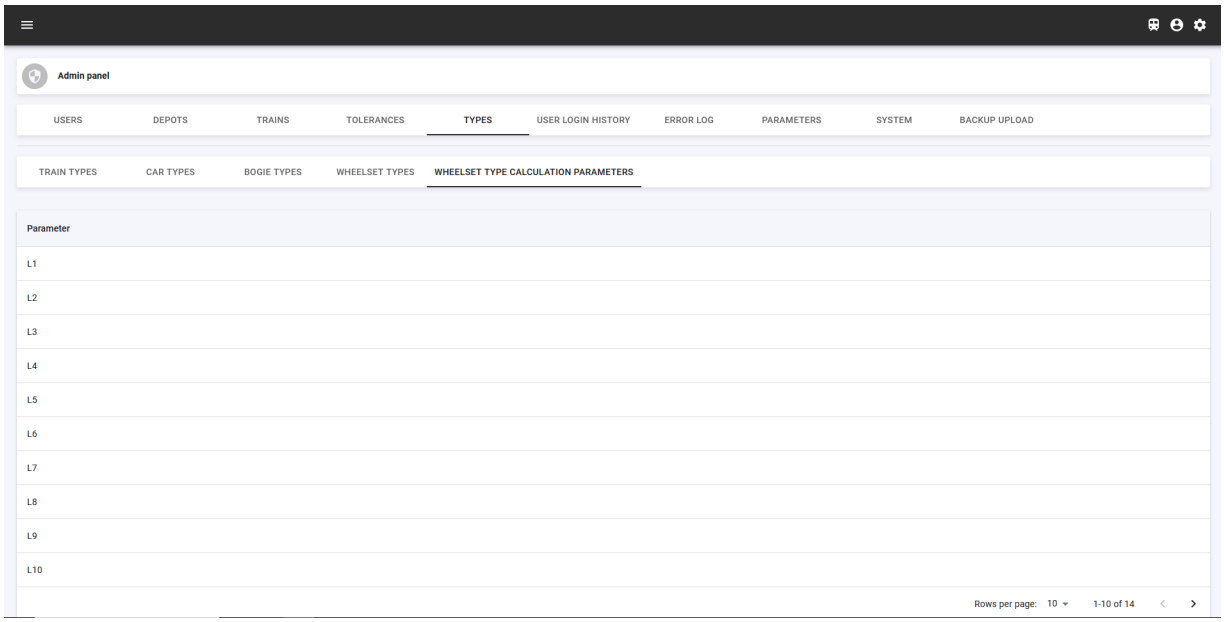
To remove a parameter from the list, click 🗑.
To add a new type, click the **NEW TYPE** button.



Enter the name of the wheelset type, parameters and click the **CREATE** button.

9.3.5.5.5. "Wheelset type calculation parameters" tab

This tab contains a list of wheelset calculation parameters.



9.3.5.6. "USER LOGIN HISTORY" tab

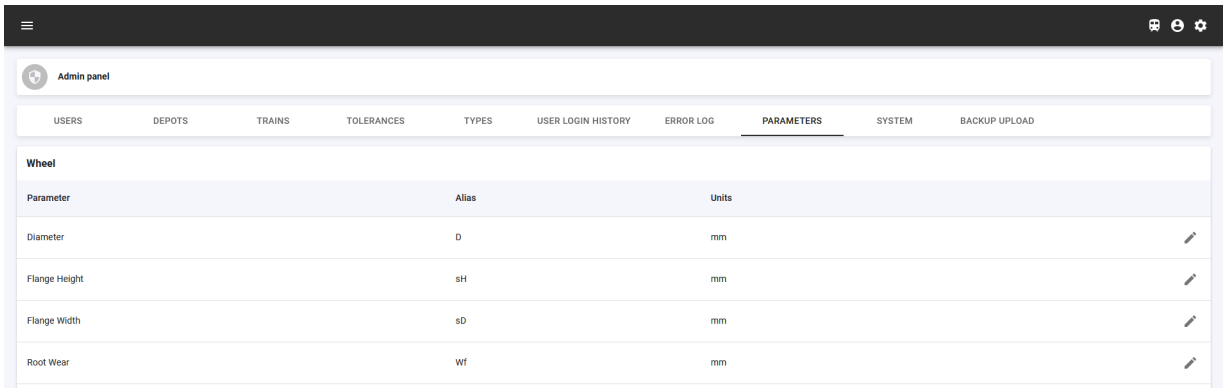
This tab displays the user authorization history.

9.3.5.7. "ERROR LOG" tab

This tab displays a log of errors that occur during the measurement process (for example, if the train number is not in the database).

9.3.5.8. "PARAMETERS" tab

This tab contains a list of measured parameters of the wheel and wheelset.

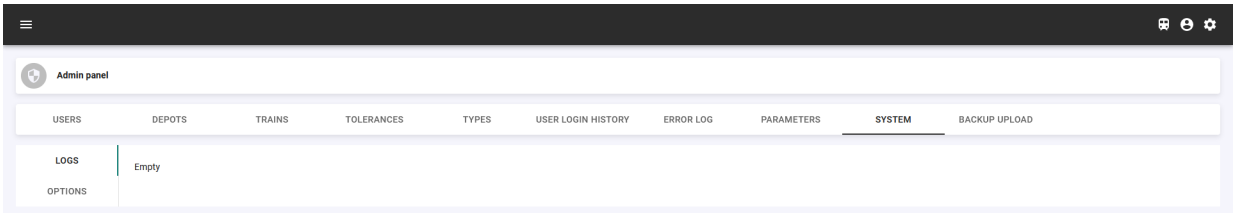


To change the alias of the parameter, click .

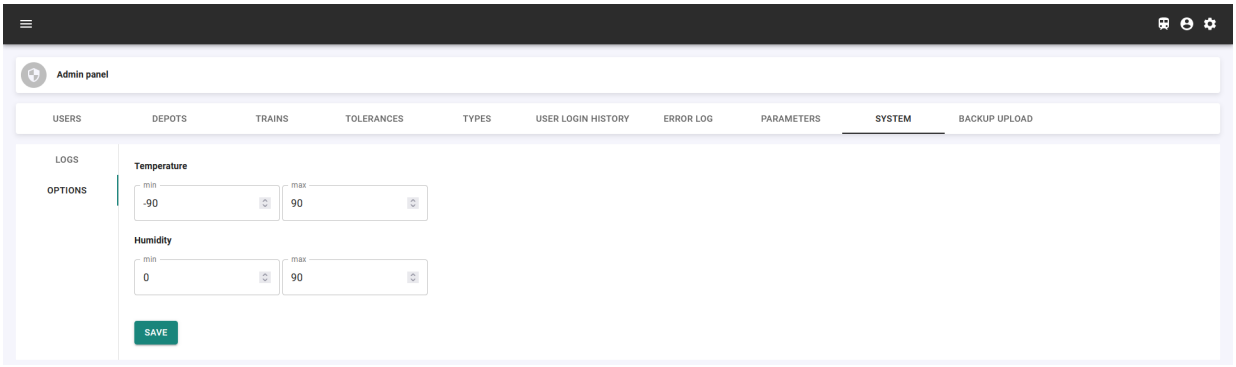
9.3.5.9. "SYSTEM" tab

To control the state of laser scanners, the measuring system provides automatic notification when the temperature inside the sensor is exceeded and when its depressurization occurs.

The **LOGS** tab displays information about exceeding temperature and humidity limits.

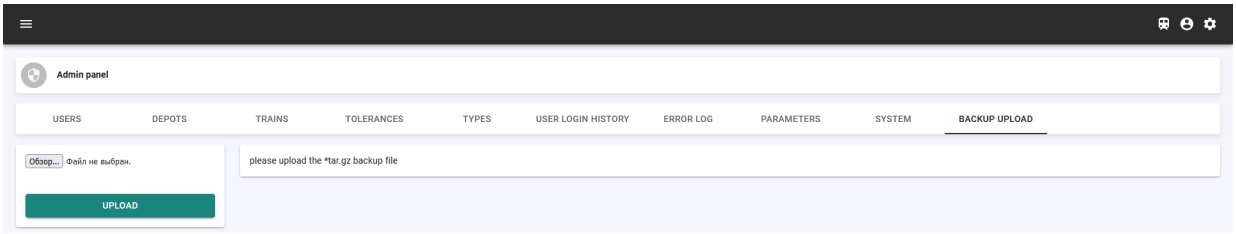


The **OPTIONS** tab is intended for setting the maximum and minimum values for air temperature and humidity. When the specified limit values are exceeded, a notification is automatically sent.



To apply the changes, click **SAVE**.

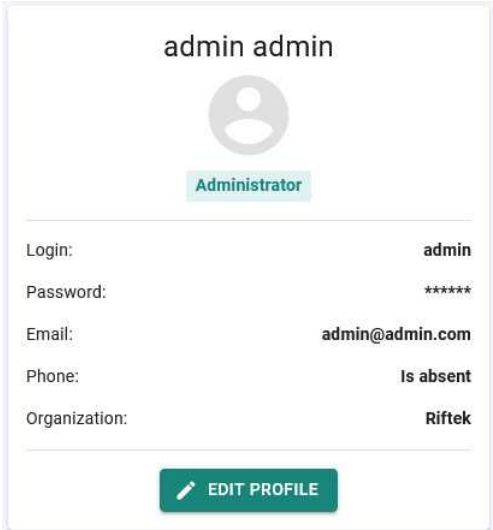
9.3.5.10. "BACKUP UPLOAD" tab



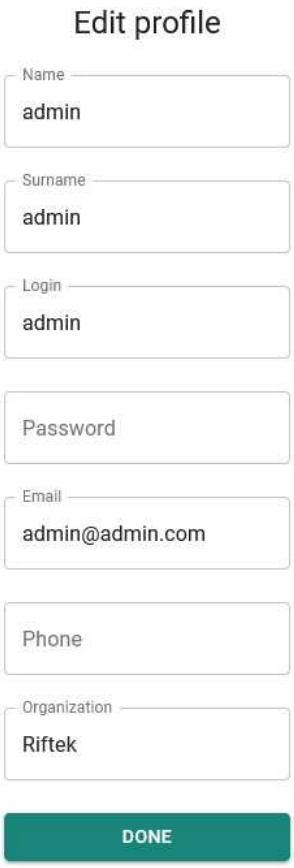
This tab is for uploading measurement results from a file.
Select the path to the file (***tar.gz**) and click **UPLOAD**.

9.4. "Profile" page

To open the **Profile** page, click on the toolbar. This page displays information about the current user:



To edit the profile, click **EDIT PROFILE**:



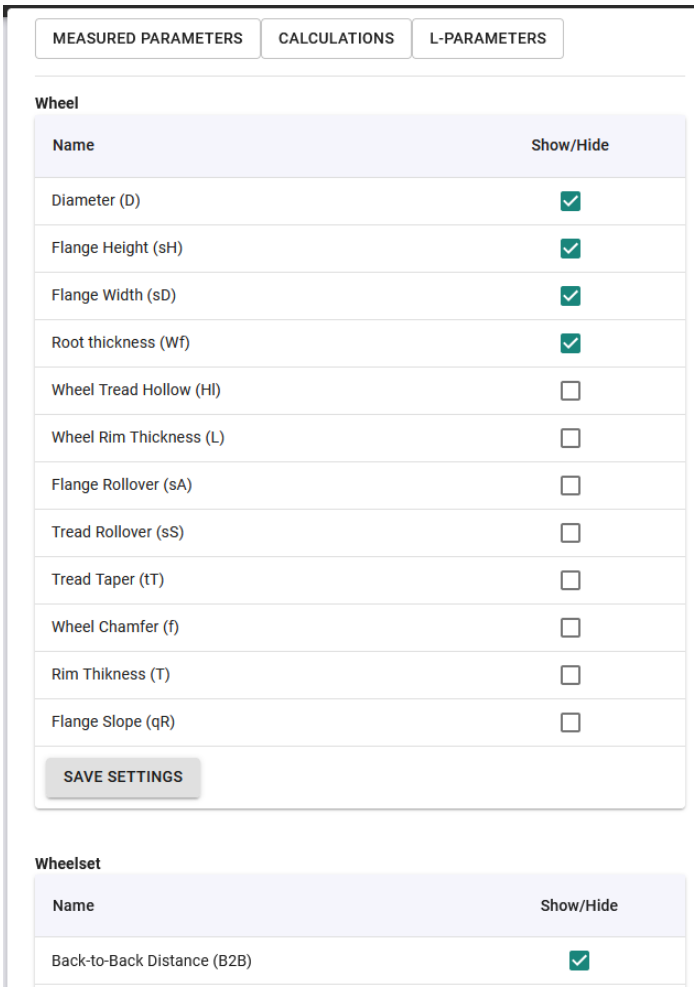
To apply the changes, click **DONE**.

9.5. "Settings" panel

To open the **Settings** panel, click on the toolbar.

9.5.1. "Measured parameters" tab

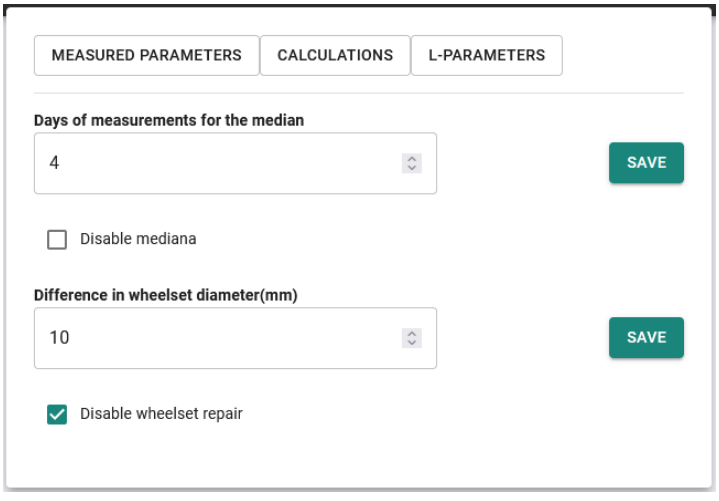
This tab is for selecting the parameters to be measured.



To select parameters, mark the checkboxes and click **SAVE SETTINGS**.
NOTE. Only the selected parameters will be calculated and displayed.

9.5.2. "Calculations" tab

On this tab, the user can set the number of measurement days to calculate the median values.



To disable the calculation of median values, select **Disable mediana**.

Also, the user can set the value of the difference in the diameter of the wheelsets (mm).

To apply the changes, click **SAVE**.

9.5.3. "L-parameters" tab

This tab displays a list of L-parameters.

9.6. System notifications

Notifications to be sent are selected by the user in the **USERS** tab (see par. 9.3.5.1).

All notifications are sent to the e-mail address specified in the user's profile.

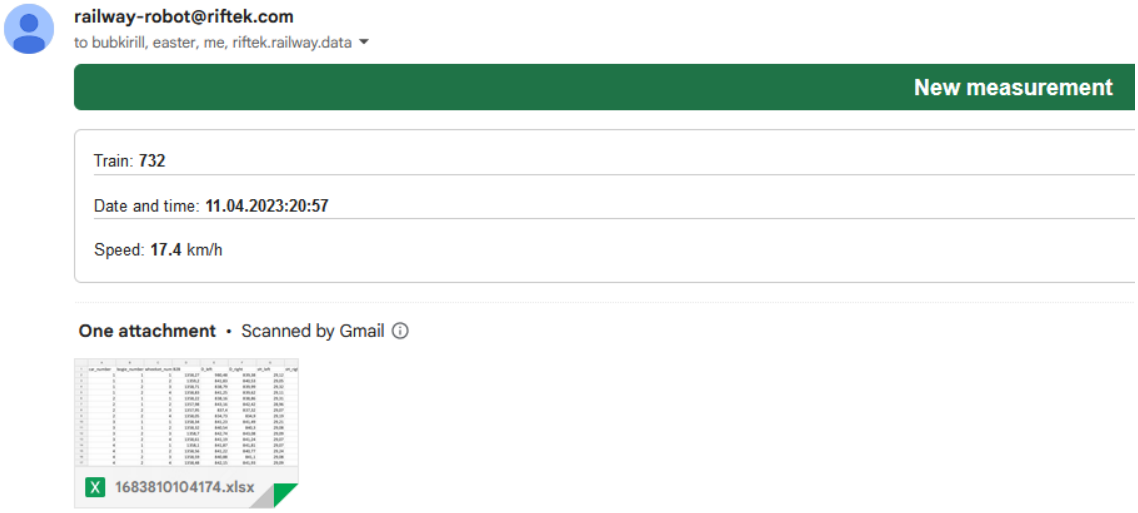
The following notifications are available:

- **All measurements** – Measurement results.
- **Measurement warnings** – These notifications are sent when the measured values are out of tolerances.
- **System faults** – Notifications about system faults.

The examples of system notifications are given in the paragraphs below.

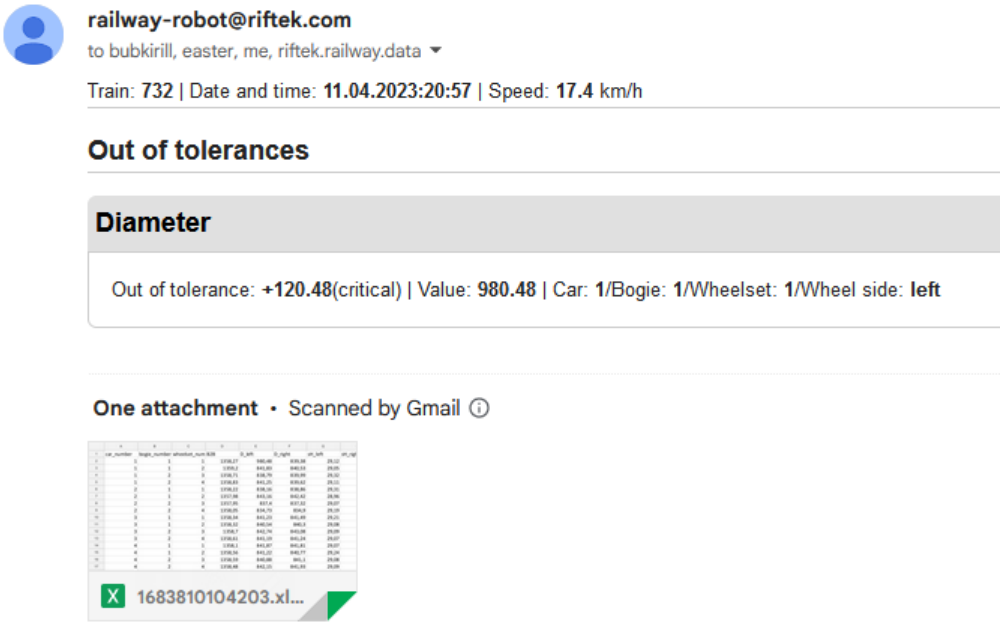
9.6.1. "All measurements" notification

This notification contains the measurement results in Excel format.



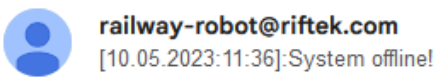
9.6.2. "Measurement warnings" notification

This notification is sent when some measurement results are out of tolerances.



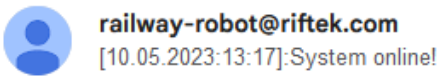
9.6.3. "System faults" notification

There are 9 types of notifications:
1) "System offline"



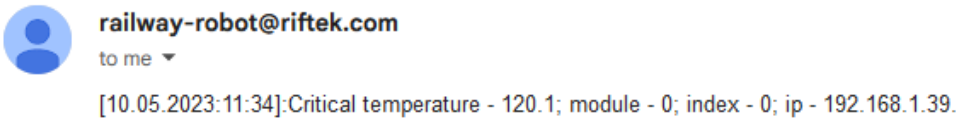
The "System offline" notification is automatically sent if the server does not receive system status data within 30 seconds. When the server receives system status data again, the "System online" notification will be sent.

2) "System online"



The "System online" notification is automatically sent when the server receives system status data after the system has been offline.

3) "Temperature and humidity of 10 scanners"

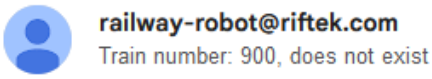


This notification is automatically sent when the temperature/humidity values are out of tolerances.

4) "Partial measurements"

This notification is sent if not all measurements have been taken.

5) "No train number"



This notification is sent if the train number is not in the database.

6) "Wrong wheelsets number"

This notification is sent if the wheelset numbers do not match.

7) "Storage is low"

This notification is sent when the SSD memory limit is exceeded.

8) "Network power lost / working from battery"

This notification is sent when the system is powered by the UPS.

9) "Charge is below 10%"

This notification is sent when the UPS is less than 10% charged.

10. Data export

10.1. Data export formats

After each measurement of the train, the measurement results are written to the database and a report is generated. The report contains the following information: the measurement date and time, the train speed, the car number, the number of wheelsets and the measured parameters. In addition, the system can provide the following data: wheel profiles, wheelsets speed, direction of wheelsets, environment temperature. Currently, the system supports three formats: CSV, XLSX, JSON. Reports are stored on the server and, if necessary, can be sent by email.

10.2. Examples

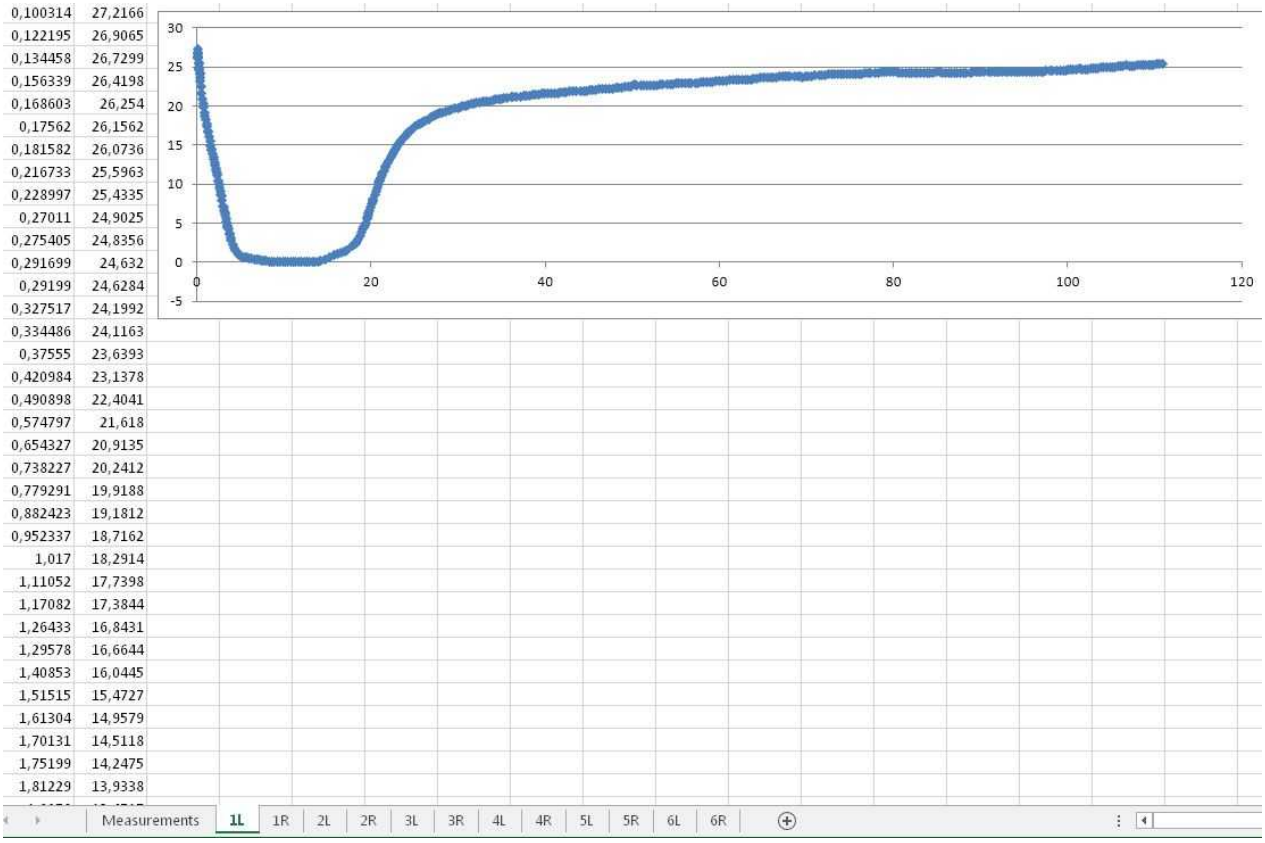
10.2.1. CSV

3DWheel Measurements								
Date: 2020/02/23								
Time: 19:59:38								
Car number: 0								
Average speed: 6.85 km/h								
#	D(L)	D(R)	sH(L)	sH(R)	sD(L)	sD(R)	qR(L)	qR(R)
1	687,3	687,98	23,64	23,1	20,45	20,49	4,41	4,02
2	688,09	686,82	22,88	24,18	23,31	24,52	3,92	4,95
3	687,11	688,52	23,73	22,94	21,51	21,04	4,44	3,89
4	688,8	687,37	22,86	23,75	23,9	24,27	3,86	4,56
5	687,08	688,03	23,57	22,93	21,9	21,43	4,49	3,97
6	688,41	688,02	22,86	23,71	24,18	24,11	4,03	4,46

10.2.2. XLSX

Measurements - Poruba								
Date: 2020/02/23								
Time of measurement: 19:59:38								
Average speed: 7 km/h								
Tram ID	Type	Wheel set	D(L)	D(R)	sH(L)	sH(R)	sD(L)	sD(R)
0	CarType	1	687,3	688	23,6	23,1	20,4	20,5
		2	688,1	686,8	22,9	24,2	23,3	24,5
		3	687,1	688,5	23,7	22,9	21,5	21
		4	688,8	687,4	22,9	23,7	23,9	24,3
		5	687,1	688	23,6	22,9	21,9	21,4
		6	688,4	688	22,9	23,7	24,2	24,1

Wheel profiles are saved in separate tabs:



0,100314	27,2166
0,122195	26,9065
0,134458	26,7299
0,156339	26,4198
0,168603	26,254
0,17562	26,1562
0,181582	26,0736
0,216733	25,5963
0,228997	25,4335
0,27011	24,9025
0,275405	24,8356
0,291699	24,632
0,29199	24,6284
0,327517	24,1992
0,334486	24,1163
0,37555	23,6393
0,420984	23,1378
0,490898	22,4041
0,574797	21,618
0,654327	20,9135
0,738227	20,2412
0,779291	19,9188
0,882423	19,1812
0,952337	18,7162
1,017	18,2914
1,11052	17,7398
1,17082	17,3844
1,26433	16,8431
1,29578	16,6644
1,40853	16,0445
1,51515	15,4727
1,61304	14,9579
1,70131	14,5118
1,75199	14,2475
1,81229	13,9338

10.2.3. JSON


```
[
  [
    [
      [
        {
          "D": 687.3026174138828,
          "L": 120.66311325665687,
          "T": 35.02020733530675,
          "oG": 0.1164466612242025,
          "qR": 4.407366434733072,
          "rO": 0.2628764034200593,
          "sD": 20.44835354487101,
          "sH": 23.644717694211888
        },
        {
          "D": 687.9751472243917,
          "L": 120.71566376306754,
          "T": 35.45981243859366,
          "oG": 0.1358842851576091,
          "qR": 4.016982293128967,
          "rO": 0.2125430822372458,
          "sD": 20.48891031742096,
          "sH": 23.09733729179089
        }
      ],
      {
        "AxisRO": 0.34539420198188964,
```

```
            "B2b": 1375.16881266826,
            "Number": 0
          }
        ],
...
...
...
[
        [
          {
            "D": 688.4073052795457,
            "L": 120.64484220838331,
            "T": 34.93728164398056,
            "oG": 0.12607032603945623,
            "qR": 4.027633367265974,
            "rO": 0.06191604669543125,
            "sD": 24.18155947185698,
            "sH": 22.85857122393622
          },
          {
            "D": 688.018169317617,
            "L": 120.67052916008655,
            "T": 35.07461368863065,
            "oG": 0.1367980419189953,
            "qR": 4.460418260097503,
            "rO": 0.07304188773745679,
            "sD": 24.109996795654297,
            "sH": 23.70566265015375
          }
        ],
        {
          "AxisRO": 0.21475389625084063,
          "B2b": 1375.499207351858,
          "Number": 5
        }
      ],
      {
        "carId": 0,
        "carNumber": "0",
        "carType": "type",
        "chassisType": "type",
        "wheelsetCount": 6
      }
    ],
    {
      "dateTime": "2020-02-23T19:59:38",
      "ok": true,
      "speed": 7,
      "version": 2
    }
]
```

11. Riftek API

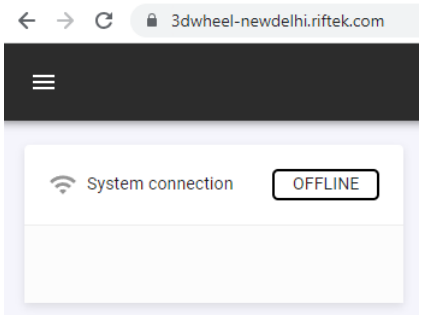
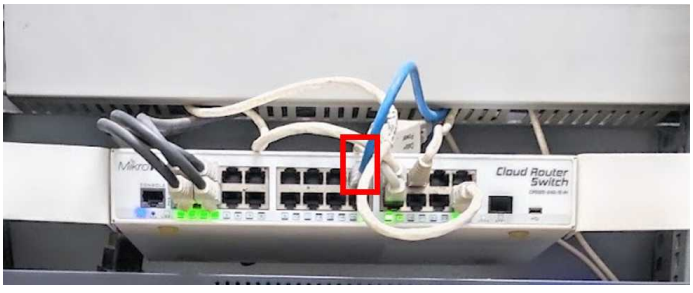
Connection through REST requests:
http://railway.riftek.com:5000/INSTALLATION_NAME/trains/TRAIN_SN/passages/latest

Below is a response to a request for measurements in JSON format (train serial number - "TRAIN_SN", in the system - "INSTALLATION_NAME"):

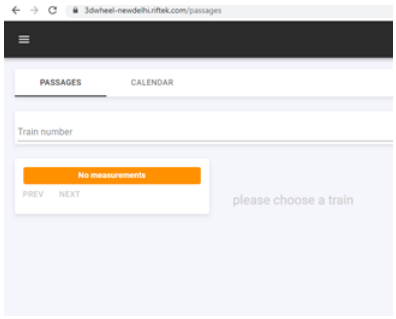

```
{
 "train_pasage": {
  "date_time": "2020-01-31 06:57:24",
  "orientation": "Forward",
  "speed_km_h": 4.8,
  "detected_wheel_pairs_count": 4,
  "train": {
   "serial_number": "1256",
   "cars": [
    {
     "serial_number": "1256_0",
     "index_number": 0,
     "orientation": "Forward",
     "car_type": "Inekon TRIO",
     "bogies": [
      {
       "serial_number": "1256_0_0",
       "index_number": 0,
       "orientation": "Forward",
       "wheel_pairs": [
        {
         "serial_number": "1256_0_0_0",
         "index_number": 0,
         "orientation": "Forward",
         "measurements": [
          {
           "type": "b2b",
           "value": 1371.57
          }
         ],
         "left_wheel": {
          "measurements": [
           {
            "type": "d",
            "value": 554.262
           },
           {
            "type": "l",
            "value": 119.498
           }
          ]
         },
         "right_wheel": {
          "measurements": [
           {
```

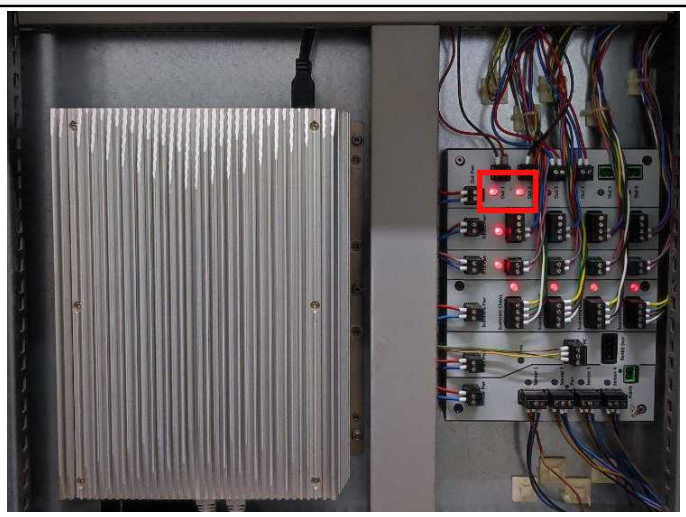
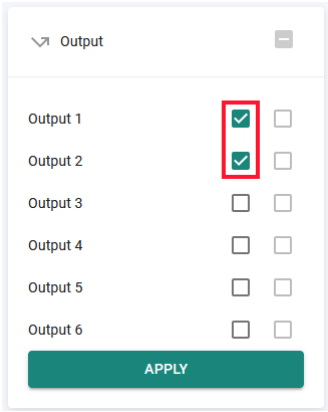
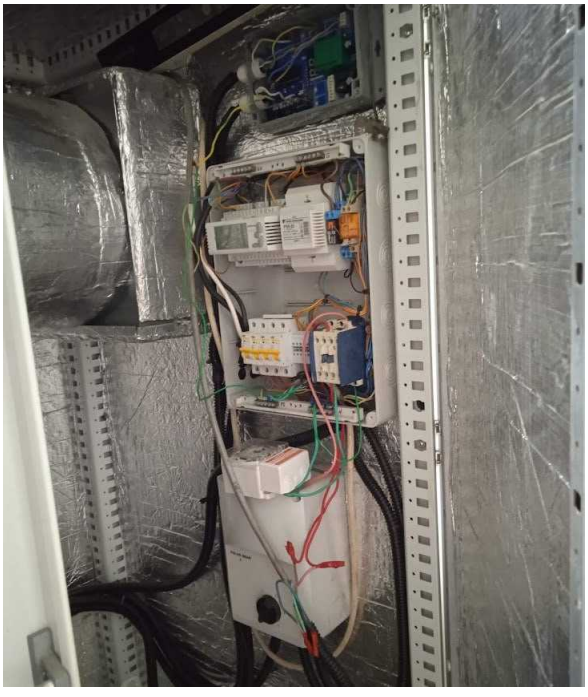
```
            "type": "d",
            "value": 554.262
          },
          {
            "type": "l",
            "value": 119.498
          }
        ]
      }
    }
  ]
 }
]
}
}
}
```


12. Troubleshooting

Problem	Cause and solution
On the System panel in the web interface, there is no access to the system (OFFLINE status) and the measurements are not coming to the database. 	**Check Internet connection.** 1) First you need to check if there is a link on the port of the network switch to which the cable from the local network (from which the system receives the Internet) is connected. The location of the network switch in the control cabinet:  The Internet cable must be connected to port 16: 

Problem	Cause and solution
	If the connection is correct, the indication under the port will be visible (“link”). If there is no link, then it is necessary to check the cable connection (the cable may be damaged). 2) The Internet resources necessary for the operation of the system in the cloud (https://3dwheel-newdelhi.riftek.com/) and for the remote maintenance of the system (vpn.riftek.com) must be available. To check if the resources are available, you need to connect a laptop (with Windows OS) to port 21 or 22 of the network switch and run the following commands in the console: *>nslookup vpn.riftek.com* *>nslookup 3dwheel-newdelhi.riftek.com* If the commands give a result, then the resource is available. If the commands do not give a result, then you need to contact the local network administrator.
	Check power. The system contains several components, the power supply of which can be checked from the indication in the control cabinet. These components are indicated in the figure below:  1 - Circuit breakers for general high voltage power supply. 2 - Circuit breakers for low voltage power supply. 3 - Circuit breakers for the measuring system components. 4 - PC indication. 5 - Controller indication. 6 - Network switch indication. For more information about these components, see par. 6.5.1.
	Check the UPS. On devices responsible for the uninterrupted operation of the system, indication should turn on when the input button on the device is pressed (this button is shown in the figure below).

Problem	Cause and solution
	 If there is no indication, make sure the power is on. If the power is on but there is no indication, contact your equipment supplier. If the UPS beeps, it means that the external power to the system has been lost and the UPS is running on the internal battery.
The train that passed through the system did not appear in the list of passages. 	**Check power and UPS.** See above - "Check power" and "Check the UPS".
	Wheel sensor activated. It is necessary to check the controller - whether the indication of the wheel sensor is on all the time (see par. 6.5.1). In the case of permanent activation, it is necessary to make sure that the sensor on the rails is not damaged. If there is no malfunction of the wheel sensors and their position relative to the rail head is correct, but the indication on the controller is constantly on, then you need to contact the manufacturer.
	Controller error. It is necessary to check if the power is supplied to the controller and the indication of all elements (see par. 6.5.1)
	Protection shutter is stuck. Make sure the protective shutters are not jammed. If problems occur with the protective shutters, the necessary service work must be carried out (see Maintenance Manual). If the problem can not be resolved, contact the manufacturer.
Partial measurements.	**Protection shutter is stuck.** If there is a problem with one shutter, then partial measurements will come because one side of the train will be measured and the side with the closed shutter will not be measured. How to solve this problem, see the previous point.
	The windows of the laser scanners need to be cleaned. If the windows of the laser scanners are not clean enough, the measurements may be unstable and some wheel parameters may not be measured. This will show up as dashes in the measurement reports. The cleaning procedure is described in the Maintenance Manual.
The train number is not recognized.	**Check the RFID power.** Two LEDs should be lit:

Problem	Cause and solution
	 If the power is on, bring the tag to the reader and clicks should be heard. If there are no clicks, it means the power is off and you need to turn it on via the web interface. On the Output panel, tick the boxes as shown in the screenshot below and click APPLY. 
Email notifications.	**"High temperature in scanners"** - Check if power is being supplied to the fan. 

Problem	Cause and solution
	   - Check if air is escaping from the protective housings. - Check the temperature of the air flow inside the protective housings.

Problem	Cause and solution
	
	"High computer temperature" - Check if the air conditioner is working in the room.  The air conditioner must be running to prevent the computer from overheating.
	"High humidity in scanners" - Check if the scanner windows are fogged up. If there is moisture on the glass, it is necessary to carry out the dehumidification procedure (see Annex 2).
	"Weak laser signal" Check scanner windows. If the windows are clean, but the signal is unstable, then there is probably a problem with the laser emission. It is necessary to contact the scanner manufacturer and temporarily replace the scanner. The procedure for replacing the scanner is described in the Maintenance Manual.

13. Annex 1. Controller RF700

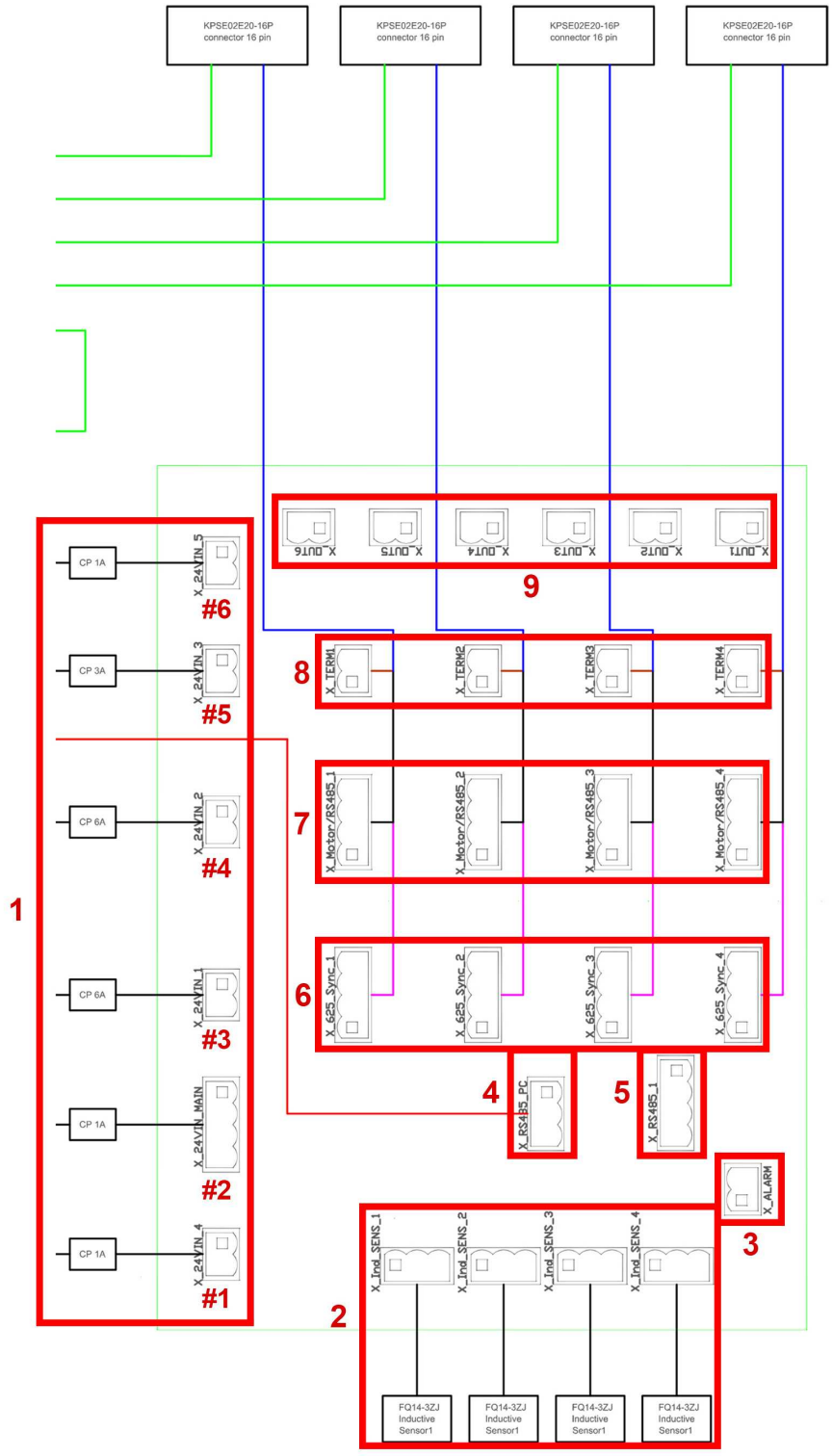


Figure A1

Description:

1	External power supply: #1 - Inductive sensors #2 - RF700 #3 - S LAN #4 - Motor #5 - Heating #6 - External devices
2	Inductive sensors
3	Measurement signal
4	Server PC
5	Motor control
6	Scanner sync & power
7	Protective shutters power
8	Heating
9	External devices

14. Annex 2. Dehumidification procedure

14.1. Equipment

The following equipment is required:

- Rotary-screw compressor with filters.

14.2. Preparing the dehumidifier for operation

1. Connect the compressor to the inlet fitting (1, see Figure A2.1).
2. Using the regulator (3) of the dehumidifier, set the pressure on the pressure measurement gauge (2) - 0.7-0.8 MPa.
3. Let it run for 30 minutes for the dehumidifier to self-clean.
4. Check the readiness of the dehumidifier by the indicator (5). This indicator should be blue.

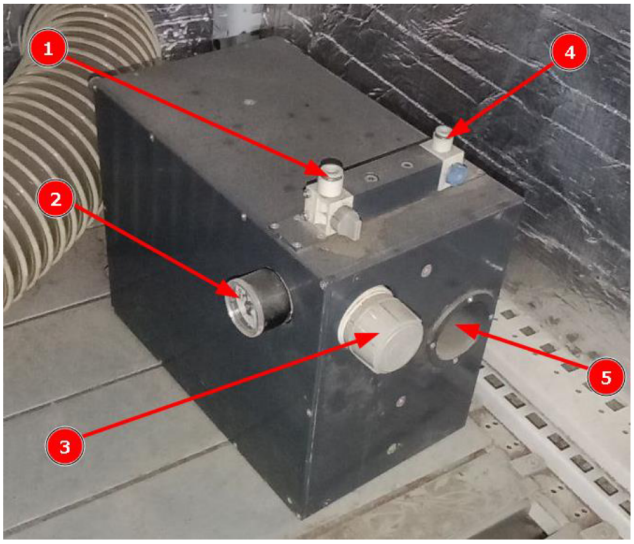


Figure A2.1

14.3. Operating the dehumidifier

1. Unscrew the two plugs of the scanner (6 and 7, see Figures A2.2 and A2.3).
2. Insert the fitting (M5 thread) into one of the holes (6) of the scanner.
3. Insert the tube from the dehumidifier outlet (4) into the scanner fitting.
4. Open the dehumidifier outlet valve and purge the scanner for 15-20 minutes. Control the degree of dehumidification using the humidity sensor of the scanner.
5. Close the dehumidifier outlet valve, plug the scanner outlet (7), open the dehumidifier valve.
6. Keep the scanner under pressure for 5 minutes.
7. Close the dehumidifier outlet valve, disconnect the fitting from the scanner and plug the hole (6) immediately.

Important! When closing holes 6 and 7 with plugs, seal the plugs immediately with sealant.

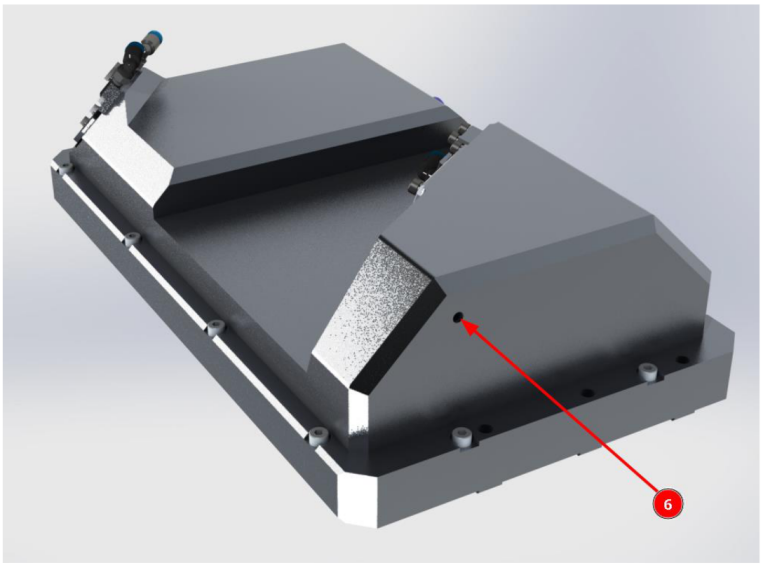


Figure A2.2

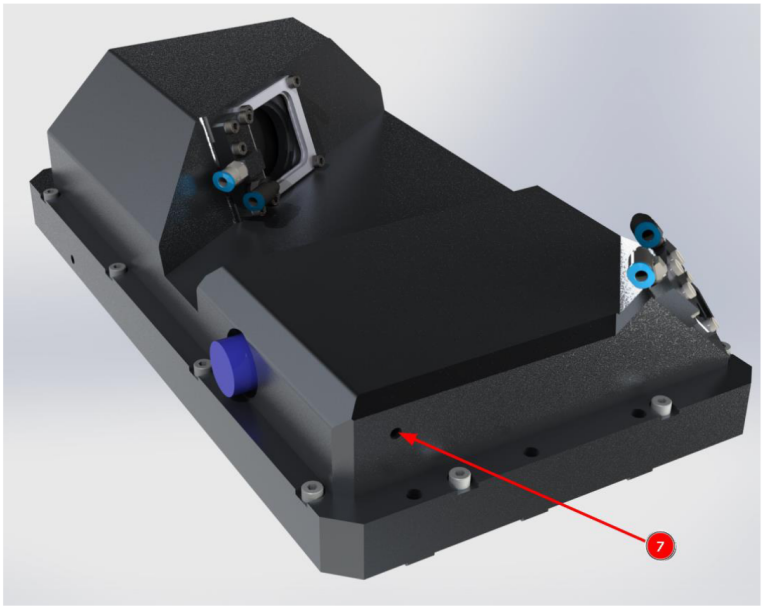
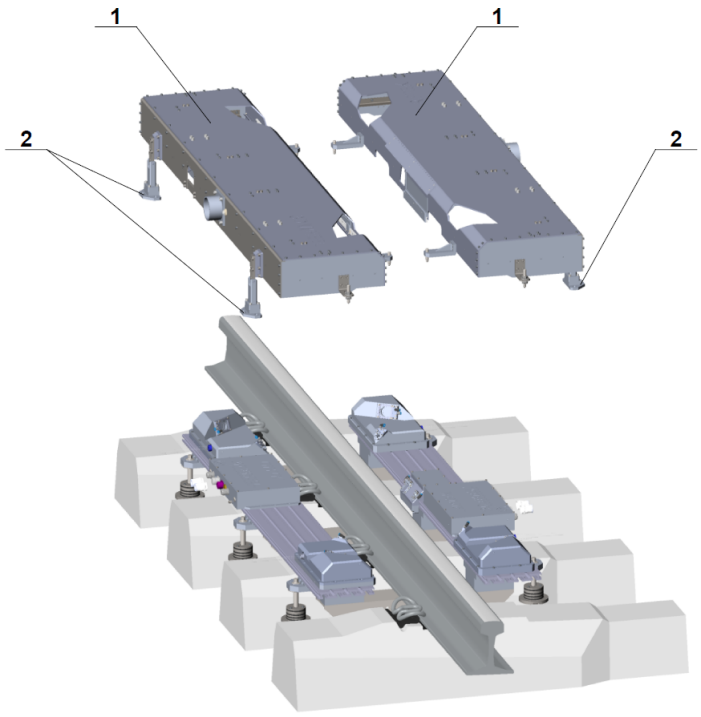


Figure A2.3

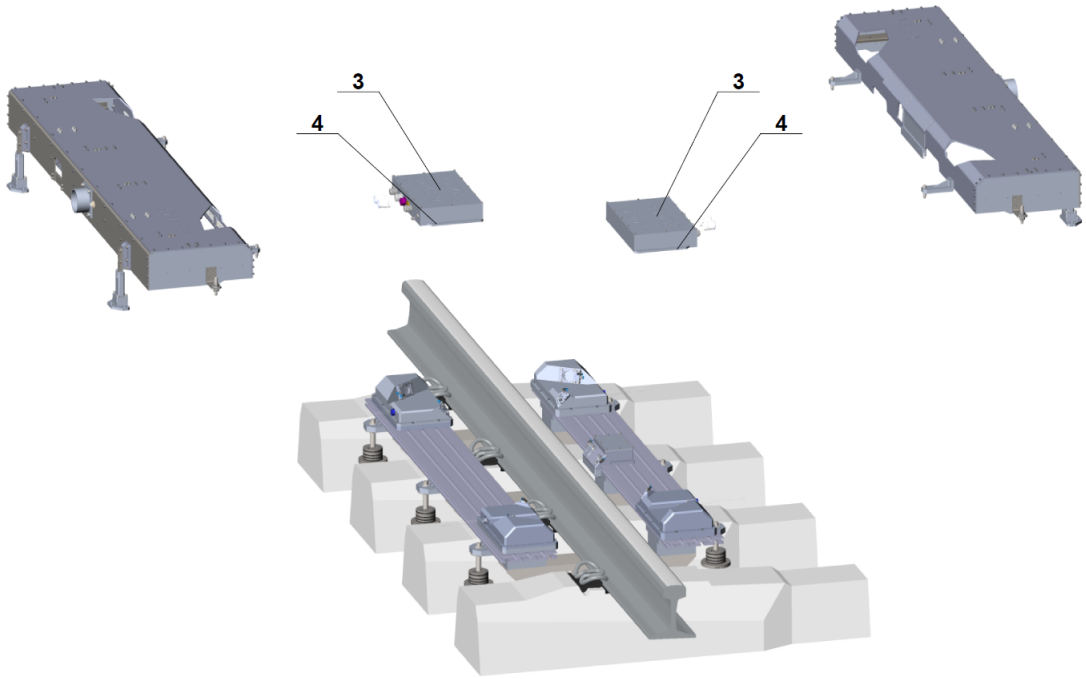
15. Annex 3. Dismounting the system

1. Unscrew the fastening of the protective housings to the foundation (M6 nuts) and remove the protective housings.



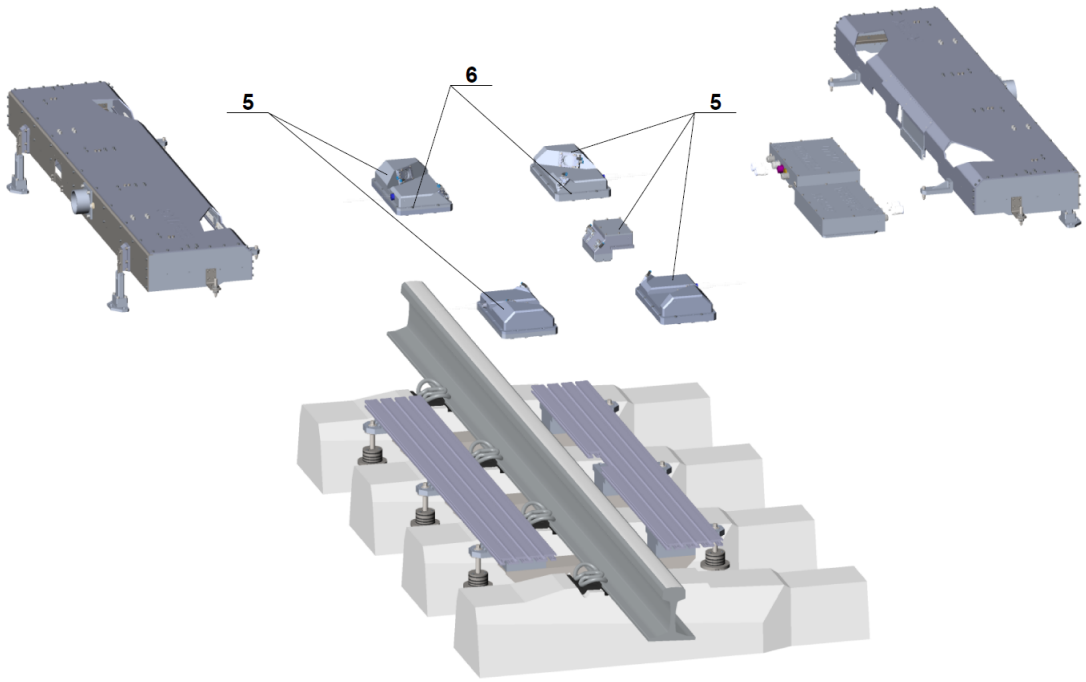
1 - Protective housings.
2 - M6 nuts.

2. Unscrew the fastening of the switching units (M5 screws) and remove the switching units.



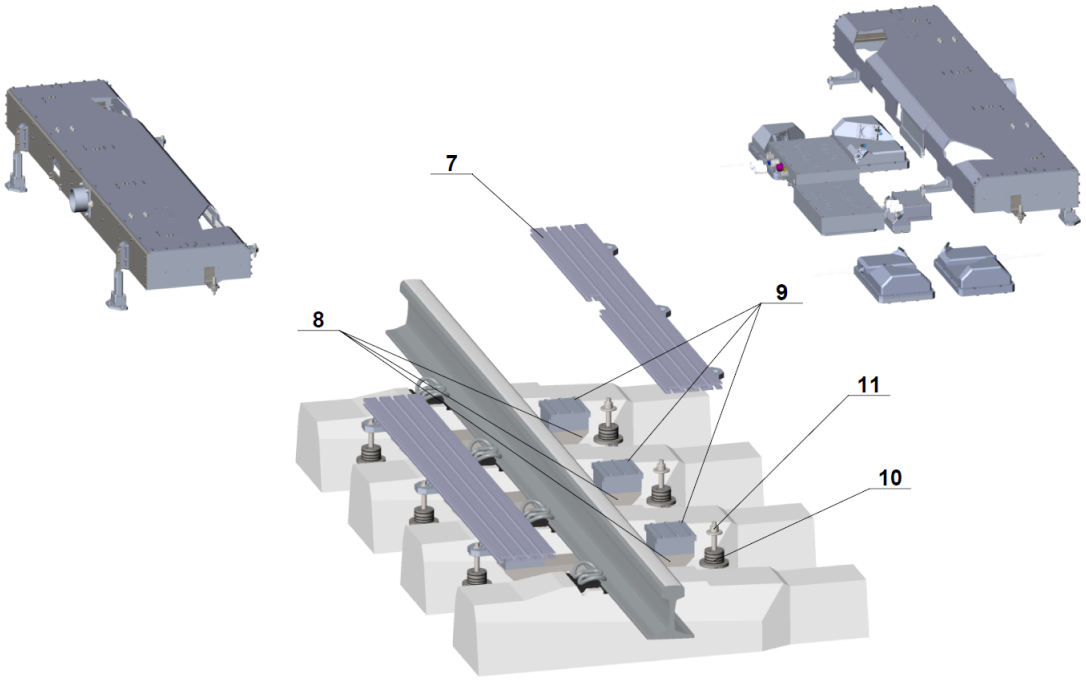
3 - Switching units.
4 - M5 screws.

3. Unscrew the fastening of the laser scanners (M5 screws) and remove the laser scanners.



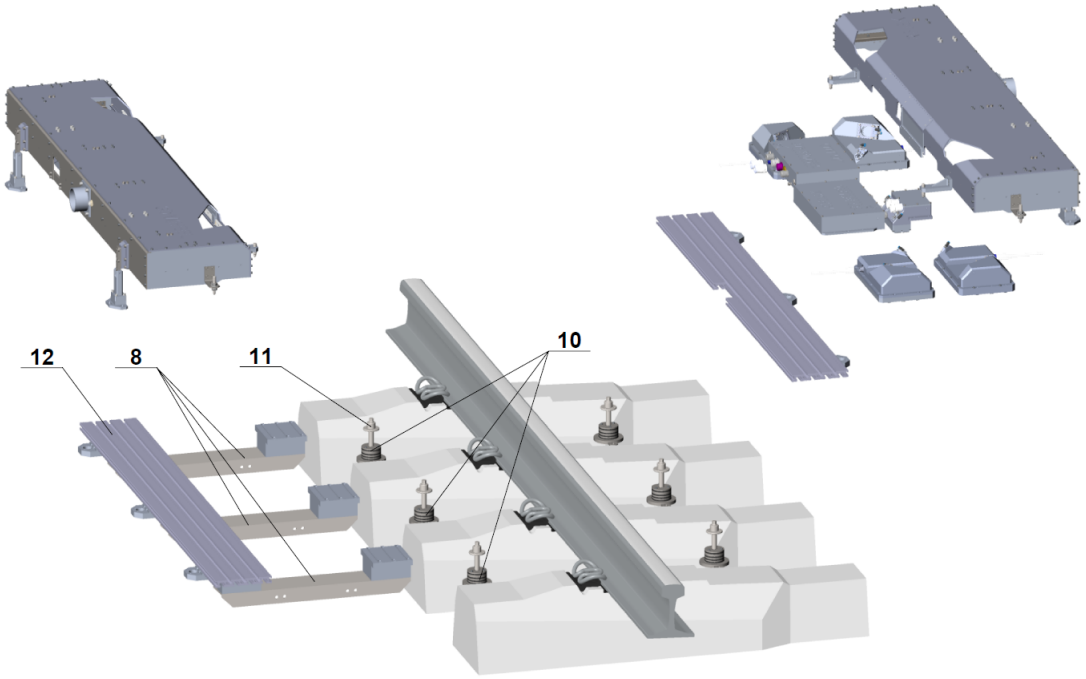
5 - Laser scanners.
6 - M5 screws.

4. Unscrew the fastening of the base between the rails to the lower beam (M8 screws), unscrew the fastening of the base to the supports (M16 nuts), remove the base.



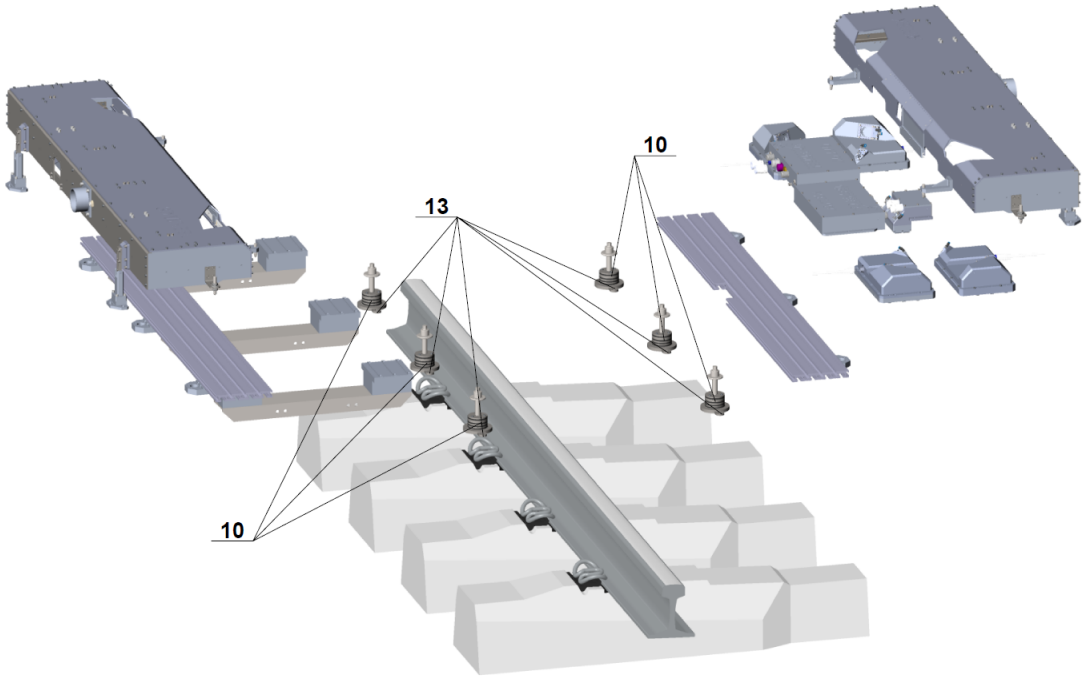
7 - Base.
8 - Lower beams.
9 - M8 screws.
10 - Supports.
11 - M16 nuts.

5. Unscrew the fastening of the base from the outer side of the rail to the supports (M8 screws) and remove the base together with the lower beams.



8 - Lower beams.
10 - Supports.
11 - M16 nuts.
12 - Base.

6. Unscrew the fastening of the supports to the foundation (M6 nuts) and remove the supports.



10 - Supports.
13 - M6 nuts.

16. Warranty policy

Warranty assurance for the Real Time Wheels Geometry Measurement System 3DWheel Series – 24 months from the date of putting in operation; warranty shelf-life – 12 months.

17. Revisions

Date	Revision	Description
17.01.2020	1.0.0	Starting document.
31.03.2020	1.1.0	1. Updated par. 6.3. "Position monitoring module". 2. Updated par. 6.4. "Identification module". 3. Updated par. 7.2. "Measured parameters". 4. Added data export examples (csv, xlxs, json).
16.09.2020	1.2.0	Updated par. 6.1. "Laser scanning modules".
15.09.2021	2.0.0	Chapter 9 "Railway administration software" has been replaced with a description of a web interface.
28.04.2023	2.1.0	The description of the web interface has been updated.

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19. RIFTEK's measurement instruments for railway transport

Railway wheel profile gauge, IKP Series

Laser Profilometer IKP-5 Series is employed for:

- Measuring geometrical parameters of the wheel flange (thickness, slope, height), rim/tire thickness.
- Taking full profile of the wheel rolling surface.
- Maintaining the wear database.
- Tolerance control and sorting when checking, inspecting, repairing and forming railway wheelsets.

Measurements are made directly on the rolling stock without rolling out the wheelset.

Rail profile measurement gauge, PRP Series

The main functions of PRP are as follows:

- Obtaining information on the cross-section profile of the railhead acting face.
- Full profile scanning and analysis of the railhead acting face.
- Visualization of combined graphic images of the actual and new cross-section profiles of the railhead.

Wheel diameter measuring gauge, IDK Series

Electronic gauge is designed to measure the wheel rolling circle diameter of railway, metro and tram wheelsets. Measurements are made directly on the rolling stock without rolling out the wheelset.

Back-to-back distance measuring gauge, IMR Series

Electronic gauge is designed to measure the back-to-back distance of railway, metro and tram wheels in the course of checkup, examination, repair and formation of wheelsets. Measurements are made directly on the rolling stock without rolling out the wheelset.

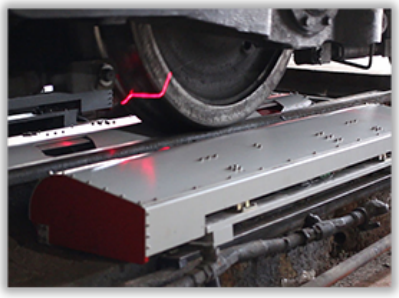
Back-to-back distance measuring gauge, IMR-L Series

Electronic gauge is designed to measure the back-to-back distance of railway, metro and tram wheels in the course of checkup, examination, repair and formation of wheelsets. Measurements are made directly on the rolling stock without rolling out the wheelset.

Disc brakes profile gauge, IKD Series

Electronic gauge is employed for laser scanning and measurement of disc brakes wear parameters.
The main functions of IKD are as follows:

- Obtaining information on the profile of the disc brakes acting face.
- Full profile scanning and analysis of the disc brakes acting face.
- Visualization of combined graphic images of the actual and new disc brakes profiles.



Real-time wheels geometry measurement system 3DWheel

The system is designed for non-contact automatic measurement of geometrical parameters of railway wheels and uses a combination of 2D laser scanners mounted wayside in the track area.
The system can be easily installed on any type of railway infrastructure.