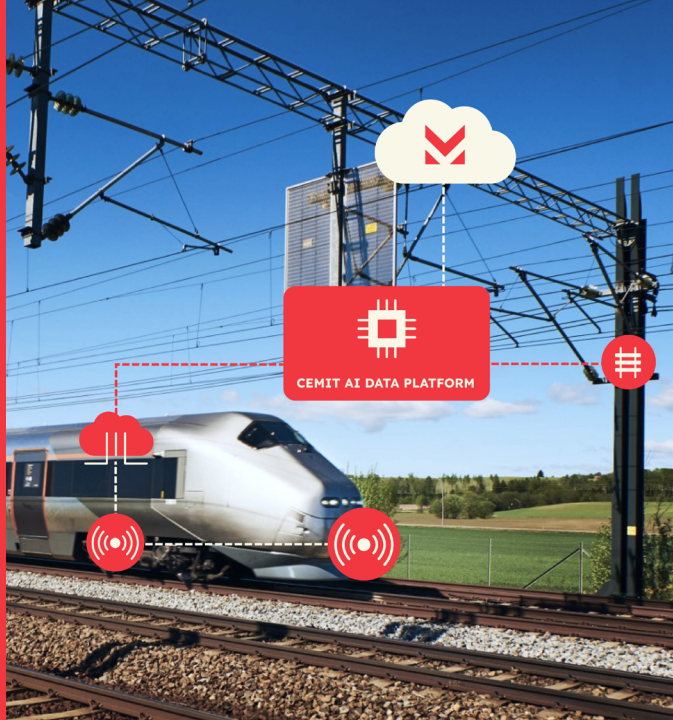
# The CEMIT low-cost, high data volume approach

How the **CEMIT AI Data platform** is transforming railway maintenance operations with data science

CEMIT



# Content

## What Is Condition-Based Maintenance?

Recent advances in sensor technology, wireless communication, data science and processing power are enabling a paradigm shift in monitoring and maintenance of physical assets, for instance manufacturing equipment or infrastructure: by deploying swarms of sensors, you can harvest data from the assets, process the data and thereby assess their current condition. This enables you to transform maintenance procedures, going from scheduled maintenance to condition-based maintenance. Performing maintenance based on the asset's actual condition, improves planning, performance, and uptime, saves money, and eliminates over-maintenance.

## What Is Predictive Maintenance?

Looking into the future, data-driven condition-based maintenance systems will gradually evolve into systems that are able to predict the long-term maintenance needs of assets. These predictive maintenance systems will harness vast amounts of data and highly accurate algorithms to forecast long in advance when a breakdown is going to happen and what the breakdown will be. They will deliver decision support for ultra-precise planning of maintenance procedures just-in-time and thus optimize maintenance even further.

# The Potential Of Condition-Based Maintenance In The Railway Sector

One of the biggest challenges facing the rail industry today is maintenance. Estimates put maintenance at over 50% of all operating costs in the sector. In Europe for instance, up to €100,000 is spent on each km of rail track per year, totalling as much as €23bn on maintenance alone (there are 230,000km of tracks within Europe).

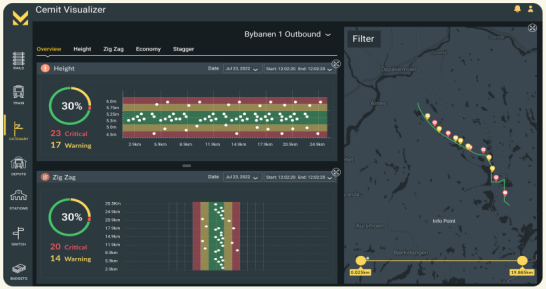
High costs are compounded by the reliance on a combination of scheduled and reactive maintenance, with little emphasis on condition-based and predictive maintenance. However, more efficient rail inspection and monitoring methods have a huge potential to reduce cost and increase reliability and uptime. The link between increased inspection frequency and fault detection has been proven in many academic studies. For example, increased track monitoring has been shown to directly correlate with a reduction in broken rail derailments, which account for over 70% of rail accidents.

To change the maintenance paradigm in the railway sector, we need data. We need large amounts of highly accurate, low-cost data measuring in near real-time the condition of both rolling stock and rail infrastructure. Then we need powerful algorithms to extract meaningful, reliable, and actionable information from the data. And last but not least, we need to present the data in ways that are tailored to fit the decision support needs of rail operators, infrastructure owners, and maintenance providers.

As data-driven condition-based maintenance systems evolve they will become increasingly able to predict future maintenance needs. More and more data from a rising number of different sources will be processed by complex algorithms and integrated into predictive maintenance systems that will be able to look into the future with great precision. These systems will be able to forecast equipment failure and thus further optimize resource planning and maintenance intervention.

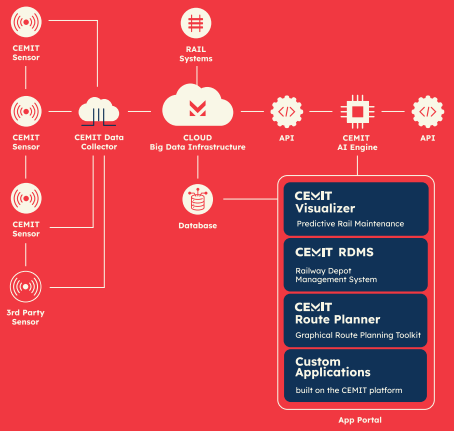
# The CEMIT AI Data Platform


Data from inertial measurement units, machine vision cameras, and other data sources are fed into the system.




The processed data is presented in the CEMIT Visualizer, a highly user-friendly tool designed to give railway infrastructure owners and maintenance providers an overview over the current condition of their assets.

# The CEMIT Low-Cost, High Data Volume Approach




Unlike other intelligent condition monitoring systems, CEMIT has chosen the concept of low-cost and high data volume. Our system can integrate various data sources. This could be open-source data, for instance weather data or other types of environmental data, and it could be siloed data held by the rail operators, for instance sensor data from on-board sensors in trains, or stationary sensors deployed across the rail infrastructure, or information about how much load each train is carrying.

Furthermore, CEMIT has developed its own sensor package for retrofitting. It consists of cost-effective sensing hardware containing commercial off the shelf technology. The sensors are non-intrusive and can be easily retrofitted to existing rolling stock, turning trains into “drones”, continuously monitoring themselves and the track. With every train run, more data is added to the data pool. This high density of data points allows for root cause analysis.

Incoming data is validated, filtered, and prepared for processing. The CEMIT AI Engine then crunches the data, looking for anomalies, allowing CEMIT’s scientists and engineers to pinpoint discrepancies and exact error locations. The CEMIT digital twin system is built from these data sets and can estimate a highly accurate track state in the present. Moreover, it has the potential to make highly probable predictions of the future development of the same tracks.

# Applications

**There are 4 main product lines within CEMITs Product Portfolio:**

## Train Condition Monitoring

Train Condition Monitoring is of great interest to Train Operators for many reasons, particularly metrics such as passenger comfort indication and wear and tear estimation. The train condition is estimated using IMU data collected by an onboard sensor. This data is then run through data analysis algorithms developed in-house to monitor the train condition. Both time and frequency domain analysis is used to extract maximum meaning from the data. Also of particular interest is the comparison of this data, both in terms of comparing datasets from multiple runs of the same train, or multiple trains over the same area of track. This gives the customer a valuable tool in root cause analysis of train condition discrepancies.

## Infrastructure Condition Monitoring

Infrastructure Condition Monitoring focuses upon the needs of the infrastructure operators and owners. There are several key features in this product line, providing condition monitoring of the rails, catenary and switches. This approach uses a range of sensors and analysis techniques which contribute to a holistic view of the railway infrastructure:

- **Switch Condition.** The currents of the point machines are measured and compared against tolerance limits and displayed in the CEMIT Visualizer interface.
- **Catenary.** The catenary's height and zigzag pattern is analyzed using mounted cameras from the front of the train. Image analysis and machine learning algorithms are utilized to compare the measured and expected data. This insight is then presented to the customer in the CEMIT Visualizer, in an intuitive and user-friendly format.
- **Rails.** The railway tracks are a key part of the railway infrastructure. There are several aspects to measure using different techniques and analysis. The superelevation of the tracks can be estimated using data collected by the on-board sensors and algorithms developed by the team in-house. This can then be compared to the track schematics provided by the infrastructure owner and deviations highlighted. This is hugely valuable information as there are strict tolerances on these values. The track width deviation can also be estimated using on-board cameras, image analysis and machine learning algorithms. This is of interest to both the infrastructure and train operators as this is a factor which can contribute to the wear and tear of the trains.

## Graphical Route Planning System

This system enables railway operators to digitally view and edit their route planning diagrams, which has historically been done using pen and paper.

## Depot Management Solution

This system is focused on Depot Owners and allows Depot Managers to have real time visibility on the usage of their depots. CEMIT installs cameras alongside the depot track, and uses image recognition and machine learning algorithms developed in-house to identify which trains have used certain tracks at the depot. This solution is particularly useful to ensure continuous automated monitoring of depot usage.

# Technology And Development Focus

In addition to its 4 main product lines, CEMIT is working on developing new technologies and solutions leveraging low cost and high data volume, together with advanced sensor systems and algorithmics. The focus areas are:

### Multi-sensor measurement of track geometry

When a railway track is constructed, its geometry is measured, showing the exact position of the tracks, the distance between the rails, the difference in height between the outer and the inner rail on a curve (super-elevation) etc. CEMIT can import these original Elevation Schematics into its mathematical modelling algorithms to build an exact digital environment of the track, forming the basis of a Digital Twin. This Digital Twin can then be held up against continuous measurements provided by sensors onboard trains. In this way we can document deviations from the original design, caused by wear and tear, weather etc. providing a continuous image of the As Is condition of the track.

Measurements are carried out by an IMU sensor onboard the train, with each sensor containing a triaxial accelerometer, a triaxial gyroscope and GPS antennas. With every train run, the IMU sensor measures the track's geometric parameters across different track conditions, including straight and curved sections. Sensor data is run through the CEMIT AI engine to build a digital twin with three-dimensional track geometry. In this way the CEMIT Digital Twin technology establishes a high-precision baseline to complement the original Elevation Schematics.

### Computer vision

Computer vision and image recognition can be utilized in several ways, in combination with CEMIT algorithms:

- Cameras installed on trains can record the status and condition of rails, masts, catenary, pantograph and other maintenance objects in the rail environment. For instance, advanced stereo vision can measure track width and reveal anomalies such as buckling.
- For increased safety and collision prevention, on-board cameras can detect intrusions into the free-room profile of a train, such as cars, persons, animals, or other trains.
- Stationary cameras can keep track of rolling stock entering and leaving a depot, recording stay-time, type of traffic, any stock re-arrangements and weather conditions.

### Acoustic Chemometrics

It is possible to use accelerometer sensors to analyze the acoustics of the rolling stock as well the infrastructure, rails, sleepers, attachment devices etc. Vibrational data can be converted into sinus curves, which are mapped into sonograms. These are 3D maps of a complete sonic picture which allows looking for anomalies that can indicate deviations from the normal. This method has the potential to replace traditional temperature sensors by converting vibrations to temperature. This allows the train operator company to guide the train drivers in how to operate trains smoother by allowing better planning for acceleration and deceleration, thus avoiding super hardening from spinning or blocking wheels.

### Predictive Maintenance

CEMIT is developing methods for using sensor input to not only document the current state of train tracks, wheels etc. but also to estimate their future state. By processing long-term sensor data, the CEMIT algorithms have the potential to build trends and make predictions, which can be fed into asset management systems, making them increasingly predictive. Based on input from the CEMIT algorithms, the systems would then be able to send alerts to maintenance teams before a fault will hit a critical level, so that maintenance can be planned accordingly. Making maintenance increasingly predictive instead of time-based, will optimize maintenance operations, reduce cost, and increase safety and efficiency.

# About CEMIT

The word CEMIT comes from the Latin word “semita,” meaning track or path. Reflecting both our strong background in the rail industry and our goal to lead the way into the future of rail technology, CEMIT is a name with purpose, representing who we are today and where we want to go tomorrow.

As rail infrastructure investment and the railway maintenance machinery market continues to increase globally, there is significant demand for a breakthrough intelligent monitoring solution – one that is low-cost, can detect a wide range of faults before they become serious, and display alerts/information in real time in an intuitive and decision-supporting way.

This is exactly what the CEMIT team of engineers, data scientists and railway experts is working towards. CEMIT technology represents an innovative, cost-effective rail infrastructure intelligent monitoring platform that has great potential to reduce failure rates and improve operational efficiency. The sensor data, gathered during normal operational hours, is analyzed using advanced intelligent algorithms in order to identify anomalies and accurately monitor when maintenance is required.

Our rail solutions ultimately harness the power of IoT and machine learning by using low-cost sensor modules and data streams, all brought together and stored on sophisticated cloud-based platforms.

At our core sits a dedication to improving system development for operations and maintenance within critical rail infrastructure. Key drivers include technologies that utilize the power of big data, digitization, and sustainability - each ensuring longevity and compliance within the industry.

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