TATA CONSULTANCY SERVICES

Building on belief

Using prescriptive maintenance to improve asset performance

Abstract

For manufacturing organizations across industries, maintenance can be a significant challenge in both performance of assets and effective use of maintenance resources and dollars. Historically, companies have relied on a preventative or time-based maintenance programs which can sub-optimize maintenance labor and parts while providing a less than desirable overall equipment effectiveness (OEE) value, specifically in terms of reliability or machine uptime.

With the advances in technology and capabilities we have seen with Industry 4.0, organizations can see dramatic improvements in OEE through the use of an IoT-enabled prescriptive maintenance solution. Prescriptive maintenance advances maintenance capabilities by collecting multiple points of data and using machine learning to constantly adjust and improve maintenance activities. The results of these programs include greater productivity, improved quality, an optimized use of maintenance resources, and most importantly, greater machine uptime.

In this paper, we detail the development of a prescriptive maintenance solution including the use of reliability-centered maintenance (RCM) and cloud analytics.

Today's manufacturers are exploring a multitude of internet of things (IoT) solutions as part of their Industry 4.0 initiatives to achieve critical business objectives and increase competitiveness and market share. These attempts are often driven by business cases centered on reducing costs, working capital, and improving cash flows. These needs are significantly more critical in the current economic climate. The reality is that most manufacturing companies are in the early stages of adopting digital technologies and lack the advanced manufacturing maturity needed to achieve such objectives. Moreover, companies lag further in evolving from preventative to prescriptive operational capabilities.

IoT enables significant breakthroughs in the areas of monitoring shop floor performance and asset reliability. What used to require specialized maintenance capabilities for complex tasks that were monitored based on a pre-determined time schedule has now evolved to constant streams of data that give us real-time insights into performance and alert us when maintenance action is necessary. This results in great value for the business. An IoT-enabled, prescriptive maintenance solution can increase asset uptime, improve operator productivity, and optimize both parts and resources utilized in the maintenance process. To capture these benefits, many manufacturers are focusing their efforts in the following areas:

- Reliability-centered maintenance (RCM)
- Overall equipment effectiveness (OEE)
- Cloud analytics

These initiatives provide manufacturers more data, visibility, and prescriptive insights into the state of their assets, allowing them to optimize maintenance scheduling and minimize the cost of planned and unplanned service time.

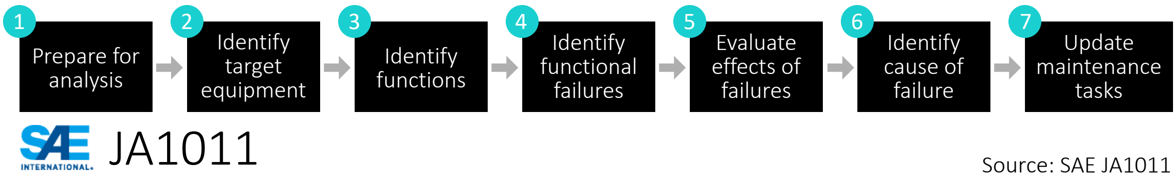
From preventative to predictive maintenance

Despite the growing awareness about the transformational role of IoT in manufacturing, most companies continue to rely on routine condition, or schedule-based, preventative maintenance as dictated by OEM recommendations and historical performance. While this has been standard procedure in the past, it does not allow companies to maximize the many benefits for the business. A prescriptive maintenance solution enabled by IoT will result in greater productivity and improved safety for the operator. Additionally, unplanned downtime and preventative maintenance activities that may not really be necessary can be reduced leading to greater machine uptime and higher OEE.

To make significant improvement and enable an IoT-prescriptive maintenance solution, the organization must utilize data science, which requires an investment and commitment to technology, and the organizational growth to effectively utilize it. Once initial implementation is complete, the maintenance organization will need multiple iterations of data collection to calibrate the model and ensure performance is in alignment with the targets set by the business. This is the key challenge in moving to an IoT-prescriptive model as results are impacted by the quality, consistency, and completeness of the data. The prescriptive model will allow the maintenance organization to focus on those maintenance tasks that are necessary to maintain equipment uptime and performance at a desired level. This effectively optimizes the use of resources (both labor and spares) and should help reduce overall maintenance costs (assuming equal desired levels of uptime).

The value of RCM

When initially implementing an IoT-prescriptive maintenance focused program, it is important to analyze and establish what needs to be measured and the acceptable range of values for optimal machine performance. One way to accelerate that process is through the use of RCM. Though historically used primarily in aerospace and utilities industries, RCM can be successfully applied to other industries as well. RCM is an intensive process, and we suggest using it on the most critical pieces of equipment as a starting point when developing your maintenance program. An effective RCM program is comprised of seven steps which are outlined below (see Figure 1).



Source: SAE JA1011

Figure 1: The seven stages of RCM

As shown above, RCM is a process that identifies critical equipment, potential equipment failures, causes of failures, mitigations of those failures, and ends with a clearly defined, comprehensive, and resource-efficient maintenance program for each asset. An optimum maintenance program is enabled including opportunities to reduce total costs while increasing asset performance and uptime.

The value of RCM, in combination with prescriptive maintenance, is that it allows the maintenance manager to identify the parts and components of critical assets that need to be monitored using IoT sensors, the number and types of failure modes per critical part or component, and the data and ranges to be collected. By doing so, manufacturers can accelerate and optimize the maintenance process by actively capturing data and measuring performance of those parts, components, and assets that are critical to the manufacturer's operations.

OEE as the leading practice

It is important to focus on the objective of applying data science to a manufacturer's maintenance capabilities. OEE can be used as the compass to measure how efficiently the manufacturing operation utilizes capacity and maximizes run time, or the percentage of manufacturing time that is truly productive. While effective maintenance is generally considered to be most impactful to the reliability component (uptime), an effective maintenance program also impacts labor productivity (rate loss) in terms of how quickly we can produce a part, as well as the quality of the part being manufactured. In summary, all components of OEE are impacted by maintenance programs and consideration should be given to which components need to be addressed when designing a maintenance program. (See Figure 2).

OEE =	Reliability ×	Productivity ×	Quality
Describe	• Critical equipment ID • Alerts on fault code frequency • Dashboard on MTBF, repair time, recurring repairs	• Alert on rate loss • Identification of bottle neck equipment • DCS Dashboard	• Alert on grade loss • LIMS dashboard
Diagnose	• Root cause analysis for downtime • Fault code pattern leading to breakdown • Anomaly in equipment channel patterns • Troubleshooting recommendations	• Trend analysis of rate loss • Correlation between product mix and rate loss • Process pattern leading to rate loss	• Trend analysis of grade loss • Process pattern leading to grade loss
Decide	• Predict potential breakdown estimation of time to fail • Maintenance schedule optimization	• Prediction of rate loss at given area	• Predict potential grade loss in key area

Figure 2: The components of OEE

OEE measures how reliable equipment is through the calculation of uptime, the productivity of equipment given the amount of time allocated for production, and finally, the level of quality of the parts being produced. We have seen OEE increases of up to 15% just by impacting the availability of the critical pieces of equipment.

Using cloud analytics

Cloud analytics is a key component of an IoT-enabled maintenance solution. The goal of using cloud analytics in this context is to enable ideation, development of solutions, and realization across maintenance operations. Utilizing the cloud in the development of a more comprehensive maintenance program consists of two phases:

Phase 1: Discovery phase

In the discovery phase, the objective is to develop a model capable of generating an efficient and effective list of parts and components that require maintenance service and associated performance values. Key activities in developing the model during this phase include:

- Analysis of historical data, including sensor data and maintenance records
- Understanding the variable and feature sections
- Developing the machine learning model
- Evaluating and validating the model, and sharing outcomes
- Reviewing outcomes with project stakeholders and obtaining approvals for implementation

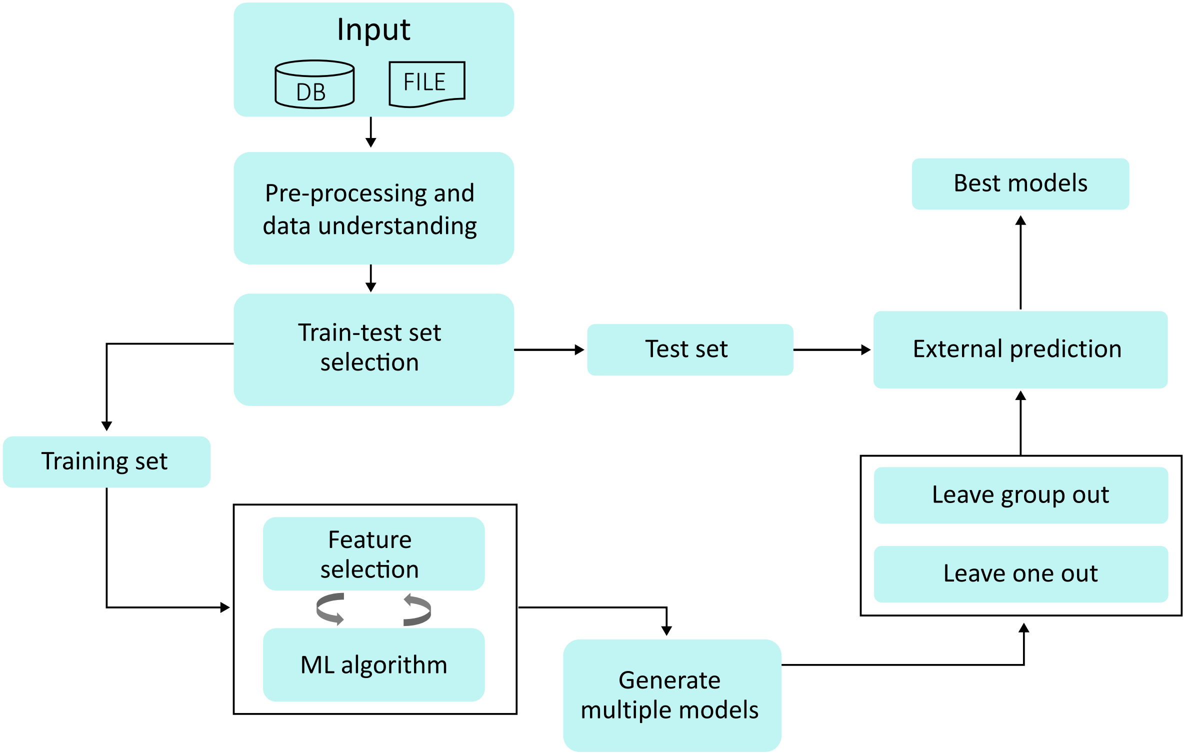


Figure 3: The discovery phase in using cloud analytics for predictive maintenance

Phase 2: Production deployment

Once the machine learning model has been completed, the focus shifts to building the technical framework using cloud services to ingest real-time sensor data and ERP maintenance data, along with building a visual prescriptive analytics dashboard.

Interpreting limited failure data

For certain applications, it is not enough to deduce predictions (the 'what'); rather, the model must also be able to explain how it arrived at those predictions (the 'how' and 'why'). Specifically, when we are working toward prescriptive maintenance applications, it is imperative for the model to pinpoint certain features or attributes as being responsible for failure prediction. Failure is defined as any negative impact on efficiency, quality, and availability. This helps the production or maintenance manager to take corrective action and solve the original problem, as well as prevent failures downstream.

Business, operational, and financial benefits

The successful implementation of a prescriptive maintenance program will yield benefits across multiple areas, including operational and financial efficiencies. Such a program would allow manufacturing organizations to:

- Optimize use of maintenance resources to do what's needed, when needed
- Increase machine uptime, leading to higher OEE
- Reduce the need for replacement equipment and ensure longer equipment life
- Reduce reliance on expensive spares inventory pool
- Reduce maintenance spend, resulting in increased earnings per share

- Build business and IT capabilities that are independent of an ERP upgrade or rollout
- Gain greater confidence in or calibration of the IoT data collection
- Customize data and reports

Benefit realization is greatly dependent on organizational process maturity, organizational change management, monitoring, and measurement capabilities. In conclusion, improved technology, augmented by low-cost IoT sensors and the ability to capture and analyze significant quantities of data, has allowed manufacturers to quickly accelerate their journey up the maintenance maturity curve and dramatically improve machine uptime.

In addition to the increased uptime and associated OEE improvements, manufacturers can optimize their maintenance plans to do what is needed and when it is needed, in the most cost-effective and efficient manner.

About the authors

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Chris has more than 25 years of experience in manufacturing and supply chain operations with an emphasis of asset maintenance performance. He has led several projects that focused on improving uptime of equipment, increasing OEE and reducing overall maintenance costs.

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