Why enterprise asset management must evolve into asset performance management

Best Practice Guide

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How APM can mature your asset maintenance processes

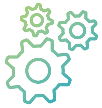
Since the Industrial Revolution, manufacturing processes have undergone several revolutions characterized by ever-greater automation. Today, the fourth industrial revolution, known as Industry 4.0, takes advantage of big data and machine learning to drive smart, highly automated processes. A similar evolution has occurred in asset maintenance. Maintenance 4.0 not only digitizes previously manual maintenance processes, it also harnesses the power of data to enable organizations to predict when assets will fail and automatically direct remediation processes. In fact, of companies that have already embraced these advances, 95% of those who responded to a PwC survey have experienced concrete results.[1]

But to take advantage of these innovations, organizations need the right technology. This guide describes why computerized maintenance management systems (CMMS) and enterprise asset management (EAM) technology must evolve to incorporate asset performance management (APM) and how they should evolve to meet modern organizations' ongoing demands to do more with less. By harnessing massive amounts of sensor data and advanced analytics, APM solutions enable organizations to optimize labor and materials, increase safety, and improve the accuracy of the capital budgeting process.

Maintenance 4.0 parallels Industry 4.0

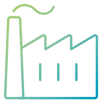
Over the past 250 years, manufacturing has travelled the well-documented road from the first industrial revolution (Industry 1.0), which featured mechanization through steam and water power; to the use of electricity for mass production in the second; to the use of computer and communications technologies in the production process in the third revolution. Today, Industry 4.0 encompasses smart and autonomous systems fueled by data and machine learning.

Less well understood, but equally momentous, has been a parallel evolution in asset maintenance. Where Maintenance 1.0 relied on highly trained specialists to visually inspect machinery, the second maintenance revolution gave humans instrumentation to measure how equipment was running, while the third used real-time monitoring to understand the condition of an asset systematically and programmatically. Now with the Internet of Things (IoT) collecting massive amounts of sensor data, Maintenance 4.0 sees that data captured in a data lake repository, and algorithms and analytics applied to better interpret that data and reveal why assets fail, when a given asset will fail, and how to correct the problem.



Industry 1.0

Mechanization, steam power, weaving loom



Industry 2.0

Mass production, assembly line, electrical energy

Industry 3.0

Automation, computers, and electronics

Industry 4.0

Cyber-physical systems, Internet of Things, networks

How organizations can achieve Maintenance 4.0?

The maintenance maturity model offers a roadmap for how asset-intensive industries can progress their maintenance operations through each successive maintenance level to maximize efficiency and reduce costs.[3]

As organizations improve their maintenance maturity, they must rely on evolving technology solutions. Computerized maintenance management systems (CMMS) automate work transactions for maintenance technicians. Enterprise asset management (EAM) solutions extend CMMS capabilities with an asset registry that provides a centralized repository of all data related to assets for use by engineers and procurement. Today, EAM is adding asset performance management (APM) capabilities that take in massive amounts of sensor data and perform predictive and risk modeling. Such APM solutions enable organizations to predict equipment failure and perform proactive decision-making that can improve safety, optimize labor and material management, and enhance capital budget planning.

Maintenance 1.0

Relying on visual inspection to detect issues, organizations at the Maintenance 1.0 level manage maintenance reactively. They allow assets to run to failure, then manage repair using a CMMS and/or EAM.

Maintenance 2.0

Here organizations perform preventative maintenance, attempting to avoid failure by maintaining machines during pre-scheduled time intervals. Preventative maintenance efforts can be managed by CMMS and/or EAM.

Maintenance 3.0

Maintenance 3.0 uses sensors to monitor assets in real time and send alerts. This corresponds to condition-based and predictive maintenance in the maintenance maturity model. An EAM system uses these alerts to perform a rudimentary type of predictive maintenance.

Maintenance 4.0

Maintenance 4.0 relies on APM solutions to manage big data from sensors and deliver analytics to determine precisely when an asset will fail, enabling enhanced predictive maintenance. APM also automates prescriptive maintenance workflows to enable organizations to proactively fix any predicted issues and avoid asset malfunction.

Maintenance Revolution Stage	Maintenance Maturity Stage	Technology
Maintenance 1.0	Reactive maintenance—assets run to failure, then fixed	CMMS and EAM
Maintenance 2.0	Preventative maintenance on predetermined schedule	CMMS and EAM
Maintenance 3.0	Condition-based maintenance—sensors monitor condition and send alerts Predictive maintenance—based on sensor data	EAM
Maintenance 4.0	Predictive maintenance—algorithms and machine learning models determine when an asset will fail Prescriptive maintenance—lays out people, processes, and tools to fix issues	APM

Source: IMPO, Moving Through the Maintenance Maturity Model 4

Why the evolution to APM is critical

Regardless of size or industry, asset-intensive organizations are always looking to do more with less. That means finding ways to extend asset life to minimize costs, while performing the right maintenance at the right moment to avoid downtime.

An EAM system enables organizations to capture the asset condition correctly and maintain a system of record so they can focus on doing the right things to maintain the asset. EAM and CMMS also manage work orders for each maintenance event to ensure proper procedures are followed.

But today, organizations that are looking to reach Maintenance 4.0 for whom reliability is a key concern understand that reactive maintenance management is no longer enough.

CMMS and EAM systems cannot manage and analyze the vast amounts of data necessary for predictive and prescriptive maintenance. These organizations need APM solutions that enable them to use the data they already collect to understand assets better, predict failures, and improve failure management, as well as accurately budget for assets as failures occur and to meet forward looking business goals.

And they want a solution that does not force them to install, manage, and maintain multiple software applications. As reliability and sustainability increasingly become a must have versus a nice to have, organizations will increasingly need an APM solution that has evolved to meet their requirements in a single system.

The five components necessary for APM

APM pulls in data that has traditionally been stored in an EAM system, as well as data from a wide range of asset measurement solutions and applies algorithms or artificial intelligence/machine learning models to enable decision support, predictive analytics, and “what if” analysis. Once organizations come up with a decision based on this analysis, the APM system can then take advantage of EAM capabilities or integrate with enterprise resource planning (ERP), product lifecycle management (PLM), supply chain management (SCM), or other systems to automate the appropriate response. Organizations can take advantage of improved analysis and greater automation to increase asset efficiency, manage asset reliability and sustainability, improve customer centricity, and optimize total cost of ownership.

The five components necessary for an APM solution include:

- **01 Asset registry**
- **02 Work history**
- **03 Real-time condition data**
- **04 Algorithms and modeling analytics**
- **05 Connectivity**

01. Asset registry

The asset registry is the heart of a traditional EAM system. It serves as a repository for information about all assets that are valuable to the organization. By using an asset registry, an organization can standardize asset definitions, minimize manual data entry, gain visibility into asset inventory, and assess risks.

The asset registry tracks metadata, the position of the asset in relevant processes, and dynamic data about the asset. Metadata includes information such as the stock of each item, serial number, part number, date the part was manufactured, where the asset resides, who is responsible for the asset, whether the organization owns or leases it, condition, documentation, and so on.

Assets rarely operate in a silo. They’re often part of larger systems where each asset impacts the other. The asset registry therefore tracks positional data (often called the equipment structure), which specifies where an asset is located within a larger system. For example, the asset could reside in a truck’s left front tire inside the wheel well. This positional data allows organizations to maintain a history of how the asset has been used. If the asset is ever refurbished and put into another structure, this information enables the organization to gauge its potential impact on the quality of that new structure.

Dynamic data is the condition data as assessed by manual discovery, tests, or telematic systems. It drives condition ratings, risk prioritization ratings, criticality ratings, availability ratings, and more.

02. Work history

Many organizations rely on original equipment manufacturer (OEM) specifications to tell them when to perform preventive maintenance and what steps to take. But by tracking all the data contained in actual work orders for each asset, organizations can maintain a real-world history of what happened to each of their assets that, with the right analytics, can enable them to better predict failures and maintain the asset proactively.

The work history tracks closing codes that indicate what happened to the part, solution codes that specify what exactly was done to fix it, as well as information such as who performed the work, tools and materials used, and how long it took to fix.

All of this data informs failure code analysis. Failure code analysis enables organizations to track an asset failure from the time it is reported until its resolution. Statistics from collected failure data provide information on when and why failures occur so organizations can take necessary steps to eliminate failure events. Ultimately, an organization can use the failure statistics to formulate its reliability centered maintenance (RCM) program.

03. Real-time condition data

Most of today's critical assets are connected to control systems through a complex web of sensors and instrumentation.

Internet of Things (IoT) and industrial IoT (IIoT) data that comes from these real-time sensors can show organizations the condition of a part or component at any point in time. This information can then be categorized and used to determine how to generate a failure signal that tells the organization when asset health is deteriorating. For example, an organization evaluating the condition of a set of ball bearings might want to create thresholds for when the rate of vibration reaches defined upper and lower levels of tolerance.

APM solutions can then combine these measurements with asset and work history data to gain a proactive understanding of when the bearing will break. If the bearing vibration reaches a threshold rate, APM can create an alarm or trigger a work activity that directs maintenance teams to fix it.

04. Algorithms and modeling analytics

Once an APM solution has gathered the necessary data, an organization can use algorithms to drive actions or employ artificial intelligence/machine learning models to enable “what if” analysis.

Algorithms
Algorithms collect asset registry, work history, and real-time condition data and use that data to predict how the equipment will behave in real time. Should the algorithm identify an impending failure, an alert will go off that can drive contextually specific actions that specify what to do, when to do it, and how to do it.

The results can also populate other systems in the organization to automate corrective actions. For example, the algorithm could generate an alert to the PLM system, which could in turn direct the creation of a specific part, an ERP system might manage the work order, an MRP system could modify production schedules and realign resources to prevent production delays.

Modeling
Analytics enable organizations to take asset registry, work order, and condition data to perform “what if” analysis to predict what could happen in the future under varying circumstances. For example, organizations performing reliability-centered maintenance can look at the reliability window that shows when the asset will fail and how it will fail and model what happens if some of the data that drives the failure changes.

They can use this modeling to predict how the asset will perform under various scenarios. For example, a utility company facing a Category 3 storm in New Orleans might use modeling to determine whether its pumps will be able to hold up to the expected storm surge. Or a department that sees $3 million is added to its budget can model various scenarios to determine whether to spend the money to purchase new assets or repair existing ones.

05. Connectivity

The more data an organization uses in algorithms or “what if” modeling, the more contextually driven the output will be. An APM solution should include application programming interfaces (APIs) to help gather condition data from systems such as process logic controls, supervisory control and data acquisition (SCADA) systems, and monitoring systems that provide data as inputs to the algorithms and analytics.

Once the APM algorithms and models have pinpointed specific actions to take, these results can drive automated processes that occur outside the APM. These activities may be automated within an ERP system, materials resource planning (MRP) application, warehouse system, supply chain execution system, or other application. The APM should therefore come with prebuilt integrations to other applications the organization may wish to use to implement the recommended action.

The benefits of APM

What are the advantages of APM? There's no simple answer. The benefits ultimately depend on the specific needs of any given organization. But one thing is certain. APM can deliver far-ranging benefits that include better planning for labor and materials, greater safety, and a more precise budgeting process.

Impact to labor

What organization doesn't want to use labor more efficiently? Yet simply reducing labor has the potential to negatively impact the business. And many organizations are unable to determine when reducing labor will have a net beneficial or harmful effect.

APM can help cut labor costs without adversely affecting the business by enabling organizations to cut out unnecessary activities and perform the right maintenance activities at the right time for the right reasons using the right human resources. For example, suppose the operations team lubricates the ball bearings in the machines on the assembly line every Thursday in a process that takes three hours. The team wants to minimize time spent on this activity. Because vibrations can cause ball bearings to gradually become spheres and ultimately break, it's important to determine when to pack the bearings with grease to reduce the vibration and when to replace them. That determination depends on factors such as how the asset is vibrating, how it heats up, and when it fails and when it doesn't. Once the APM solution enables the organization to understand these factors, the maintenance team can precisely answer the question of when to add grease or replace the bearing and can perform the right task when necessary without the need for superfluous trips.

Impact to materials

Many organizations keep extra materials on hand. They might stockpile spare parts so that if a machine on the assembly line goes down, they can fix it quickly to prevent widespread work stoppage. But extra materials can degrade over time. The cost and infrequency of use means that holding this extra inventory presents a financial risk, since the materials might pass their expiration date without ever being used. Alternatively, some other department might take the materials out of the storeroom without informing the team that initially ordered them, which means these parts would be no longer available when needed.

APM enables organizations to identify the key components they need to have on hand and which ones are not necessary to keep in inventory—reducing the overall cost of inventory and minimizing the risk that critical inventory will expire. This process considers the asset's nature, its operation, seasonality (if any), the OEM details, and other factors.

Impact to safety

With APM, organizations that perform ongoing monitoring of asset condition—using IoT sensors, for example—can combine condition data with work history data to perform analysis that predicts when that equipment will fail and what the potential result of that failure would be. In the case of the fertilizer plant, that information could have warned the staff in the storage area about the conditions that could cause the equipment to spark. Knowing that such an event could occur, the warehouse crew would have understood the importance of storing that equipment far from flammable materials.

Impact to budgeting

All organizations want to create accurate budgets. When it comes to asset management, precision budgeting means predicting what assets the organization will need to purchase or replace given operating conditions and business objectives.

Knowing what assets the organizations has, their condition, how they have performed under various conditions in the past, which are at risk, and which are the highest priority for replacement in any given area, time, or season enables organizations to better predict what repairs and replacements should be in the budget.

APM enables organizations to capture large amounts of data from assets over time, perform failure analysis and then model what will happen under various conditions in order to create more precise budgets. For example, a transportation company can model the impact of high heat in the summer or extreme cold in the winter on their trucks. Alternatively, as they look to invest in new equipment, they can model what would happen if they put electric vehicles on their routes. Would electric vehicles even work? Would the costs be the same?

One transportation company that uses APM has been able to operate within 2% of its planned budget for more than 15 years because the company knows so much about its assets and processes and has been able to streamline its inventory and inspection processes as a result.

Impact to Asset Investment Planning

Asset Investment Planning (AIP) is a data-driven capital plan that allows asset-heavy organizations to prioritize their capital budget in an efficient and justifiable manner so they can better manage assets and meet service objectives. AIP enables organizations to explore “what if” scenarios to create near- and long-term plans that consider service-level objectives, asset criticality, forecasted condition, acceptable risk tolerances, and financial constraints.

When APM is integrated with AIP it provides many of the inputs necessary to perform an analysis of what assets to invest in, whether that investment should be for repair, refurbishment, or replacement and when the investment should occur.

For example, APM provides an inventory of all assets in the organization. It tracks the condition of each asset, its rate of deterioration and remaining life as well as which assets are likely to fail, and which are likely to run in a steady state for many years. It also helps organizations determine the criticality of that asset to the business and the consequences of failure.

AIP informs the APM plan to ensure investments are made taking financial requirements into consideration as well. For example, if the organization determines that it will need to replace significant numbers of assets 10 years down the road, the organization might want to start its replacement program early to avoid taking a large financial hit all at once.

1. PwC and Mainnovation, Maintenance 4.0, Jan 17, 2019
2. Simio LLC, “Simio’s 8 reasons to adopt Industry 4.0,” April 12, 2018.
3. Industrial Maintenance & Plant Operations (IMPO), Moving Through the Maintenance Maturity Model, February 14, 2020.
4. IMPO

Evolve your EAM solution to APM today

Asset-intensive organizations are intent on increasing their maintenance maturity so they can do more with less without impacting their operations. By evolving their EAM solution to incorporate APM capabilities, these organizations can manage and analyze the vast amounts of data and automated workflows necessary for predictive and prescriptive maintenance. Not only can organizations use APM to understand assets better, predict failures, and manage failures better, they can simplify their operations through use of a single system. As a result, organizations can reduce inventory and labor costs, improve safety, and create more accurate budgets.

Learn more

About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Hexagon's PPM division empowers its clients to transform unstructured information into a smart digital asset to visualize, build and manage structures and facilities of all complexities, ensuring safe and efficient operation throughout the entire lifecycle.

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