Unlocking the ROI Potential of Condition Monitoring and Predictive Maintenance

Condition Monitoring (CM) and Predictive Maintenance (PdM) are the top return on investment (ROI) opportunities in manufacturing and industrial process applications. PdM delivers ROI in asset intensive industries including manufacturing and industrial process operations.

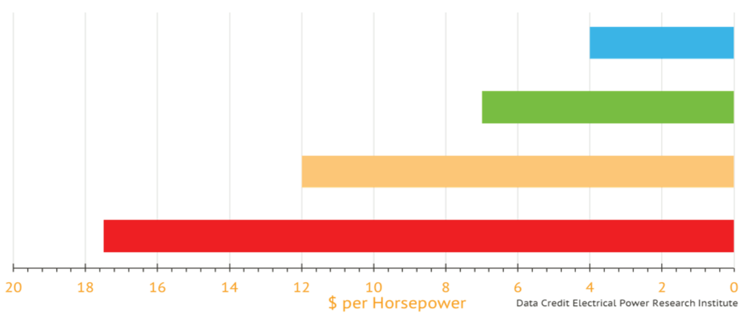
Business Benefits Accrue from CM & PdM

Businesses need their assets to operate at full capacity with the lowest maintenance costs possible. CM and PdM allow this balance to occur. When asset condition data is integrated with maintenance and operations data, it gives a holistic, analytic view for predicting maintenance needs, operational anomalies, and business outcomes.

In fact, there are many publications illustrating a lower cost of maintenance and higher production output when CM and PdM are part of a proactive approach to managing important assets in the production process. The well-known chart below illustrates the significant maintenance cost production when CM and PdM can detect maintenance needs in advance, allowing for planning, budgeting, and scheduling the maintenance event.

CM & PdM Business Benefits:

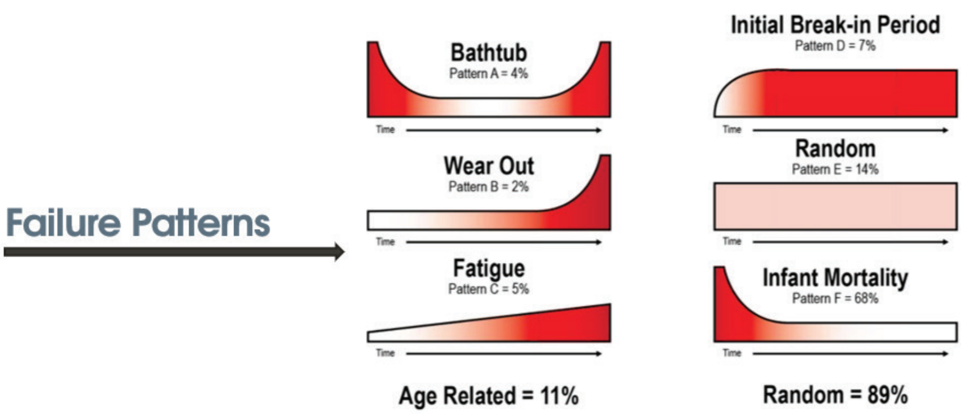
1. Increased Safety
2. Maximized Production
3. Minimized Operational Costs



Business Benefits (cont.)

CM and PdM are core to identifying asset problems before they occur, allowing for repair at an optimized point in time. PdM provides time to plan for correction well in advance of functional failure, allowing for optimization of downtime and resources, and as a result maximizing uptime and production.

There are several failure patterns identified in another often-referenced survey indicating that over 80% of equipment failures are random in nature. It is all the environmental, operational, mechanical, electrical, chemical, and biological physics that interact together, randomizing failure. Monitoring our assets is the best way to detect failure patterns as early as possible.



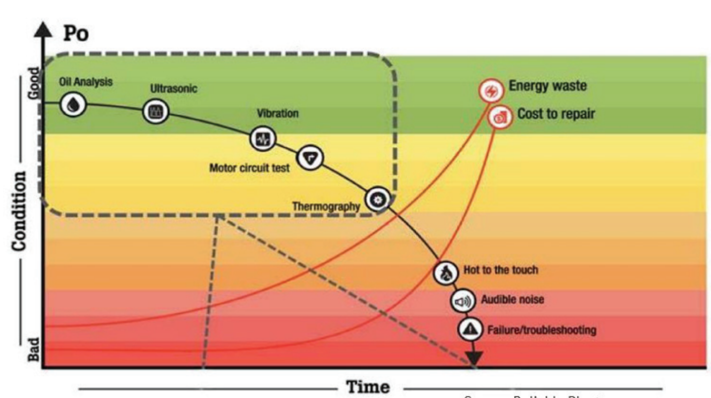
Source: John Moubray, Nolan and Heap

In addition to safety, production and cost benefits; a condition monitoring and predictive maintenance effort provides streamlined asset management and asset visibility. It also significantly reduces the risk of failure, avoiding any consequences. Lower risk typically results in lower insurance costs and higher plant valuation. A condition monitoring and predictive maintenance program can also be your foundation to an Industry 4.0 effort.

Monitoring the Equipment

In fact, many sources report lower costs of operation and maintenance when defects that cause equipment failure are detected early. We often refer to this P to F (P-F) curve to represent the degradation curve of an asset. At the upper left of the curve, we find point "P" representing the first opportunity to detect a defect that leads to functional failure of our asset. There are several opportunities along the P to F curve where we can detect the defect(s) that will lead the asset to failure. This is the role of condition monitoring, detecting defects.

Potential Failure (P-F) Curve



Source: Reliable Plant

Monitoring the Equipment (cont.)

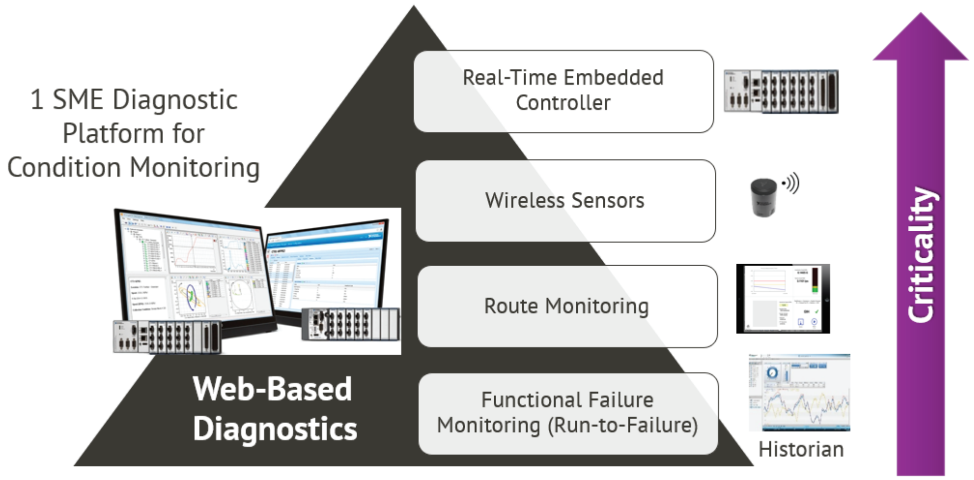
There are several inspection technologies we can deploy to detect early signs or signals of defects within our assets. These include vibration, motor current, oil analysis, and ultrasonic technologies.

Results from inspections are logged in a time series database such that trend analytics can drive corrective action planning. Early detection gives us time to plan for corrective action. Early detection reduces our risk of failure and our cost to repair.

Yet, it takes Reliability and Systems Engineering to first understand the assets, how they are designed to function, and how they are likely to fail. With this knowledge, we can identify the sensors and analytics needed to predict a future maintenance requirement.

The engineering effort creates an asset catalog, a listing of all assets at the plant site. A criticality analysis is then performed on the assets, considering a failure's impact on production, product quality, cost to repair, safety, and the environment. One might think of the criticality effort as assessing the consequences of failure. Next, the engineering effort considers the likely failure modes of the equipment. Finally, balancing consequences with predictive maintenance efforts, equipment inspection plans are developed for all equipment. With solid equipment maintenance and inspection plans, we significantly lower the risk of the consequences occurring.

There are many forms of inspections we can employ. For the most critical assets, one might want an always on monitoring system. Gas turbines in power generation plants, as well as turbomachinery in process plants are often monitored by real-time always on monitoring systems. These systems can measure vibration, motor current, dynamic pressure, temperature, ultrasonic, oil, and other sensors with 4-20ma, voltage, Modbus, or OPC UA outputs. However, they are the most expensive option for monitoring, yet provide a comprehensive analysis and diagnostic capability.



As semiconductor, communications, and battery technologies have advanced; there are now many wireless sensor options for each inspection technology. We use wireless sensors for equipment that operates in stable operating conditions (speeds, loads, duty, etc.). These sensors provide measurements a few times daily, providing more than adequate visibility for important equipment in the plant.

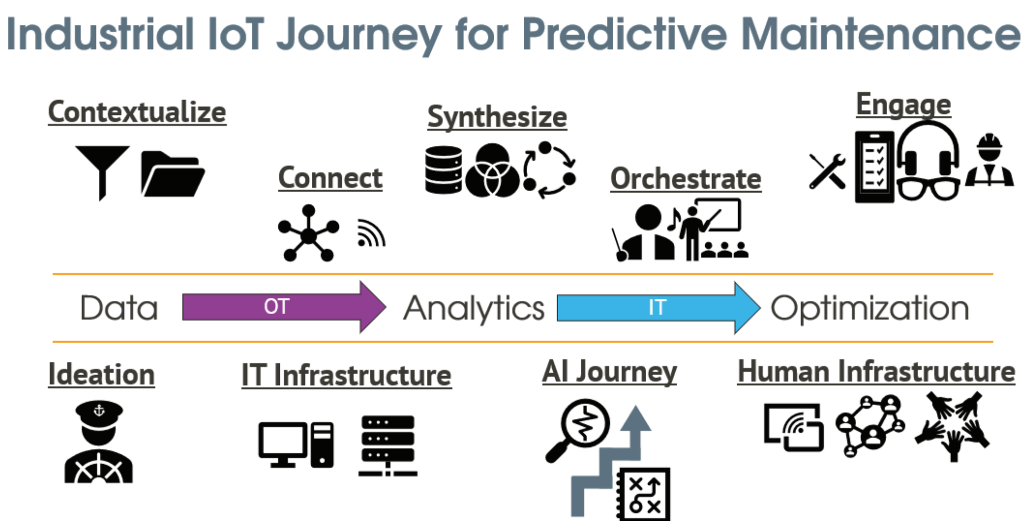
Monitoring the Equipment (cont.)

In a similar light, industrial tablets are effective in human assisted inspections where both sensors and human observations can be recorded together in a single inspection visit. Wearable tablets are now available with heads up displays, noise cancellation, voice recognition, and live cameras. The hard hat mounted tablet is an effective tool for routine inspections conducted once per month of more frequently. As with real-time and wireless options, the tablet-based inspection records data for analysis and trending. The down-side of human assisted inspections includes man-hours for inspection and travel, as well as required effort to address human safety.

Lastly, it is possible to use control systems data to monitor the function and performance of the equipment. While this method gives us late warning of failure, with trend analysis it is possible to detect an impending failure several days in advance. While this does not meet our criteria for advanced planning, budgeting, and scheduling; it can work for less critical assets where replacement of components is quick, easy, and spares are readily available.

Developing a Roadmap to CM and PdM

To get to our future, from where we are, we need a roadmap, a team playbook. One should begin with contextualizing areas of improvement and brainstorming on ideas to realize improvements.



We often begin with an Ideation phase where we establish a team with plant leadership and stakeholders, to create a vision with low hanging use cases.

We then Contextualize the improvements by working with subject matter experts (SMEs) to identify Throughput, Capacity, Quality, Uptime, Maintenance Costs, Worker Efficiency, Competition, and other opportunities for improvement and return.

Developing a Roadmap to CM and PdM (cont.)

Next, we Architect the Information Technology Infrastructure. This effort includes Wireless Networks, Security, Data Management (Historian), Edge Compute, Hybrid IT, Application Interfaces, all with a focus on system reliability and long-term maintainability.

We then Connect the data. Data comes from the condition monitoring hardware, control systems, equipment health analytics, production logs, maintenance management systems, etc.

Next, we Synthesize and synchronize the data often using a Time Series Database with contextual data from planning and maintenance systems. We Correlate, Find Patterns, and work to Optimize.

With data synthesized, we can begin an analytics or AI Journey to automate analytics. We often start with thresholds (Alerts) and business key performance indicators (KPIs). We can advance to anomaly detection, classification, forecasting, and machine learning.

The goal of course is to improve decisions, actions, and the bottom line of our production facility. The next three parts of the roadmap are all about information delivery. These roadmap components are as follows.

Human Infrastructure Dashboards connect the workers to their metrics, data, information and status dashboards. Often these are web-based displays available in their office, or in the field with tablets, mobile devices, and even heads up displays on our helmet mounted tablets.

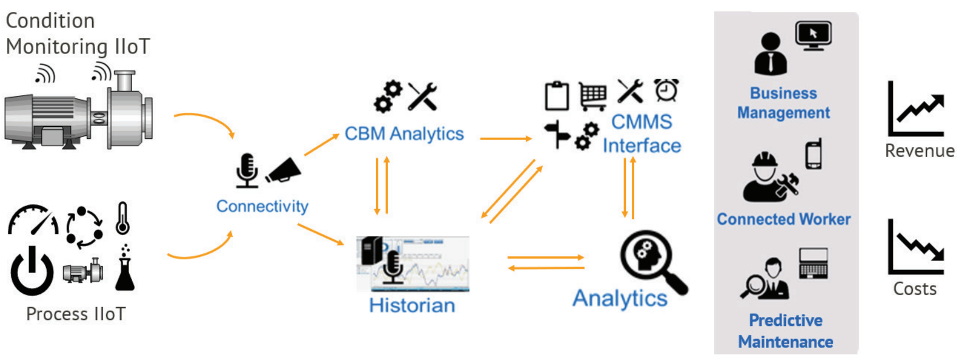
Orchestrate the call to action with information and detail as to next steps, collaboration, and so forth.

Engage the worker performing any field work as well as the worker performing planning work. Deliver task specific data and information efficiently, allowing tasks to be completed efficiently and correctly the first time.

This upfront design and roadmap are made with client leadership and stakeholders with an eye on a future state vision that continually yields business benefits. It is a workshop effort, including pre and post workshop tasks. It is important to work with a team experienced in all aspects of the journey, both planning and implementation.

Expected Results

In the end, we have a system that balances effort and results with the ability to grow and expand. Building on best practices for condition monitoring and predictive maintenance, we build an open architecture system that supports both today and tomorrow's technology, allowing for best in class technology components.



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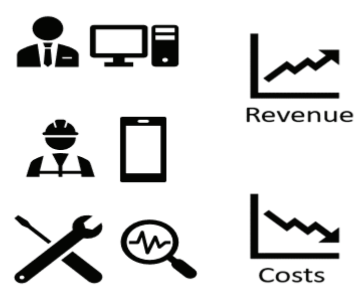
technology with a human touch

Expected Results (cont.)

Using asset function requirements and asset failure modes knowledge, sensors to detect changes are installed and connected to edge analytics. Initial analytics runs in CBM analytics and in the Historian. Both CBM and the Historian report anomalies to the Asset Management System or Computerized Maintenance Management System (CMMS). The historian keeps all data, operational events, and maintenance events time synchronized. Predictive analytics finds patterns in the data, reports anomalies, and recognizes known patterns.

Actionable information is assembled from the subsystems and delivered to human data consumers. Business Management dashboards keep leadership informed of production, costs, problems, and areas for improvement. Connected Worker heads up displays aid the fielded worker with work instructions, documentation, trends, and remote expert support. Predictive Maintenance dashboards deliver statistics and trends in asset health, maintenance cost, production capacity, and work management.

Summary



What might be your organizations goals? Lowering the cost of production, improving product output, smoothing the business process? From a maintenance perspective, perhaps it is first time fix by knowing what really needs to be replaced or adjusted. Perhaps it is keeping the assets operational for a longer time period. Perhaps it is reducing unnecessary part exchanges or lowering spare parts inventory costs. All of these are possible with an integrated condition monitoring and predictive maintenance program.

To bring it all together, CBT works as an Information Technology and Operational Technology systems integrator. The CBT partner ecosystem includes sensors and diagnostic software for collecting and interpreting machinery and fixed asset data. Our ecosystem includes Industrial indoor/outdoor networking, along with needed security. Our ecosystem includes Powerful compute and storage infrastructure with best in class system management tools to keep the infrastructure running and current. And perhaps most importantly, it includes the interfaces for the people to connect and interact with the process of production and maintenance.

So, let's get started with an initial meeting to identify goals and build your roadmap to higher production and lower costs. We listen for industry challenges, human performance, equipment productivity, company goals, and expected future state of your operation. We want to understand your challenges and your desired outcome. We will create your architecture and organizational roadmap. We will leverage Industrial IoT and Industry 4.0. We will implement for fast ROI, with the ability to scale adding valuable use cases along the way.

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