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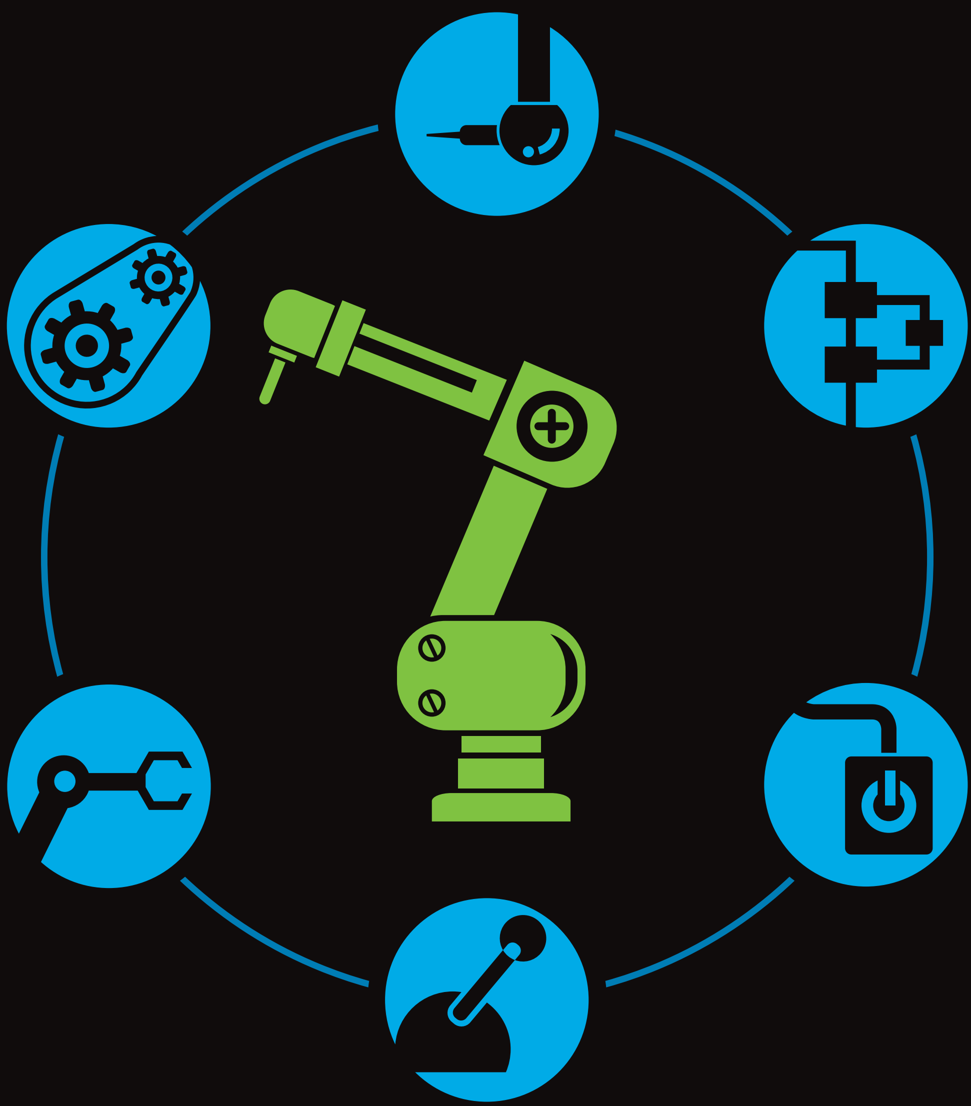


Predictive maintenance and the smart factory

Predictive maintenance connects machines to reliability professionals through the power of the smart factory

Traditionally, maintenance professionals have combined many techniques, both quantitative and qualitative, in an effort to predict impending failures and mitigate downtime in their manufacturing facilities. Predictive maintenance offers them the potential to optimize maintenance tasks in real time, maximizing the useful life of their equipment while still avoiding disruption to operations.

Introduction

Maintenance and reliability professionals in the manufacturing industry face a number of challenges, but the goal of any maintenance organization is always the same: to maximize asset availability. In this article, we'll focus on fixed assets, the machines on the shop floor that turn raw material into finished goods.

Today, poor maintenance strategies can reduce a plant's overall productive capacity by 5 to 20 percent.[1] Recent studies also show that unplanned downtime is costing industrial manufacturers an estimated $50 billion each year.[2] This begs the question, "How often should a machine be taken offline to be serviced?" Traditionally, this dilemma forced most maintenance organizations into a trade-off situation where they had to choose between maximizing the useful life of a part at the risk of machine downtime (run-to-failure) or attempting to maximize uptime through early replacement of potentially good parts (time-based preventive maintenance), which has been demonstrated to be ineffective for most equipment components.

Oftentimes, maximum utilization of tooling or machine components can be achieved by running them until they fail. But this can lead to catastrophic machine damage as parts begin to vibrate, overheat, and break, reinforcing the old adage "pay me now or pay me later." And, while run-to-failure may be an acceptable approach for some assets, it still needs to be understood that unplanned downtime is almost always more expensive and time consuming to correct. Conversely, you might consider more frequent replacement of parts and servicing of equipment. But this can not only increase replacement costs over time, it can also increase planned downtime and disruption to operations.

Spare-parts management presents a similar challenge that can feel like a constant balancing act. With limited budgets, maintenance professionals must evaluate which parts they'll need and when to procure them. If the spare is not on hand or on order when it's needed, the downtime of an asset can be anywhere from days to weeks—or even months—while waiting for the replacement part. This typically leads to the buildup of spares inventory, which not only ties up working capital, but also increases the risk of excess and obsolescence that erodes the bottom line.

Breaking the tradeoff: Leveraging the power of the smart factory

Predictive maintenance (PdM) aims to break these tradeoffs by empowering companies to maximize the useful life of their parts while avoiding unplanned downtime and minimizing planned downtime. With the advent of Industry 4.0 for manufacturing, companies are able to leverage new technologies in order to monitor and gain deeper insight into their operations in real time, turning a typical manufacturing facility into a smart factory. Simply put, a smart factory is one equipped with technology that enables machine-to-machine (M2M) and machine-to-human (M2H) communication in tandem with analytical and cognitive technologies so that decisions are made correctly and on time.

PdM (which has been around for many years now) utilizes data from various sources, such as critical equipment sensors, enterprise resource planning (ERP) systems, computerized maintenance management systems (CMMS), and production data. Smart factory management systems couple this data with advanced prediction models and analytical tools to predict failures and address them proactively. Additionally, over time, new machine-learning technology can increase the accuracy of the predictive algorithms, leading to even better performance.

In contrast, traditional preventative maintenance (PM) programs often require very time-consuming, manual data crunching and analysis to gain any real insights from the data being collected. While many have had some success with these strategies, they typically rely heavily on "tribal knowledge" estimates or require in-depth knowledge and analysis of each individual piece of equipment on an ongoing basis to stay accurate.

In line with the maintenance goal of maximizing machine availability, Deloitte identified two main business objectives of all manufacturing companies operating in the Industry 4.0 era:[3]

1. Operating the business
2. Growing the business

While growing the business focuses on top-line growth, operating the business often seeks to cut costs. When you consider the number of person-hours spent performing routine machine inspections that don't lead to any key findings or trigger a work order, in addition to the effort spent firefighting unplanned downtime, the case for PdM starts to become clearer. PdM technologies can pull data from multiple sources and legacy systems in order to provide real-time advanced insights, allowing computer systems to do the legwork so maintenance managers can deploy their resources more efficiently and effectively.

Getting to predictive maintenance: An exploration of the technologies

Maintenance organizations across industries are, by design or default, at different stages of maturity. Some may be running scheduled maintenance checks based on estimates or OEM recommendations, while others may utilize statistics-based programs individually tailored to each fixed asset. Still, others—particularly in the aerospace and energy sectors—are already employing continuous monitoring technologies of their assets, but may only be monitoring the outputs of the data, rather than leveraging advanced predictive models.

As with anything, there are steps to take on the journey toward reliability optimization, beginning with some of the basics of preventive maintenance and reliability-centered maintenance, while simultaneously piloting PdM with one or two well-suited assets. Prime assets for one of these pilots should be highly integral to operations and must fail with some regularity in order to create baseline predictive algorithms.

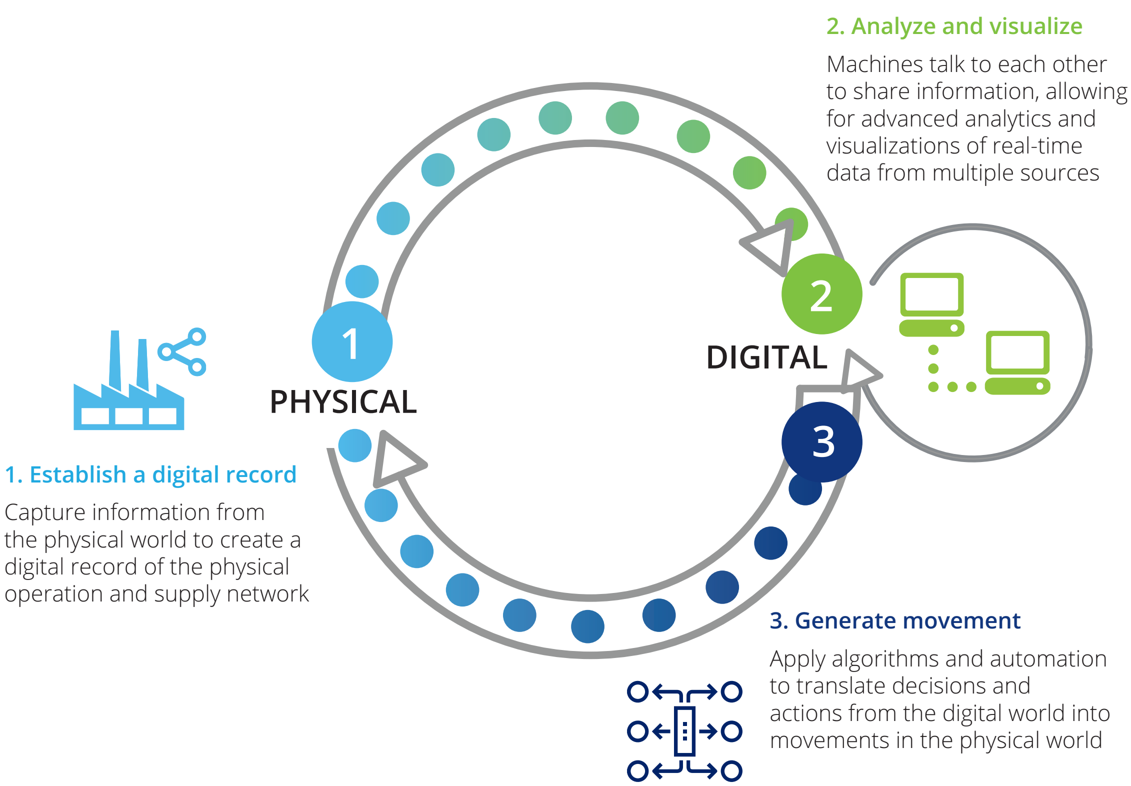
Now, the idea of PdM sounds enticing. But how does it work? Many of the technologies that make up a smart factory are not necessarily new, but have become much more affordable, more robust, more advanced, and integrated for business use. Computing, storage, and network bandwidth all are now available at fractions of the cost compared to just 20 years ago,[4] making piloting and scaling financially feasible.

Let's explore some of the technologies that make up a smart factory and make PdM possible.

Internet of Things

The Internet of Things (IoT) is perhaps the biggest piece of the PdM puzzle. The internet as we know it has connected your laptop and mobile device to large server farms full of website data coded in HTML. IoT is similar, but the data is created in a continuous stream from your assets to private enterprise servers. IoT translates physical actions from machines into digital signals using sensors such as temperature, vibration, or conductivity. Data can also be streamed from other sources, such as a machine's programmable logic controller (PLC), manufacturing execution system (MES) terminals, CMMS, or even an ERP system. IoT completes the first half of the physical-to-digital-to-physical (P-D-P) loop (Figure 1 below). This smart factory concept was introduced in Deloitte's discussion on [The Rise of the Digital Supply Network.] Once the physical actions have been translated into digital signals via sensors, they are processed, aggregated, and analyzed. With the affordability of bandwidth and storage, massive amounts of data can be transmitted to give not only a full picture of assets in a single plant, but of an entire production network.

Figure 1: Physical-to-digital-to-physical loop and related technologies



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Analytics and visualization

The second step in the P-D-P loop is to analyze and visualize the digital signals using advanced analytics and predictive algorithms. Advanced business intelligence (BI) tools are no longer only for data scientists. Many analytics platforms are beginning to incorporate high-level solutions for unstructured data, cognitive technologies, machine learning, and visualization. Operations analysts, who are more in-touch with the manufacturing processes, can easily create dashboards using modern APIs (application program interfaces) created specifically for the everyday user.

Another trend is data moving back to the edge. Similar to the lean technique of storing tooling at the point-of-use, data computation will be done at the "edge," meaning it's processed at the machine where it's generated. Insights can be pushed directly to machine operators and maintenance technicians. As data is beginning to approach the zettabytes (that's 10^{21} bytes), edge computing reduces the overall burden on a computer network by distributing some of the processing work to a network's outer nodes to alleviate core network traffic and improve application performance.[5]

Closing the physical-to-digital-to-physical loop

Finally, after the signals have been processed, analyzed, and visualized, it's time to turn those insights back into physical action. In some cases, the digital conclusions drawn may instruct robots or machines to alter their functions. In other cases, maintenance alerts will spur a technician into action. Consider a situation where the predictive algorithms would trigger the creation of a maintenance work-order in the company's CMMS system, check the ERP system for spares on hand, and automatically create a purchase request for any additional parts required. Then, the maintenance manager only has to approve the items in the workflow and dispatch the appropriate technician, all automated and prior to unplanned downtime.

Potential benefits:

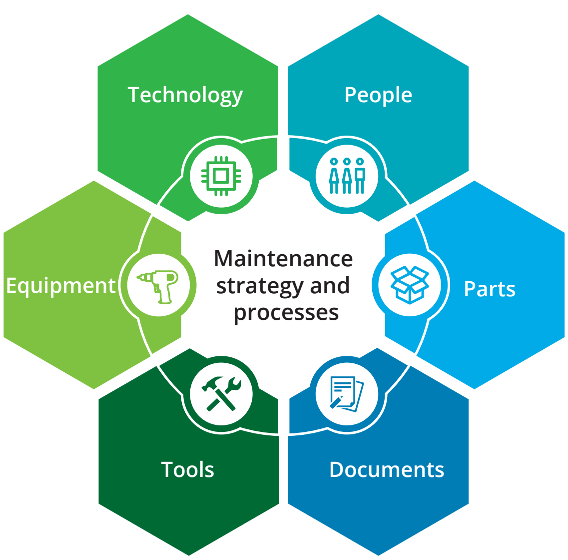
The challenges at first glance might seem steep to overcome. However, the benefits of digital transformation far outweigh the risks. These benefits include:[6]

- Material cost savings (5-10 percent in operations and MRO material spend)
- Reduced inventory carrying costs
- Increased equipment uptime and availability (10-20 percent)
- Reduced maintenance planning time (20-50 percent)
- Reduced overall maintenance costs (5-10 percent)
- Improved HS&E compliance
- Less time spent on brute-force information extraction and validation
- More time spent on data-driven problem solving
- Clear linkages to initiatives, performance, and accountability
- More confidence in data and information leading to ownership of decisions

Building the foundation: Seven maintenance pillars for success

Technology alone cannot get you there—you also need to focus on process and organizational changes. Successful maintenance organizations should be able to deploy all appropriate resources (human resources, technical instructions/reference materials, spare parts, and tooling) when and where they are needed in support of operations. To accomplish this, there are a number of key areas that need to be addressed. All too frequently, companies tend to spend their time and money on major technology enhancements, such as more robust computer-managed maintenance systems (CMMS) or reliability software, without first applying enough focus on some of the more fundamental elements of the organization. It should be understood that there is no "silver bullet" computerized solution which will alleviate the need for some initial ground work, including determining exactly what type of maintenance organization and methodology makes sense for a particular operation. In order to optimize a maintenance organization, there are seven primary focus areas that should be considered (see Figure 2).

Figure 2: Maintenance pillars for success



Maintenance strategy and processes are the core elements for any successful maintenance organization. And it's important to note here that while technology is a key enabler (and the primary focus of this paper), it's only one of the seven pillars for success. Without the fundamental building blocks in place, investment in technology will likely never yield the desired results. It should also be understood that not all companies require the same level of reliability from their assets. A good place to start is to assess your organization's mission requirements and maintenance program maturity. Ask yourself some of the following questions:

- How reliable do our assets need to be? What are our availability targets?
- Do our technicians have the right skills to perform the work required?
- Do we have the right spare parts in the right place at the right time?
- Are our processes well-documented, accessible, and useful?
- Do we have the right tools for the job?
- How do we determine when it's time to replace an asset rather than maintain it?
- What data do we already have that isn't being used effectively?
- Have we identified the critical assets in our production system?
- Are there some critical assets that would benefit from a PdM pilot?
- What is the value of PdM across our entire enterprise?

From undertakings big or small, no maintenance organization can be successful without considering the foundational maintenance strategy and processes in tandem with the technology that enables them.

Let's talk

Smart factories and PdM are the future. And the options are endless. But it can be overwhelming to determine what your next step should be or how to drive value through investments in maintenance optimization. Deloitte has the unique capability to combine deep knowledge and understanding of maintenance operations with the digital technologies that are shaping the future. Whether you're just getting started on your maintenance journey or ready to redefine maintenance altogether, we have the right team to assist you along the way.

Endnotes

[1] http://www.ptc.com/product-lifecycle-report/iot-slashes-downtime-with-predictive-maintenance
[2] http://partners.wsj.com/emerson/unlocking-performance/how-manufacturers-can-achieve-top-quartile-performance/
[3] https://dupress.deloitte.com/dup-us-en/focus/industry-4-0/manufacturing-ecosystems-exploring-world-connected-enterprises.html
[4] https://dupress.deloitte.com/content/dam/dup-us-en/articles/3465_Digital-supply-network/DUP_Digital-supply-network.pdf
[5] http://insights.wired.com/profiles/blogs/the-edge-of-computing-it-s-not-all-about-the-cloud#axzz4ZFqo7srQ
[6] Internal Deloitte analysis

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