

Trimble GEDO Systems

Track Survey Solutions



Railway Measurement Solutions

Railways are essential components of the global economy and infrastructure. Throughout their life cycle, rail operators demand an efficient approach to planning, construction, operations, maintenance and expansion. These applications call for innovative solutions for measurement and information management.

Based on decades of experience in the rail industry, Trimble® GEDO systems combine positioning and measurement sensors with communications and software. Trimble systems provide fast, accurate and reliable solutions for railway spatial information needs.

KEY BENEFITS:

- ▶ Speed and precision in measurement operations
- ▶ Accurate and reliable information on track and facilities
- ▶ Maximizes utilization of track shutdowns and breaks in train schedule
- ▶ Increased efficiency in planning, design, and construction
- ▶ Reduced downtime for measurement and maintenance



Planning

Trimble GEDO systems collect and manage detailed information needed by planners and designers.

BIM

To support BIM-based project management, high-resolution and precise point cloud data obtained with Trimble GEDO systems are used as the basis for modelling for planning as well as condition monitoring during and after construction.

Modernization and Expansion

High-resolution data from Trimble GEDO systems assist planners to update facilities and track for larger, faster rolling stock.

Construction

Use Trimble GEDO systems for precise alignment of track and for post-construction inspections and approvals.

Maintenance

Trimble GEDO systems increase productivity in inspection and tamping operations.

Signalling (ETCS and PTC)

Use Trimble GEDO systems to collect and manage information on location of track, signal structures and construction projects alongside the railway infrastructure.

Clearance Analysis

Clearance can be checked based on high-resolution and precise point cloud data collected with Trimble GEDO systems.

TRIMBLE GEDO SYSTEM

Speed and Precision

Continuous measurements using GNSS, optical systems, laser scanning, and inertial measurement technology

Gather precise data on track and track conditions

Safety

Small, lightweight field equipment, can be operated by one person

Install and remove from track quickly and easily

Flexibility

System configurations for each application

Modular and upgradeable system to accommodate future needs

Optimized use of equipment and personnel

Coordinated with In Sync with Railway Processes

Digital data for fast and secure information exchange

Reduced downtime for inspection and maintenance



TRIMBLE GEDO SYSTEM

Trimble GEDO systems utilize Trimble GNSS, Trimble Total Stations, inertial measurement and related sensor technologies to capture precise positioning data on railway track and surrounding features. Based on decades of experience in the railway industry, Trimble GEDO systems provide efficient tools and workflows throughout the rail measurement process. By integrating rugged field hardware with customized software and dedicated workflows, Trimble GEDO systems reduce rework and increase productivity across the entire process.

Flexible Trimble GEDO systems provide maximum return on your investment. You can quickly configure your system to perform track as-built, track inspection, track construction and maintenance tasks as well as planning tasks for improvements, updates and expansion. As your client's needs change, Trimble GEDO systems can adapt to new requirements for measurement and data management tasks.



Solutions for Track Documentation

Efficient management demands accurate information. To provide complete information, rail operators need productive rail measuring systems to provide accurate surveys of existing track.

The Trimble GEDO system is a fast, efficient tool to measure, record and document detailed information about existing track. By simply walking the track, you can capture detailed information for asset management, realignment, GIS, design, and quality control.

To use the Trimble GEDO system, a single operator pushes an easy to operate track measurement trolley along the track. All components needed for taking measurements, data capture and user guidance are integrated into a rugged, weatherproof system. All critical data is collected and stored in a single step.

Measurement of As-built Track Conditions

In addition to capturing the absolute track position, the system measures and stores cant and gauge. Measurements can be captured as the operator moves along the track continuously or by stopping at specified points of interest.

Determining the Track Position

With the Trimble GEDO system, you can quickly survey existing railway lines without the need for track alignment data. Using GNSS or optical surveying techniques, the system provides survey-quality location of the Trimble GEDO track measurement trolley. Results can be tied to national or operator-specific coordinate systems.

Fast, Precise Measurements

When configured with a Trimble S-Series Total Station, the Trimble GEDO trolley can collect data with millimeter precision while covering 600 m and up to 1,200 m of track in one hour. Systems configured with Trimble GNSS can cover up to 3,000 m of track per hour with centimeter precision. Combining inertial measurement technology with Trimble GNSS or laser distance measurement allows track surveys with a high inner accuracy of a few millimeter and a productivity of more than 2,500 m per hour. Pure relative surveys can be done with up to 5,000 m per hour.

Measure Track in Any Location

Use the Trimble GEDO system to collect information on a wide variety of track. You can measure main lines, sidings, and spurs as well as urban trams and metro lines. The system can also measure track in industrial or commercial facilities. The Trimble GEDO system can use both GNSS and optical measurements and therefore provides accurate positioning information in all locations with confidence.

TRIMBLE GEDO IN ACTION: TRACK DATA FOR PTC

California-based Cinquini & Passarino, Inc. uses Trimble GEDO Rec system to capture data for more than 80 km of track for Positive Train Control (PTC). Limited to working at night in four-hour windows, the Cinquini & Passarino teams covered 8 km – 13 km each night. Using standard PTC data model definitions they collected more than 120,000 points maintaining an accuracy of 2.5 cm or better.

TRIMBLE GEDO FOR TRACK DOCUMENTATION

Fast, Reliable Data Collection

Capture data over long stretches of track

Collect information while in continuous motion

Gather precise measurements on track position, gauge, and cant

Positioning with GNSS, Total Station, IMU or Profiler

Gather track position data with high precision

Operate in tunnels and urban areas

Integrate with other Trimble surveying systems

Simple and Lightweight

One person can assemble and operate trolley

Single screw design to quickly adapt to different gauges

Reduce costs for surveying and inspection

Safety

Minimized disruption to regular rail traffic

Reduce the number of people near the track

Reduce downtime for inspection and maintenance



INTEGRATED TRIMBLE GEDO SYSTEMS FOR TRACK SURVEY AND CONTROL

The track position measurement can be performed with different GEDO system configurations:

- ▶ GEDO Rec for geodetic track survey with total station or GNSS
- ▶ GEDO Vorsys using an alignment method
- ▶ GEDO IMS as a highly productive system based on inertial measurement technology

The respective field software guides and informs the operator to ensure complete and accurate data acquisition. The Trimble GEDO CE 2.0 trolley can be quickly removed from the track in order to avoid interruption of revenue operations. The GEDO Office software is used for data processing and analysis. Track position data can be transferred to GIS and planning systems.



Solutions for Precise Slab Track Construction

Slab track construction calls for fast, precise measurements, and calculation and display of results in real-time. The Trimble GEDO system allows you to measure for precise adjustments, inspections, and quality checks. In one operation, the Trimble GEDO system captures 3D coordinates of the track with gauge and cant. The information is compared to the design, and offsets and correction values are displayed in the field. Work crews make the necessary adjustments on-the-fly.

Trimble GEDO Office is used to import and quality-check the data prior to the field work, and to upload data to the field computer. Data can be imported from commonly used rail design software packages or manually entered from paper plans.

Tools for Slab Track Construction and Alignment

Trimble GEDO combines measurements, field software and office software to increase productivity and confidence in the construction process and quality control. The system measures horizontal and vertical alignment, cant and gauge in a single step. Working alongside track construction teams, the Trimble GEDO system calculates live delta values between design and measured track positions. Construction teams can make rough and precise track adjustments as well as performing a final quality check quickly and with confidence.

Track Construction for High-Speed Railways

Trimble GEDO measurement systems provide millimeter accuracy for construction, adjustment and inspection. Working in real-time, the system displays measurements and information to ensure that tracks precisely conform to design. Trimble GEDO systems support high-speed rail construction worldwide.

TRIMBLE GEDO IN ACTION:

SUPERVISION OF SLAB TRACK INSTALLATION AT TUNNEL ZIERENBERG

A.I.T. GmbH was responsible for construction supervision of the ballastless track in the newly built Zierenberg Tunnel of Deutsche Bahn AG. In the project, the connection to the ballasted track was built with the Rheda 2000 system. The remaining track was built with the IVES system from Rhomberg-Sersa.

The Trimble GEDO CE 2.0 system was used for acceptance measurements prior to concreting and control measurements after completion.

TRIMBLE GEDO IN ACTION:

CONTROL OF THE HANOVER-BERLIN SLAB TRACK SETTLEMENT

As a service provider for Deutsche Bahn AG the engineering firm GI-CONSULT GmbH used the Trimble GEDO CE 2.0 system to control the settlement of the installed slab track (System Rheda 2000) on the high-speed connection between Hanover and Berlin. The measurements were only taken in nightshifts. The collected data was used to calculate new gradients for the track for nearly 1,000 m and to control around 400 m of reconstructed slab track areas. The track is approved for speeds up to 300 km/h.

TRIMBLE GEDO FOR SLAB TRACK CONSTRUCTION

System for Precise Measurements

Measurements for adjustment, documentation and acceptance

Real-time control of construction results

Display correction values in the field

Reduction in construction costs

Advanced Data Management

Import of alignment data in industry standard formats

Functionality to edit and validate alignment data

Support for FAKOP® system for track widening

Fast, error-free data transfer to field systems

Quality Control and Inspections

Compare design to measured track

Documentation of final track position

Fast measurement process reduces construction delays

Consideration of load conditions on bridge structures (pre-camber information)

Precise Measurements

Construction and inspection of high-speed railway lines

Millimeter accuracy conforms to project requirements

Reduces downtime caused by inspection and maintenance



TRIMBLE GEDO SYSTEMS FOR BALLASTLESS TRACK SYSTEMS FOR METROS AND ON HIGH-SPEED RAILWAY LINES

The Trimble GEDO track measurement trolley in combination with Trimble GEDO Track software enables precise track adjustment during slab track construction as well as the subsequent track position control. The flexible measurement configuration facilitates close cooperation with the construction team. If it is not possible to use a track measurement trolley due to the chosen track installation method (i.e. Iron Horse system), the electronic GEDO Track Bar is used in combination with the Trimble GEDO Track software.

The system can also be equipped with rail inclination sensors for adjustment systems in case the rail inclination needs to be set and documented.

The GEDO Office software is used for data analysis, the generation of plate correction lists and the preparation of final quality reports.



Solutions for Railway Tamping Measurements

Tamping is essential for railway maintenance to ensure track quality and stable ballast. Trimble GEDO provides an integrated solution for measurement and quality control to support tamping machines and operations.

The Trimble GEDO track measurement trolley is used to capture the existing track geometry. Measurement data is quickly analyzed and prepared for output to tamping machines. The ballast volume can be planned for the respective route sections. After the tamping work has been completed, the Trimble GEDO track measurement trolley is used to carry out a track re-measurement to ensure that the work has been carried out correctly.

For safety and convenience, the lightweight Trimble GEDO track measurement trolley can be quickly removed from and lifted back into the track. Regular train traffic as well as tamping and construction machines are not affected by the track measurement trolley and the user.

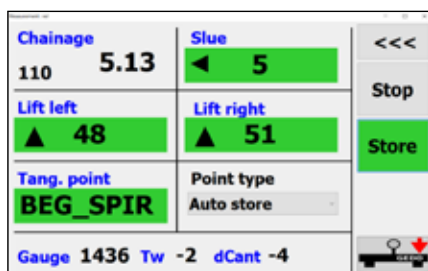
Reduced Surveying Costs for Tamping and Inspection

The Trimble GEDO system provides savings in time and labor costs for pre- and post-tamping surveys. In a single pass, the system collects information on track position, cant, and gauge. The Trimble GEDO track measurement trolley can operate at speeds of more than 2,500 meters per hour. The system records all data electronically, eliminating potential delays and errors in handwritten notes. The Trimble GEDO system compares measured data with design information to produce adjustment data needed by the tamping machine.

When compared to conventional surveying methods, labor costs are significantly reduced. Digital data management streamlines the capture and transfer of track information. Because the data is collected and checked in the field, the Trimble GEDO system reduces the possibility for costly revisits and rework.

KEY BENEFITS:

- ▶ Reduced downtime for pre-tamping surveys
- ▶ Fast field operations reduces idling time for tamping machines
- ▶ Eliminates errors and delays in data transfers



TRIMBLE GEDO IN ACTION:

SPITZKE SE

Spitzke SE received a contract for rail maintenance from Deutsche Bahn AG. Using the Trimble GEDO system for pre-tamping measurements, Spitzke SE reduced labor costs by more than 80 percent and increased the productivity of the tamping machine by 30 percent. The accurate measurements allowed construction managers to make quick decisions on tamping parameters and the quantity of ballast required.

TRIMBLE GEDO FOR RAIL TAMPING

GEDO Track Measurement Trolley for Fast Measurements

Reduces time and costs for pre-tamping surveys

Lightweight, easy and quick to remove from the track

Increases safety and schedule flexibility

Advanced Data Management

Quickly process and analyze field data

Prepare data for tamping machines

Fast, error-free data transfer to field systems

Fast measurements and results and therefore fewer delays

Quality Control and Inspections

Compare design to measured track

Post-tamping inspections to confirm final track position

Support for platform edges

Comparison of nominal and actual positions at control points

Efficient Measurements and Analysis

Reduces idling time for tamping machines

Reduces downtime caused by inspection and maintenance

Operates on standard and high-speed railway lines



TRIMBLE GEDO SYSTEMS FOR PRE-MEASUREMENT FOR TAMPING

Pre-measurement for tamping machines and related control measurements can be carried out with different GEDO system configurations:

- ▶ GEDO Track using a traditional geodetic setup method with one or two total stations
- ▶ GEDO Vorsys as a universal and effective system using alignment based method
- ▶ GEDO IMS as a highly productive system based on inertial measurement technology for long distances

The respective field software guides the operator to ensure complete and exact data acquisition. During the measurement tangent points are displayed and the user is already informed in the field about the deviation from the desired track position.

The GEDO Office software is used for data processing, analysis, data preparation for the tamping machine and the creation of quality reports.



Solutions for Line Upgrading and Reconstruction Projects

Many infrastructure operators face major challenges when upgrading existing railway lines. Often tamping machines with insufficient precise absolute reference technology are used to measure the existing track. In contrast, a geodetic track survey enables the creation of a complete 3D track alignment. This offers significantly enhanced driving dynamics and reduction in wear.

However, the installation and measurement of fixed reference points along the track is complex and expensive. The Trimble GEDO IMS system in combination with a Trimble GNSS receiver and the Trimble GEDO Profiler can help.

Track Survey and Reference Points

The combination of inertial measurement technology and GNSS enables capturing track in an absolute coordinate system with GNSS accuracy. The high inner accuracy of the track position is derived by a inertial measurement unit which is a system component of the GEDO IMS system. Parallel to the track recording, new points adjacent to the track can be measured with the Trimble GEDO Profiler at any time. The coordinates of the newly created reference points are available as control points for later measurements.

Alignment

The Trimble GEDO NovaTrack software allows the calculation of a new track alignment from the measured track. Regression algorithms are used to calculate an approximated track alignment, which can be optimized by using a graphical-interactive editor. The result is a full 3D alignment, consisting of horizontal, vertical, and cant alignment components.

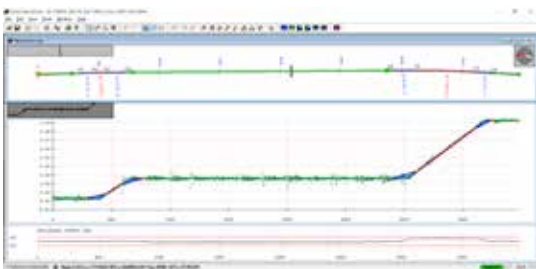
Construction

All subsequent reconstruction work will be carried out utilizing the established reference points along the track and the newly calculated track alignment. Trimble GEDO Vorsys and Trimble GEDO IMS systems are used for measurement tasks during construction and pre-measurement work to support the track tamping process.

Consistency in data management during the exchange between field and office systems within the Trimble GEDO system components ensures that re-construction projects can be carried out without delay while utilizing heavy construction equipment productively. Infrastructure operators benefit from the improved track geometry quality and shortened project duration.

KEY BENEFITS:

- ▶ No time-consuming and complex surveying work (traverse measurements and level runs) needed to establish permanent reference points
- ▶ Productive and precise determination of track position
- ▶ Consistent data flow from the initial track survey, calculation of an improved track alignment, all the way to the tamping machine



TRIMBLE GEDO IMS SYSTEM

Integrated System

Flexible system configuration
Combination of different technologies depending on application
Everything from a single source

Measurement Efficiency

Marking and measurement of temporary reference points
Integrated system with GNSS and IMU technology
Combination with 3D laser scanning possible

Modern Data Management

Fast processing and evaluation of measurement data
Data storage in central database
Consistent data storage for all work steps involved
Joint analysis of data from different sources

Powerful Data Analysis

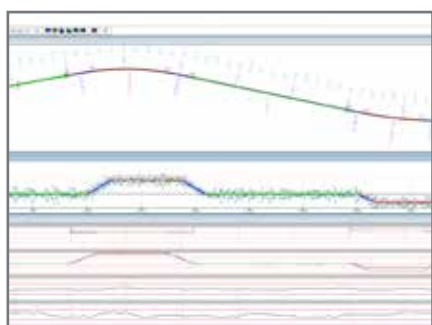
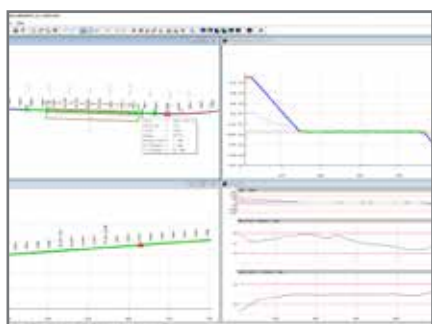
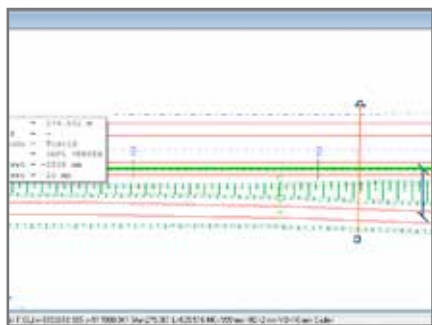
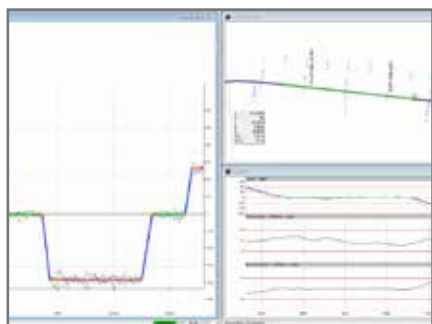
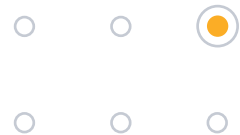
Semi-automatic generation of full 3D track alignment
Graphical user guidance for alignment optimization
Direct data output to the tamping machine



TRIMBLE GEDO SYSTEMS FOR LINE UPGRADING AND RE-CONSTRUCTION PROJECTS

The Trimble GEDO IMS system is used in combination with Trimble GNSS and Profiler for the initial measurement of the existing track. The result is a trajectory of the actual track position and coordinates for the temporarily marked control points, measured with the GEDO Profiler. Based on this data, the Trimble GEDO NovaTrack software calculates an improved alignment and optimizes and adjusts it according to the project specifications. The differences between the nominal and actual track position can be used immediately for tamping work. In large re-construction projects with several tamping runs, the temporary marking is used for laying track and the subsequent pre-measuring work for the tamping machines. The Trimble GEDO IMS system with Profiler or the Trimble GEDO Vorsys system are used as pre-measurement systems.

Trimble GEDO Office and Trimble GEDO NovaTrack software packages are used for data processing, analysis, alignment calculation, data preparation for the tamping machine and the creation of quality reports.



Track Alignment Calculation

GEDO NovaTrack

Track Alignment Calculation and Optimization

Trimble GEDO NovaTrack software enables automatic and semi-automatic calculation of a track alignment based on track survey data from Trimble GEDO systems. In this process the alignment elements are estimated and adjusted with optimal parameters and absolute position based on the chosen track alignment framework. The Trimble GEDO NovaTrack software automatically processes and analyses GEDO track survey data, such as coordinates, cant and gauge, and creates the best possible alignment design.

Features

Trimble GEDO NovaTrack's calculation engine includes advanced algorithms for approximating and displaying alignment elements. These include the approximate position based on curvature and direction methods, and automatic sequencing of alignment elements, such as transition curves, circular arcs and straight lines.

Automatic Process

The statistical calculation of Trimble GEDO NovaTrack includes regression analysis of the track measurement data and the conversion into alignment elements. It offers several scenarios for adapting elements to the existing track position. Using robust regression methods, parameters of the individual elements are determined and optimized through a calibration process.

Data Exchange

New alignment data for horizontal, vertical and cant alignments are exported directly into the GEDO exchange format. This simplifies the direct import of information into Trimble GEDO Office and Trimble GEDO Scan Office software, as well as field applications such as Trimble Access Rail (modules Stakeout and GEDO Track), GEDO Vorsys and GEDO IMS.

KEY BENEFITS:

- ▶ Full alignment data compatibility with Trimble GEDO track measurement systems
- ▶ Automatic and semi-automatic calculation of geometry elements
- ▶ Import of background maps for horizontal/vertical distance check
- ▶ Calculation and graphics update on-the-fly

Solutions for Track Stakeout

Trimble Access Rail

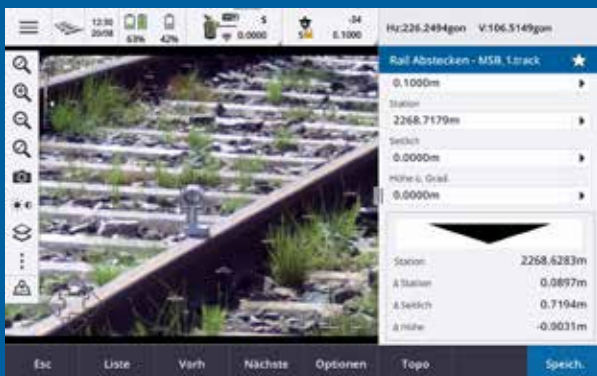
Trimble Access Rail Module Stakeout

The Trimble Access Rail application with the Stakeout module is used for all surveying tasks within the scope of track recording and track stakeout where a direct reference to the nominal track is required.

The application is fully integrated in Trimble Access and uses instrument setup routines and all instrument control features from Trimble Access. It can work with both Trimble total stations and Trimble GNSS receivers.

All calculations are carried out based on a design track alignment with horizontal, vertical and cant alignment elements and a chainage line. All common transition curves and track shears are supported.

Based on the measurements, the current chainage and distance measurements in position and height to the track alignment are displayed directly in the field. When a main point is selected or a stake-out value is specified, the differences between the target value and the current position are displayed. The calculation can be done either horizontally or in a canted system. The interactive map view shows the track alignment with its main points and all measured points.



KEY BENEFITS:

- ▶ Digital data flow from the office to the field
- ▶ Alignment-based measurement with real-time information in the field
- ▶ Calculation either horizontally or in a canted system
- ▶ Support of all common track alignment elements
- ▶ Total station and GNSS-based data capture for reliable positioning
- ▶ Data check at the office in advance optimizes work in the field



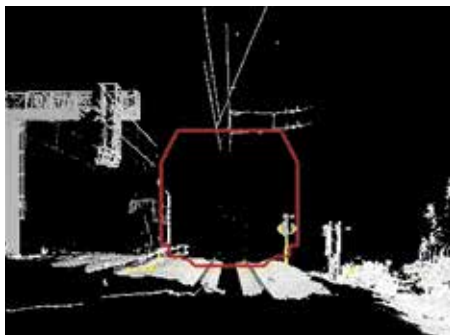
Solutions for Asset Data Collection and Clearance Analysis

As demand for rail transport increases, railways are introducing rolling stock that is faster and larger than existing rail cars. To ensure that tracks and facilities can support the new cars, railways need to collect detailed information about existing tracks and surrounding structures.

The Trimble GEDO Scan system combines precise positioning with 3D laser scanning to capture high-density information in tunnels and underpasses, stations, rail yards and other areas where clearance tolerances are critical. Trimble GEDO Scan replaces slow, labor-intensive measurements with high-speed measurements and automated data collection.

KEY BENEFITS:

- ▶ Fast, accurate data collection and processing
- ▶ Reduce survey time on site and downtime for railway operators
- ▶ 3D point clouds for design and analysis
- ▶ Quickly identify clearance issues
- ▶ Plan new construction and rolling stock with confidence



3D LASER SCANNING FOR RAILWAY APPLICATIONS

Railway Design

- ▶ Develop accurate, detailed models of existing conditions. All features can be tied directly to the track alignment
- ▶ Detect and analyze clearance encroachments. Compare clearance envelopes against existing features and provide information for track clearance databases
- ▶ Test new track design alignments using Trimble visualization and animation tools

Construction

- ▶ Final inspections
- ▶ As-built survey and documentation
- ▶ Quality control
- ▶ Clearance analysis

Asset Management

- ▶ Collect information on railway facilities and structures

TRIMBLE GEDO IN ACTION: CLEARANCE DATA FOR THE LIRA DATA-BASE OF DEUTSCHE BAHN AG

As a service provider for Deutsche Bahn AG and contractor for rail construction companies, Ingenieurbüro Herzbruch GmbH has been using the GEDO Scan system for clearance measurements for many years. Clearance profiles are measured at critical points along the tracks, and the information obtained is processed for Deutsche Bahn AG's LIRA database.

TRIMBLE GEDO SCAN SYSTEM

GEDO Track Measurement Trolley System

Acquisition of scan data, track position, cant and gauge in one operation

Fast and easy removal of measurement trolley off the track

Safety and flexible planning

Complete scan data in one operation

Collect Data for Planning and Design

High-resolution point cloud for as-built modeling and condition monitoring in BIM-compliant projects

Precise and detailed information on track and structures

Analysis of clearances taking into account local requirements

Generation of cross-section drawings

Optimized Systems for Railway Scanning

Capture of hundreds of thousands of points per second

Acquisition of complete profiles in tunnels and underpasses

Absolute or relative positioning

Integrated System

Streamlined data flow

Single system for measurement, processing and data analysis

Combine scanning with data from other Trimble GEDO applications



TRIMBLE GEDO SYSTEMS FOR ASSET DATA COLLECTION AND CLEARANCE ANALYSIS

To generate accurate 3D point cloud data, the Trimble GEDO track measurement trolley is operated in combination with the Trimble GEDO GX50 laser scanner, which is optimized for kinematic applications, or a terrestrial laser scanner in helical mode.

The GEDO Scan system, consisting of the Trimble GEDO track measurement trolley and laser scanner, is used for simple clearance inspections.

For as-built and advanced clearance analysis, the Trimble GEDO Scan system can be combined with other GEDO systems.

- ▶ GEDO Rec-Scan utilizing a geodetic surveying method
- ▶ GEDO Vorsys-Scan as a universal system utilizing the alignment method
- ▶ GEDO IMS-Scan as a highly-productive system based on inertial measurement technology optimized for long distances and underground railways

GEDO Scan Office software is used for data processing and analysis. High-resolution 3D point clouds of the entire track system are created. Based on this track system, object documentation and clearance analysis are carried out.



Mobile Mapping for Rail As-built Surveys & Asset Management

Whether for rail construction or asset management projects, the Trimble MX9 mobile mapping solution provides a complete field-to-finish mobile mapping solution that combines state-of-the-art hardware with intuitive field software and a reliable, efficient office software workflows.

The Trimble MX9 efficiently captures high-precision survey data that facilitates the design of rail infrastructure and mapping of corridor features to build a comprehensive asset database. Expensive track closures can be avoided and the risk associated with pedestrian site access is minimized.

Rich data enables the delivery of a wide range of products from terrain models and volumetric analysis to detailed CAD designs and GIS asset databases. A complete as-built documentation can be created after a construction project to use the information in a BIM compliant project and throughout the lifecycle of the asset.

KEY BENEFITS:

- ▶ Premium technology, simple to operate
- ▶ Quickly and efficiently survey large projects
- ▶ Avoid the cost for closures and unnecessary safety risks
- ▶ Capture vast amounts of data that can be accessed by multiple stakeholders for a variety of use cases

Railway As-Built Survey & Mapping

- ▶ Mounting of MX9 on a train or train car
- ▶ Mapping at normal operational speeds
- ▶ As-built surveys on and next to track
- ▶ Digitization projects

Asset Management & Maintenance

- ▶ Assess current conditions of track and track surroundings
- ▶ Collect data for line upgrading projects

TRIMBLE MX9 IN ACTION: RAILWAY LINE AS-BUILT DIGITIZATION

"We used the Trimble MX9 in one of our pilot digitization projects to record the as-built of a railway line directly on and next to the track during regular, scheduled operation.

The simplicity of the system and the recording of all areas thanks to the MX9's butterfly configuration impressed us.

What we appreciate about Trimble's mobile mapping and scan systems is the openness of the data format for measurement results.

This enables us to use software we already have in-house, that are used for other applications, for further data analysis."

Dr. Helge Grafinger, Rhomberg-Sersa Rail Group

TRIMBLE MX9 MOBILE MAPPING SYSTEM

Innovative Mobile Mapping System for Large-Scale Projects

Very high point cloud density and immersive imagery

State-of-the-art Trimble GNSS and inertial technology

Dual and single laser configuration available according to customer requirements

Light & Compact, Simple to Operate

Lightweight and compact premium mobile mapping system that is quick and easy to install

Simple installation for quick commissioning and handling during operation

Integrated Software Workflows

Streamlined software workflows enable data and images to flow efficiently between field and the office

Fits seamlessly into the Trimble ecosystem including Trimble GEDO office software solutions for data preparation, processing, and analysis

Additional option to publish and transfer MX9 data into third party CAD and GIS environments



TRIMBLE MX9 SYSTEM: COMPLETE FIELD-TO-FINISH MOBILE MAPPING SOLUTION

The Trimble MX9 captures precise object locations with corridor features to form the basis for building a comprehensive asset database.

- ▶ Avoid costly railway closures and minimize the risk associated with pedestrian site access with effective and fast data capture from a safe distance
- ▶ Deliver a wide range of products, from as-built topographic surveys and digital terrain models to rich GIS asset databases
- ▶ Get complete as-built information after a construction project and utilize this information in a GIS or BIM throughout the lifecycle of the asset

The Trimble MX9 allows GIS deliverables for transportation infrastructure to be generated more safely, easily and cost effectively. It allows technicians to seamlessly collect data, including all railway infrastructure, in the immediate vicinity of the project corridor, as they drive. The MX9 captures high density, colored point clouds and precise panoramic and multi-orientation views of the area. This rich geospatial data is a solid foundation for a full range of transportation asset management and topographic mapping applications.

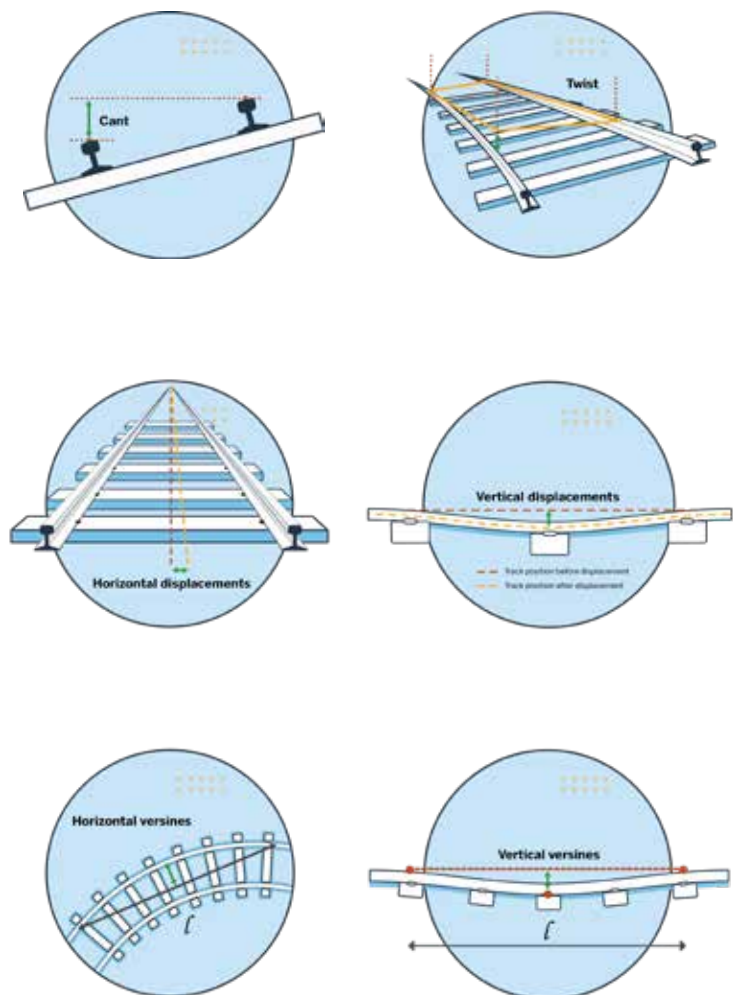
The Trimble MX9 mobile mapping system has received product approval from **Deutsche Bahn** for the recording of tracks, constraint points of the alignment, light space, topographic objects and panoramic images and is approved for use on the Deutsche Bahn network.



Automated Rail Monitoring for Real-Time Analysis & Safety

Rail monitoring is one of the critical components to ensure safe and continuous rail traffic. It is an activity that plays a crucial role in support of rail line operator safety during construction projects on or close to existing railroad tracks. Frequent rail monitoring can also help identify track changes caused by activities such as tectonic movement, heat waves, and other environmental conditions.

Trimble 4D Control™ (T4D) software introduces the T4D Rail module, the first add-on module to the platform. The module offers a versatile rail monitoring solution that meets the industry's demanding requirements for accuracy and efficiency. Using the module within a Trimble product ecosystem will significantly simplify the integration of fieldwork results and eliminate a significant amount of the office work required to detect movement with confidence.



T4D RAIL HIGHLIGHTS

- ▶ One module for both automated and semi-automated rail monitoring
- ▶ Seamless integration of accurate track as-builts collected with the Trimble GEDO measurement system or Trimble Access Track Gauge Survey app
- ▶ Automated rail track geometry monitoring
- ▶ Support for both geodetic (total stations) and geotechnical sensors (tiltmeters)
- ▶ Automatic calculation, charting, and alarming on all track geometry parameters



The versatile and durable Trimble S-Series total stations are indispensable tools for rail monitoring, reliably capturing data even in the most challenging rail environments. Equipped with MagDrive technology and boasting a high IP classification rating for dust and waterproofing, these instruments excel in rugged conditions.

These total stations measure permanently installed prisms that are then combined with the as-built survey data collected to calculate offsets between prisms and the actual rail. With each new round of measurements, these offsets are applied, and the actual rail coordinates are utilized for parameter calculation, providing essential information to understand track movement.

Even in cases where an as-built survey is unavailable, specific parameter calculations are still achievable based on prism coordinates.

In rail monitoring projects, geotechnical sensors like tiltmeters offer a precise solution for monitoring one of the most crucial rail parameters: Twist. Tiltmeters are particularly valuable in areas where achieving a clear line of sight is challenging or when extensive coverage is required.

They can also complement an automated monitoring total station (AMTS) for redundancy purposes, ensuring measurement flow during all weather and traffic conditions. This makes them an essential tool in Trimble's arsenal for rail monitoring tasks.

Data from both total stations and tiltmeters can be processed and visualized in T4D Rail, allowing for more informed decision-making and proactive maintenance.



"With this technology, I believe we can spend more time focusing on the data analysis thanks to the automated charts and faster setups, and we also spend less time in the field gathering data."

Florian von Matt, Wild Ingenieure AG, discussing the Trimble Access Track Gauge Survey app in combination with T4D Rail.



The Versatile Solution for Rail Measurements

The Trimble GEDO track measurement trolley offers an optimum in productivity and flexibility. Developed with years of experience, the Trimble GEDO track measurement trolley is a key component of Trimble GEDO field measurement systems. Easily adjusted to fit different track gauges, the lightweight trolley is designed for operation by one person. Powered by removable Trimble S-Series batteries, the system can operate for up to 16 hours on one set of batteries.

Benefits

- ▶ Lightweight, easy to use by one person (depending on configuration)
- ▶ Configurable to work with an integrated Trimble GNSS receiver, 3D laser scanner, total station or IMU
- ▶ Built-in sensors for rail gauge, cant and distance
- ▶ Onboard cable-free Bluetooth® communications
- ▶ Removable rechargeable batteries for reliable power
- ▶ Single and dual trolley configurations to optimize speed and accuracy
- ▶ Non-profiled wheels for long life and low maintenance
- ▶ Specially raised trolley versions available for ballastless track projects with Iron Horse systems

Track Measurement Trolley

- ▶ Gauges: 1000 mm, 1067 mm, 1100 mm, 1435 mm, 1520 mm, 1524 mm, 1600 mm, 1668 mm, 1676 mm, other gauges on request (i.e. 760 mm, 950 mm)
- ▶ Gauge measurement range: -20 mm to +60 mm
- ▶ Gauge measurement accuracy: ± 0.3 mm
- ▶ Cant measurement range: $\pm 9^\circ$ or ± 235 mm
- ▶ Cant measurement accuracy: ± 0.5 mm (static)
- ▶ Weight: 16.0 kg
- ▶ Power: Self-contained, field replaceable
- ▶ Battery type: Trimble S-Series Li-Ion, rechargeable
- ▶ Battery life: 8–10 hours per battery
- ▶ Certified by: Network Rail (United Kingdom), SNCF (France) and other railway operators around the world

TRIMBLE GEDO CERTIFICATION

The Trimble GEDO CE 2.0 system is approved by Network Rail (United Kingdom), SNCF (France) and other railway operators worldwide as track measurement equipment. Within the scope of the approvals, the compatibility with the network, the suitability of the test method, the functionality as well as the operational safety and ergonomics were verified. The Trimble GEDO CE 2.0 track measuring trolley meets the requirements of DIN EN 13977 „Safety requirements for portable machines and trolleys for construction and maintenance“ and is therefore also approved for use at DB AG and on other European networks.

TRIMBLE GEDO HARDWARE

- | | | | |
|------------------------------------|--------------------------|-------------------|-------------------------|
| 1 Trimble S-Series Total Station | 5 Total station adapters | A Brake | E Inclination sensor |
| 2 Precise prism | 6 Trimble GEDO Profiler | B Pushing rod | F Battery holder |
| 3 Laser Scanner | 7 Trimble GEDO IMU | C Universal mount | G Gauge sensor |
| 4 Active Trimble MultiTrack Target | 8 Trimble GNSS Receiver | D Gauge adapter | H Spring loaded contact |
| | 9 Trimble Control Units | | I Odometer |



Non-profiled wheels for long life and low maintenance; bearings 14 mm below rails



Elevated trolley for slab track construction using Iron Horse method



Adapter available for different track gauges



Battery holder with in-field replaceable Trimble S-Series Li-Ion batteries



Integrated electronic box with Bluetooth communication

LED strip for illumination



Integrated Software for Efficiency and Accuracy

Seamless Flow of Data and Information for Measurement and Analysis

The Trimble GEDO system ensures easy, secure data management throughout data collection and analysis. In the office, Trimble GEDO software provides data management and analysis in a modern, cohesive software environment. Importing data from external sources, both digital and paper plans, is fast and efficient. You can quickly complete your work and provide deliverables to clients and colleagues.

Field Solutions

TA Track Gauge Survey: Application for geodetic track surveying with a Trimble total station and a mechanical track measurement bar.

TA Rail Module Stakeout: For track stakeout with design alignment data and without utilizing a track measurement trolley.

The following Trimble GEDO field software is used in conjunction with the Trimble GEDO CE 2.0 track measurement trolley:

TA Rail Module Gauge & Cant: For simple track control to record the track gauge, cant and twist together with the current chainage.

TA Rail Module GEDO Rec*: For geodetic track surveying with a Trimble S/SX series total station or a Trimble GNSS receiver. The results of the measurement are the coordinates of the left rail, right rail and track center as well as the track gauge and cant.

TA Rail Module GEDO Track*: For geodetic alignment based measurements. Based on the measurements from the geodetic sensor and the cant and gauge values from the trolley, the differences between design and as-built are calculated and visualized live in the field. These are calculated either horizontally or in a canted system for the complete track (left and right rail).

If a track measuring trolley cannot be used due to the construction method or due to the low construction output, the electronic Trimble GEDO Track Bar is used in the TA Rail modules GEDO Rec and GEDO Track.

* The GEDO Rec and GEDO Track applications are available for some software functions that have not yet been ported to TA Rail modules GEDO Rec / GEDO Track.

KEY BENEFITS:

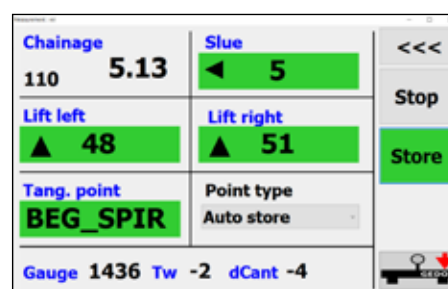
- ▶ Simple operation and clear user interface with focus on the essentials
- ▶ Integrated software eliminates data reformatting and transfers
- ▶ Consistent look and feel streamlines workflows and reduces training needs



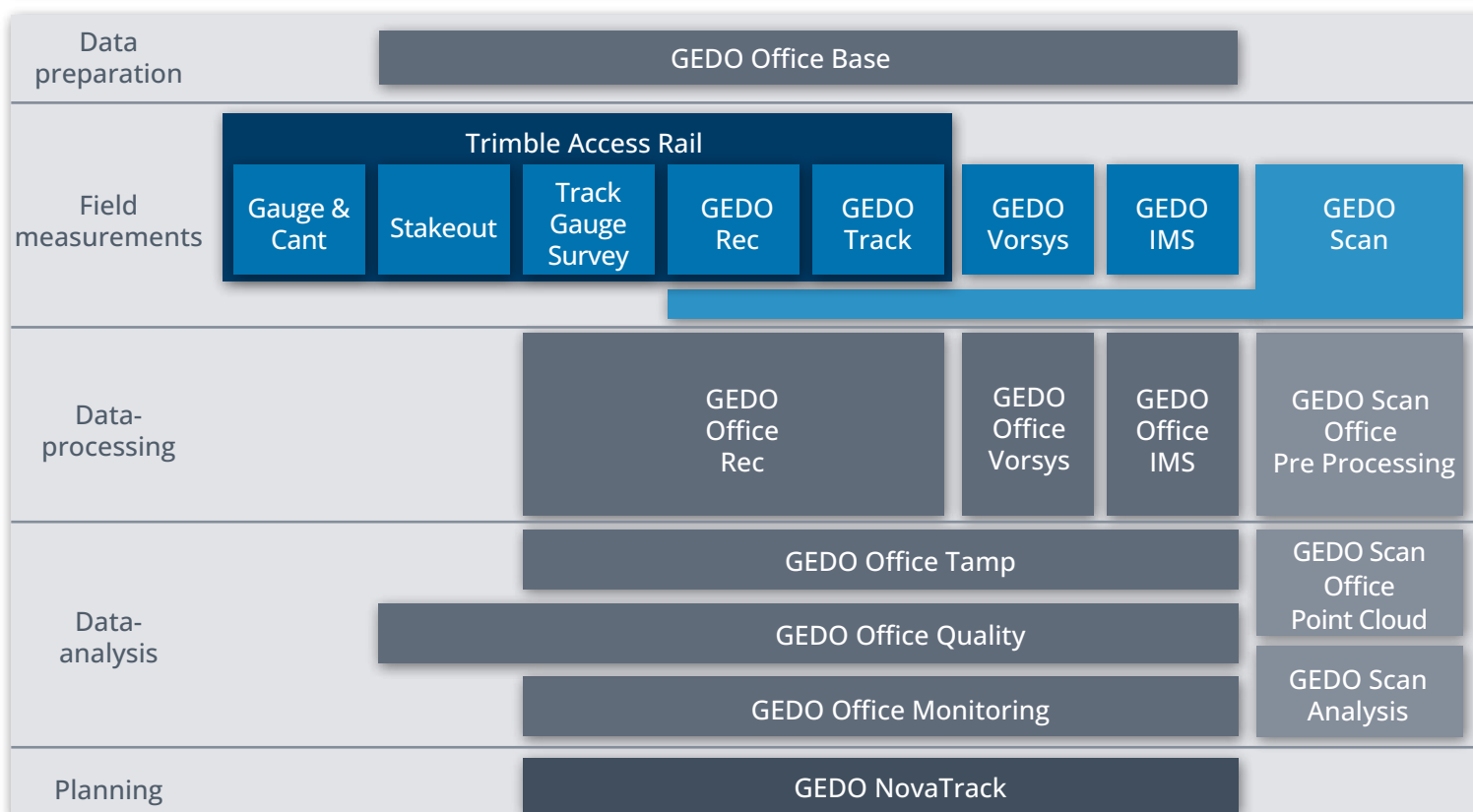
GEDO Scan: Supports kinematic data collection of 3D laser scan data in combination with a Trimble GEDO CE 2.0 track measurement trolley and a Trimble laser scanner. Data can be collected stand alone, in combination with GEDO Rec, GEDO Track or GEDO Vorsys as well as fully integrated with GEDO IMS.

GEDO IMS: Software for flexible and productive usage for several track survey applications. It is used in combination with the Trimble GEDO CE 2.0 track measurement trolley and the Trimble GEDO IMU. If used for track survey on lines with reference points along the track, the Trimble GEDO Profiler is added to the setup. For re-construction projects without reference points a Trimble GNSS receiver is used in addition. Combined with a laser scanner the software controls the full three dimensional data collection.

GEDO Vorsys: Software for high productive pre-measurement for tramping or track survey utilizing two trolleys in combination with a Trimble S-Series total station. The alignment based measurement method guarantees high inner accuracy and very high productivity. Measurements can be taken based on classic paper plans or based on digital alignment data. All differences between design and as-built are shown in the field. An optimized user interface enables the usage by track construction workers.



GEDO Software



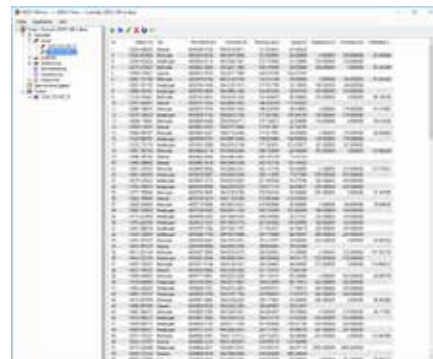
Software for Data Processing and Analysis in the Office



GEDO Office Base: Module for alignment data input and import of design data. Standard design data formats are supported (i.e. Verm.ESN, LandXML). Alignment data can be checked and validated prior to using it in the field.

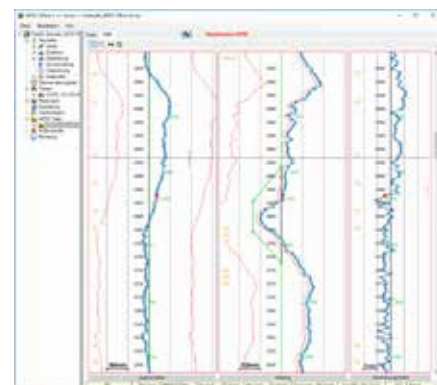
GEDO Office Module Rec: Module for evaluation and further processing of TA Track Gauge Survey, TA Rail modules GEDO Rec and GEDO Track measurements. Station setups can be re-calculated. Different matching algorithms are used to connect the overlapping areas. Coordinate export for the left rail, center line and right rail including cant and gauge values. The differences between design and as-built are calculated.

GEDO Office Module Vorsys: Module for processing GEDO Vorsys field data. Measured data can be re-processed based on another design or new reference point coordinates. Measurements taken without alignment data for track survey purposes can be processed as well. The differences between design and as-built are calculated.



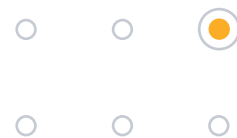
GEDO Office Module IMS: Module for processing GEDO IMS field data. Measured data segments can be analyzed and re-processed based on new reference point coordinates as well as merged to a line. The differences between design and as-built are calculated.

GEDO Office Module Tamp: Module for data preparation for tamping machines. Measured and processed data from TA Rail modules GEDO Rec and GEDO Track, GEDO Vorsys and GEDO IMS can be used. A graphical interface allows an easy ramp definition by focusing on minimum lift values, maximum lift and shift values and other constraints. Data for all common tamping machines can be exported.



KEY BENEFITS:

- ▶ Simple and clear user interface and operation
- ▶ Flexible data adjustment and re-calculation taking into account any data or framework modifications
- ▶ Individual definition of parameters for calculation and output
- ▶ Concise quality reports



GEDO Office Module Quality: Generates track quality reports. In addition to flexible travel chord evaluations, special calculations can be carried out and special formats such as MKS (manual replacement measurement DB AG), Speed Raiser (Network Rail) or TUCRail (Belgium) can be created. For slab track projects, the necessary corrections are optimized and correction lists are created.

GEDO Office Module Monitoring: Module for comparison of measurements from different epochs for monitoring tasks and control of tamping work.

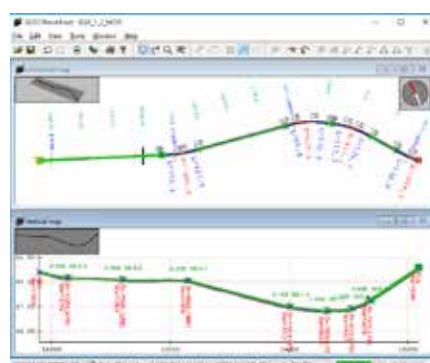
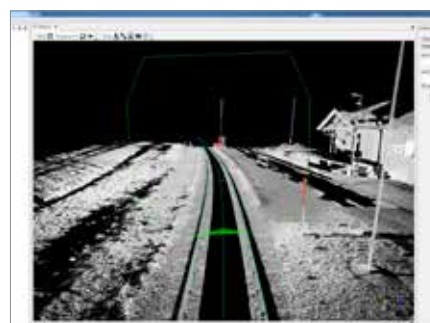
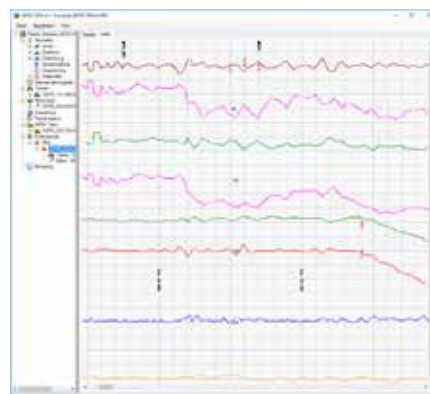
GEDO Scan Office: The GEDO Scan Pre-Processing module pre-processes GEDO Scan measurements. Purely relative measurements are then immediately available. Absolute measurements are available for analysis as 3D point cloud after synchronization with the track geometry.

The GEDO Scan Office Point Cloud module enables track-specific analysis of the point cloud. The distances of objects relative to the track position or between objects can be measured. The clearance can be checked with a static clearance envelope or on the basis of a 3D wagon model. The position of the adjacent track can be detected from the scan. Overhead lines are detected and the distances to the track position are calculated. Points can be taken directly from the point cloud and line objects can be registered automatically. Cross profiles generated along the tracks are further processed and vectorized in Trimble GEDO Scan Analysis. After automatic dimensioning, profiles can be exported into DXF files.

In addition to the data kinematically recorded with the Trimble GEDO Scan system, already pre-processed and synchronized terrestrial laser scanning data and point clouds from mobile mapping systems can also be imported and analyzed.

Additional modules (i.e. WinLUE, Clearroute, Banedanmark) allow the export of analysis results according to the requirements of the infrastructure operators for the respective clearance databases.

GEDO NovaTrack: For semi-automatic calculation of new alignments or new proposed track based on GEDO measurements.





Customized Solutions

Around the world, different construction methods require different track measurement approaches. In many areas, new approaches to increase quality and to reduce costs are being developed and tested. In addition to Trimble GEDO track measurement trolleys and software, Trimble is able to develop measurement solutions that are tailored to your construction needs. The Trimble GEDO staff of in-house development experts provide fast, flexible implementation for your needs.

TRIMBLE GEDO SPS SYSTEMS FOR SLAB ADJUSTMENT

GEDO SPS

Trimble GEDO SPS is a single-source system developed by our engineers with years of on-site experience. During slab adjustment, the GEDO SPS measuring bar communicates with a Trimble TSC3 Controller running GEDO SPS software. Results are displayed immediately in the field and the workers can make adjustments according to the measured information.

GEDO J-Slab

Developed to support Japanese slab track techniques, Trimble GEDO J-Slab is optimized to support larger ranges for side and height adjustment. You can use GEDO J-Slab for mounting Japanese slabs, and then use GEDO Track for fine adjustment of the rails.

GEDO Systems for Bögl Slab Track

Developed in cooperation with Max Bögl, the Bögl SPS and Bögl SSPS systems enable precise adjustment of the Bögl system of preassembled rail plates. The Trimble solution provides high inner accuracy and allows for fast construction progress. These specialized applications support the construction of slabs for high-speed switches.

GEDO Track Bar for Slab Systems

Electronic GEDO Track Bar adapted to the respective slab system for use with GEDO Track software to adjust the slabs. The precise adaptation to the support points of the slabs together with integrated sensors and a total station enable highly accurate slab positioning.

BÖGL SPS IN ACTION: NEW RAILWAY PROJECT EBENSFELD- ERFURT

The German based company MAX BÖGL uses the custom specific SPS and SSPS systems to adjust more than 10,000 standard, special, compensation, and turn-out slabs. Some of the major challenges to overcome for the 32,3 km project were the difficult site access and time constraints.



Trimble GEDO Track Bar

The electronic Trimble GEDO Track bar is an ideal solution for slab track measurements when the Trimble GEDO track measurement trolley is not suitable, or when you need to measure only a few locations on the track. It is easy to carry and place the bar where needed.

- ▶ Built-in gauge and cant sensors
- ▶ Bluetooth communications to Trimble field controllers
- ▶ Prism for total station based measurements
- ▶ Easy handling with low weight



Trimble Track Measuring Accessories

Railway survey work requires specialized equipment, tools and accessories. Some work can only be done with the right tools tailored to the job at hand. For other jobs having specialized tools will increase the productivity and accuracy of your results. Trimble offers a wide range of solutions to meet country specific as well as worldwide needs for railway survey work.



TRIMBLE GEDO SPS SYSTEM

The Trimble GEDO SPS system is a flexible measurement solution to adjust pre-fabricated slabs. The adjustment is done based on digital alignment data and precise reference points.

The system can be adapted to various slab types, workflows and construction methods where no rail is installed during adjustment.

All measurements are made by a Trimble total station in combination with additional sensors and special bars that are positioned on the slabs.

The Trimble GEDO SPS system provides precise correction values for height and side adjustment at all required locations on the slab. A simple and easy to use user interface enables construction workers to operate the system.

About Trimble

Founded in 1978, Trimble is a publicly traded company headquartered in Westminster (Colorado, USA). Trimble serves its customers with employees and distribution partners in more than 100 countries. The company's more than 1,800 patents provide the basis for the broadest portfolio of positioning solutions in the industry. Trimble's integrated solutions allow customers to collect, manage and analyze complex information faster and easier, making them more productive, efficient and profitable.

Trimble Railway solutions combine measurement with data management, communications and customized software to deliver accurate information with speed and reliability. Trimble solutions enable advanced process and workflow integration for a more streamlined operation. From feasibility studies through construction and operation, Trimble Railway solutions help keep your operation running smoothly and safely.

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