

***Enhancing Predictive Maintenance  
with IoT-powered Vibration Monitoring.***



***White paper.***

May 2023 Publication



## **Executive summary.**

Predictive maintenance is crucial for ensuring industrial equipment's efficiency. Yet, the success of predictive maintenance strategies largely depends on accurate data, smooth adoption, and, after all, a reliable solution that eases common challenges.

**How to enhance the effects of predictive maintenance efforts?** First and foremost, the Internet of Things (IoT) has significantly improved the capabilities of vibration monitoring systems, a core component of predictive maintenance. In its essence, vibration monitoring is an enabler – allowing for early detection of potential mechanical failures, wear, or misalignments by continuously measuring and analyzing vibrations in rotating equipment.

By utilizing advanced sensors, edge computing, and wireless communication, IoT-enabled monitoring systems can collect real-time data on equipment performance and transmit it to centralized platforms for further analysis. This data flow enables predictive maintenance strategies that empower operators to anticipate and address issues proactively, thus preventing costly unscheduled shutdowns and extending equipment lifecycles.

Another consideration when looking to enhance predictive maintenance is its adoption – namely, how to leverage the unique combination of vibration monitoring and IoT in the best possible way. The benefits are numerous: informed decision-making, optimized maintenance processes, and overall operational excellence.

In a nutshell, IoT-enabled vibration monitoring systems can greatly enhance predictive maintenance effectiveness. Nevertheless, it is equally important to identify a reliable solution that brings this approach's benefits to life.



***The evolution of maintenance.***

## Maintenance philosophies.

Vibration monitoring has become a key aspect of maintenance, especially when it comes to rotating equipment. But it hasn't always been the case. Maintenance philosophies have undergone significant evolution over the past fifty years, reflecting the changing needs and growing complexity of industrial systems. Following rapid development, innovative technology has opened new horizons for monitoring equipment's operating conditions to ensure effective maintenance.

**Run-to-failure.** Initially, maintenance practices were primarily reactive in nature, focusing on repairing equipment only after a failure occurred. This approach, known as "run-to-failure," prioritized short-term cost savings over long-term reliability.

However, as industries became more competitive and the importance of equipment availability and reliability grew, it became clear that a reactive approach was insufficient for maintaining modern industrial systems.

**Preventive maintenance.** The shift towards a more proactive maintenance philosophy began with the introduction of preventive maintenance. This strategy involves regularly scheduled inspections, lubrication, and component replacements based on predetermined intervals or equipment usage.



The goal of preventive maintenance is to identify and address potential issues before they escalate into catastrophic failures, thus reducing downtime and increasing overall equipment efficiency. However, preventive maintenance has its drawbacks, as it can lead to unnecessary maintenance on equipment that may not yet require servicing, resulting in wasted resources and increased costs.

**Predictive Maintenance.** In recent years, the focus has turned to predictive maintenance and condition-based maintenance, leveraging advancements in technology and data analytics to optimize maintenance activities further. Predictive maintenance and condition-based maintenance involve monitoring equipment conditions in real-time, using sensors, data analysis, and machine learning algorithms to identify anomalies, wear patterns, and other indicators of impending failure.

By making maintenance decisions based on the actual condition of equipment, industrial businesses can minimize unnecessary maintenance activities, reduce downtime, and extend equipment lifecycles.

The evolution towards data-driven, intelligent maintenance strategies reflects the growing importance of maximizing efficiency and operational excellence in today's competitive industrial landscape.

Condition-based technologies such as infrared thermography, acoustic monitoring, vibration analysis, and oil analysis are utilized by predictive maintenance. Preventive maintenance, for example, involves conducting maintenance on assets at fixed intervals, regardless of whether they require maintenance or not. Unlike preventive maintenance, predictive maintenance does not follow a fixed maintenance schedule.

**Prescriptive maintenance** is a maintenance strategy that uses IoT, machine learning, and artificial intelligence (AI) algorithms to monitor equipment conditions, analyze data, and recommend specific maintenance actions.

Prescriptive maintenance provides detailed recommendations based on the analyzed data, while considering the current environmental conditions, equipment performance history, and usage patterns. This approach aims to improve maintenance efficiency, reduce downtime, and extend equipment lifespan.



## **ROI of a strong predictive maintenance program.**

The total cost of ownership (TCO) – all the expenses associated with owning and operating a piece of equipment across its entire lifecycle – offers an accurate basis for determining the actual cost vs. return on investment (ROI) than the initial purchase price alone. And there is a good reason why – maintenance costs, besides operation and personnel, significantly impact TCO. That's why reducing downtime is critical when looking to optimize the total cost of ownership.

According to Control Engineering Journal, applying TCO strictly on CAPEX and OPEX fails to capture many of the benefits generated from enhancing the performance of an asset. In the evolution of maintenance, predictive maintenance has become essential for businesses looking to improve their bottom line.

A smart predictive maintenance implementation allows industrial businesses to make maintenance operations at the right time, not too early (thus wasting parts) or too late (missing root causes). A data-forward model of predictive maintenance enables a holistic overview of interconnected technologies and assets rather than a fragmented one where symptoms are repaired instead of addressing core problems.

A report by the US Department of Energy on “Achieving Operational Efficiency” has revealed that average ROI is up to 10 times higher in predictive versus preventive measures. Reduction in maintenance costs ranges at 25-30% higher. Elimination of breakdowns is especially impressive at 70-75% higher than preventive strategies.

### **Using vibration analysis in predictive maintenance.**

Much has been written about predictive maintenance techniques; coming to the practical side, vibration analysis offers an effective method for monitoring the health of rotating equipment. And here is why. Whenever a machine is in operation, it is natural that it produces vibrations. To measure these vibrations, an accelerometer is affixed to the machine, which creates an electrical signal proportional to the magnitude and frequency of the machine's vibrations. The frequency of vibration is typically recorded in hertz or cycles per minute, and this data can be used to analyze the machine's performance and identify potential issues.

Considering the scope of pressure points and torsional stress points involved at every connection of rotating equipment, it comes as little surprise that proper maintenance is a priority to keeping runtimes steady and uninterrupted. With high pressure and intense rotational power at the core of these technologies, stress points are focused on the seals, belts, brakes, and bearings that connect the moving parts of a rotating machinery asset.

In this setting, vibration analysis focuses on identifying the early warning signs of mechanical issues such as misalignments, unbalances, bearing defects, and gear faults. By continuously measuring and analyzing the vibration patterns produced by machinery during operation, this technique enables maintenance teams to detect anomalies and diagnose potential issues before they escalate into catastrophic failures or costly downtime. In fact, vibration analysis can provide actionable insights weeks or months before a failure occurs, allowing enough time for intervention.

There are other ways to predict a failure of stationary rotating equipment, such as using sound and temperature; however, these two methodologies narrow the window within which asset owners can undertake an action to prevent a failure from occurring.

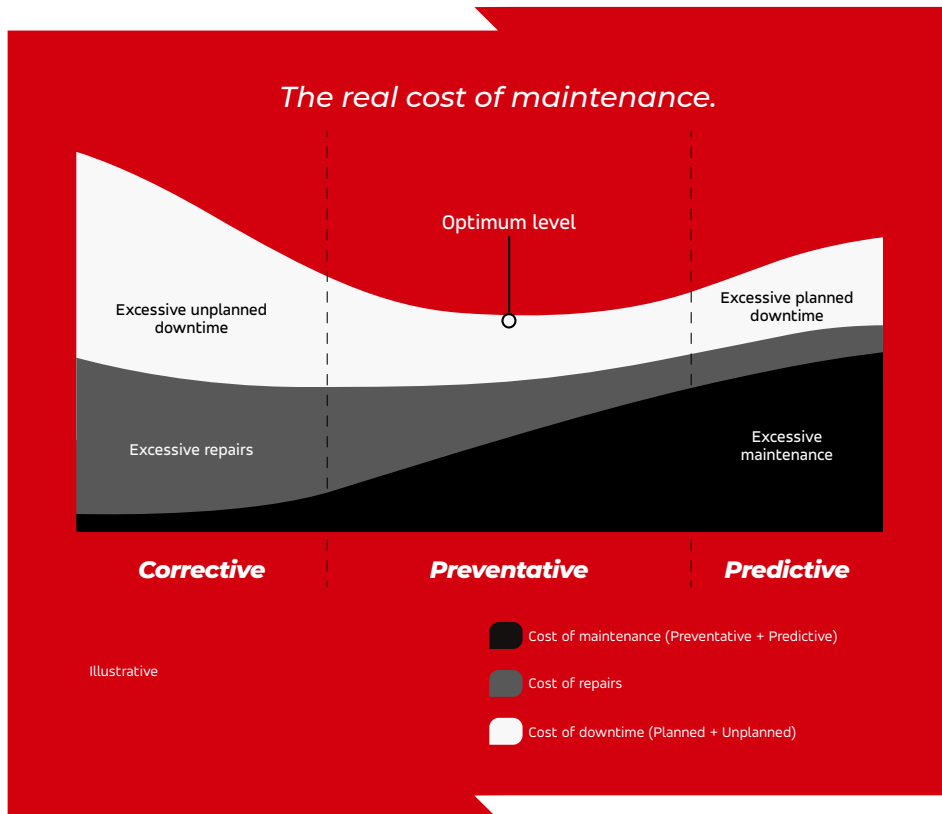
One of the main advantages of vibration analysis is its ability to provide real-time insights into equipment conditions. By employing advanced sensors and data acquisition systems, vibration data can be collected, processed, and analyzed rapidly, allowing maintenance teams to make informed decisions based on up-to-date information.

This continuous flow of data helps create a more accurate and dynamic picture of equipment health, enabling industrial businesses to optimize their maintenance strategies and allocate resources more efficiently.

What's more, vibration analysis contributes to the development of more sophisticated machine learning and AI models. With the vast amount of data generated through continuous monitoring, these models can be trained to recognize specific patterns associated with different types of faults. As a result, the accuracy of fault detection and diagnosis is significantly enhanced – leading to improved reliability and reduced instances of false alarms or missed issues.

**Using vibration analysis in predictive maintenance programs has proven to be a valuable tool for enhancing equipment reliability and operational efficiency. By providing real-time insights into machinery health and enabling early detection of potential issues, vibration analysis helps industrial companies minimize downtime, reduce maintenance costs, and extend the lifespan of their assets.**

As industrial sectors continue to adopt advanced analytics, the role of vibration analysis in predictive maintenance will remain a critical component of effective asset management strategies.



A close-up photograph of a gear train, showing multiple gears of different sizes meshed together. The image is heavily stylized with a red color overlay, giving it a high-contrast, industrial appearance. The gears are arranged in a complex, overlapping pattern, and the lighting highlights the metallic surfaces and the teeth of the gears.

## ***IoT-powered vibration monitoring of rotating equipment.***

According to scientific research conducted in 2019 by Malla and Panigrahi, vibration-based monitoring can detect 90% of machine faults or failures. This is possible since each system component has its own vibration signature related to the respective machine's operating conditions.

Naturally, rotating machinery is subject to wear and tear - its components can experience misalignment, imbalance, and bearing failure. Vibration monitoring helps identify these issues early on by continuously tracking the amplitude, frequency, and other characteristics of vibrations generated during equipment operation. Advanced technologies, such as the Industrial Internet of Things (IIoT) and machine learning algorithms, have significantly improved the capabilities of vibration monitoring systems.

### How to analyze vibration data of rotating equipment?

#### The Process:

**Data collection.** The first step is to gather vibration data using appropriate sensors mounted on the rotating equipment, such as accelerometers, velocity sensors, or displacement probes.

**Data acquisition and preprocessing.** Vibration data is recorded and processed using a data acquisition system (DAQ) or signal analyzer. Preprocessing may involve filtering the raw data to remove noise or irrelevant frequency components, amplifying the signal, or converting the data from the time domain to the frequency domain using a technique like Fast Fourier Transform (FFT).

**Frequency analysis.** Analyzing the frequency content of the vibration data is crucial for identifying specific issues within the rotating equipment. Common faults or problems, such as misalignments or bearing defects, exhibit characteristic frequency patterns that can be identified by examining the vibration spectrum.

**Time waveform analysis.** Examining the time-domain waveform of the vibration signal can provide valuable insights into the machinery's operating condition. Characteristics such as amplitude, shape, and repetitive patterns can help identify specific problems or confirm the findings from the frequency analysis.

**Trend analysis.** Monitoring and comparing vibration data trends over time can help detect gradual changes in equipment conditions, enabling early detection of potential issues.

**Advanced techniques.** In some cases, more advanced analytical methods may be necessary. These can include techniques like envelope analysis for detecting bearing defects or machine learning algorithms to enhance fault detection.

**Reporting and decision-making.** After analyzing the vibration data, the findings are usually documented and communicated to relevant stakeholders.

#### **What is the role of the wireless data core?**

This wireless data core allows for real-time monitoring and analysis of the equipment's performance without the need for physical connections or manual data collection. The wireless data core can be integrated into an IoT (Internet of Things) system, enabling remote monitoring, alerts, and maintenance scheduling for better overall asset management. It plays a vital role when it comes to IoT-powered vibration monitoring of rotating equipment.

#### **Why vibration sensors?**

Vibration sensors, also known as accelerometers or vibration transducers, are devices that measure vibrations and oscillations in various systems and structures. They play a crucial role in monitoring the health and performance of machinery, predicting failures, and ensuring the safety and efficiency of industrial processes. Modern sensors can collect vast amounts of data in real time, while powerful analytics tools can process and interpret this data to identify patterns and trends indicative of equipment health.

According to Fortune Business Insights, the global predictive maintenance market size was USD 2,387.6 million in 2018 is projected to reach USD 18,551.0 million by 2026, exhibiting a compound annual growth rate of 29.8% during the forecast period. It comes as no surprise that the vibration monitoring segment held the largest share in the global predictive maintenance market – reducing risk and uncertainty.

Ultimately, IoT-enabled vibration monitoring is a powerful tool for enhancing predictive maintenance and taking it to the next level. By leveraging IoT technology, industrial companies can continuously monitor their equipment and gain real-time insights into the performance of their machinery.

This allows for data-driven decision-making and optimizing maintenance schedules, increasing equipment lifespan, and reducing overall operating costs. With IoT-powered vibration monitoring, businesses can improve efficiency, increase safety, and ultimately enhance their bottom line.

## ***Unlocking predictive maintenance.***

Considering the aging maintenance workforce and the global economic uncertainty, digitalization and IoT-powered predictive maintenance provide a building block for resilience in the long run. Action is a huge differentiator for those industrial companies that want to future-proof their businesses.

Ultimately, it comes down to one question – how to offer better services, generate more revenue, and manage more assets by leveraging the power of an IoT-powered predictive maintenance approach?

We have already mentioned the importance of identifying a reliable predictive maintenance solution that brings all these benefits to life. All that is possible with SKYLER – an end-to-end, IoT-enabled Predictive Maintenance Solution that enables operators of rotating equipment to maximize equipment efficiencies and, therefore, optimize their total cost of ownership.

One of the respondents in a survey on Predictive Maintenance 4.0 conducted by Pricewaterhouse Coopers shared the biggest obstacle to overcome when adopting predictive maintenance strategies:



The first step is the most difficult one. Select a piece of equipment, choose an approach [...] just do something and get started! That has been the biggest hurdle for us. Once the first success stories start emerging, people become enthusiastic and things start to roll.



#### **Why is SKYLER a perfect fit for rotating equipment?**

Used across industries, rotating equipment is mission-critical in manufacturing. From compressors to pumps to motors, plant profitability revolves around equipment productivity. To ensure reliability, operators of rotating equipment seek to keep factors like alignment and balance at peak potential. While this legacy equipment is built to withstand considerable forces of pressure, constant stress on machinery components poses a constant threat of failure and downtime.

## How SKYLER works – functionality highlights.



### SKYLER Node & Bridge.

Tested, industry-grade hardware supported by deployment tool kit for easy field installations.



### Connectivity Package.

SIM Card and Data included allows the system to operate independently from the factory network.



### Expert Notes & Reports.

Expert notes and reports help streamline the communication with the End Users and build a historical asset's track record.



### SKYLER Analytics Engine.

Powerful analytic models proactively provide early alerts, health state classification, and detailed fault insights.



### Expert Tools.

Web-based Data Visualization and Analysis tools empower reliability experts to investigate assets remotely.



### White Label Dashboards.

The white labelled solution allows you to bring the predictive maintenance to the market under your own brand.



## Use case: SKYLER

Rotating equipment is a critical component of many industrial processes, and breakdowns can lead to costly downtime and lost productivity. However, with the advent of IoT-enabled predictive maintenance solutions, businesses can now monitor their rotating equipment in real-time and proactively address potential issues before they result in catastrophic failure. We will explore the benefits of SKYLER in a particular use case.

By utilizing predictive maintenance techniques, it is possible to extend the lifespan of industrial cooling towers beyond their typical life expectancy. Among the most common issues are the following:

- **Water Quality Issues**
- **Corrosion of internal structures**
- **Mechanical damage of moving parts**

Therefore, cooling towers' bearings may experience wear and tear over time and require maintenance or replacement to ensure proper functioning. SKYLER detected a Ball Pass Frequency Inner Race (BPFI) pattern, indicating a bearing degradation, which led to taking full control over the damage process and a deliberate decision to stop the equipment for bearing exchange. In the end, what was discovered was a bearing inner ring chipping and scorching marks indicating outer race looseness.



By proactively addressing issues before they escalate, industrial businesses can reduce unplanned downtime, extend the lifespan of their equipment, and avoid costly repairs. Additionally, this type of predictive maintenance approach can lead to better overall equipment performance, improved safety, and increased productivity. All that is needed is a reliable solution that complements the organizational and maintenance needs of industrial businesses.

# ***Predict a better future.***



**SKYLER**

*Beyond Predictive Maintenance*

***The most complete end-to-end solution for rotating equipment.***



**Easy.**



**Expert-Led.**



**End-to-End.**

Skyler is an end-to-end, IoT-enabled Predictive Maintenance Solution that enables OEMs & MROs to energize their service business by offering new service packages with unique warranties.

By empowering stronger customer relationships, Skyler enables the creation of stable & recurring revenue streams and maximizes equipment efficiencies. This is beyond predictive maintenance.

[www.relayr.io/skyler](http://www.relayr.io/skyler)



relayr.

[info@relayr.io](mailto:info@relayr.io)

[www.relayr.io](http://www.relayr.io)

A Munich Re company