



CYIENT

ENGINEERING SOLUTIONS FOR PREDICTIVE MAINTENANCE IN RAIL

Success factors, first steps and lessons learned from other industries.

Introduction

Predictive maintenance (PM) is one of the most discussed and sought-after MRO (maintenance, repair & overhaul) strategies in the rail industry today.

As shown in Figure 1, PM is all about predicting the optimal maintenance timing. Looming faults are identified proactively and necessary maintenance work can be started in time before a fault occurs.

As such, it is the next stage in the classic preventive maintenance strategies, ranging from planned to condition-based maintenance. Availability of systems can be increased significantly while reducing maintenance costs if the maintenance needs of systems can be predicted, allowing necessary actions to be taken in time.

Recent advancements in sensors and communication technologies have led to continuous data collection from various systems and subsystems in trains, enabling monitoring of mechanical and electrical conditions, operational efficiency and multiple other performance indicators.

These new capabilities enable planning of maintenance activities with the maximum interval between repairs, while minimizing the number and cost of unscheduled outages created by system failures.

Normal mechanical failure modes degrade at a speed directly proportional to their severity. If the problem is detected early, major repairs can usually be prevented. Today's technology makes it possible to affordably collect huge amounts of data from hundreds of systems in a single train, analyse that data in real time and detect problems before they actually happen.

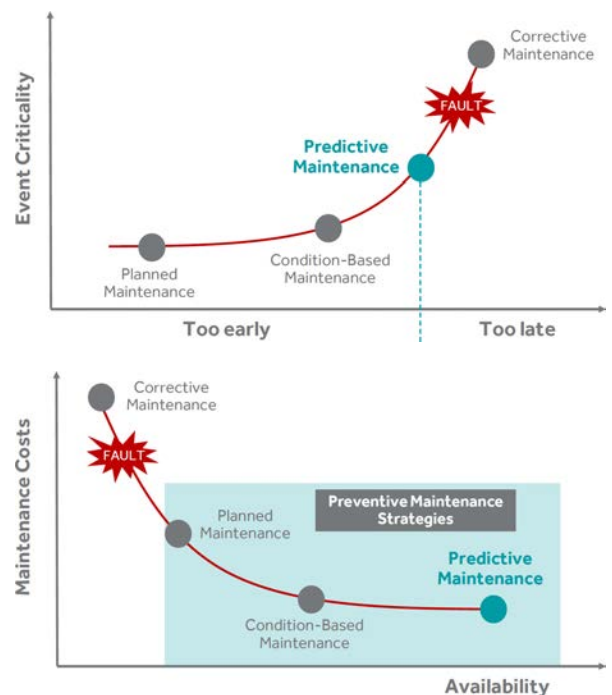


Figure 1: The optimal maintenance timing: higher availability and lower maintenance costs

Benefits of predictive maintenance

Key drivers of PM include availability and cost efficiency. It helps to improve reliability and further develop maintenance strategies by reducing maintenance costs. This enhances the overall effectiveness of transportation systems, ultimately leading to improved safety and higher customer satisfaction. Affordable PM solutions can generate ROI quickly while completely transforming the maintenance landscape. Computing systems are evolving rapidly to on-board intelligent systems for PM without taking data to any remote cloud. However, these technologies are new and, as such, immature within this sector. The rail industry has developed many asset management systems so far – but are they really predictive?

Success factors and methodology for predictive maintenance in rail

Lessons learned from other industries, especially from aerospace

Whereas PM is relatively new in the rail industry, it is already a mature and proven concept in other industries, such as aerospace. For example, PM of aircraft engines is very common.

With a wealth of experience in PM solutions, especially within the aerospace and heavy engineering market, Cyient has developed a robust methodology, which can be adapted to rail.

Cyient's methodology for successful PM solution development comprises four stages. Each stage successively ensures that prediction is possible and that it can be implemented in the given maintenance context.



Step 1: Choose the right system or subsystem for prediction

Selection of the system is the most critical step in building a PM solution. It is crucial to define a narrow scope and not try to predict everything. Brake systems and door pneumatics would be typical examples of such systems and subsystems.

Firstly, it is important to identify what is possible to predict. This is possible by mapping the available systems into a prediction possibility zone and a prediction effectiveness zone as shown in Figures 2 and 3. Inaccurate selection of a system can not only lead to failed outcome, but can also limit confidence in the PM solutions, leading the organization to dismiss such solutions even though there is a strong need.

Prediction possibility zone

The objective here is to predict the failure of the most critical systems. However, such systems run the risk of leaving very little data to build any consistent model. Conversely, there is limited value in predicting the failure of less relevant systems.

It is important to select those critical events that leave enough digital footprints required to build a consistent predictive model. So the prediction possibility and viability zone is somewhere in between those limits of frequency of occurrence and event criticality. As shown in Figure 2, an ideal system or subsystem has to be chosen for building the PM solution based on the prediction possibility zone. This approach helps to ensure the outcomes are realistic before deploying resources to the development activity.

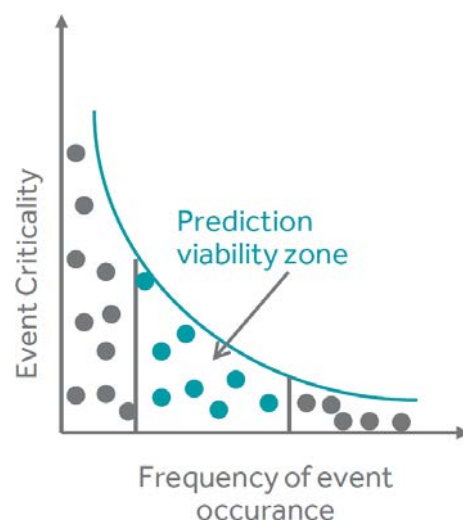


Figure 2: Prediction possibility zone

Step 2: Get the necessary data

Prediction effectiveness zone

Another way to look at system selection is by finding where prediction is more effective from a maintenance point of view. The failure rate of mechanical and electrical systems typically follows a bathtub curve as shown in Figure 3.

Bathtub curve: Hypothetical failure rate versus time

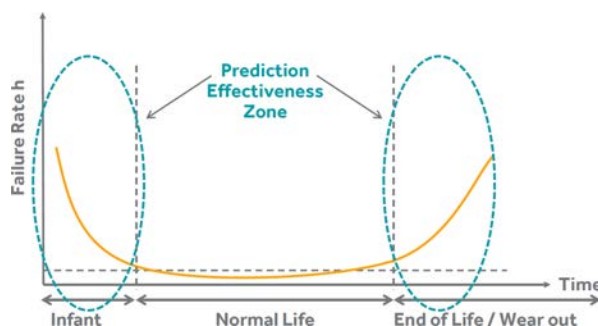


Figure 3: Prediction effectiveness zone

In order to realize quick ROI, either infant or end-of-life systems are more suitable for deploying PM solutions.

It is generally assumed that the sheer volume of data generated from systems is sufficient to build PM solutions from it. However, it is important to remember the objectives behind collecting each data set. They may have been deployed without any PM solution in mind.

As such, preparing the data required for building PM solutions is one of the key activities in the process of solution development. It is not always what organizations already have, but it's about what the solution needs. A fair understanding of the objectives is necessary to come up with the required data sets.

The bottom-up approach, by which data scientists explore the available data to come up with insights and possibly interesting patterns, is just a nice-to-have exercise, often meeting no business objectives. However, the top-down approach often leads to a successful outcome. This is where the business objectives are clearly defined first, then one drills down to identify the required data sets, and then the data is prepared in order to develop an algorithm.

Step 3: Marry rail expertise with data analytics

The right algorithm is the key to happiness

It is generally assumed that a data scientist is all that is needed to build a cutting-edge algorithm for a PM solution. A data scientist can develop any algorithm, but it takes a lot more to deliver the right algorithm for a specific business need. Experience shows it is the domain expert, as opposed to the data scientist, that is the real hero in achieving a successful solution. It's always the domain expert who guides the data scientist in building the right algorithm.



Step 4: Identify the value-add of PM for maintenance strategies

The scope of a PM solution can go beyond merely predicting a failure since in most business situations prediction is not the only objective. It's also about identifying various business scenarios and building appropriate prescriptive actions.

An effective PM solution drives maintenance performance indicators, and as such supports the maintenance teams in:

1. Identifying the next maintenance action,
2. Planning the just-in-time inventory for replacement of parts, subsystems or systems, and
3. Suggesting which systems need an upgrade in their design due to their continued poor performance.

This is possible by understanding the reasons behind various failure patterns and categorizing them into various action buckets. As such, PM solutions address both short-term and long-term objectives.

Summary

PM is the most discussed and sought-after MRO strategy in the rail industry today. It is all about predicting the optimal maintenance timing. Looming faults are proactively identified and necessary maintenance work can be started in time before a fault occurs. As such, it is the next stage in the classic preventive maintenance strategies.

Whereas PM is relatively new in the rail industry, it is already a mature and proven concept in other industries, especially aerospace.

With rail and aerospace as two of its core industries, Cyient has developed winning strategies and methodologies for the development of PM solutions. The success of a PM solution lies in selection of the right systems, creating and preparing the necessary data, and getting the right combination of rail industry experts and data scientists on board.

In addition, it is worthwhile to identify the value-add of PM for maintenance strategies to deliver beyond mere prediction of failures, e.g. to identify those systems that need design upgrades. Above all, besides increased availability and cost efficiency, commuters will appreciate fewer delays and increased safety, resulting in higher customer satisfaction.

Bibliography

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About Cyient

We create and deliver services that enhance your business agility. Our leading-edge solutions enable major organizations worldwide to achieve measurable and substantial benefits. Solutions include product development and life-cycle support, process and network engineering, plus data transformation and analytics.

We utilize a global delivery model. And we have more than 12,500 associates across 38 global locations, with delivery centers in North America, Europe, the Middle East and Asia Pacific. We are experts in the aerospace, consumer, energy, medical, oil and gas, mining, heavy equipment, semiconductor, rail transportation, communications and utilities industries.

This makes us your ideal partner. Whether you want to design innovative products faster, optimize R&D costs, improve time to market, enhance operational efficiency or maximize the return on investment in your networks, we help you make a difference to your customer. This might be a quieter flight, a longer-lasting toothbrush, more robust broadband connectivity, or more reliable GPS navigation.

We are proud of our robust internal processes. To ensure your IP security, solution quality and on-time delivery, we align with industry best practices and internationally renowned standards and frameworks. These include ISO 9001:2008, ISO 27001:2005 (information security), AS9100 C (aerospace), and ISO 13485 (medical devices). Cyient is a public limited company and listed on the NSE/BSE stock exchange.

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