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a Baker Hughes business

# Making the case for plant-wide condition monitoring

## Lower costs, mitigate risk, and increase ROI using condition monitoring

Plant managers know that ensuring all plant assets remain healthy, online, and productive is priority #1. Historically, the only way to measure machines with certainty was to frequently conduct in-person monitoring of the health of every eligible machine in a plant—an endeavor that was nearly impossible and led to wasted travel time and resources. Until now. Plant-wide wireless capabilities can provide condition monitoring for every asset class within almost every industry setting. Bringing both protection and condition monitoring into a single system with one HMI (along with hosting and implementation) has truly brought condition monitoring into a new age.

Many maintenance and reliability professionals today have adopted modern online condition monitoring and protection technologies for highly critical turbomachinery assets. Proactive prediction of potential issues on these assets is smart and safe since they have significant impact on the health and safety of the facility. Simultaneously, auxiliary or plant-wide assets are traditionally checked via periodic walk-around monitoring, which is economical but infrequent. This leaves opportunities for improvement. Enter systems like System 1, which extends condition monitoring to every asset across the plant, from the most crucial to the machines that only receive periodic scheduled maintenance checks. The advent of wireless solutions continues to expand condition monitoring programs by complimenting wired and traditional walk around programs.

Maintenance budgets are typically allocated to the most critical equipment, rather than plant-wide counterparts, making adoption of new monitoring technologies inconsistent. This leaves potentially catastrophic gaps in monitoring, and piece-mealed maintenance methods that expose plants to significant financial and environmental risks. For example: a nuclear power plant going off the grid for a week could cost $13,860,000, a single stream mineral process stopped for a second results in a $3,200 loss, restarting a cement kiln could cost $75,000, and a boiler restart at a 650 MW power plant yields about a $300,000 loss and these numbers come from asset types often considered "non-critical". (A single cargo ship stuck dockside longer than scheduled costs up to $40,000 per hour)

Today, a single enterprise solution is available to monitor the health of our critical and supporting machinery alike. The "eagle-eye view" data collected from a plant-wide condition monitoring system empowers plant operators to make informed proactive decisions about individual machine maintenance, provides a holistic view of the health of their interconnected factory equipment, and helps to better predict potential downtime. It also improves overall plant ROI and decreases risk associated with reactive, outdated and spotty maintenance techniques.

Many software platforms have advanced analytic capabilities, but the interface and data are only understandable for data scientists. More modern systems, like System 1, have HMIs and work spaces that are easy to navigate for anyone in the plant. Even plant personnel who aren't advanced in diagnostics can keep an eye on how their plant-wide assets are performing using wireless technology and real-time data.

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# Current maintenance techniques leave risky monitoring gaps

Maintenance professionals hold tremendous responsibility. As the safeguards of plant equipment, they're caring for massive investments, preventing costly downtime, avoiding potentially catastrophic environmental hazards, and protecting the health and lives of countless individuals who work within plant walls.

Traditionally, maintenance and reliability professionals were forced to rely on costly and antiquated maintenance techniques that only provided a partial view of equipment health. 'Run-to-failure' maximized the useful life of any given part but risked catastrophic downtime and safety issues when the part failed. Time-based preventative maintenance proactively replaced parts before they failed, forcing the company to purchase potentially unnecessary parts for healthy machines. Furthermore, this strategy alone only accounts for 10 to 15% of the assets in a typical industrial facility.

With the introduction of proactive maintenance, the ability to use data to recognize when damage had occurred that would lead to machine failure was available for the first time, allowing treatment of a specific problem before it progressed. Due to the limitations of monitoring technology and budgetary constraints, predictive techniques have traditionally focused on monitoring highly critical machinery. Unfortunately, this narrow focus leaves acute vulnerabilities in overall maintenance strategy:

- **Blind spots:** Monitoring only critical machinery leaves massive gaps in proactive maintenance strategy
- **Narrow view:** Current condition monitoring techniques (Portables, Process monitoring and historian systems, Operator rounds, etc.) do not provide a holistic plant-wide view, or provide data infrequently, forcing maintenance teams to make decisions based on incomplete data
- **Simplification:** By utilizing a vendor who is able to supply all required hardware and software systems and services, you reduce the complexity and inefficiencies inherent with relying on multiple vendors

Additionally, many plant maintenance experts are approaching retirement and the next generation are not being trained to take their place. As machine complexity increases and expertise levels decline, the risks associated with continuing to utilize incomplete maintenance and reliability strategies becomes overwhelming:

- Machine failure and unexpected downtime
- Decreased ROI
- Creeping Costs (Direct and hidden – See below graphic)
- Inefficient spare parts management
- Human safety
- Environmental hazards.

## The "Iceberg" model

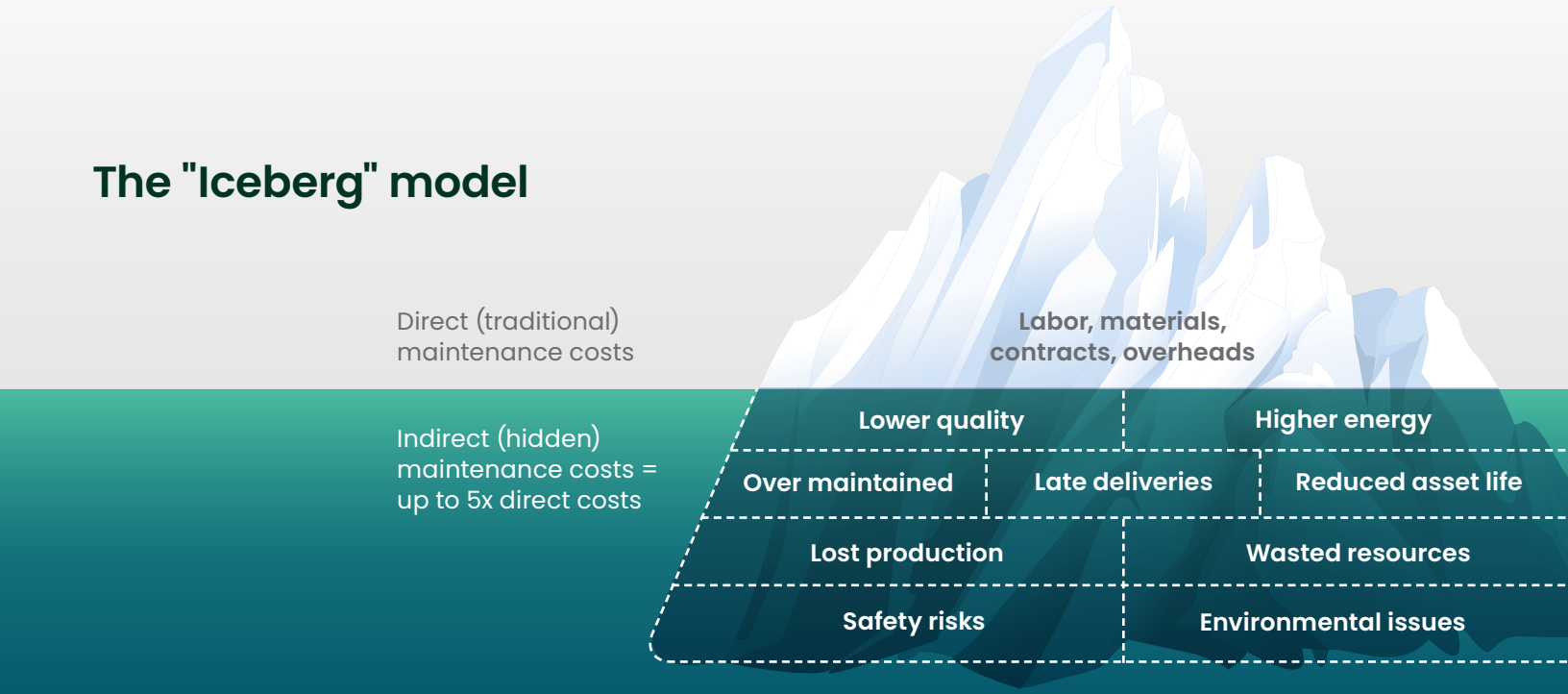


Figure: Total costs of maintenance – the "Iceberg" model (Wienker et al.,2016, p.414)

# The future of effective maintenance is plant-wide condition monitoring

## What is plant-wide condition monitoring?

Imagine a world where a reliability manager can monitor the health of nearly all plant machinery and make intelligent maintenance decisions based on real-time data. This scenario is today's reality. The next evolution in predictive maintenance strategy will be a transition to nimble and accurate real-time condition monitoring of an entire industrial facility. More than that, a robust condition monitoring system will have available hosting and alert systems that bring everything into a single view. Viewing and administrative access can be assigned appropriately,

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In addition to the most important assets found in industrial facilities, there are often a host of "supporting" assets that make up the balance of the plant such as pumps, motors, blowers, heat exchangers, fans, and others.

This auxiliary or plant-wide equipment may be spared or unspared, and its impact on the process stream may vary from minor to critical. Regardless, these machines can benefit from condition monitoring to help access the aforementioned "blind spots" created by outdated maintenance techniques.

Predictive plant-wide condition monitoring is the monitoring of all eligible machinery in an industrial plant. It requires the adoption of a unified system of monitoring hardware, software, and analysis system support. Within this unified system, the unique criticality and failure modes of each machine should dictate the appropriate monitoring hardware used on it; from portable data collectors to continuous and online.

## Proactive vs. reactive

Monitoring hardware and software solutions have made huge technological advances in recent years. Techniques that only a few years ago were only able to identify the fact that irreversible damage had started can now be used to identify root cause failure characteristics in progress and before the damage starts, truly enabling maintenance and reliability teams to be strategic and proactive rather than tactical and reactive for the first time.

## WirelessHART (wHART) technology for sensors

Advancements in sensor systems are improving the way industries communicate with the monitored assets around the clock. "Best-in-class



## Case Study: Preventing asset problems with wireless condition monitoring

**Situation:** Eldorado Brasil Celulose, the largest single-line kraft pulp operation in the world partnered with Bently Nevada to install Ranger Pro Wireless Sensors Systems on equipment not previously monitored via wireless sensors. The Ranger Pro system in conjunction with the System 1 software platform was able to identify a bearing failure on a bottom digester cooling booster pump motor. The motor presented an evolution in the PeakDemod (Peak) vibration levels, with symptoms of BPFI (Ball Pass Frequency Inner Race) failure in the bearing on the opposite side of the coupling (NDE).

The PeakDemod is an algorithm present in wireless Ranger Pro sensor that demodulates the high vibration frequency signals, allowing early identification of rolling element bearing failures.

**Action:** With the help of the data from Ranger Pro, the plant was able to track the evolution of the failure and establish operations actions to mitigate the effect of the failure until a scheduled maintenance could be scheduled on this production critical asset. After the scheduled motor maintenance, the bearing was analyzed by the Eldorado's team of bearing specialists, evidencing the failure in the bearing inner race.

**Results:** Because the plant was able to perform on-line tracking of the pending failure and implement mitigation actions until the day of scheduled maintenance, they avoided the need for emergency maintenance and the loss of about 2,740 tons of pulp production. Considering an average of $684.00 US Dollars per ton of pulp in January 2020, the saving was about $1,874,000 US Dollars.

wireless systems allow plant operators to select from either WirelessHART or ISA100 communication protocols depending on which is used in their facilities. While this sensor network technology has been around for more than a decade, it has become more relevant as it aids modern wireless systems in ways that mitigate risks for all assets, not just critical ones.

### Industry 4.0 and the future of data-powered maintenance

Since the Industrial Revolution, the manufacturing industries have seen three major technological advances: steam engine-powered factories in the nineteenth century, mass production powered by electrification in the twentieth century and automated machinery in the 1970's.

We are now entering the fourth phase of technological advancement, known as Industry 4.0. During this phase, we will see the rise of manufacturing processes that are digitally connected along the entire value chain via smart machines, remote sensor monitoring, and IT systems.

A connected and fully-integrated plant-wide condition monitoring system offers a holistic view of the entire plant, enabling powerful predictive analytics. The unparalleled amount of data collected by such a system empowers reliability managers and proactive maintenance teams to make smarter decisions. Collecting data before a failure occurs allows for better monitoring to detect failures and analysis of what went wrong to avoid future outages—administrators can't easily recreate uncollected data later.

That same connected system also offers decision makers the opportunity to quickly assess the health and operability of every individual plant in their portfolio. This eagle-eye view

**"You cannot recreate uncollected data after failure unless you monitor before failure occurs."**

of plant operation will be an essential prerequisite for the larger organization's transition to Industry 4.0. A system that can also host the software frees up even more resources for plant employees' time, energy, and bottom-line concerns. Any point in the supply chain can have a failure that leads to catastrophic loss, making a truly holistic monitoring system is the only way forward.


## Case Study: Engineers to monitor and diagnose faults on hard-to-access seawater pumps

**Situation:** The shipping department of one of the world's largest energy companies was looking for an accurate way to monitor hard-to-access equipment as the next step in the expansion of their shipboard condition monitoring program. They chose to do a trial of Bently Nevada **AnomAlert** condition monitoring system, installing it on two seawater pumps aboard a Liquefied Natural Gas (LNG) carrier.

**Action:** The two motor-driven seawater pumps that were selected for monitoring were vertical, double-suction centrifugal pumps in the Main Cooling system. After installation, initial assessments with early reports indicated that both monitored seawater pumps were experiencing rubs, misalignment, a vane pass anomaly, and a reduction in pumping efficiency that suggested that early misalignment had contributed to impeller damage.

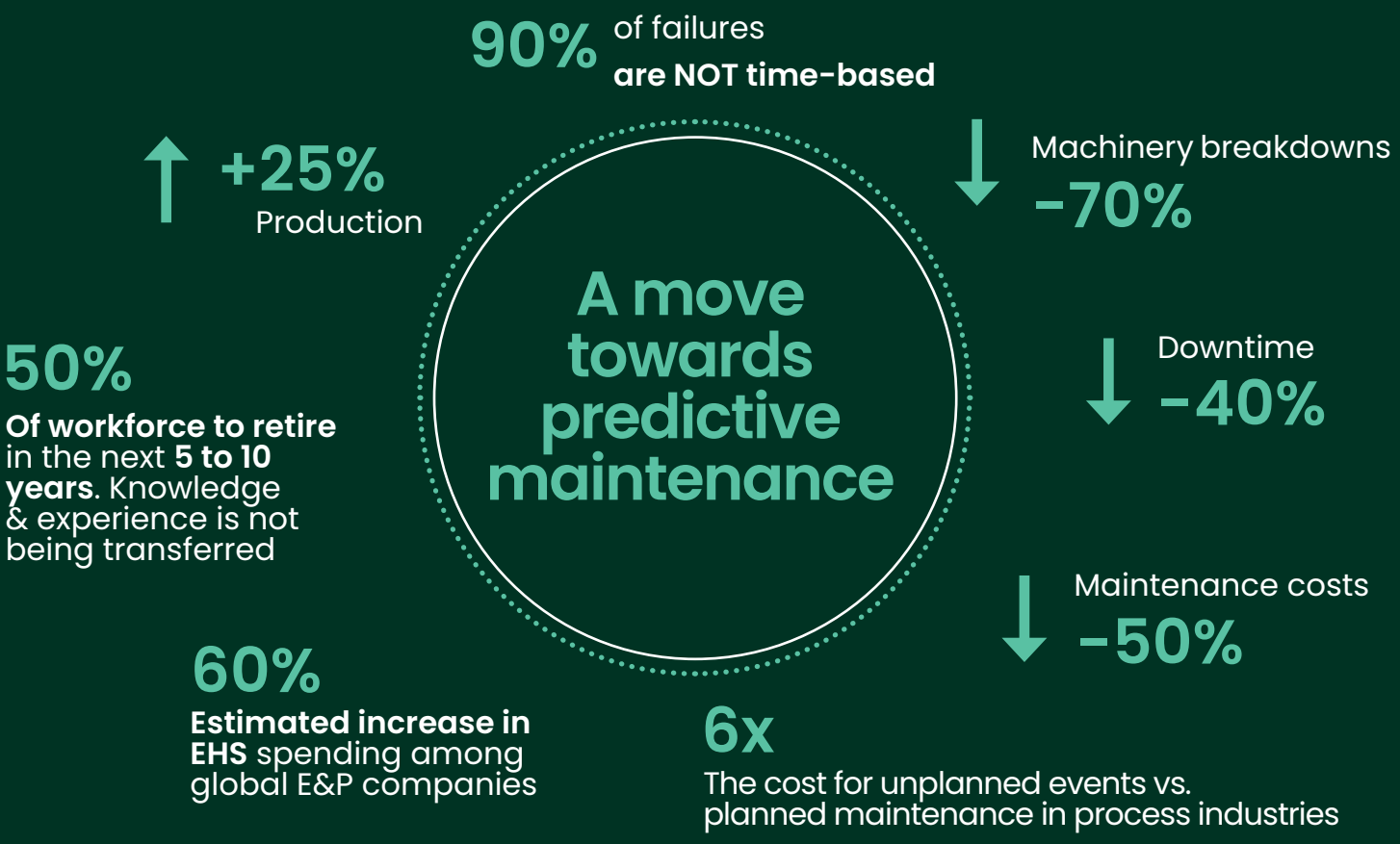
The engineers decided to continue to monitor the pumps to confirm the early reports. Successive data collected confirmed a gradual decrease in power consumption as the pump was able to do less useful work. Maintenance monitoring specialists predicted that pump performance would continue to decrease as erosion advanced.

Once the power factor fell below a pre-determined threshold, maintenance was scheduled to disassemble the motor and pump to compare the as-found conditions with the assessments provided by the AnomAlert unit. When the upper casing cover was removed, it was very apparent that the flow vanes (fins) had suffered significant metal loss due to erosion. The impeller had light fouling, and the wear rings had eroded, causing a reduction in performance by allowing recirculation flow. A small hole had also eroded in the pump casing where a flow disturbance was produced by a wear ring retaining screw.

Maintenance teams took appropriate action to repair the pumps back to good working order.

**Results:** At the successful completion of the trial, the Engineering Superintendent concluded: "The online system monitoring was the most beneficial part of the trial process. Using a simple traffic light system to identify that a fault exists, when and where appropriate, allowed for intrusive investigations and repair before failure. This remote on-line indication has enabled a reduction in maintenance man-hours and downtime."

The application of AnomAlert technology facilitated the implementation of a proactive approach to pump maintenance, which resulted in a 90% cost saving over the older method of replacing the entire pump after it failed.




[1] A survey of 500 plants by Keith Mobley, "Introduction to Predictive Maintenance"
[2] U.S. Department of Energy

# The journey to plant-wide monitoring

Industrial maintenance trends continue to indicate that maintenance experts will increasingly be required to do their jobs in higher-value facilities with fewer resources.

**Modern industrial maintenance trends include:**

- Downsizing plant staff
- Maintenance expertise levels decreasing as maintenance workforce ages with no one trained to replace them
- Predictive reliability maintenance works
- Industry by Industry – A 2018 Frost & Sullivan "Digitization of Condition Monitoring" study compared the various "invest to transform" trends emerging from the adoption of plant-wide wireless condition monitoring:
  - The oil and gas industry is moving from siloed oilfield operations to integrated production fields.
  - The power industry is seeing the benefits of smart meters and decentralized power generation units with the integration of network and security operation centers.
  - The mining industry is identifying the reliability gaps in current operations at mining facilities and implementing corrective actions.
  - The food and beverage industry is driven by the need to reduce maintenance costs, centralize visibility of filling machine lines, and standardize the drying process.
  - The pulp and paper industry is focused on detecting early bearing degradation and maximizing sensitivity to low level vibrations, and identifying high frequencies for monitoring speed rollers.

# How to get started

If you are interested in learning more about plant-wide condition monitoring solutions, here is a quick "get started" outline and next steps to learn more.

Embrace the future of condition monitoring to support proactive and predictive maintenance. Transitioning from current maintenance strategy to a holistic, plant-wide approach will not happen overnight. Before we even begin the journey, we must truly embrace the belief that the future of industrial maintenance lies with interconnected predictive solutions. Once we understand that the future of maintenance will look very different than when we started out, we can begin to plot our journey to plant-wide.

Make the case for plant-wide. A true plant-wide condition monitoring solution requires significant investment as it's an integrated system of hardware, software, and monitoring services, all working together. The better we are able to justify the investment by addressing the following three areas, the more successful we'll be when discussing the transformation with key company decision makers:

A. Increase Efficiency. How will plant-wide monitoring increase plant efficiency in terms of both preventing plant downtime and personnel?

B. Mitigate Risk. What are the specific risk areas that the new solution will help mitigate? Where are the blind-spots in your current monitoring system? What are the associated costs if a machine fails? Explain how a plant-wide system will help eliminate those blind spots.

C. ROI in the Short and Long-Term. Identify specific ROI areas of opportunity that a plant-wide solution will address. How will the investment pay off in the short-term and long-term?

***Choose the right condition monitoring partner.*** The maintenance industry is flooded with hundreds of monitoring solutions and technology partners. It can be difficult to know which one to choose. When you begin to think about a plant-wide solution, the field becomes a bit narrower as very few companies offer a true plant-wide unified hardware, software, and services monitoring solution.

Ultimately, you should partner with a company that has proven their commitment to helping you succeed – someone you can trust with your most valued assets. The company you partner with should be able to add wireless sensors, connect racks, or complete more complicated plant-wide projects that get your predictive condition monitoring up and running. Having a single vendor with a holistic approach will change the way you look at asset monitoring.

Making the transition from critical-only condition monitoring to a plant-wide approach has the potential to elevate a plant to best-in-class status. A fully integrated and modern plant increases the level of sophistication, productivity, and reliability for the entire industrial maintenance field. As we improve safety, uptime, and capabilities, our living standards around the world increase as well, thanks again to manufacturing innovations.

## Case Study: Monitoring a refinery electric motor in Thailand

**Situation:** The electric motor at a refinery in Thailand is monitored by Bently Nevada's System 1 Evolution condition monitoring software. Consistent vibration data acquired daily for six months by the System 1 software identified a machine fault. The Baker Hughes customer then installed the Ranger Pro wireless sensor system, which observed bearing fault frequency peaks on the PeakDemod spectrum plot at the motor bearing.

**Action:** Automated data collection from the Ranger Pro system enabled prompt diagnosis by the Bently Nevada Machinery Diagnosis Services (MDS) experts of an ongoing bearing failure that could be fixed at a later date. The customer was able to continue operating the unit safely while it arranged spare parts and resources, and planned for an overhaul. The motor bearing was replaced during a scheduled outage.

**Results:** Unplanned downtime was avoided. Continuous data from the Ranger Pro system enabled the prompt diagnosis of an ongoing bearing failure, and gave the customer the confidence needed to operate the system until a scheduled outage. The customer also saved $10,000 through the early detection of the bearing fault. With the overhaul, possible secondary damage was avoided.

## About Bently Nevada

For six decades the Bently Nevada product line has supported the most demanding applications in multiple industries. And even as we protect and monitor your machinery, we constantly strive to refine and improve our offerings—and help enable your success. Combining plant-wide condition monitoring solutions and wireless capabilities with hosting and implementation means overarching coverage with the simplicity of one vendor.

We design and deliver solutions for all of your monitoring needs—including sensors, distributed and rack-based monitors, software, and supporting services—with the goals of increased availability and production, lower maintenance costs, and reduced risk in safety, environmental, and asset upsets.

Over 60 years of innovation in asset protection and condition monitoring, with more than 240 international patents and over 4 million sensor monitoring points installed, means Bently Nevada is an experienced partner. We offer the user experience of a modern and intuitive interface, best in-class anti-friction and hydrodynamic bearing diagnostics, remote portable data transfer, and more.

Baker Hughes



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