Understanding the Enterprise Asset Maintenance Maturity Model

A framework to guide manufacturers toward optimum EAM
Introduction
Now that most manufacturers have started deploying Industry 4.0 technologies, many are taking a closer look at how to leverage them in one of their most critical functions: asset maintenance. However, sorting through when to use which technology to improve maintenance on a wide variety of assets can be confusing even for the most digital-savvy executive. Which assets need to be upgraded immediately to the next level of maintenance, and which can wait? What are the benefits and drawbacks of each level of maintenance maturity? What technologies are required to achieve varying levels of maturity? Even what level of maturity is the organization as a whole operating at now?

That’s where the Maintenance Maturity Model comes in. This framework helps leaders identify their current state and create a roadmap leading to optimum EAM. Here’s a quick look at the model’s five levels of maturity.

Reactive Maintenance
At the first level of asset maintenance maturity, reactive maintenance, industrial organizations allow factory assets to run until failure before repairing or replacing them. Because they view any effort to proactively maintain assets as a waste of resources, they invest a bare minimum into maintenance. Some organizations at this level even postpone purchasing replacement parts and forego retaining a maintenance staff. For most manufacturers, this level is a historical vestige that’s no longer relevant.

Benefits: The money saved with reactive maintenance comes from not paying for a large maintenance staff or parts inventory, as well as not taking the asset offline while it’s working just fine.

Drawbacks: The unplanned downtime and production delays that result from a reactive maintenance strategy wreak havoc within manufacturing plants, which reverberates through the business.
Digital Tools & Technology: Reactive maintenance is a manual process that does not require digital tools or technology.

Strategy Considerations: Few, if any, modern industrial organizations practice reactive maintenance extensively. However, the approach still may have a place when optimizing an EAM strategy. For example, a reactive approach can be practical when an asset is non-critical, where a malfunction will not result in a work stoppage, or when the asset can easily and inexpensively be fixed or replaced. In a large factory setting, for example, an organization may decide to replace light bulbs in non-production locations only after they've burned out.

Maintenance staff rushes to repair downed equipment as the time-is-money pressure bears down. Operators brace themselves for the chaos of catching up once the machine is back online, and customers await late delivery. Ancillary costs rise, also. When assets are not kept in good condition, they tend to have more serious and costly mechanical failures, which would have been avoided with a more proactive maintenance approach, and safety and environmental risks increase.

Preventive Maintenance
Once manufacturers realize that the costs of unplanned downtime outweigh the resource “savings” from reactive maintenance, they graduate to practicing preventive, or scheduled, maintenance. This approach takes into account the full return on investment of proactive maintenance, including reduced unplanned downtime and improved asset availability.

At this level of maturity, manufacturers plan routine inspections on fixed schedules, lubrication, adjustments, and full or partial service to improve mean-time-between-failure (MTBF) and extend the lifespan of the equipment. They also maintain spare parts inventory to speed repairs. Generally, this planned maintenance follows the asset builder’s guidelines, based on its understanding of the asset's expected runtime and an estimate of the asset's projected lifespan.

Benefits: Preventive maintenance reduces unplanned downtime, extending the MTBF and, in most cases, the asset’s lifespan.

Drawbacks: Performing maintenance on healthy machines involves incurring unnecessary costs and downtime, yet still leaves the organization vulnerable to experiencing a failure between service intervals.

When you take your car for an oil change on a set schedule, whether based on mileage or time, you’re likely to be changing it earlier than necessary. Similarly, taking machines offline for preventive maintenance means falling short of maximum asset uptime and sometimes performing more maintenance than is needed.
Digital Tools & Technologies: At its most rudimentary, preventive maintenance requires no more than the asset’s owner’s manual and a calendar. Some manufacturers maintain electronic calendars and set scheduled alerts. The most advanced organizations invest in EAM at this stage to help them manage maintenance routines and maintenance, repair, and operations (MRO) inventory.

Strategic Considerations: At a minimum, most production equipment requires preventive maintenance to avoid costly breakdowns that cause downtime, to ensure upstream equipment is not also damaged, processes are not disrupted, and safety and environmental risks are reduced.

Condition-based Monitoring
To further optimize a preventive maintenance strategy, industrial organizations adopt condition-based monitoring of the critical aspects of assets that are vital to operations. These assets include those that will impact upstream equipment and processes, whether by causing other machine malfunctions or work stoppages.

With awareness gained from preventive efforts, manufacturers can identify parameters—such as vibration, temperature, or pressure—and key performance indicators that diagnose the part’s health. With close monitoring, operators confirm whether conditions are within normal ranges or take action when they’re not.

Benefits: By monitoring a potential single point of failure and being alerted to an out-of-spec condition, manufacturers can take action to rectify the situation before the deviation negatively impacts production.

Drawbacks: Because this approach looks only at a few critical failure points on specific vital equipment, it leaves unknown the health of the asset as a whole. Also, gathering and analyzing the data and determining countermeasures is a time-consuming process if done manually.
Digital Tools & Technology: Early efforts to implement condition-based monitoring can begin manually. For example, having discovered through earlier preventive efforts that a piece of equipment works best when the oil pressure or coolant temperature falls within a specific range, operators can conduct regular checks and take action when necessary.

Most manufacturers quickly discover the benefits of automated monitoring. Production facilities have numerous sophisticated pieces of equipment, each of which, in turn, has various potential failure points. With IIoT sensors monitoring the condition and transmitting the data to an EAM system, the data collection and analysis that would be overwhelming as manual tasks are completed with ease.

Strategic Considerations: Every industrial organization has equipment so vital to operations and business performance that condition-based maintenance is required.

Organizations maintaining assets at this maturity level are starting to understand the business-wide implications of asset maintenance, and so are creating corporate policies and documented business processes to manage these critical assets. Their maintenance professionals also will have a structured program for continually improving asset reliability, maintenance productivity, and MRO supply chain performance.

Predictive Maintenance (PdM)
The fourth level of maintenance maturity extends condition-based monitoring to all aspects of an asset. By increasing the deployment of machine sensors and condition monitoring tools, companies streamline the capture of data—vibration, flow, pressure, temperature, wear, energy consumption, and lubricant health, among others. This data informs predictive analytics, which then automatically alerts operators when a reading deviates from a predefined range. Such systems allow for proactive repair, replacement, and problem-solving based on actual use.

For example, today’s cars have sensors that continuously monitor oil pressure, tire inflation, braking and cooling systems, and the like. Drivers can check these parameters via dashboard monitors and are alerted when the system detects that service is necessary.

Benefits: Predictive maintenance eliminates the breakdowns of reactive maintenance, the waste of unnecessary resource use of preventive maintenance, and the too-narrow focus of condition-based monitoring. Instead, PdM ensures that maintenance is completed based on real-time use, never too early or too late, which is the most cost-effective way to keep the line running.

Drawbacks: Though PdM streamlines the capture and analysis of asset condition data, well-trained maintenance personnel still must know what action to take upon receiving a system alert.
Digital Tools & Technologies: Organizations maintaining assets at this level of maturity use advanced technology, such as the IIoT and enterprise asset management (EAM) software, to automate the data collection and analysis needed to monitor asset condition. More sophisticated management systems feature artificial intelligence and some machine learning, which enable the system to improve asset maintenance continuously.

To manage the massive amounts of data that are collected, manufacturers must begin to adopt new data management technology and strategies. Many will move at least some data to the cloud, a vast network of remote servers that are accessible via internet-capable devices, which operates as a single system to store and manage data and run applications. In some cases, they will maintain some data in on-premise systems.

In other situations, they will consider edge computing, where the data and computing resources are located near a data collection device, which minimizes the need for long-communication back to a central server (whether cloud or on-premise). An edge computing solution is useful for meters, video cameras, and sensors whose data are used locally, and transmission delays (latency) are unacceptable. Leveraging edge computing also reduces bandwidth usage on the network.

Strategic Considerations: PdM requires a significant amount of operations data to create algorithms that inform predictions.

Organizations should not expect to leapfrog earlier maturity levels to deploy predictive maintenance. Instead, companies should gather and begin compiling the data needed for PdM as they move through the levels.

Prescriptive Maintenance (RxM)
At the most mature level of maintenance maturity, predictive maintenance combines techniques from other levels with operator involvement and more extensive automation. The increased automation shifts even more of the work previously performed by maintenance personnel to the system. Prescriptive maintenance (RxM) systems not only identify issues before they happen, but they also advise maintenance personnel the actions to take to avoid asset malfunction.

Benefits: By allowing the automated system to execute more tasks—collecting and analyzing data, maintaining spare parts inventory, and determining repair processes—prescriptive maintenance frees maintenance technicians to focus on broader scope repair data analysis and major maintenance activities.

Drawbacks: To achieve prescriptive maintenance requires enormous amounts of data, and not every asset requires such an intense maintenance approach.
Digital Tools & Technologies: Prescriptive maintenance is the most digitized maintenance approach available today. At this level, advanced technology integrates multiple systems, including EAM, inventory, and reliability-centered maintenance (RCM) systems. RxM also leverages advanced IIoT; optimized allocation of edge, cloud and on-premise computing; and EAM software with AI and machine learning capabilities. The AI and machine learning algorithms get smarter over time, becoming more accurate at predicting the time of a potential failure, determining the root cause, and prescribing what to do to keep it from failing. All the analysis is done in real time, taking into account the asset’s current condition and its environment.

The integration enables the system to monitor an asset, analyze the data, send an alert, produce work orders and tool requests, order replacement parts, and inform maintenance personnel of tooling and process needed to return the asset to optimum performance. In doing so, it optimizes maintenance while improving safety, compliance, efficiency, reliability, and production quality.

Strategic Considerations: Corporations that are using RxM view maintenance as a strategic differentiator and include maintenance as part of the total company business plan.

An optimum EAM strategy will execute maintenance at all levels of maturity, depending on how critical an asset is in helping the organization achieve its business objectives. Asset management is a journey with a continually changing destination, and technology helps guide the way.