

# CONDITION MONITORING

Acquiring data for infrastructure management

	<b>MEASUREMENT TYPES &amp; SYSTEMS</b> Characteristics and features, advantages and benefits of physical measurement types and measurement systems.
	<b>CARRIER PLATFORMS</b> Platforms, functionality and operating the measurement system.
	<b>MEASUREMENT-AS-A-SERVICE (MaaS)</b> MaaS for measurement, data processing and evaluation of data.
	<b>DATA PROCESSING</b> From acquisition to actual output.
	<b>USE CASES</b> How to use measurement systems in the real world.

# SUPPLIERS OF CONDITION MONITORING PRODUCTS

## OVERVIEW



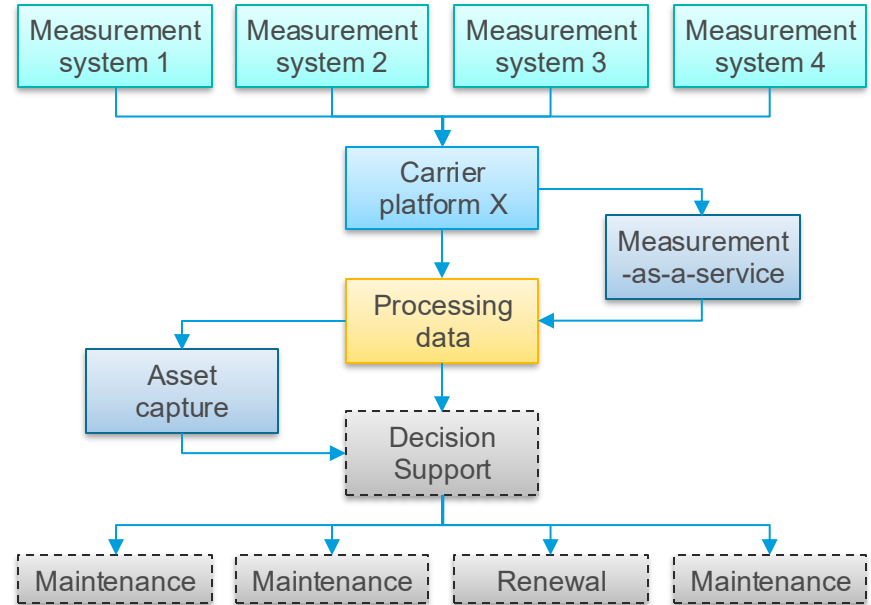
Measurement systems	Relative track geometry (DMA & tmc)
	Absolute/referenced track geometry (tmc)
	Rail profile (DMA)
	Ground penetrating radar (RTA)
	Turnout & crossing (DMA)
	LiDAR-based scanning (DMA/tmc)
	Superstructure images (DMA)
	Corrugation (DMA & tmc/PIT)
	Axle Box Acceleration (DMA)
	Thermal Imaging (DMA)
Catenary and power rail systems (DMA)	
Temperature Monitors (DualInventive)	
Driver's view (DMA & tmc)	
Carrier platforms	P&T InfraSpector
	P&T InfraSpector Container/Truck
	Robel ROSPECT
	(Installation on) Commercial vehicles (Installation on) On-track machines
Measurement-as-a-service	Franz Plasser Vermietungen
	Plasser Italiana

PREFERRED PARTNERS OF THE DRSA

# Condition Monitoring Process

## OVERVIEW AND COHERENCE

- The products for the condition monitoring covers several categories:
  - (Individual) Measurement systems
  - Carrier platforms (with multiple systems)
    - Measurement-as-a-service
  - Processing of data to location-aligned output into output data (InfraOS measurement data format)
    - Asset capture for master data
- The focus of condition monitoring is to ensure the safety of the railway infrastructure and to figure out where to do maintenance and renewal
- The product benefits will be evaluated on what output data is **used for**. This will be described by features, advantages and benefits according to ISO 55000 ([see also extended explanation here](#))
- In the integrated solution, the data is used as input for decision support tools, together with master data





1

## Measurement types

Presentation of the measurement types and systems



2

## Carrier platforms

Which carrier platforms are available



3

## Measurement-as-a-service

All in one solution



4

## Data processing

How to produce measurement data



5

## Use cases

Real world applications





# MEASUREMENT TYPES & SYSTEMS

Overview and features, advantages and benefits on principal measurement types and measurement systems

# Relative Track Geometry

FAB ANALYSIS



- Uses an inertial measurement unit and track gauge detection to capture deviations in track geometry.
- Measures the track geometry and analyses the data regarding safety and quality of the Infrastructure
- Typically the raw output is a space-curve which is filtered into various wavelengths and measurement bases e.g. according to EN13848

Features	Advantages	Benefits
<ul style="list-style-type: none"><li>• Longitudinal level<ul style="list-style-type: none"><li>• Alignment</li><li>• Cross level</li><li>• Twist</li></ul></li><li>• Track gauge</li></ul>	<ul style="list-style-type: none"><li>• Used for periodic monitoring of relative track geometry.</li><li>• Identifying areas requiring tamping or track bed renewal.</li><li>• Supports predictive maintenance by tracking trends in track degradation.</li><li>• Helps maintain track stability and prevent sudden geometric failures (isolated defects).</li></ul>	<ul style="list-style-type: none"><li>SAF Prevents derailments due to poor geometry.</li><li>PCT Reduces speed restrictions.</li><li>SUST Reduces ballast degradation by keeping optimum condition of track.</li><li>FIN Reduces corrective tamping costs.</li></ul>

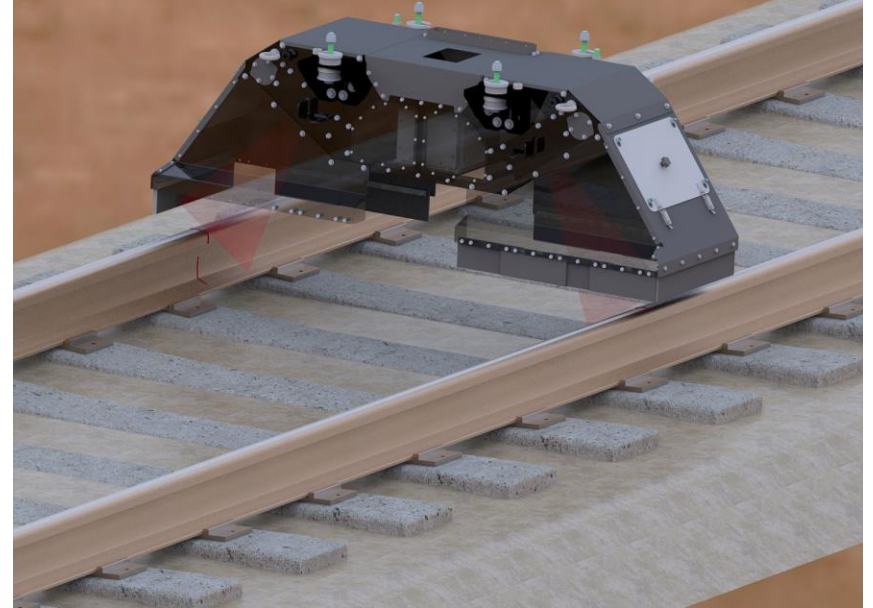
# DMA: Track Geometry Measurement (TGMS)



MEASURES MANY TRACK GEOMETRICAL PARAMETERS TO FIND DEFECTS AND ENHANCE SAFETY.

DMA's TGMS is a compact, non-contact system designed to monitor key track geometry parameters across mainline railways, metros, and tramways. Its advanced optical and inertial technology ensures precise measurements, enhancing rail safety and operational efficiency.

- **Comprehensive parameter monitoring:** Measures gauge, cross-level, alignment, longitudinal level, twist, track curvature, and cant to detect defects and improve safety.
- **Versatile installation and durability:** Compact design allows for easy installation on various vehicles, including bogies and body cars, with a long design life ensuring low life cycle costs.
- **High-speed and environmental adaptability:** Capable of performing high-speed measurements and is available in versions suitable for extreme cold or hot environments.



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# TMC: PosTG

## PRECISION TRACK GEOMETRY MEASUREMENT

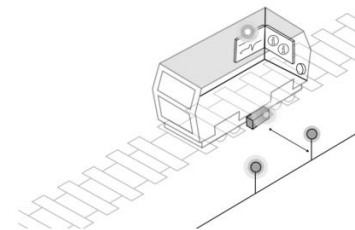
PosTG is an advanced inertial measurement system that enhances railway track surveying by providing highly accurate position and orientation data. It integrates seamlessly with existing measurement systems, ensuring compliance with industry standards while operating at high speeds.

- **Advanced inertial measurement:** PosTG utilizes 3D inertial space curves to assess loaded relative track geometry, enhancing data quality. It does not require a minimum speed.
- **Seamless integration and precision:** Compatible with various gauge measurement systems, PosTG ensures high positioning accuracy and complies with EN13848 standards.
- **Efficient deployment across all vehicles:** Requiring only a single sensor calibration, PosTG operates independently of vehicle dynamics or direction, suitable for speeds up to 300 km/h.



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# Absolute Track Geometry



## FAB ANALYSIS

- Employs high-precision GNSS, inertial measurement units (IMUs), and cameras to determine the absolute position of the railway track.
- Captures positional data in relation to a global coordinate system, ensuring alignment compliance and long-term positional stability.
- Enables accurate comparison between as-built and design track alignments, facilitating geospatial asset management and long-term planning.

### Features

- Track position in absolute coordinates

### Advantages

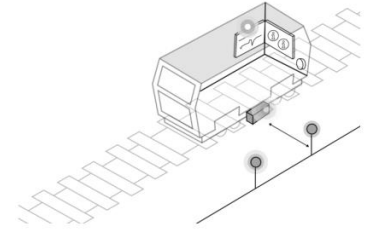
- Provides absolute positioning of the track in relation to a fixed reference system.
- Essential for new track construction and repositioning existing tracks.
  - Ensures track alignment is within tolerances, reducing long-term stress on rails and sleepers.
  - Supports long-term maintenance strategies.

### Benefits

- SAF Ensures track is correctly placed. Compliance to regulation.
- PCT Pre-measurement optimizes use of track possession time.
- SUST Reduce resources spent on unnecessary repositioning.
- FIN Reduces corrective tamping costs. Avoids misalignment-related wear.

# Referenced Track Geometry

## FAB ANALYSIS



- Defines track position relative to fixed reference points: Establishes the exact location of the track based on geodetic fix-points.
- Measures deviations from the designed alignment and calculate lifting and lining values for tamping machines
- Provides a stable framework for assessing track condition over time and ensuring alignment accuracy.

### Features

- Horizontal and vertical distance from track to fix point
  - Cant in track
- Lifting/lining values for tamping

### Advantages

- Compares track geometry with a predefined reference model.
- Detects slow deformations and settlements over time, allowing early intervention before thresholds are exceeded.
- Particularly useful for high-speed railways where geometric precision is critical.

### Benefits

- SAF Ensures track is correctly placed. Compliance to regulation.
- PCT Pre-measurement optimizes use of track possession time.
- SUST Reduce resources spent on unnecessary repositioning.
- FIN Reduces corrective tamping costs. Avoids misalignment-related wear.

# TMC: tmRTG/tmATG

MEASUREMENT OF LIFT/SLEW VALUES FOR TAMPING WITH UP TO 80 KM/H (50 MPH)

Track Machines Connected GmbH's tmRTG and tmATG systems revolutionize track measurement by enabling faster, safer, and more precise surveying without the need for track closures.

- **Rapid and safe measurements:** Measure 100 km of track in just 75 minutes at speeds up to 80 km/h, eliminating the need for track closures and reducing risks to maintenance staff.
- **Digital precision:** Utilizes permanently installed reference markers and onboard sensors to provide highly accurate track geometry data, enhancing infrastructure safety and longevity.
- **Resource efficiency:** Streamlines the measurement process through a web-based platform, reducing time and costs associated with traditional surveying methods.



[PICTURE IS LINK TO FURTHER INFORMATION](#)

# Rail Profile

## FAB ANALYSIS



- Captures the cross-sectional shape of the rail: Measures the railhead, gauge, and wear to assess its condition.
- Tracks wear and deformation over time: Identifies material loss, flattening, and irregularities affecting wheel-rail interaction.
- Supports maintenance and replacement decisions: Provides data for grinding, reprofiling, or replacing rails to ensure safe operation.

### Features

- Rail wear (vertical & lateral)
  - Rail inclination
  - Head loss
- Profile coordinates

### Advantages

- Measures rail wear and head profile with high precision.
- Allows for determination if grinding is necessary to restore reference profile and maintain optimal wheel-rail interaction.
- Allows for identification of excessive wear trends for timely rail replacement before failures occur.

### Benefits

- SAF Allows for prevention of rail breaks, which can lead to derailment, and excessive wear.
- PCT Reduces risk of rail breakage delays.
- SUST Extends rail life.
- FIN Reduces rail renewal costs.

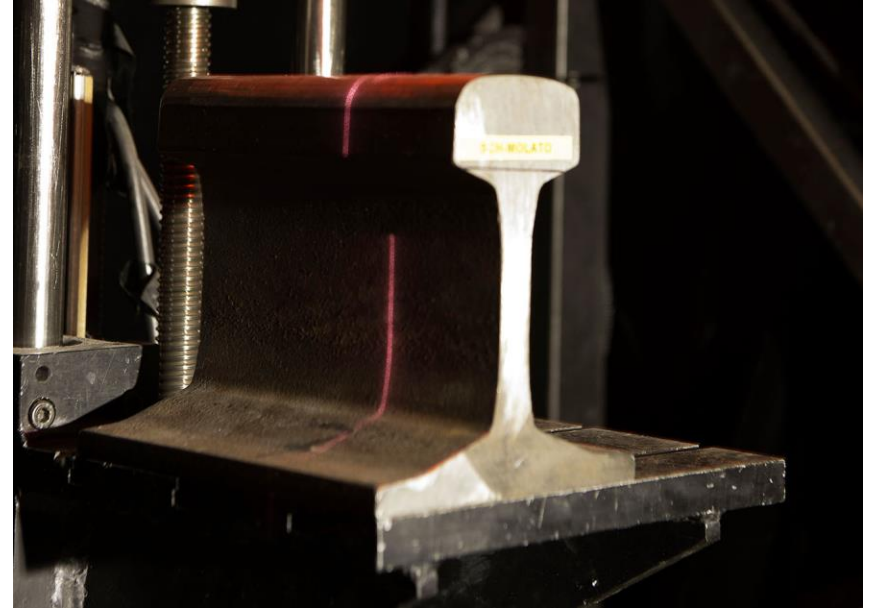
# DMA: Rail Profile Measurement (RPMS)



## PRECISION RAIL PROFILE MEASUREMENT

DMA's RPMS employs high-resolution laser triangulation technology to monitor rail profiles and assess rail wear, ensuring precise and efficient track maintenance.

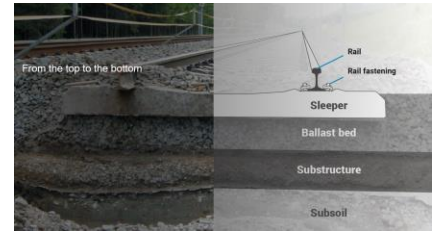
- **Accurate rail wear assessment:** Provides detailed measurements of rail profiles to identify wear patterns and inform maintenance decisions.
- **Non-contact laser technology:** Utilizes advanced laser triangulation for precise, high-resolution data collection without physical contact.
- **Multiple applications and versions:** The system can be utilized for a range of different applications from high-speed rail profile and wear measurements to lower-speed rail grinding and head loss evaluation



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# Ground Penetrating Radar

## FAB ANALYSIS



- Detects subsurface conditions: Uses electromagnetic waves to assess trackbed layers, ballast condition, and underlying structures.
- Identifies moisture, voids, and degradation: Reveals hidden issues like water intrusion, ballast fouling, and subgrade instability.
- Supports predictive maintenance: Helps prevent track settlement and failures by monitoring structural integrity over time.

### Features

- Layer boundaries/thicknesses
  - Ballast condition
    - Fouling
  - Moisture content
  - Substructure layers

### Advantages

- Uses radar to assess ballast and substructure conditions, detecting water retention, fouling, and weak layers.
- Helps plan ballast cleaning, renewal, and drainage improvements.
- Reduces the need for disruptive manual inspections and prevents track settlements.

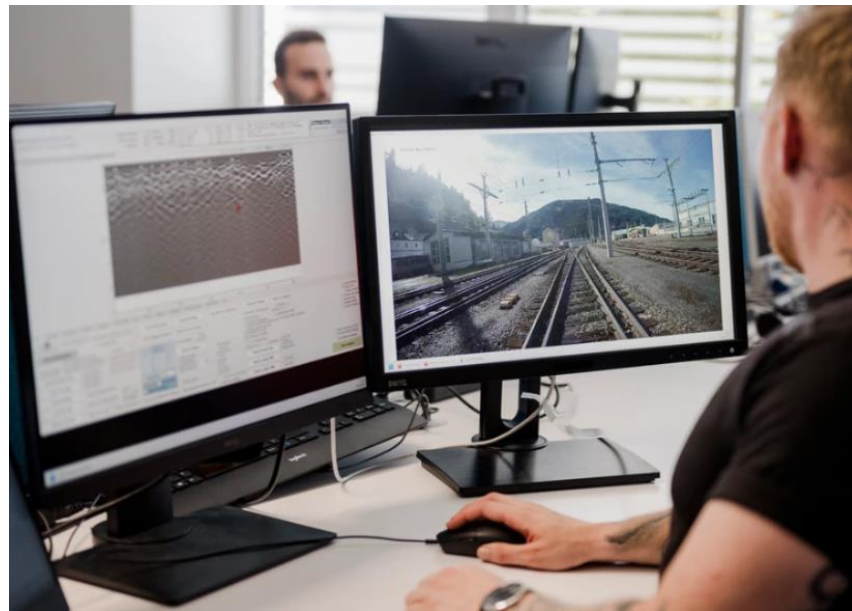
### Benefits

- SAF Prevents track instability.
- PCT Avoids settlement-related slow orders.
- SUST Optimizes track bed interventions.
- FIN Avoids emergency ballast replacements.

# Railtrack Analyzer: GPR

PROVIDES FAST, HIGH-RESOLUTION GPR SOLUTIONS FOR PRECISE TRACKBED ANALYSIS AND EFFICIENT, SELF-INSTALLABLE RAILWAY INSPECTIONS.

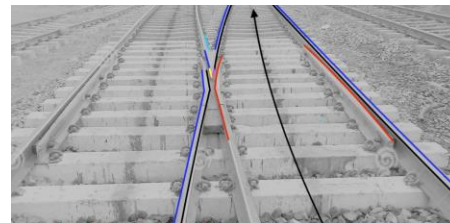
- Rail Track Analyzer GmbH specializes in Ground Penetrating Radar (GPR) technology tailored for railway trackbed inspections. Their solutions encompass:
  - **GroundScanner:** A high-speed, three-channel GPR system designed for geotechnical inspections to identify trackbed key performance indicators.
  - **ObjectScanner:** A high-resolution, multi-channel GPR system aimed at detecting objects within the trackbed.
  - **ExpertAnalysis:** A service providing detailed reports on trackbed conditions, including ballast fouling, humidity/permeability, clay fouling/mudpumping, layer thickness, and undulation of layer boundaries.
  - **Viewer:** A professional viewer that offers comprehensive visualization of measurement results, facilitating easy navigation through measurement runs and detailed analysis.
- These solutions are specifically designed for railway applications, ensuring precise and high-quality results through systems that are quick and easy to mount, with the capability for self-installation in under 90 minutes.



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# Switches & Crossings

## FAB ANALYSIS



- Captures geometric parameters and alignment: Measures track gauge with high sampling rate
- Allows for evaluation of the correct functionality and safety of switches
- Supports maintenance planning: Provides data for tamping, grinding, adjustment, or replacement of components.

### Features

- Continuous track gauge
  - Switch geometry
  - Component wear
  - Gauge variations

### Advantages

- Examines the geometry of turnouts and crossings to detect wear in blades, crossing noses, and check rails. Identifies gauge variations and component wear that could lead to derailments.
- Helps prioritize replacement or grinding activities to extend component life.

### Benefits

- SAF Allows for decreasing risk of derailment at critical points.
- PcT Reduce turnout-related failures.
- SUST Optimizes grinding/replacement schedules.
- FIN Lowers renewal costs.

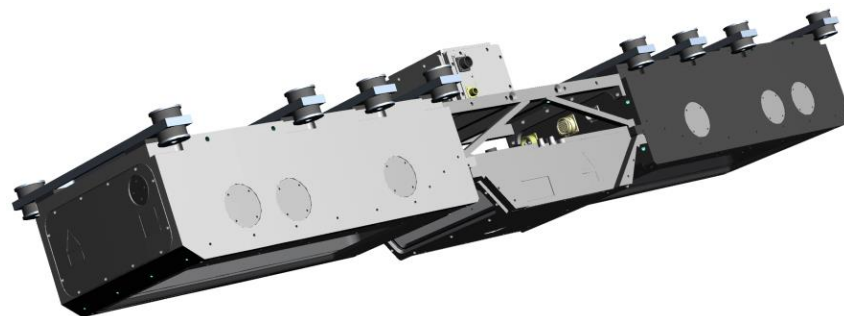
# DMA: Turnout & Crossing Measurement



AUTOMATED AND PRECISE TURNOUT & CROSSING MEASUREMENTS

DMA's TCMS is a specialized solution designed to enhance railway safety through effective turnout inspection.

- **Comprehensive Inspection:** The system facilitates detailed inspections of turnouts and crossings, identifying potential defects that could compromise safety.
- **Efficient Maintenance:** By enabling precise measurements under load, the TCMS supports targeted maintenance activities, reducing the likelihood of rail traffic disruptions.
- **Enhanced Safety:** Regular use of the TCMS contributes to improved railway safety by ensuring that turnouts and crossings are in optimal condition.



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# Vogel & Plöttscher: Hand Measurement Devices



DELIVERS HIGH-PRECISION MEASUREMENT TOOLS THAT DRIVE PROACTIVE, COST-EFFECTIVE, AND SAFE RAILWAY INFRASTRUCTURE MAINTENANCE.

- Among the key systems are the MessReg CTS II, designed for continuous track geometry measurement, and the MessReg CDM, which enables continuous switch inspection.
- Both trolleys provide comprehensive condition monitoring directly on site.
- The RMF 1100 is a certified and officially approved system for high-precision measurement of the longitudinal rail profile.
- It is specifically designed for the continuous inspection and acceptance of rail reprofiling operations—such as grinding or milling—in full compliance with relevant industry standards.
- The system delivers simultaneous, high-accuracy measurements on both the left and right rails, ensuring reliable quality control throughout the process.
- The PML is a laser-based transfer rail profile measurement device that captures the rail profile and metal removal. It is available in point-to-point or continuous measurement configurations.
- These and many other precision instruments from Vogel & Plöttscher contribute significantly to safe and efficient track maintenance worldwide.



# LIDAR-based Scanning

## FAB ANALYSIS

- High-precision 3D mapping: Uses laser scanning to capture the railway corridor, including structure gauge clearances, vegetation encroachment, and ballast profiles.
- Detects obstructions and deviations: Identifies intrusions into clearance zones and vegetation growth affecting operations.
- Supports maintenance planning: Provides accurate data for proactive trimming, ballast regulation, and infrastructure adjustments.

Features	Advantages	Benefits
<ul style="list-style-type: none"><li>• Point cloud (georeferenced)<ul style="list-style-type: none"><li>• Clearance gauge<ul style="list-style-type: none"><li>• Asset capture</li></ul></li><li>• Vegetation management<ul style="list-style-type: none"><li>• PRM validation</li></ul></li></ul></li></ul>	<ul style="list-style-type: none"><li>• Captures high-resolution 3D models of the track corridor, including trackside assets, vegetation, and structures.</li><li>• Ensures clearance compliance and detects potential obstructions.<ul style="list-style-type: none"><li>• Supports infrastructure asset management and helps reduce manual surveying efforts.</li></ul></li></ul>	<ul style="list-style-type: none"><li>SAF Prevents clearance infringements. Automates survey processes.</li><li>PcT Reduces incidents caused by objects. Minimizes manual inspections.</li><li>SUST Reduce transport of manual survey teams.</li><li>FIN Cheaper and faster than manual surveying.</li></ul>

# DMA: Clearance Profile Measurement (CPMS)



## PRECISION 3D POINT CLOUD

DMA's CPMS is a non-contact, laser-based optical system designed to measure clearance profiles and extract secondary measurements such as catenary geometry from the profiles. It can be mounted at the end of any railway car or vehicle and is housed in a protective casing.

- **Accurate clearance assessment:** Provides precise measurements of clearance profiles to ensure safe train operations.
- **Non-contact laser technology:** Utilizes advanced laser-based optical measurement for high-resolution data collection without physical contact.
- **Versatile installation:** Can be mounted at the end of any railway car or vehicle, housed in a protective casing for durability.



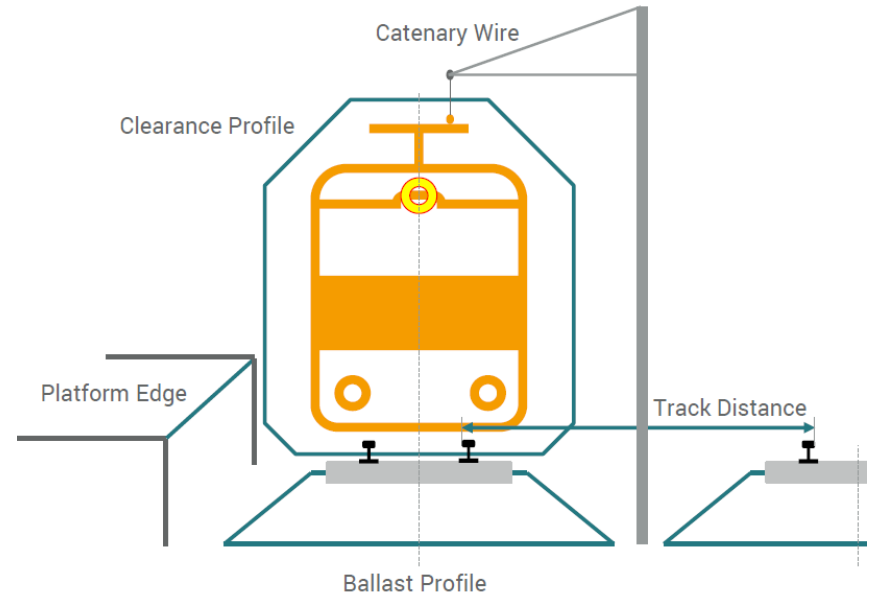
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# TMC: Environmental scanning (tmENV)

SUITE OF PRODUCTS BASED ON LIDAR POINT CLOUD PROCESSING E.G. BALLAST VOLUMES, STRUCTURE GAUGE CLASH DETECTION ETC.

tmENV is an advanced system that rapidly and accurately measures various parameters of the track environment, creating a virtual representation to enhance infrastructure management.

- **Comprehensive environmental assessment:** Measures distances from the track to critical points such as platform edges, contact wires, and adjacent tracks, and precisely determines ballast profiles.
- **High-speed, non-intrusive measurements:** Utilizes a rotating laser scanner mounted on a rail vehicle to capture data without requiring track closures, ensuring safety and efficiency.
- **Real-time data access and analysis:** Processes data onboard with algorithms and provides access through an intuitive web-based platform, facilitating timely decision-making.

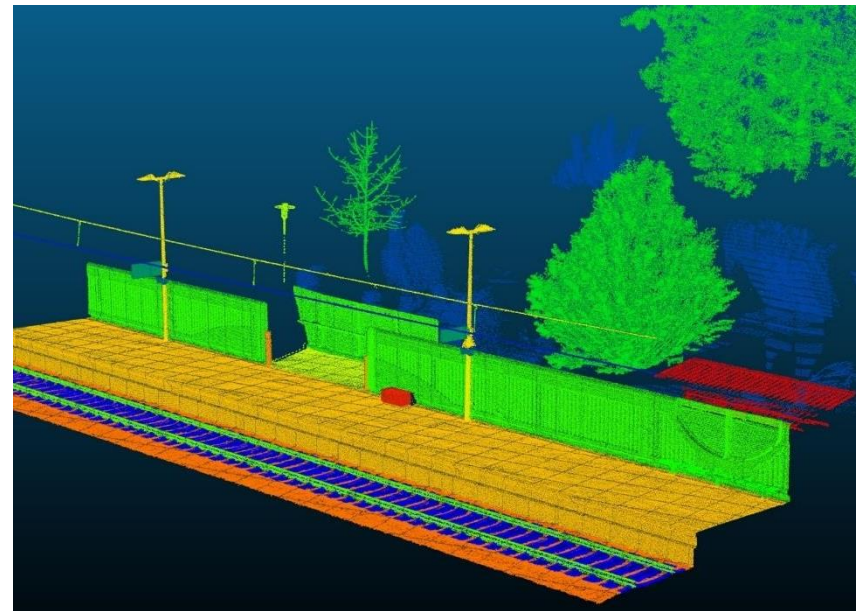


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# TMC: Inventory-as-a-Service

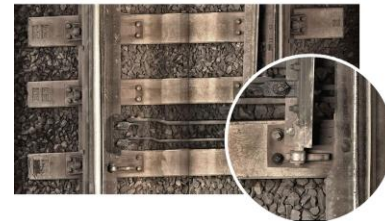
## RAILWAY ASSET CAPTURE BASED ON LIDAR POINT CLOUD

- Many railway networks all over the world exist since decades or longer. The knowledge of the exact location of all the assets along the track is crucial for continuous data processing in planning phases, for construction scheduling and progress control as well as for the maintenance and operation.
- Often, the actual data is only available as paper plans or PDFs that are archived on a network drive or in other locations. The need for an up-to-date digital inventory of the infrastructure is essential, especially for the planning and implementation of large construction projects.
- Inventory-as-a-service offers an innovative solution for precise data collection of your railway infrastructure. By using advanced technologies such as point cloud analysis and AI-supported classification, we ensure that your inventory data is always up-to-date and complete. This gives you a solid basis for efficient planning and cost savings.



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# Superstructure Images



## FAB ANALYSIS

- High-resolution imaging of track components: Captures continuous line-scan images of rails, sleepers, and fasteners for detailed inspection.
- Automated detection: Uses image recognition algorithms to identify missing fasteners, cracked sleepers, and other structural issues.
- Reduces manual inspection requirements while enhancing defect detection accuracy through machine learning models.

### Features

- Sleeper cracking
- Fastener defects
- Rail surface anomalies
  - Joint defects

### Advantages

- AI-powered image analysis detects defects in sleepers, fastenings, and rail surface conditions.
- Automates routine inspections, reducing reliance on manual labor.
- Provides early warnings for component failures, allowing proactive maintenance.

### Benefits

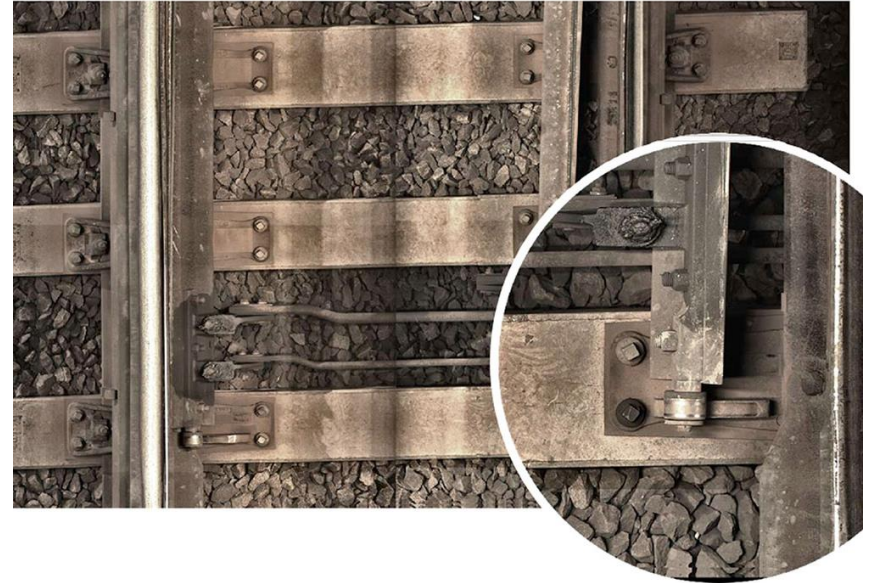
- SAF Detects early-stage failures.
- PCT Reduces unexpected failures. Minimizes reactive maintenance.
- SUST Reduces transport for manual inspections.
- FIN Significantly faster than manual inspections.

# DMA: Track Component Video Inspection



ALLOWS FOR A WIDE RANGE OF TRACK INSPECTIONS WITHOUT CREW IN THE TRACK AREA

- **High-resolution imaging:** Captures detailed images of rail surfaces and track components for thorough analysis.
- **Advanced technology:** Utilizes high-speed cameras paired with an LED illumination system to ensure clarity and precision in various lighting conditions.
- **Enhanced maintenance planning:** Provides critical visual data to inform timely interventions, promoting efficient resource allocation and system reliability.



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# Rail Corrugation



## FAB ANALYSIS

- Rail corrugation is characterized by periodic wear patterns on the rail surface
- Rail corrugation causes increased noise and vibration: Leads to rolling noise, passenger discomfort, and accelerated track and vehicle wear.
- Rail corrugation is measured to assess severity and maintenance needs: Data informs rail grinding schedules to restore smooth running conditions.
- The measured rail surface is usually filtered for different wavelengths, e.g. in accordance with EN13231

Features	Advantages	Benefits
<ul style="list-style-type: none"><li>• Amplitude and RMS value of the corrugation</li><li>• Dominant wavelength</li></ul>	<ul style="list-style-type: none"><li>• Identifies rail surface corrugation that contribute to increased rolling noise, wheel wear, and track vibrations.</li><li>• Enables targeted rail grinding to smoothen corrugation patterns, reducing dynamic forces on rolling stock.</li><li>• Helps in diagnosing root causes of corrugation formation (e.g., traction forces, wheel-rail interactions, material properties).</li></ul>	<ul style="list-style-type: none"><li><b>SAF</b> Reduces excessive dynamic forces that could lead to rail fatigue and track component failure.</li><li><b>PCT</b> Reduce sloworders due to uncomfortable ride.</li><li><b>SUST</b> Minimizes track-induced vibrations that affect ride comfort and vehicle stability.</li><li><b>FIN</b> Prevents excessive material loss, optimizing rail life.</li></ul>

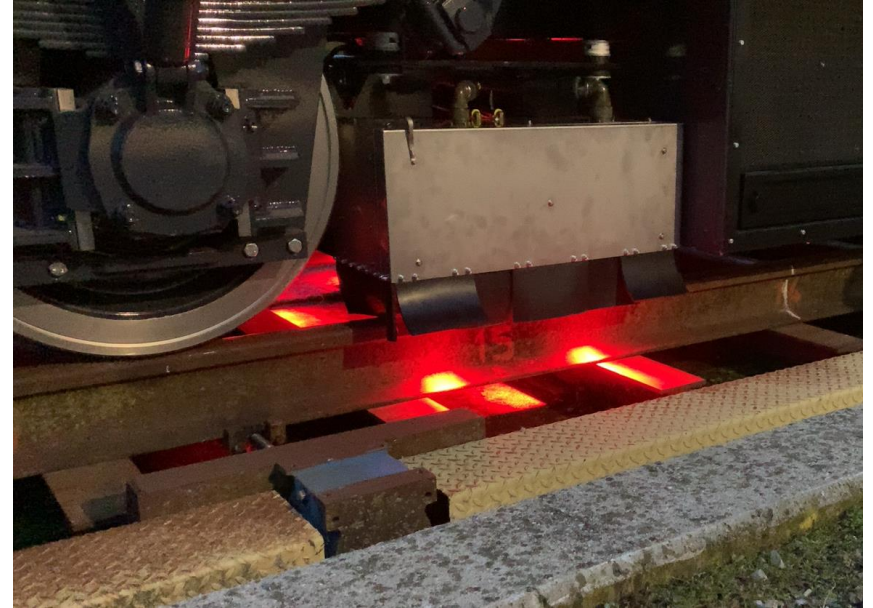
# DMA: Rail Corrugation Measurement (RCMS)



HIGH-PRECISION CORRUGATION MONITORING SYSTEM FOR SAFE, COST-EFFICIENT RAIL MAINTENANCE AND GRINDING PLANNING

DMA's RCMS provides EN 13231-3-compliant, high-precision rail corrugation monitoring using laser and sensor technology, helping infrastructure managers reduce noise, improve safety, and optimize grinding strategies.

- **Accurate, real-time data:** Scans rail surfaces continuously with pinpoint accuracy across four wavelength bands (10–1000 mm).
- **Seamless operation:** Integrates GPS and odometer signals for defect localization and generates automatic reports for decision support.
- **Efficient and easy to deploy:** Compatible with various vehicles and supported by intuitive software for fast implementation.

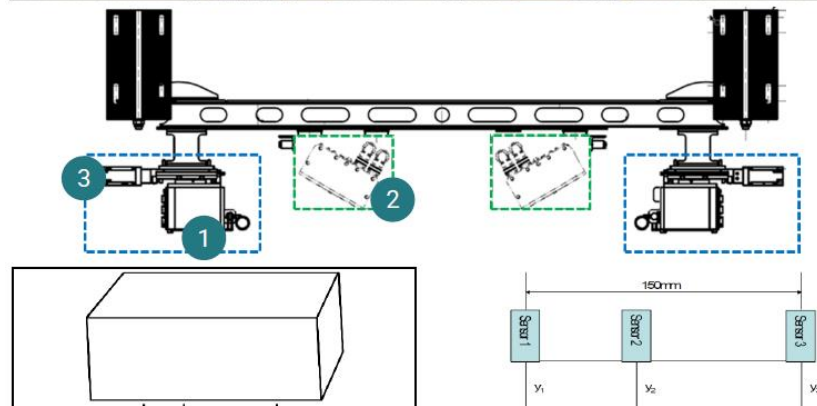


# TMC: Rail Corrugation (tmRCM)

HIGH-SPEED, HIGH-PRECISION CORRUGATION MEASUREMENT SYSTEM FOR RELIABLE GRINDING PLANNING AND DIGITAL TRACK MAINTENANCE

tmRCM is a proven, non-contact system for accurate rail corrugation monitoring. It supports grinding operations, integrates into digital platforms, and ensures repeatable, speed-independent results compliant with EN 13231-2.

- **Speed-independent and vehicle-agnostic:** Operates from 0–250 km/h on all vehicle types, unaffected by driving direction or dynamics.
- **Grinding support and exception detection:** Enables pre-grinding assessments and highlights threshold violations. Due to optical measurement it is however not ideal for post-measurement.
- **Integrated digital workflow:** Embedded in tmOS with live data view, position/time sync, and full connectivity to cloud or on-premise systems.



# Catenary and power rail geometry and wear

## FAB ANALYSIS

- Measures overhead line position and contact force: Ensures correct wire height, stagger, and tension for reliable pantograph contact.
- Monitors third rail wear and alignment: Detects degradation, uneven wear, and misalignment affecting power transmission.
- Supports preventive maintenance: Provides data to optimize catenary adjustments and third rail replacements, reducing electrical failures.

Features	Advantages	Benefits
<ul style="list-style-type: none"><li>• Contact wire height</li><li>• Contact wire stagger (zig zag)<ul style="list-style-type: none"><li>• Contact wire wear</li><li>• 3<sup>rd</sup> rail geometry</li></ul></li></ul>	<ul style="list-style-type: none"><li>• Measures wire height, stagger, and pantograph interaction forces.<ul style="list-style-type: none"><li>• Detects excessive wear, or misalignment, preventing contact wire failures.</li></ul></li><li>• Improves safe and efficient energy transmission for electric trains.</li></ul>	<ul style="list-style-type: none"><li>SAF Avoids contact loss and arcing.</li><li>PCT Reduces power-related delays</li><li>SUST Extends wire life.</li><li>FIN Reduces unplanned replacements.</li></ul>

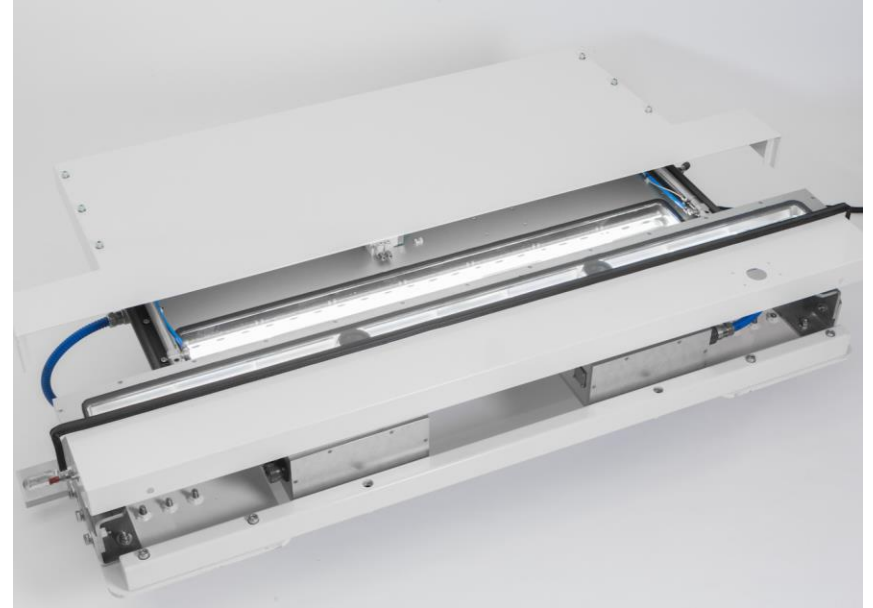
# DMA: Wire Wear Measurement (WWMS)



## PRECISE MEASUREMENT OF CATENARY WEAR

DMA's WWMS is an optical instrument designed to accurately assess catenary wire wear, ensuring optimal maintenance and safety in railway operations.

- **Precise catenary wear assessment:** Utilizes advanced optical technology to measure wire wear with high accuracy.
- **Non-contact measurement:** Employs a non-invasive approach, preserving the integrity of the catenary system during assessments.
- **Enhanced maintenance planning:** Provides critical data to inform timely interventions, promoting efficient resource allocation and system reliability.



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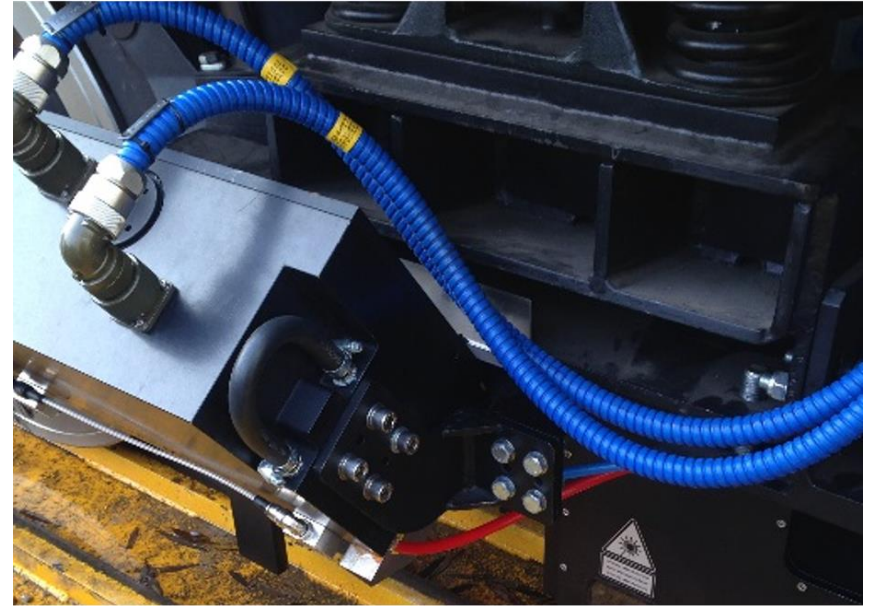
# DMA: Power Rail Measurement (TRMS)



## PRECISE MEASUREMENT OF POWER RAILS

DMA's Power Rail Measurement System (TRMS) provides precise measurements of power rail geometry, evaluating its position relative to the running track.

- **Accurate power rail positioning:** Assesses power rail gauge and height in relation to the running track.
- **Enhanced maintenance planning:** Delivers critical data to inform timely interventions, promoting efficient resource allocation and system reliability.
- **Non-contact measurement:** Employs a non-invasive approach, preserving the integrity of the power rail system during assessments.



# DMA: Radar-based Catenary Geometry



NON-CONTACT AND NON-OPTICAL, MAINTENANCE FREE, MEASUREMENT OF CATENARY GEOMETRY

DMA's Wire Geometry Measuring System (WGMS) enables precise measurement of catenary wire positions relative to the track axis and running plane, ensuring optimal alignment and maintenance.

- **Accurate catenary positioning:** Measures wire geometry in relation to track axis and running plane.
- **Enhanced maintenance planning:** Provides critical data to inform timely interventions, promoting efficient resource allocation and system reliability.
- **Non-contact measurement:** Employs a non-invasive approach, preserving the integrity of the catenary system during assessments.

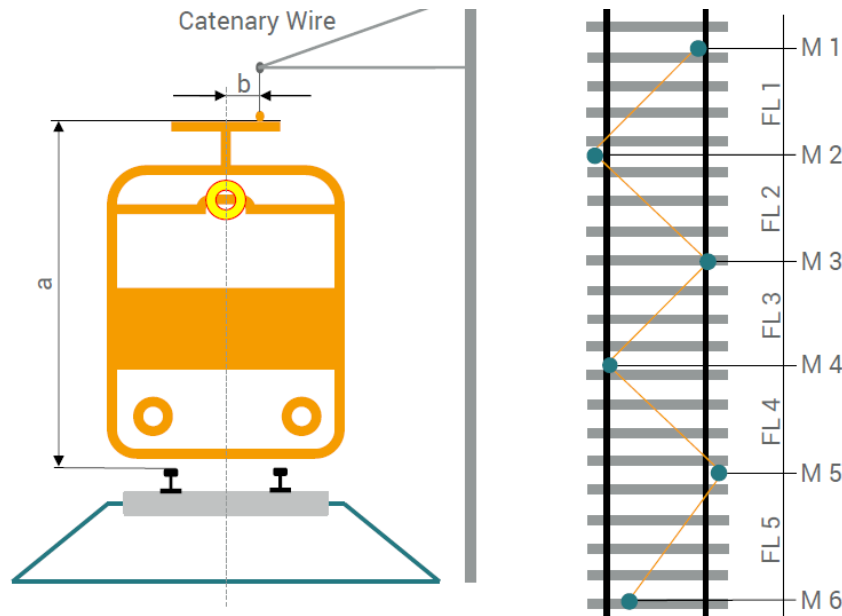


# TMC: Catenary Geometry (tmENV CWM)

PRECISE CATENARY WIRE MEASUREMENT FOR RELIABLE MAST POSITIONING AND DYNAMIC INFRASTRUCTURE MONITORING

tmENV CWM functionality delivers precise height and stagger data of overhead lines, enabling accurate mast positioning and field length calculation—supporting both dynamic and stationary operations.

- **Live wire scanning:** Measures catenary height and stagger relative to top of rail and track axis.
- **Intelligent infrastructure analysis:** Calculates mast positions and field lengths for layout validation.
- **Flexible deployment:** Supports stationary checks and dynamic measurements during operation.
- **Integrated digital workflow:** Embedded in tmOS with live data view, position/time sync, and full connectivity to cloud or on-premise systems.



# Driver's view

## FAB ANALYSIS



- Can be used to capture different views of the track, beyond drivers view, such as catenary / pantograph or track side monitoring
- Supports safety and operational assessments: Helps identify obstructions, track defects, and visibility issues affecting train operations.
- Used for training, incident investigation, and maintenance planning: Provides valuable visual data for improving driver awareness and infrastructure management.

### Features

- Video/images of driver's view

### Advantages

- Records high-resolution forward-facing video to document track conditions, obstacles, and unauthorized access.
- Supports incident analysis and post-event investigations.
- Used in combination with AI for hazard detection and response planning.

### Benefits

- SAF Identifies hazards.
- PCT Assists in rapid incident resolution.
- SUST Reduces transport to manual inspections.
- FIN Supports liability claims.

# DMA: Driver's View Video



OVERVIEW IMAGES LIKE SEEN FROM THE TRAIN DRIVER'S PERSPECTIVE

DMA's DVV system captures high-resolution digital images of the track from the driver's perspective, facilitating thorough visual analysis of safety conditions and detected anomalies.

- **Comprehensive visual documentation:** Provides detailed imagery for in-depth review and analysis of track conditions.
- **Enhanced safety monitoring:** Assists in identifying potential hazards and exceptions along the railway.
- **Efficient data collection:** Enables systematic recording of track visuals for maintenance and safety assessments.



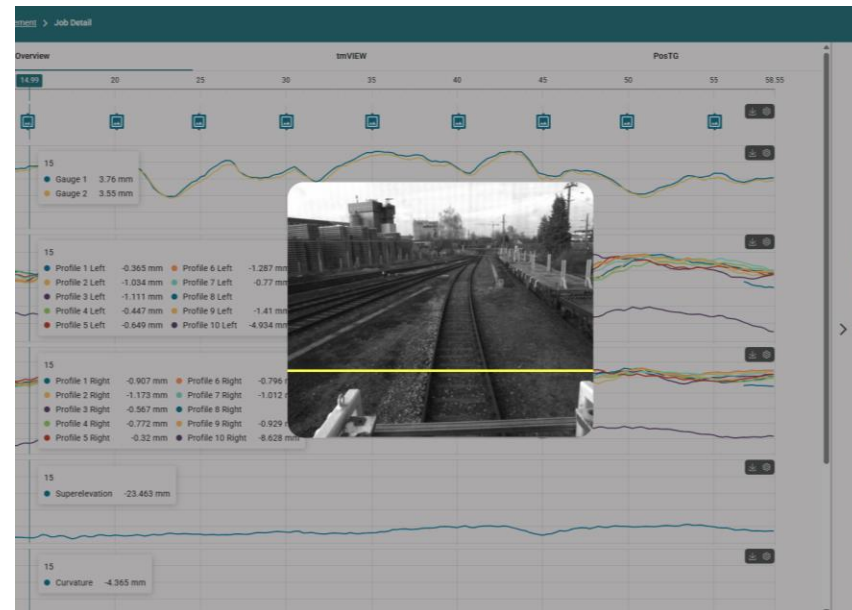
[PICTURE IS LINK TO FURTHER INFORMATION](#)

# TMC: Driver's View (tmVIEW)

HIGH-RESOLUTION VISUAL INSPECTION SYSTEM WITH FULL TRACK LOCALIZATION AND SEAMLESS INTEGRATION INTO TMOs

tmVIEW is a digital image capture and processing system for documenting track conditions, surroundings, and tunnel walls — fully integrated with tmOS for precise localization.

- **Color image capture:** Records at fixed intervals (e.g. every 2 m) with up to two cameras mounted on the measuring vehicle.
- **Contextual visualization:** Distance indication line enhances spatial awareness in image review.
- **Seamless system integration:** Images are linked to GPS, Line/Code/Track and stored in tmOS with track-positioning tags.



# Rail Defects – Rolling Contact Fatigue



## FAB ANALYSIS

- Surface and subsurface cracks caused by wheel-rail contact: Develops due to high stresses and repeated loading cycles.
- Leads to material degradation and potential rail failure: Includes defects like head checks, squats, and shelling, which can grow over time.
- Monitored to prevent breakage and ensure safety: Requires regular inspection and maintenance strategies like grinding or rail replacement.

Features	Advantages	Benefits
<ul style="list-style-type: none"> <li>• Length</li> <li>• Depth</li> </ul> <p>of</p> <ul style="list-style-type: none"> <li>• Internal rail defects                             <ul style="list-style-type: none"> <li>• Cracks</li> </ul> </li> <li>• Surface defects</li> </ul>	<ul style="list-style-type: none"> <li>• Uses high-frequency ultrasound waves to detect internal rail defects, including cracks and inclusions.</li> <li>• Eddy current detection for surface defects.</li> <li>• Identifies hidden structural weaknesses before they lead to fractures.</li> <li>• Critical for ensuring rail integrity and reducing breakage-related disruptions.</li> </ul>	<ul style="list-style-type: none"> <li>SAF Prevents sudden rail fractures.</li> <li>PCT Avoids delays from rail failures.</li> <li>SUST Optimizes renewal schedules.</li> <li>FIN Reduces rail defect-related costs.</li> </ul>

# V&P: Rail Surface Crack Measurement (RSCM)

TYPICAL DEFECTS LIKE RCF, METAL LOSS OR PITTING ARE CAPTURED AND ANALYZED DOWN TO DEPTHS OF 7 MM

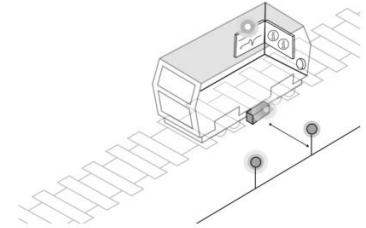
Vogel & Plötscher's RSCM is a cutting-edge system designed for the early detection of rail surface cracks, enhancing maintenance efficiency and ensuring railway safety.

- **Early detection of rail surface cracks:** Utilizes advanced technology to identify and measure surface cracks, preventing potential rail failures.
- **High-resolution imaging:** Employs sophisticated imaging techniques to capture detailed views of rail surfaces, facilitating accurate assessments.
- **Efficient data analysis:** Provides comprehensive data to inform maintenance decisions, optimizing resource allocation and improving track reliability.



PICTURE IS LINK TO FURTHER INFORMATION

# Standardized Client Documentation



## FAB ANALYSIS

- Standardized client handover documentation based on international standards
- As-inspected from various measurement systems e.g. according to EN13848-2 for relative track geometry
- As-maintained from various work processes e.g. according to EN13231-1 for track works

### Features

- As-inspected report
- As-maintained report

### Advantages

- Provides traceability and validation of infrastructure conditions before and after maintenance interventions, reducing disputes.
- Ensures compliance with international railway standards for measurement and maintenance, facilitating regulatory approvals.

### Benefits

- SAF** Ensures transparent documentation, reducing risks of misalignment or substandard work.
- PCT** Reduces delays caused by inconsistencies in work execution by providing a structured framework for quality assurance
- SUST** Supports lifecycle-based asset management by tracking historical maintenance actions and their impact on infrastructure degradation.
- FIN** Reduces cost for customizing documentation and making instructions for it.

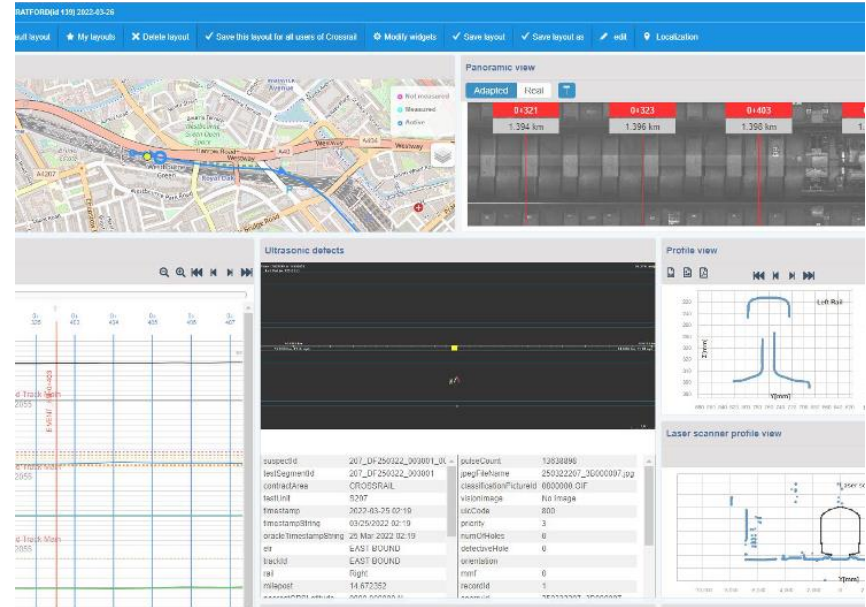
# DMA: TracksNet-based Quality Reports



CUSTOMIZABLE, INDEX-BASED REPORTING PLATFORM TRANSFORMING INFRASTRUCTURE DATA INTO ACTIONABLE MAINTENANCE INSIGHTS.

TracksNet provides infrastructure managers with a web-based environment for localized, multi-source data integration and customizable quality reports to support informed maintenance decisions.

- Advanced analytics and index reporting: Automatically computes key indicators like TQI, TRI, and GQI, with options for custom combinations and norm-based evaluations.
- Customizable and accessible: Web-based interface with modular workspace layouts, multi-user access, and compatibility across browsers and devices.
- Actionable insights over time: Enables trend analysis, historical comparisons, and predictive modeling for a shift from reactive to preventive maintenance.



# TMC: tmOS-based System Protocols

TRANSPARENT DATA HANDOVER FROM WORK SITE TO ASSET MANAGEMENT (AS INSPECTED, AS MAINTAINED)

- Standardized reports with visualization of measurement data according to international standards
- Bridges the gap between fieldwork and asset management, improving overall efficiency and safety while aligning with international quality standards.
- As inspected: Track geometry EN13848 (Longitudinal level, alignment, twist, gauge)
- As maintained: Ballasted track EN13231-1
- System is flexible and continuously with an expanding list of systems being supported





# CARRIER PLATFORMS

Platforms for installing and operating  
the measurement systems

# P&T: InfraSpector

**Plasser & Theurer**  
Plasser Italiana

HIGH QUALITY MEASUREMENT WITH A SELF-SUFFICIENT INSPECTION VEHICLE

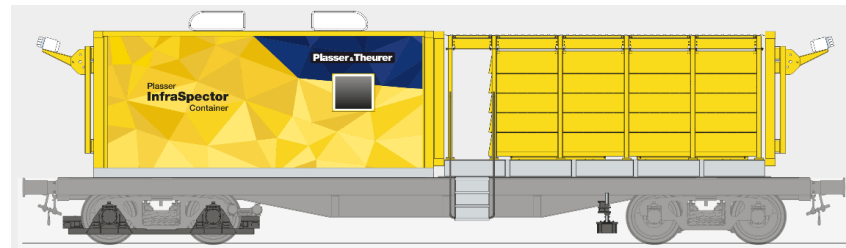
- The Plasser InfraSpector is a series of self-propelled measuring vehicles for speeds of up to 160 km/h.
- Available in different lengths: Pivot pin distance 10.8, 12.5 and 18 meter.
- The drive is integrated underfloor in a modular design
- Safe, ergonomic working environment with a roomy interior
- Space for all measuring systems of the DRS Alliance
- Highly accurate measurement under real conditions (with real axle load)
- High machine availability thanks of the modular design
- Plasser has supplied already 210 measuring vehicles worldwide



# P&T: InfraSpector Container

## COST EFFICIENT MEASURING PLATFORM

- Simple and effective, the Plasser InfraSpector Container provides a platform for measuring railway infrastructure at speeds of up to 120 km/h. The measured data is used for inspecting, reviewing, and planning maintenance measures.
- A container carrier wagon with installed measuring sensors provides the basis. The two-part container design holds space for all the necessary computer units, air-conditioned workstations for operating the systems and monitoring during operation. The energy supply with generator and diesel tank is located in a separate second section. Alternatively, a battery-operated power supply can also be provided.



PICTURE IS LINK TO FURTHER INFORMATION

# P&T: InfraSpector Truck

## FLEXIBLE ROAD-RAIL VEHICLE

- The Plasser InfraSpector Truck offers flexible transfer options. When starting out on the road, it is then possible to switch to the rail running gear at a suitable location. For example, a railway crossing with a width of only 6 metres is sufficient.
- The InfraSpector Truck can travel on the rail up to a speed of 60 km/h
- When travelling on track, the machine can be controlled in both directions. The data obtained is analysed and processed in the air-conditioned workroom: the track geometry, the rail's longitudinal profile and cross section, and the structure gauge. Plasser Italiana offers measurement services throughout Europe with this vehicle. In addition, systems can be integrated for the diagnostics areas of the track (B), rail (R), turnout (S) and overhead contact line (C), such as an ultrasonic measuring system (R).



PICTURE IS LINK TO FURTHER INFORMATION

# Robel: ROSPECT

## CAN FIT ANYWHERE

The ROSPECT solution offers advanced automation for railway inspections, enhancing safety, efficiency, and sustainability. Its capability to perform high-precision, real-time defect detection and track measurement ensures proactive maintenance while reducing costs and downtime.

- Modular, light weighted measurement and inspection platform up to 30 km/h, bi-directional driving, craneable.
  - Self-propelled, battery driven, 4 persons
  - Adjustable gauge from 1000-1435 mm
- Measurement
  - Track geometry, rail profile and wear, ground penetration radar, environmental scanning, corrugation (8km/h), switch measurement
- Inspection
  - Ultrasonic, eddy current, RSCM (8km/h)
- Software: tmOS integrated



# Commercial Vehicles

## HIGH-FREQUENT MEASUREMENTS UNDER REAL CONDITION

Measurement systems can be mounted on regular commercial trains for continuous infrastructure monitoring—offering a cost-effective, scalable alternative to dedicated inspection fleets.

- Advantages:
  - Reduces costs by using existing rolling stock
  - Enables frequent, real-world data collection
  - Enhances safety through automation
- Challenges:
  - Variable data quality across train types
  - Integration, power, and approval requirements
  - Some measurements still need specialized equipment



PICTURE IS LINK TO FURTHER INFORMATION

# On-track Machines

**Plasser & Theurer**

IT IS ALREADY THERE

Some of the measurement systems can be installed on on-track machines (e.g., tamping, grinding, and ballast management machines) with measurement systems to monitor track conditions before, during, and after maintenance activities.

## Advantages

- Integrated quality control – Immediate validation of maintenance effectiveness, reducing the need for rework.
- Cost-efficiency – Utilizes existing work machines, eliminating the need for separate measurement runs.
- High-precision data – Machines operate at controlled speeds, improving measurement accuracy



*PICTURE IS LINK TO FURTHER INFORMATION*

# Diagnostic Areas

## OVERVIEW OF CARRIER PLATFORM COMPATIBILITY

Carrier platform	Conventional rail	High-speed	Heavy haul	Light rail	Metro
P&T InfraSpector/VT-series	X	X	X	X	X
P&T InfraSpector Container	X	X	X	X	X
P&T InfraSpector Truck	X		X	X	X
Robel ROSPECT				X	X
(Installation on) Commercial vehicles	X	X	X	X	X
(Installation on) On-track machines	X	X	X	X	X



## MEASUREMENT- AS-A-SERVICE (MaaS)

All-in-one: Measurement, post-processing and delivery of data

# P&T: MaaS with InfraSpector

**Franz Plasser**  
**Plasser Italiana**  
**Plasser UK**

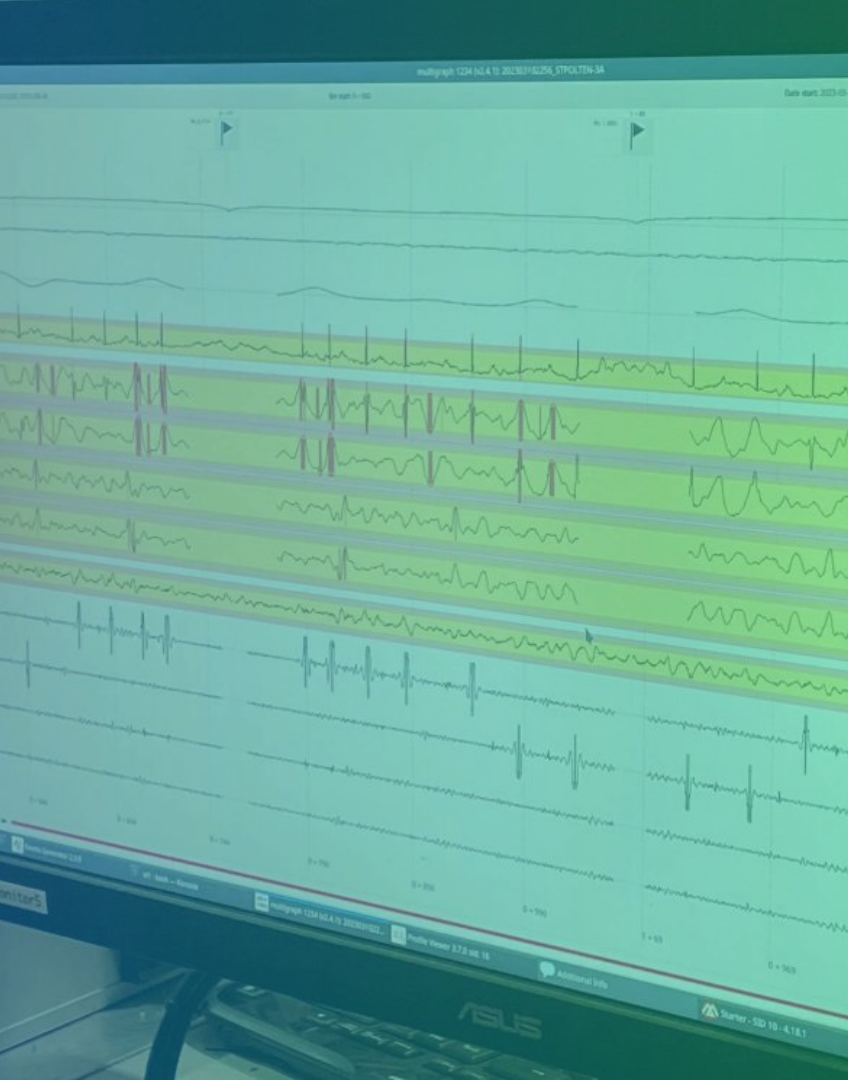
CERTIFIED MEASUREMENT AND REPORTING – ON DEMAND, INVESTMENT-FREE AND TAILORED TO YOUR NETWORK

MaaS offers certified infrastructure diagnostics without the need for internal investment—leveraging onboard or Plasser-operated systems to deliver quality reports and insights on demand.

- **No upfront investment:** Measurement delivered as a flexible, scalable service using Plasser vehicles or customer rolling stock.
- **Certified and up-to-date:** Always calibrated, standards-compliant systems ensure high-quality, real-world measurement data.
- **Tailored data and expert insights:** Receive ready-to-use reports, including turnout inspection, geometry trends, and predictive indicators.

Category	Description	VT1	VT2	VT3	VT4	VT5
Vehicle data	Image					
	Propulsion	Self	Self	Self	Towed	Hi-rail
	Speed	100 km/h	120 km/h	100 km/h	120 km/h	60 km/h

Category	Measurement system	VT1	VT2	VT3	VT4	VT5
Track bed	Relative track geometry	✓	✓	✓	✓	✓
	Ref/abs track geometry	✓	✓	✓	✓	
	Ground penetrating radar	✓	✓	✓	✓	
	Laser scanning (LiDAR)	✓	✓	✓	✓	✓
	Track components	✓	✓	✓		
Rail	Rail profile	✓	✓	✓	✓	✓
	Corrugation					✓
	Ultrasonic					(✓)
S&C	Turnout & crossing	✓	✓	✓		
	Catenary geometry	✓	✓	✓	✓	✓
Catenary	Catenary wear			✓		(✓)
	Pantograph					
General	Cab view (video/image)	✓	✓	✓	✓	✓
	Mobile mapping	✓	✓	✓		



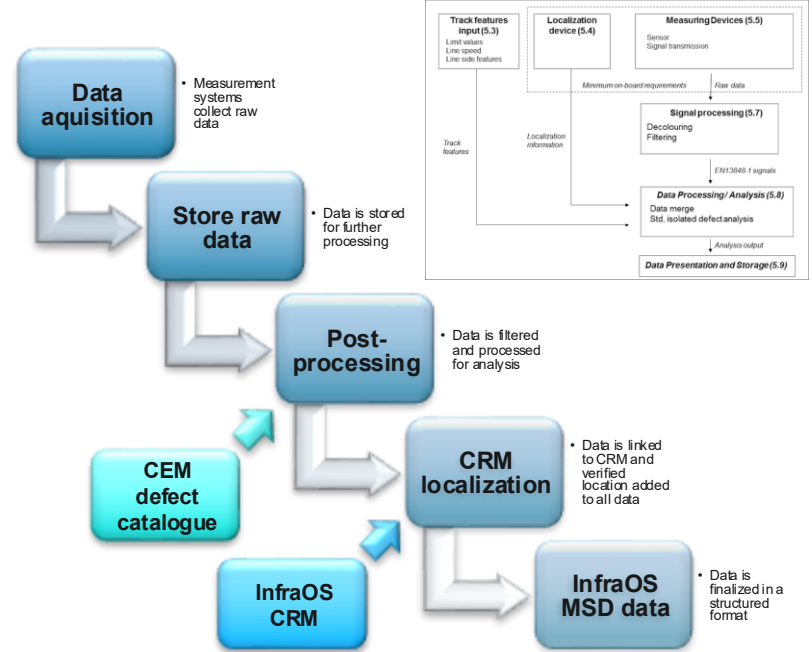
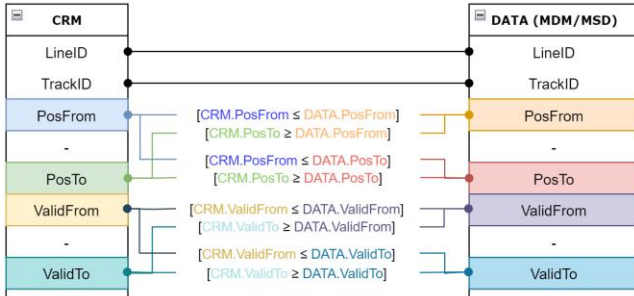
# DATA PROCESSING

From acquisition to actual output

# Generic Measurement Data Processing Workflow

## THE PROCESS TO STANDARDIZED OUTPUT DATA

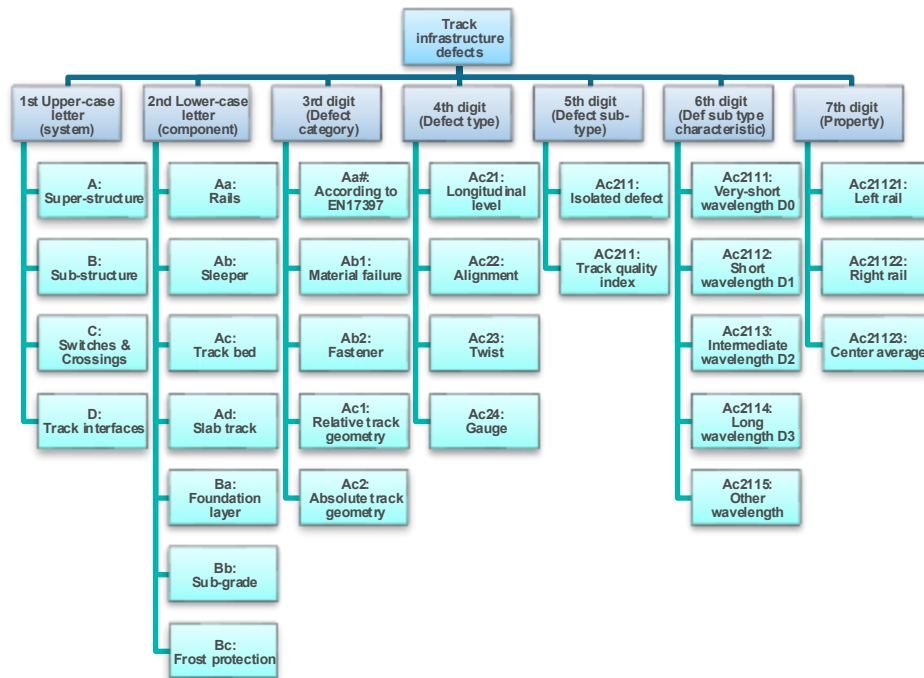
- For the completeness of the integrated infrastructure management solution, it is important that all measurement data fits into the decision support solutions, by adhering to the InfraOS standard
  - Including classification according to defect catalogue
- This means that the final product of any measurement system is the InfraOS MSD data, where every data point has been allocated a verified position on the CRM.
  - This includes, if applicable, correction for longitudinal displacement in the data (see EN13848-2).



# Appendix: International Standard Defect Catalogue


UNDER DEVELOPMENT IN CEN/TC 256/SC1/WG21: CATALOGUE OF DEFECTS FOR TRACK INFRASTRUCTURE

- Today, across a large part of the rail industry, rail defect experts all know that a “227” is a squat. It is a well-defined term, which everybody agrees on, all condition monitoring systems use, principal illustrations exist, and it is easy to ask: “how many 227s do you got per km?” to benchmark maintenance issues and performance across different networks.
- The general idea of the defect catalogue is to make a non-language dependent unambiguous definition and classification of track defects in a similar way as rail defects are in UIC 712/EN 17397. It should have a structured numbering system which both allows for the full scope of track related defects and incorporates the existing rail defect classification system.
- The new classification codes should be an integrated part of measurement data in the generic information architecture.

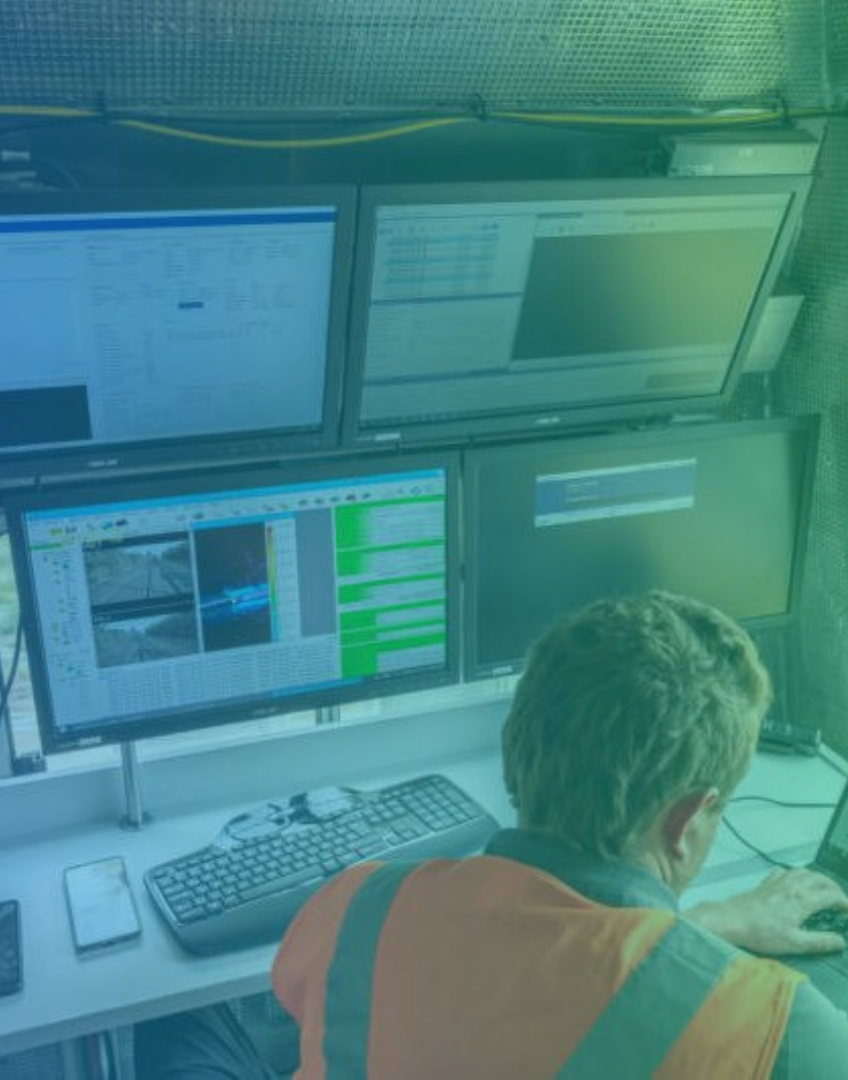


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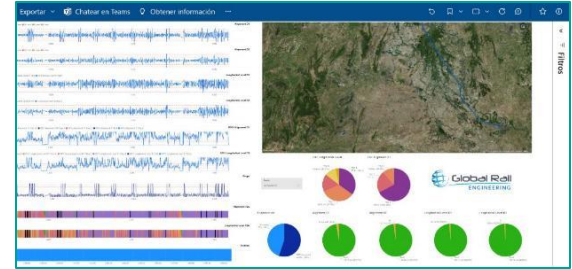
Defect code	Ad1111x
Defect name	Superstructure – Track bed – Relative track geometry – Longitudinal level – D1 – Isolated defect
Definition	A localized relative track geometry deviation in longitudinal level D1 ( $\lambda=3-25\text{m}$ ) exceeding predefined thresholds, requiring targeted maintenance intervention.
References	EN13848-5
	

- This is a preliminary sample of how a defect definition and classification could look like in the new standard.
- In this way it is clearly and unambiguously defined what a defect with code Ad1111x is called and how it should be interpreted
- All measurement systems should be able to add the code to the measurement data
- This will then be used for standardized decision support on how to treat such a defect – when it is clearly defined, so is the method of repair.



## USE CASES

How to use measurement systems in the real world



- Dehli-Agra car inspection
- On site audit of track degradation
- Maintenance audit

- Setup of measurement equipment
- Measurement runs between Dehli & Agra
- Condition report

- General BI data setup
- Hot spot evaluation
- Maintenance and design recommendation

# Cerrejon, Colombia

## INFRASTRUCTURE CONDITION ASSESSMENT

Plasser & Theurer

RailtrackAnalyzer

Global Rail  
CONSULTING

DMA  
ACCURATE RAIL CO. E.



- Track Inspection
- Wheel inspection
- Maintenance Evaluation

- Installation of the track geometry measuring system, GPR and Lidar scanner on a On-Track machine
- Measurement campaign

- General BI data setup
- Hot spot evaluation
- Maintenance activities and strategy recommendation

## END TO END BALLAST BED MANAGEMENT

**Plasser & Theurer**

**OBERMEYER**  
Infrastruktur

**tmc**  
Track Machines Connected

**RailtrackAnalyzer**

**DGNSS**  
SENSORS



- Setup of reference system
- Installation of reference points
- QR-coding

- Development of track bed container solution
- Measurement equipment

- Update of the existing maintenance machines
- Setup of data environment

# Measurement-as-a-service



ON DEMAND, INVESTMENT-FREE AND TAILORED TO YOUR NETWORK



- ÖBB pilot project at St. Pölten Hbf
- 61 turnouts measured in one night
- Four minutes per piece on average

- Digital twin on Offenburg project in Germany
- 50 km railway line
- No impact on regular traffic

- InfraSpector-series used to inspect for a European client
- 23.600 km inspected
- Three campaigns annually