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White Paper

How to Balance IIoT Systems with Existing Predictive Maintenance Programs

With hundreds or thousands of assets to track, how do modern predictive maintenance programmes implement IIoT condition monitoring systems with existing maintenance programmes and expertise?

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How to Balance IIoT with Existing Predictive Maintenance Programmes

Benefits of augmenting existing route-based monitoring programmes with IIoT sensors.

Condition monitoring based on industrial Internet of things (IIoT) networked sensors can greatly improve operational efficiency, increasing productivity and reducing catastrophic failures. Many maintenance departments would love to switch from route-based readings to IIoT condition monitoring. The problem is that most companies have hundreds, if not thousands of assets to track, far more than they could possibly afford to equip with IIoT sensors. How do they gain the benefits of IIoT condition monitoring without excessive capital outlay? The answer is by not replacing their existing route-based monitoring programmes but by augmenting them with strategically installed IIoT sensors. This hybrid approach places IIoT condition monitors where they provide the greatest increase in productivity while maintaining the benefits of existing route-based programmes and expertise.

Learn how the two approaches complement each other, techniques for succeeding with IIoT systems like online condition monitoring, and how to start a pilot programme that will demonstrate the benefits of the system to your organization.

Reviewing the technology

Unplanned downtime, particularly when caused by catastrophic failure of critical components, can be expensive. Lost production and spare parts are just the start. Depending on the asset, the entire production floor, and any production lines depending on these assets, may be halted as well. The location of the asset may require extra equipment such as cranes that can be expensive and difficult to acquire on short notice. Spare parts may require advance lead time or entail premium pricing for rapid delivery. Staff will be idled while production is held up.

Building an effective hybrid monitoring strategy to reduce unscheduled downtime begins with understanding the strengths and weaknesses of the two approaches.

Route-based monitoring requires minimal hardware investment and installation time. On the downside, it's labor-intensive and requires an ongoing programme to routinely take data. It is very cost effective to cover hundreds or thousands of points but the data it provides is sporadic. It can identify an existing defect, but that is no guarantee that additional issues won't arise immediately after the reading. Once a problem is identified, it requires more frequent data collection to continually monitor the asset. The safest way to truly avoid unplanned downtime or catastrophic failure is to replace the asset right away, which may be sooner than necessary.

The solution is continuous monitoring, but traditional systems typically require large upfront investments in infrastructure, software licenses and equipment such as local storage servers. Traditional systems also adjusting existing PLC architecture and maintaining software updates and licenses.

In contrast to both route-based and traditional continuous systems, IIoT-based condition monitoring provides what can be near-continuous 24/7-based monitoring with little upfront investment or software maintenance due to their cloud-based nature. IIoT systems can be accessed via web portal from any connected device by multiple users simultaneously and they are easy to install and maintain requiring wi-fi or cellular data access only. On the downside, some systems can be less cost effective to monitor hundreds or thousands of assets compared to route-base manually data collection. The solution is to maximize benefits by applying both techniques.

A hybrid strategy

A hybrid monitoring programme uses a combination of route-based monitoring to cover all assets within a facility while applying IIoT systems to priority groups of assets or assets that are identified as troubled during route. Let’s look at three case studies in which IIoT condition monitoring augmented an existing route-based programme to improve operations and/or increase capabilities.

Case Study #1: Running Troubled Asset to Next Scheduled Maintenance

Background: Paper manufacturing is a tightly synchronized process. Wood pulp enters the line from the head box as a process slurry and exits at the uptake roll as finished paper. In between, it passes through banks of high-speed rollers that squeeze out water, adjust thickness, and dry the paper, maintaining precise web tension all the while. Equipment failure in this type of system does more than just stop production. It disrupts the process, requiring time-consuming cleanup and restart. This downtime can cost as much as $10,000 per hour and stretch into days.

Problem: A developing bearing problem on a critical roller that fed paper stock into multiple converting lines was identified during route-based vibration monitoring (see figure 1). The line operated 24/7 and was not scheduled for downtime. A full bearing failure would result in massive unplanned downtime, but repairs would also cause the line to significantly miss production goals. The facility needed to continue operations while continually monitoring the bearing until scheduled maintenance occurred or until conditions required replacement.

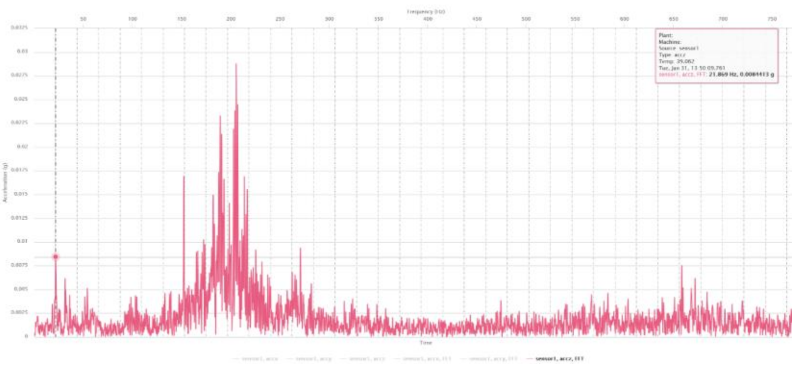


Figure 1: Plot of acceleration versus frequency exhibits sidebands around 150 Hz to 200 Hz, characteristic of bearing damage.

Solution: The reliability team installed an IIoT based condition monitoring system on the bearing in question and remotely monitored the health. They continued production with the troubled asset, relying on automatic data acquisition and cloud-based analysis to monitor the bearing and alert them of any sudden changes in condition.

Results: The IIoT system made it possible to confidently run the asset for three more weeks, until it could be replaced during routine maintenance (see figure 2). The facility avoided unplanned downtime while being assured of early warning of changing conditions that could lead to catastrophic failure.

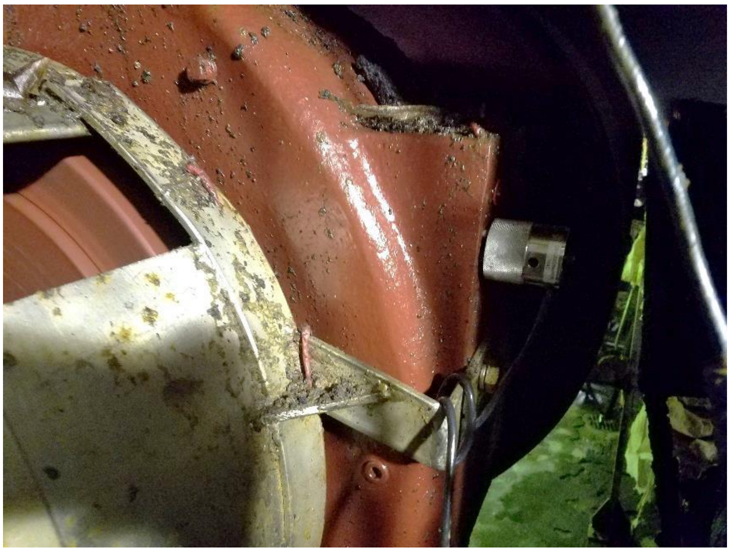


Figure 2: Picture of suction roll with IIoT sensor installed.

Case Study #2: Coverage of Multiple Locations

Background: Cement processing is a complex, multistep process. When a reliability expert was hired by a processor to raise uptime across five separate facilities, his challenge wasn't isolating issues but monitoring dozens of critical assets simultaneously. At least one of the assets, the kiln, can be damaged beyond repair within minutes of a bearing failure, and it's so expensive that rather than replacing it, a company might close the plant.

Problem: The five plants were located in five different states. The reliability expert previously used route-based monitoring to detect defects, but it wasn't practical for this client. Meanwhile, particularly in the case of the kiln, there was no margin for error, making the episodic nature of route-based monitoring problematic.

Solution: The reliability expert installed IIoT-based sensors on the five critical-path assets at each location for 24/7 monitoring. He also used route-based monitoring to identify additional troubled assets to monitor with a "roving" IIoT sensor unit. IIoT sensors were configured to send alerts any time the vibration spectrum exceeded specific conditions.

Results: Cloud-based IIoT-based sensors made it possible to monitor multiple assets across five facilities in different geographic locations. The expert had immediate access to both raw data and web-based analytic tools any time the system alerted him to problems. Early detection of issues significantly reduced downtime and, in particular, catastrophic failure, which also cut repair costs. In addition, the reduction in the need for on-site data acquisition left the technician with more time for serving other clients.

Case study #3: Maximize Lifetime of Troubled Asset

Background: The 100,000 sq-ft production facility for a food processor depended on a single rooftop blower. When it failed, production had to be halted at a cost of $10,000/hour.

Problem: Route-based monitoring identified a bearing defect. Because failure wasn't imminent, the manufacturer wanted continue production as long as possible. Unfortunately, the rooftop location made the blower hard to access for more frequent manual readings (see figure 3). The rooftop room housing the motors could be unbearably hot in summertime. In the winter, snow and ice made it actively dangerous.

Figure 3: Rooftop shed containing the motors for the rooftop blower was difficult and even potentially dangerous to access in extreme summer and winter conditions.

Solution: The reliability expert installed an IIoT sensor on the system, attaching one sensor each to the inboard and outboard sides of the motor and the fan. He set FFT bin alarms for 1x, 2x and 3x of the fan shaft speed. Monitoring continued while repairs were planned and parts ordered.

A little less than one month after the installation, RMS alarms were triggered. An email notification was sent to the customer and the reliability expert. A review of the time waveform and vibration frequency spectrum revealed the presence of multiple harmonics of 1x fan shaft speed (see figure 4). After consulting, the team decided to run production through the end of the shift. At that point, the bearing was replaced.

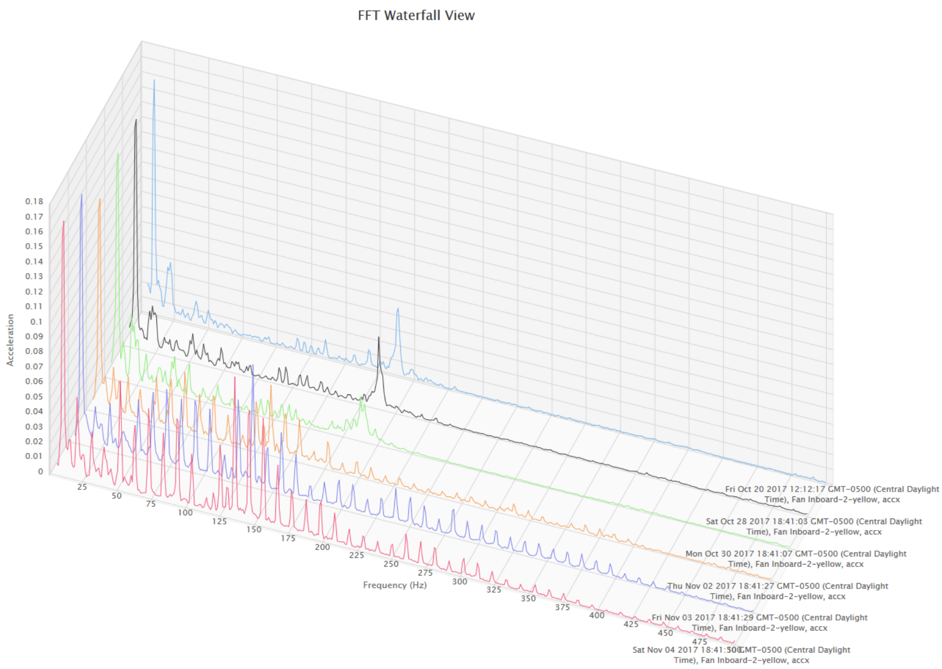


Figure 4: Waterfall plot of frequency spectra highlights the emergence of harmonics as the bearing defect worsens. Data is displayed chronologically from back to front.

Results: the IIoT sensor enabled production to continue with the troubled bearing for 53 days after discovery of the defect. The issue did not cause any unscheduled downtime and incurred no excessive charges for the repair.

Getting Started with IIoT Condition Monitoring

Although it can be tempting to install sensors on equipment across the plant, this can often result in a deluge of data that is rarely even viewed, let alone able to generate insights. The result is often an expensive effort that squanders money and staff hours, causes frustration, and generally fails to deliver the promised benefits. The best approach is to start with an audit to identify a group of assets or an asset class within your facility.

Assets with a history of failure
Assets that have failed previously, particularly if they have failed frequently, are excellent candidates for IIoT condition monitoring. These systems not only help prevent downtime, they generate data that could help identify root cause of failure. This opens the way to potentially modifying maintenance and operations to mitigate the problem.

Critical assets
Traditionally, online continuous monitoring systems were applied to expensive equipment such as hydroelectric or gas turbines. Motors costing a few thousand dollars each were not considered important enough to justify monitoring equipment. However, this approach does not consider the impact of downtime on production. Prioritizing assets based on their criticality to production instead of cost will help identify potential candidates for IIoT systems.

Troubled assets
Route-based monitoring can be used to identify troubled assets, but it's not necessarily effective for preventing unscheduled downtime. Once an issue has been identified, IIoT sensors can be installed to provide continuous readings. Triggers can be set generate alerts when units exceed certain conditions. The advance warning enables reliability services to monitor assets while continuing operations. When necessary, maintenance can be scheduled in advance to enable parts and equipment to be ordered in advance, and otherwise minimize the impact on production

Difficult-to-replace assets
Some assets require expensive equipment for the replacement process. A rooftop fan, for example, might require a hoist or crane that can be expensive to rent, time consuming to operate, and unavailable on short notice. Alternatively, a specialty motor with custom parts or certifications may entail a lead time of weeks or months, or involve a charge for express delivery. Receiving advance warning of issues makes it possible to schedule maintenance and minimize interruption.

Remote and hard-to-reach assets
Assets that are difficult to access are good candidates for IIoT condition monitoring. This may involve an asset in an inaccessible location, a confined space, or a hazardous environment. Overtaxed maintenance staff may avoid monitoring as a result. Hard-to-reach assets may also present a concern if the asset cannot be safely monitored while running.

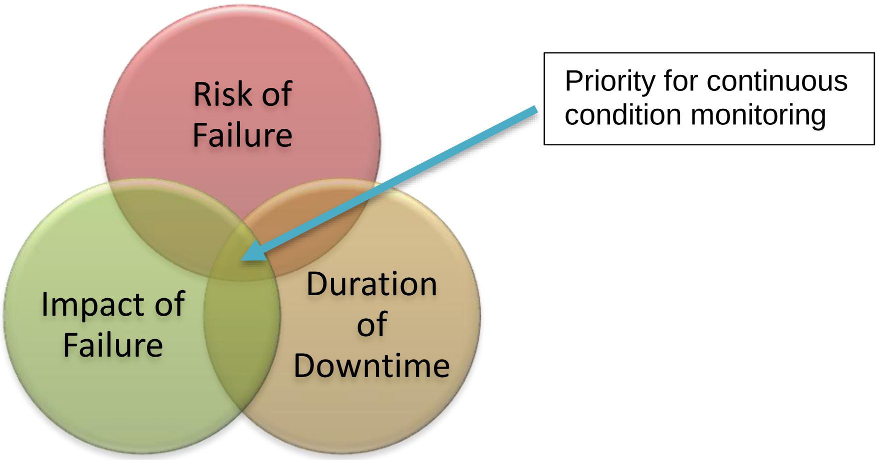
Setting Priorities

Even after auditing assets and grouping them into classes suitable for monitoring, programme managers are likely to find themselves with a long list of components but no clear idea how to start. The best approach is to conduct a pilot project based on assets likely to lead to success, justifying the investment and demonstrating the value of deploying IIoT based monitoring systems.

In order to develop a pilot project, the next step is to prioritize assets based on:

- Risk of Failure: Consider environment, regularity of maintenance and frequency of failure

- Impact of Failure: Consider how many cells/lines/facilities will be impacted and any further processes down the line
- Duration of Downtime: Consider if a replacement is available on site, lead time of parts and equipment needed for repair



The most effective choices for a pilot programme are those most likely to have problems over the project duration. Consider those least likely to be monitored effectively using route-based monitoring. In particular, focus on assets likely to fail rapidly once a defect emerges.

Asset Class	Risk of Failure	Impact of Failure	Duration of Downtime	Priority
Conveyor Motors	Medium – routinely lubricated but dirty environment	High	Low – easily replaced, spare motors on site	Medium
Boiler Feed Pumps	Low – routinely lubricated, well maintained	High	Low – backup system available	Low
Blower Motors	**High – located on roof, exposed to environment**	**High**	**High – no backup available**	**High**

Table 1: Example of prioritizing assets for remote monitoring

High on all factors, great candidate for pilot project

Low
Medium
High

A successful pilot programme requires effective remote monitoring system. When considering a pilot programme, where short term results are ideal, vibration analysis is arguably the most effective monitoring technology for rotating assets. Vibration data can be used to predict several failure modes in rotating assets including misalignment, looseness, bearing defects and more. One of the key benefits is that it lends itself to continuous monitoring by software. The vibration analyst establishes triggers and sets alerts for whenever a condition is violated.

An ideal IIoT sensor should be easy and fast to install so that it can be applied quickly to any troubled asset. Data capture using existing communications infrastructure will minimize the need for IT involvement in approvals. Systems should give access to raw data as well as comprehensive visualization and analysis tools such as time waveforms, vibration spectra (FFTs), waterfall plots, etc. The alarming system should provide options for customization and more sophisticated options like elimination of false positives.

Be sure that the system provides sufficient accuracy and resolution to identify the issues of interest. This is a particular concern for vibration-monitoring systems, which need to operate at high enough frequency to track the physical phenomena of interest. Input from multiple data sensor types such as vibration, temperature, real-time speed, etc. will provide a more complete picture of asset health (see figure 5). The system should be rugged enough to survive prolonged exposure to environmental conditions.

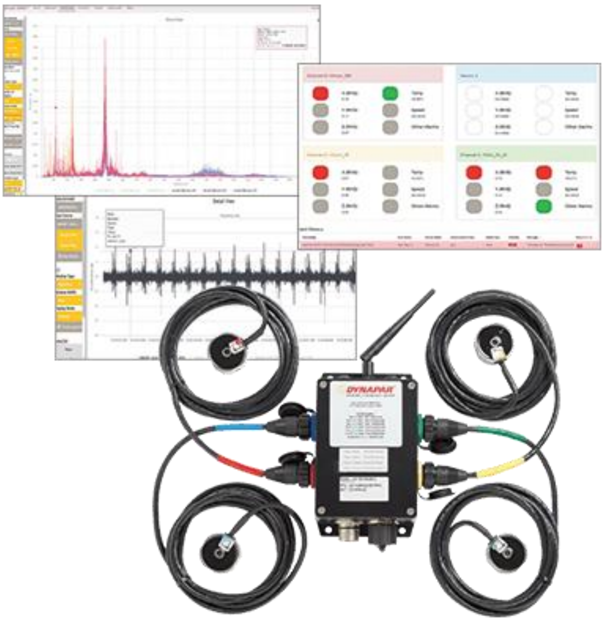


Figure 5: With the advent of the industrial internet of things (IIoT), devices that utilize cloud-storage and embedded computing have driven down the cost of continuous vibration monitoring. Some devices allow multiple sensor inputs, such as temperature and speed, to provide a more complete picture of asset health.

In addition to choosing appropriate assets and installing an optimal system, it’s important to follow best practices. Be sure to establish good baseline data at the start – condition monitoring needs data to define the performance of a healthy system. Acquire data at sufficient frequencies to reveal changes in asset health without filling up storage space with meaningless readings.

One of the major advantages to this type of pilot programme is that it can be used to demonstrate the value of the technology, making it possible to get management buy-in to invest in future systems. Have a quantitative goal you wish to achieve, such as reducing downtime by 20% make sure you define what performance will be considered successful. The small scale of a pilot project makes it easy to troubleshoot and optimize the process for future applications. Don’t aim to broadly deploy the technology in your plant overnight; instead, plan to start small and expand outward.

IIoT-based monitoring can augment existing route-based readings to improve productivity and decrease unscheduled downtime while minimizing cost investment. A comprehensive audit of assets, combined with troubled components identified using manual readings will help establish a pilot project to test out the technology. Demonstrating success with the pilot project will not only optimize output but also increase support for applying the technology elsewhere throughout the organization. Finally, the technology provides a method for reliability experts to spend more time keeping equipment running and less time traveling around and taking readings.

About the Author

Abhishek, a Mechanical Engineer, and Category II Vibration Analyst, certified by the Vibration Institute in Oak Brook, USA, has extensive experience in the design and development of heavy-duty industrial products including rotary encoders and vibration monitoring systems. Abhishek holds a master's in mechanical engineering from the University of Alabama in Huntsville, and currently pursuing his MBA from Wisconsin School of Business, Madison, USA. Prior to joining Dynapar, Abhishek worked at Caterpillar where he designed and developed common rail fuel injectors used in on- & off-highway trucks and power generators.

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