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Train Conformity Check System™
TCCS

Train Conformity Check System™

The TCCS™ (Train Conformity Check System) is a technological system that automatically detects ‘irregular conditions’ that affect rolling stock in transit.

Main Features

TCCS™ system analyses the data acquired from its subsystems and detects possible defects and hazardous conditions such as:

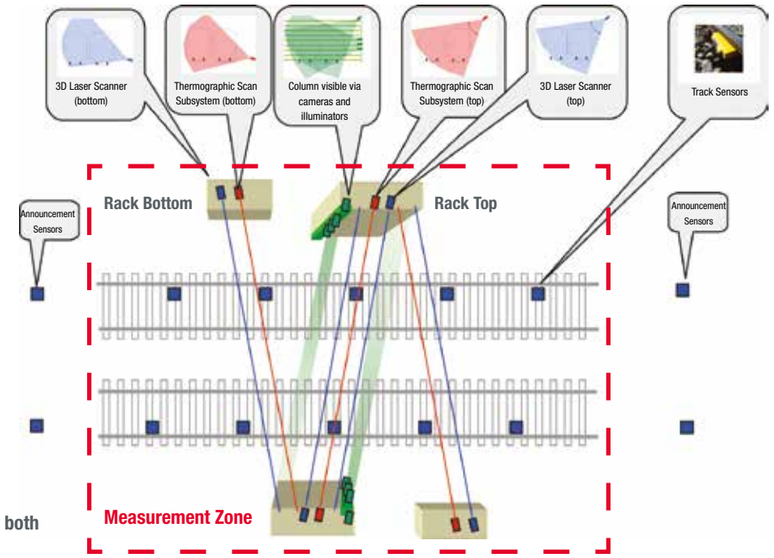
- **Violation of three-dimensional profile limits**
- **Overheating of rolling stock components**
- **Fire on board**
- **High Resolution images to verify the failures (the system selects and highlights specific critical areas)**

NOTE: High resolution image subsystem is a subsystem for verification and not for detection.

The TCCS™ system automatically implements the detection functions on the train when it transits over the Measurement Zone. The Measurement Zone has acquisition and monitoring devices installed on both tracks in both directions. Configuring the TCCS™ for partial operation (unidirectional/bidirectional) is also possible.

The TCCS™ will communicate any abnormal condition to the Operators in the Control Center, which allows them to adopt immediate countermeasures.
Additionally the system is preset to send alarms to the signalling system so that the train involved can be stopped automatically.

Measurement Zone



Same acquisition system on both track sides

TCCS™ System Composition

The TCCS™ system can integrate the following subsystems:

- **Tracking subsystem**: performs the Composition and Displacement function
- **3D Laser Scan subsystem**: performs the Rolling Stock Profile Acquisition and Analysis function
- **Thermographic Scan subsystem**: performs the Rolling Stock Acquisition and Thermographic Analysis function
- **High Resolution Imaging subsystem**: performs the High-Resolution Image Acquisition function
- **Radio Frequency IDentification (RFID)**: identifies those vehicles equipped with tags.

TCCS™ System operating mode

The TCCS™ system carries out the processing operations below:

- Identifies the train univocally by time/date, track and direction of transit. It can also associate the transit with the number of the train entered by the Operator or received from the Traffic Management system
- Identifies and classifies vehicles according to standard types
- Generates alarms when anomalous situations are detected such as when the values obtained from the sensor measurements are shown not to correspond with the threshold values associated with the vehicle classification. In general, several threshold values are configured for the various alarms, e.g.Alert; Alarms
- Stores and sends all of the alarms generated by the TCCS™ system's processing operations to the Control Center where they can be accessed via a Web interface
- The transit data and thermographic, gauge and high-resolution images for all trains transited are also available via the Operator Interface
- The acquired data, alarms and significant processing results are stored on a disk where they are available for reference by the Operators
- Operators can access the stored data through the Control Center workstation, the maintenance console located in the Shelter, and from any one Web workstation which has been enabled to access the TCCS™ system.

Composition and Displacement

The Composition and Displacement (CD) function detects the train as it approaches the Measurement Zone (even at the permitted max. speed) through Transit Announcement Sensors placed along the line and installed at a set distance from the Measurement Zone. The subsystem operation is based on inductive Wheel Sensors fitted onto the track.

The function ensures:

- Activation/deactivation of other subsystems
- Train detection and measurement of approach speed
- Train number and transit time assignment
- Calculation of train direction, speed and composition, and axle count and spatial distribution
- System synchronisation, measurement of axle distances and rolling stock kinematical tracking.

The TCCS™ system features a 'Rolling Stock Database' where the physical characteristics (i.e. axle distances and vehicle dimensions) of all vehicle types (known or recognisable) which run across the Measurement Zone are stored.

The CD function compares the vehicle's axle distances with the ones available in the TCCS™ system's 'Rolling Stock Database'. It also allows to:

- Divide the train into individual vehicles
- Assign each train axle to the corresponding vehicle
- Identify bogies and assign them to the corresponding vehicle and associated axle
- Assign a type from the 'Rolling Stock Database' to each vehicle.

Rolling Stock Profile Acquisition and Analysis

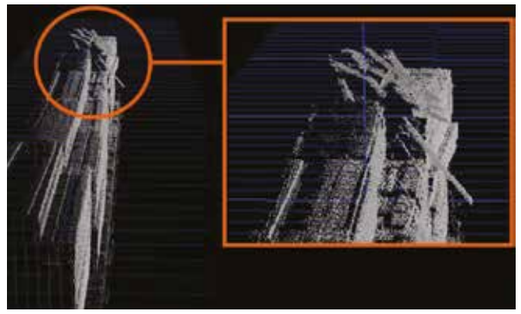
The TCCS™ system detects the Rolling Stock Gauge via 'Laser Scanners'.

To identify any excessive Rolling Stock Profile, the TCCS™ system:

- Uses the position and displacement information received from the CD function to re-proportionate the image, compensate for any speed changes that occurred during the acquisition, and obtain a proportionate image of the vehicles in transit
- Uses the information produced by the CD function according to the segmentation calculation results to isolate the image portion corresponding to every vehicle
- Segments the final image to include the entire train
- Uses the information about the type of each vehicle to apply specific analysis criteria. (It is possible to define the alarm criteria and threshold values to be applied)
- Compares the positions of detected points with the corresponding 'Maximum Loading Gauges'
- Uses the information regarding vehicle type and the acquired 3D profile to apply the limit profiles and alarm generation rules peculiar to the vehicle type.

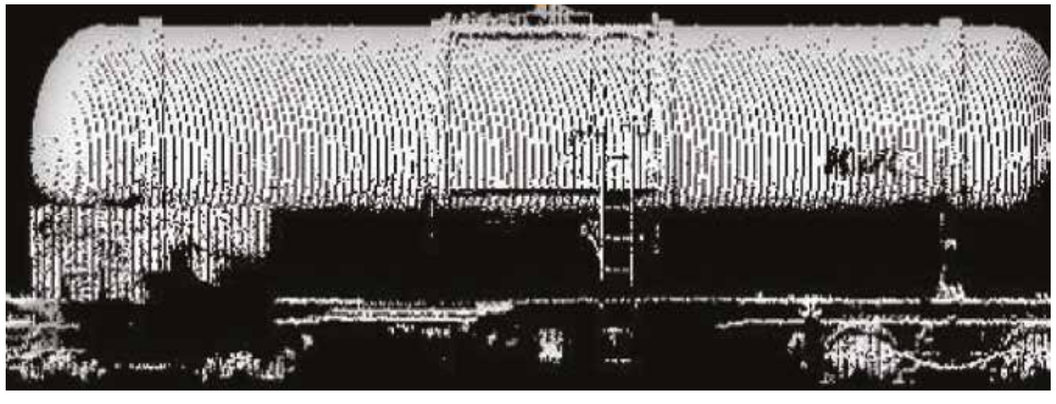
This supports the correct management of different cases and exceptions, for example vehicles that might otherwise generate improper alarms when running as a departure from the established gauge limits.

Vehicles that, although not out of gauge and not considered to be the source of a hazard, generate frequent alarms due to their construction features (i.e. passenger trains with curtains fluttering).



Functionality and accuracy are guaranteed by:

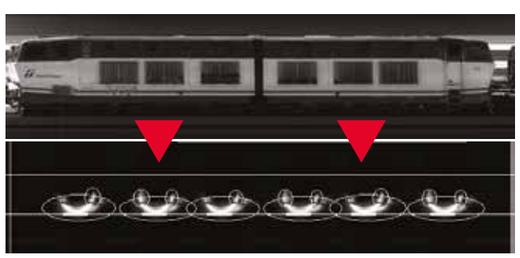
- **Self-diagnosis**: For every acquisition cycle each scanner generates a set of diagnostic data from internal sensors (i.e. internal temperature, laser temperature, laser status, polygon motion status, correct rotation speed, block actuation, Firmware anomalies, etc.). This data is monitored by the TCCS™ system to ensure correct operation of the sensors
- **Self-calibration**: Each scanner implements an internal self-calibration device (measurement offset check and correction) which is activated for each scan, compensates for slight accuracy deviations and detects measuring system malfunctions
- **Filter**: The scanners feature a Software filter that eliminates the acquisitions that might cause false alarms
- **Analysis**: The TCCS™ conducts a check for consistency, in terms of availability of an adequate number of acquired points, on the gauge image acquired for each train.



Rolling Stock Acquisition and Thermographic Analysis

The TCCS™ is able to detect the areas that feature anomalous temperatures on the surfaces of the rolling stock and their loads, by making use of 'Linear Infrared Thermographs'. To identify the areas that feature anomalous temperatures, the thermographic system conducts the following operations:

- Acquires vertical measuring scans and places them side-by-side to obtain a thermographic image of the running train
- Uses the position and displacement information originating from the appropriate function to re-proportionate the image, compensate for the oversampling and speed changes which may have occurred during the acquisitions and obtain a proportionate thermal image of the train in transit
- Uses information about the vehicle divisions produced by the CD function according to the segmentation calculation results to isolate the image portion corresponding to every vehicle
- Identifies the reference lines (i.e. vehicle head and tail, axle positions, etc.) needed to the zone-specific thermographic analysis system
- Uses the information about the type of each vehicle to select the reference map that will make it possible to apply different alarm thresholds according to vehicle areas. This information is contained in the 'Rolling Stock Database' which defines the thermographic zones (geometrical areas) and temperature threshold values to be applied, for each type of vehicle
- Compares the temperatures measured by the IRS at each point of the vehicle surface with the ones relative to the alarm thresholds defined for each zone that represent the 'alarm map' for the type of vehicle concerned
- Releases alarms (classified according to the zone and intensity) in case the alarm thresholds defined in the reference map for individual construction types are exceeded by the values measured by the thermographs.



The thermographic alarms are generated by dividing the image into portions ('cells') featuring randomly created shapes, and by verifying that the set limits have been exceeded inside each cell. Such limits are related to the temperatures (thermal threshold values) and the shapes of the heat spots found. The procedure makes use of a highly versatile system, the configuration of which is based on:

- **Grid** - provides the image's geometrical division into zones
- **Map** - contains the alarm thresholds (i.e. temperatures) and the filtering rules for each zone
- **Cascaded selection algorithm** - allows to select the correct map-and-grid pair to be used for the vehicle being analysed.

The grid files contain the division into geometrical areas ('cells') of the image being analysed. This division is functional to the application of temperature threshold values and/or filtering rules peculiar to each cell.

Self-diagnosis, Self-checks and Filters

The processing unit available on the thermographic sensor carries out a number of efficiency checks on its own operation, as well as integrity checks on its own status.

- The implemented modular software architecture allows you to real-time verify the correct execution of all phases during a train transit
- Upon each transit – and in order to guarantee greater measurement accuracy – a sensor "dark current" reset procedure is performed: this operation resets the original zero value of the dark voltage by compensating for the minor accuracy deviations
- A few measures can be taken to cope with extraordinary situations and also ensure the optimum availability of the thermograph:
  - A watch-dog device is available on the processing unit, which is controlled by the main application capable of resetting the unit itself automatically in case of blocks due to possible software and, also, of restoring the thermograph's perfect operating conditions immediately
  - The processing unit can in turn reset the sensor control microcontroller (in case it detects any out-of-control inconsistency) and quickly normalize again the proper conditions
  - A system for checking the acquisition chain integrity is available to the thermographic components, too.

Special measures can be taken to filter the sun reflections.

High-resolution Image Acquisition

The TCCS™ system can detect high-resolution images by through linear, high-resolution black-and-white cameras.

To process the high-resolution images, the High Resolution Imaging Subsystem carries out the following operations:

- Acquires vertical measuring scans and places them side-by-side to obtain a thermographic image of the running train
- Uses the position and displacement information originating from the appropriate function to re-proportionate the image, compensate for the oversampling and speed changes which may have occurred during the acquisitions and obtain a proportionate image of the train in transit
- Uses information about the divisions into vehicles produced by the Composition and Displacement function according to the segmentation calculation results to isolate the image portion corresponding to every vehicle
- Identifies the reference lines (i.e. vehicle head and tail, axle positions, etc.) needed to the zone-specific subsystem
- Uses the information about the type of each vehicle to select the reference map that will make it possible to select the areas of concern you wish to automatically display for each type of vehicle. This information is contained in the 'Rolling Stock Database' which defines for each type of vehicle, the areas of concern to be displayed.

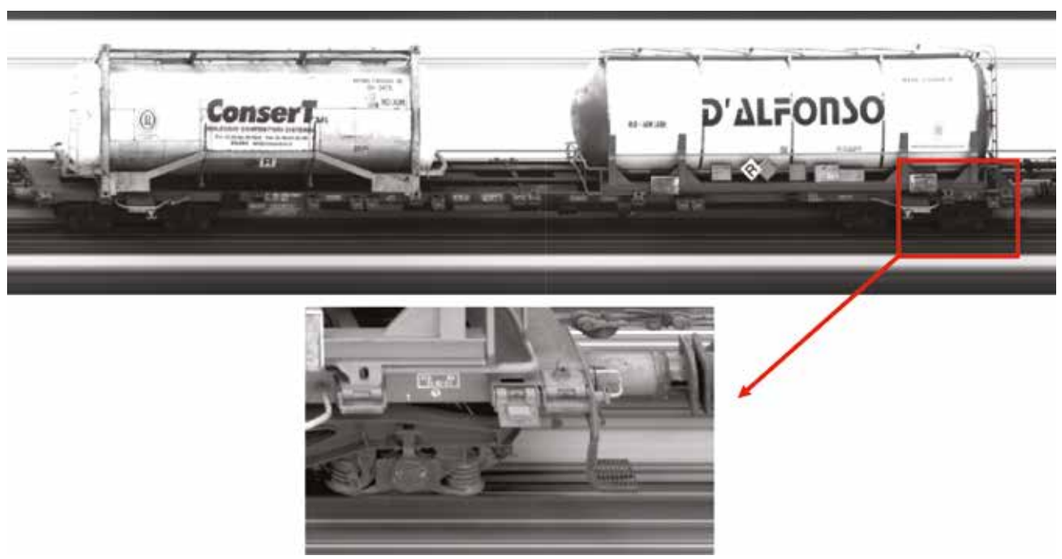
The System can operate both during the day and at night, by making use of solid-state NIR (Near-InfraRed) lighting ensuring no disturbance to drivers.

The high-resolution images are used by the remote Operators to check the generated alarms, without having to stop the subtrains. The images are stored for use both off- and on-line. The visible system can be configured and is able to automatically select the most important vehicle components according to the user's specific requirements including:

- Brake blocks
- Couplers
- Suspension springs
- Uncoupling levers
- Anti-friction wedges and bogie bolster area ends
- Doorway steps
- Bearing end caps
- Bogie side frame
- Brake hose.

The High Resolution Imaging Subsystem produces a very high resolution image (approximately 70 MB) for each single car. Depending on the available band width, and to minimise transmission time, images are compressed by 90%, to approximately 7 MB.
It would take no more than 3 seconds to transmit this compressed image across a bandwidth of 20 Mbps, would occur. Provisions are available to enable users to make adjustments depending on available bandwidth. This does not apply to the selected highlighted portions you wish to view automatically, which are available as high-resolution images.
Correct functionality and accurate measurements are guaranteed by:

- **Self-diagnosis:** Each camera produces a set of diagnostic data which is monitored by the TCCS™ system so that a self-diagnosis can be performed and correct camera operation is ensured.



Tag Reader RFID (Radio Frequency IDentification)

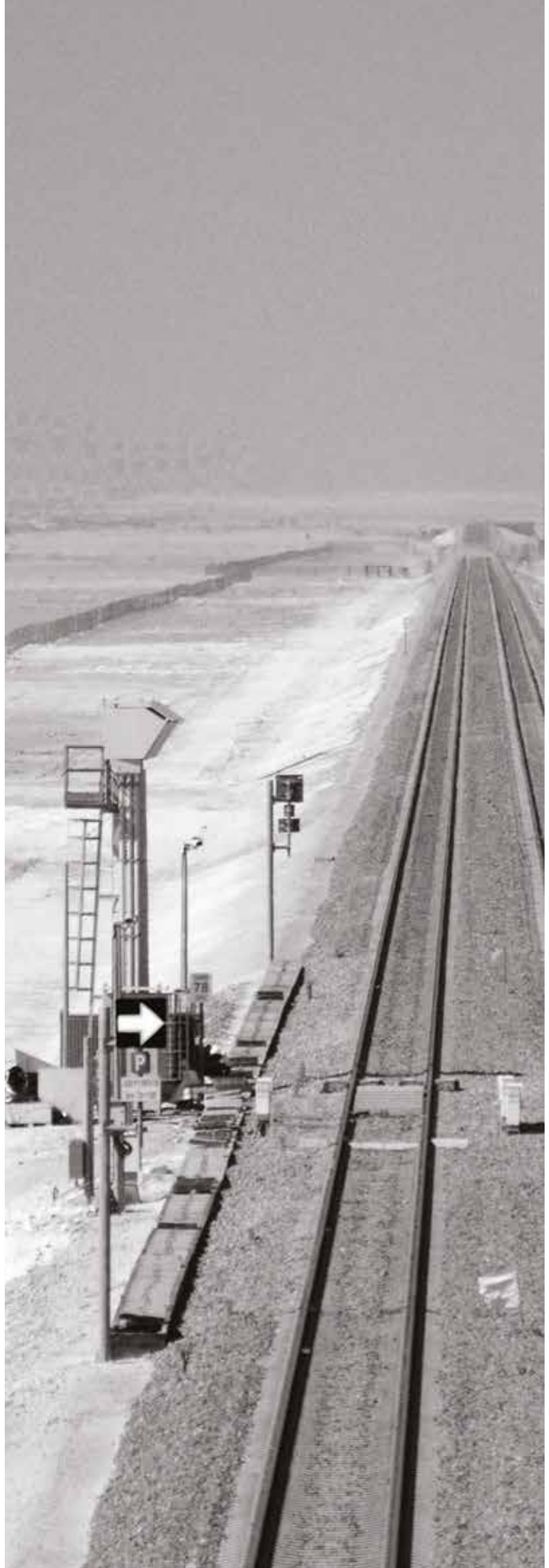
The system allows the user to acquire the Tag identification from the vehicles and locomotives that make up a train. The system associates the acquired data with the presented alarms and the train consist.

This allows it to keep a history log and to also perform analyses over time of the various wagons and locomotives that have run across the Measurement Zone.

Interfacing with the Traffic Command and Control Systems

The main purpose of interfacing is to acquire the train number so that any transit instances can be automatically identified on the Operator Interface and in the archive. The Command and Control System can, if set to do so, send the ‘train numbers’ of the approaching trains directly to the Measurement Zones where the TCCS™ portal is located. In case where connection with the Command and Control System is unavailable, the TCCS™ system’s Operator Interface allows the Operator to manually enter the ‘train number’.

Additionally interfacing enables alarms to be sent and allow the Traffic Management System to stop the train. The train consist can be transmitted to the Command and Control Center.



Maintainability and Maintenance Operator Safety

The TCCS™ system does not interfere with ordinary maintenance operations undertaken on the railway systems adjacent or close to the system. It has been designed and manufactured to ensure that the optic radiation emissions of any one radiating component are not dangerous (pursuant to the laws and regulations in force) to passengers, drivers, maintenance operators or to anyone standing on or by the railway track in the vicinity of the installation site.

The light radiation generated by the TCCS™ system’s laser scanners is invisible to the drivers. (Please note the thermographs are passive devices and do not emit radiation).

The TCCS™ system can be started from a remote workstation and regular maintenance operations and component replacement can be carried out easily and safely by the operating personnel.

The sensors can be accessed by fixed footbridges to enable check and replacement operations to be easily carried out, even when the line is operating as usual.

The processing equipment is housed inside a shelter at the Measurement Zone. It is wide enough to allow maintenance personnel to work safely and securely, far from bad weather.

All system components are factory-adjusted (prior to the installation or following repair) and are equipped with self-calibration devices if necessary. Additionally replacing a sensor requires no subsequent geometric re-alignment, because of the repeatability of the coupling between the sensor seat and the sensor itself.

The TCCS™ system’s geometric alignment, i.e. every action connected to the adjustment or modification of the optical detection device position during installation takes place in accordance with specific procedures documented and supported by appropriate tools.

The TCCS™ system features specific procedures documented and supported by appropriate tools to check and, if necessary, perform the system’s geometrical reconfiguration in connection with track displacement (e.g. natural subsidence, maintenance work due to the packing of sleepers, levelling operations, cleaning of the ballast).

All materials used in are fireproof and do not release any toxic gas

The TCCS™ System does not interfere with the train running conditions, the power supply systems or the train running control systems.

Operator Interface (HMI)

The Operator Interface is a web server based interface. Access can be gained by using an ordinary PC equiped with a standard browser. The system manages the Operator's identity and access is protected by personal passwords.

- The Operator Interface makes it possible to access more comprehensive self-diagnostic information by: Self-diagnosis of train transit acquisition and processing; the status of TCCS™ system components; and interfaces with the external systems
- Notes associated with the alarms which can be used to classify the alarms according to detailed types.

Additionally the Operator can record:
- Notes associated with the trains transited, in order to point out significant events
- Notes associated with the alarms, which can be used to classify the alarms according to detailed types (e.g. door open, load displaced, etc.) for statistical purposes.

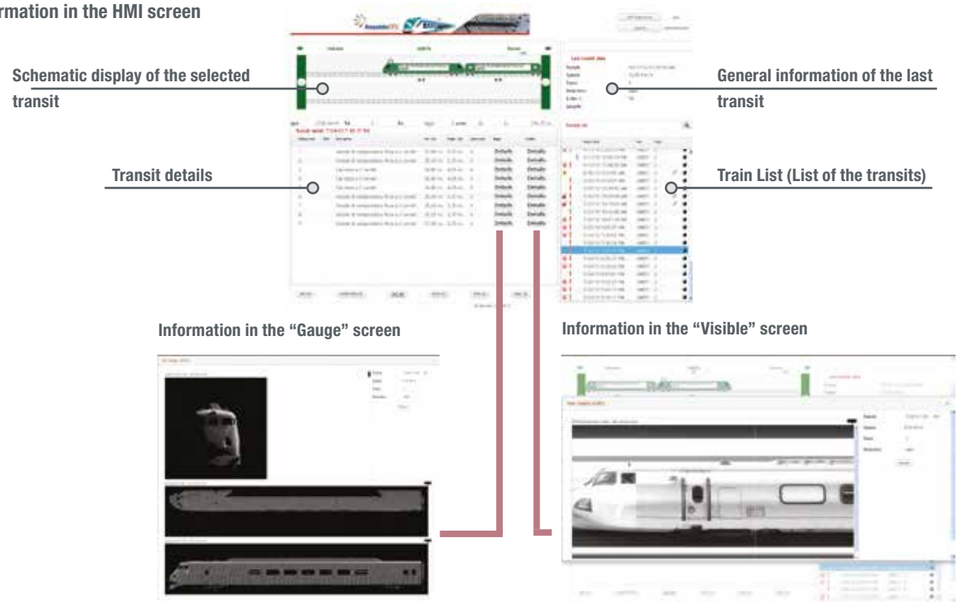
The Operator Interface also includes a section, for the maintenance Operator which can be used to configure alarm thresholds relative to thermographic and profile analyses.

All of the operations carried out by the Operator upon log-in/log-off, alarm recognition and notes are permanently recorded into the Database over a time period consistent with the HW physical dimensions.

The system features a Back-up function which ensures that the data is not lost in case of storing medium HW malfunctions.

The interface allows the Operator to:
- Display the list of transits in the installation site
- Highlight any alarm with visual and acoustic (if re-quired) signals
- Display alarm details
- Manage alarmed transits recognition
- Manage data, measures and imagea (high resolution images, 3D laser scan images, Thermographic images) of the rail car selected
- Keep track of the operator notes and comments on alarmed transits
- Display the diagnostic status
- Activate/deactivate each subsystem.

Information in the HMI screen

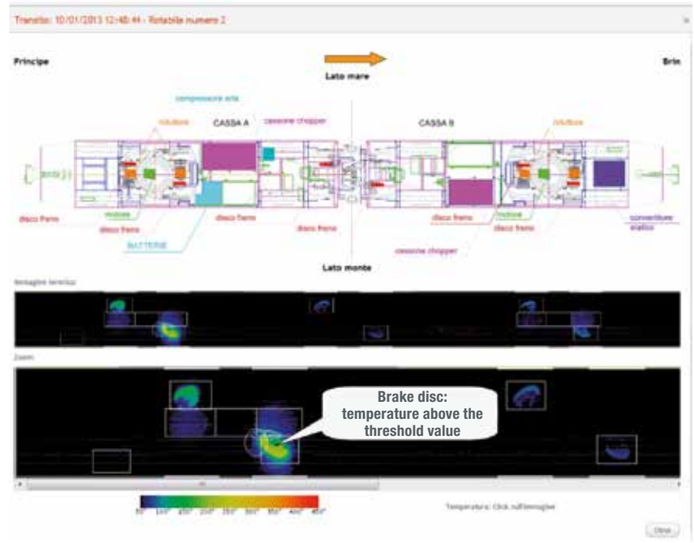


Undercarriage Temperature Analysis System

The Undercarriage Temperature Analysis system is detects thermal anomalies of a train and notify the Operator in real time.

The system has been designed based on the specific requirements prescribed by the Customer.

It consists of the following subsystems:
- Tracking subsystem
- Thermographic Scan subsystem
- Tag reader RFID (Radio Frequency IDentificator).



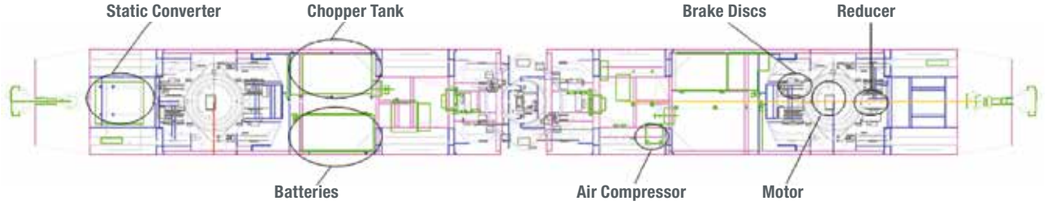
The Wheel Sensors detect the train transit and activate the data acquisition. They also detect the axle transit time distribution, making it possible to determine the train position, type and speed even when the train speed changes during the transit.

The infrared scanner scans the undercarriage of all vehicles measuring the temperature and acquiring linear thermographic images.

The data processing server correlates the linear thermographic images with the information obtained from the wheel sensors, and thus obtains a thermographic map of the train's underbody.

The high level of system configurability makes it possible to analyse several undercarriage components, by dividing the thermographic map into zones and applying the most suitable threshold to the identified zones. Critical temperatures can be identified by applying alarm thresholds to prevent possible accidents and ensure the safe running of the train in transit.

The Undercarriage Temperature Analysis System controls and monitors several components such as:
- Static Converter
- Chopper Tank
- Brake Discs
- Reducer
- Batteries
- Air Compressor
- Motor.



Components Monitored by Undercarriage Temperature Analysis System

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