

Transforming Railroad Asset Management: Going Smart with Predictive Maintenance

Abstract

As one of the most asset-intensive industries in the world, the rail industry invests nearly 20% of its revenue in asset maintenance to ensure safe operations. What's more, significant challenges such as spiraling maintenance costs, narrow maintenance windows, non-availability of talent for remote condition monitoring, and heightened customer expectations, plague the industry. Railroad companies are therefore moving from the traditional scheduled maintenance strategies to asset condition based predictive maintenance to enhance utilization, reduce costs and safeguard the durability of their railway networks.

Predictive maintenance involves the deployment of sensor-based diagnostic monitoring in real-time for assets and sub-systems that provide enough time to act - based on the recorded condition parameters.

The paper discusses how railroad companies can use next-gen digital technologies such as remote sensors, edge computing, IoT platforms and Big Data analytics to formulate predictive maintenance strategies. It also highlights the impact of such strategies in driving significant improvements in reliability, asset availability, cost efficiency, and customer satisfaction.

Why the Rail Industry is Moving to a Predictive Maintenance Paradigm

In this industry, equipment failures can result in fatal consequences; unplanned outages and unreliable operations can severely impact revenues as well as customer satisfaction and safety. Time-based traditional maintenance strategies fail to capture the exact state of an asset, and lead to unnecessary maintenance and high operating costs. Little wonder predictive maintenance is a hot button issue in the rail industry today. The approach allows users to continuously monitor assets, proactively identify probable defects, and initiate necessary maintenance work before an asset fails, enhancing system availability and reducing maintenance costs.

Sensors placed along railway tracks or mounted onboard rolling stock help railway companies remotely capture critical parameters associated with rolling stock as well as fixed infrastructure - in real time. Along with asset related data, other data like weather and geographical conditions can also be captured to enable superior asset management. The data captured across the network of sensors is fed into predictive model, enabling proactive maintenance operations to eliminate unplanned downtime of assets.

The benefits do not end there. Accurate forecasting of spare parts requirement through predictive analytics helps cut down on their procurement and shipping costs. Accurate insights into manpower requirements also help drive precise maintenance crew scheduling. Predictive maintenance solutions also play a critical part in supplier contract negotiations. They provide relevant data such as warranty information, supplier details, traceability and demand forecasting, to help railway companies negotiate the best price, including terms and conditions for the new contract.

Four Key Ingredients of a Successful Predictive Maintenance Strategy

So how can railroad companies develop a successful predictive maintenance strategy? Focusing on the following four areas is critical:

- **Identify data needs:** Most current systems in rail organizations are incapable of meeting the data requirements needed for predictive maintenance. One of the first steps is to obtain the data required for the solution

development process using a top down approach. Clearly defining the business objectives allows solution developers to drill down and pinpoint the required data.

- **Define the right system requirements:** This is the most crucial step in developing a predictive maintenance solution. It is important to define scope of the solution, and identify business critical needs and parameters for prediction. A wrong system can lead to unsuccessful outcomes and limit user confidence.
- **Blend data analytics with domain expertise:** While data scientists help develop predictive algorithms, rail domain expertise is essential to guide data scientists in building the right algorithm aligned with specific business needs.
- **Create an environment for value-addition:** The scope of a predictive management solution goes beyond predicting failures to predicting several business scenarios, deploying suitable prescriptive actions and improving maintenance related performance indicators. These include suggesting the next maintenance activity, just-in-time inventory planning for replacement of parts, identifying systems that need an upgrade in their design due to their continued poor performance, and so on.

The Role of Digital Technologies in developing Smart Maintenance Strategies

It's clear that adopting relevant emerging technologies such as sensors help achieve new levels of success and efficiency across the rail industry using predictive maintenance strategies. But with the sensor data volumes growing phenomenally over time, data management and analysis needs are growing. To turn this enormous data into actionable insights, major railroad companies are turning to cloud-based IoT and Big Data technologies. Big Data analytics can help connect the dots across the entire rail network such as rails, bridges, stations, and so on. It enables companies to develop predictive algorithms from heterogeneous data sources, real-time communications, and scalable data structures. The result: rapid insights from disparate sources of information to help improve asset availability and service levels, reduce service delays due to unplanned outages, and implement smarter maintenance strategies.

Understanding the Roadblocks

Despite the promise of predictive maintenance strategies, many rail organizations continue to delay investing in them. The reason: it is difficult to shift from traditional, scheduled maintenance to a predictive model in one leap. Nature of maintenance practices, resources, as well as geographic and weather conditions vary from region to region, as a result of which trains and networks are designed and developed to meet specific requirements – a major barrier to the adoption of predictive maintenance. Additional challenges include:

- **Developing confidence in the predictions:** Rail companies that are in the initial stages of IoT implementation are facing the challenge of 'false alarms'. To mitigate this, along with accurate predictive algorithms, it is necessary to incorporate noise correction methods.
- **Meeting regulatory compliance demands:** Safety is paramount to railway transportation, leading to regulatory constraints on the asset maintenance and certification procedures.
- **Developing the required tool kit and desired skill set:** Predictive maintenance requires the deployment of latest technologies, making it difficult to create large scale skill sets in new technologies within the organization. Similarly, it is also important to develop the necessary skills to understand the predictions and historical data and correlate the facts to drive accurate asset status, what-if analysis, and improved decisions.
- **Need for large capital outlays:** Railways typically deal with a large asset base that operates in harsh operational conditions. Migrating large scale operations from traditional to predictive maintenance demands huge investments in terms of time, money, and technology along with meticulous planning.

Deploying Next-gen IoT Platform-based Predictive Maintenance

A software that can predict failures and trigger maintenance workflows and interventions needs extensive access to high quality data from multiple sources such as diagnostic vans, way side sensors and so on (see Figure 1). To produce rapid ROI

while transforming the maintenance procedures completely, the solution must be truly flexible, scalable and integrated to meet dynamic requirements.

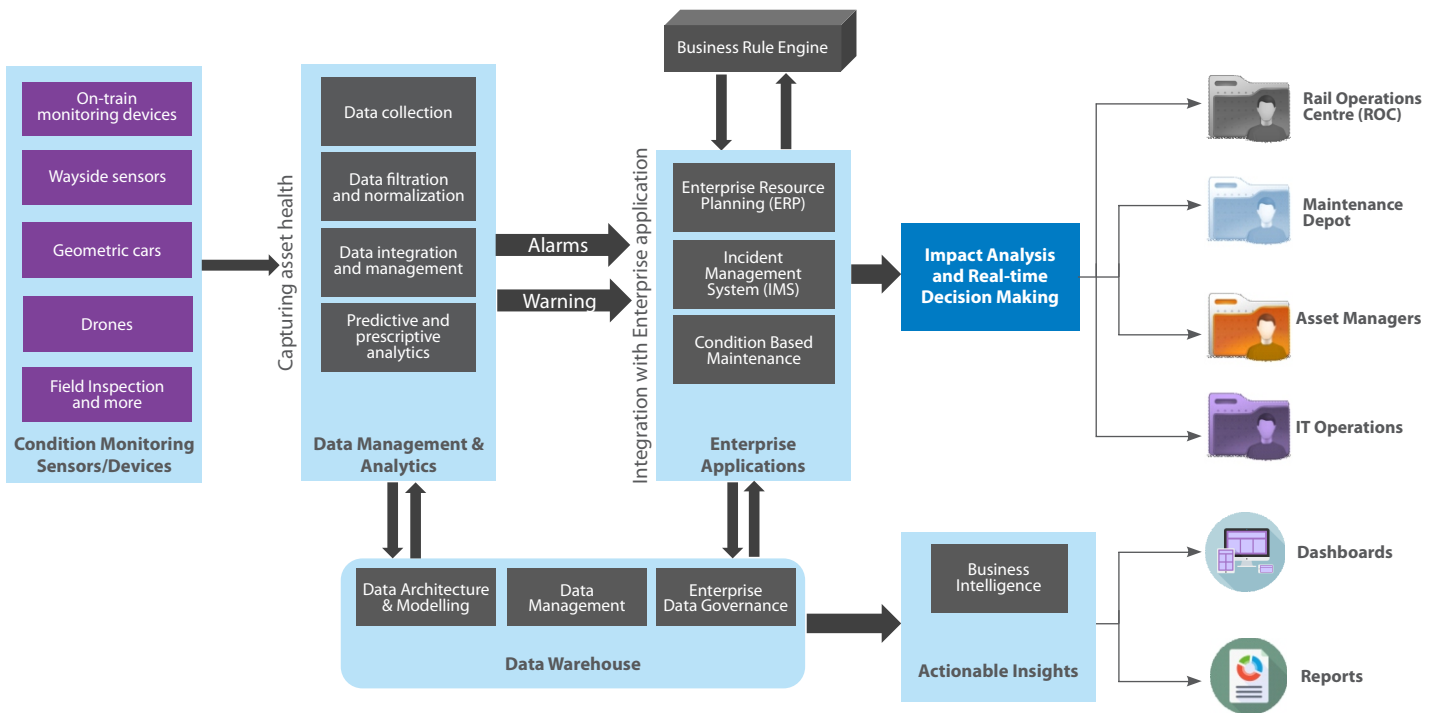


Figure 1: High-level View of IoT-based Predictive Maintenance Solution

We believe an IoT-based platform with the following capabilities is best-suited to monitor and analyze asset health data for railroad companies:

- Data capture and management:** The platform should host a diverse range of sensors to capture asset data from various condition monitoring devices- irrespective of the data format, data source, or the type of sensor. This raw data can be processed at the edge and stored in databases or file systems depending on the type.
- Analytics and business intelligence:** The platform should use the available sensor data along with other relevant data to develop meaningful insights using various analytics tools such as machine learning algorithms for anomaly detection, and real-time warnings, predictive asset health assessment, stream analytics and so on. With dashboards based on historic asset condition data and predictive analysis of sensor data, the platform will enable business intelligence and drive superior decision-making.
- Integration with enterprise applications:** The platform should seamlessly integrate with enterprise asset management (EAM), data warehouse, and other enterprise

IT systems using standard middleware platforms to create a unified view and trigger events and workflows for subsequent activities.

- **Cloud-enabled:** The platform should be deployed on the cloud to allow for scale and adjustments based on changing business requirements.

Rethinking Rail Asset Management

Today' rail customers demand flawless, reliable, and safe services. For railroad companies, catering to these growing expectations requires the deployment of next-gen digital technologies to redefine and re-imagining several organizational processes in addition to upskilling their workforce. The time is ripe for data analysts, computer professionals, and rail domain experts to work collaboratively to drive predictive monitoring strategies through digital technologies such as IoT, Big Data technologies, and sophisticated predictive analytics algorithms.

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