The Keys to CBM/PHM Success
How to avoid the pitfalls and plan for a win
Introduction
Maintaining and increasing asset performance while reducing the cost to maintain, repair, and replace it is a key priority for organizations across all industries. Downtime of mission-critical assets results in higher repair costs, customer dissatisfaction, and lower revenue.

To mitigate this risk, many companies are turning to Condition Based Maintenance (CBM) programs. Predictive Health Maintenance (PHM) is another term that is commonly used to refer to these programs. While some organizations see tremendous results with improved productivity and controlled costs, others spend millions of dollars only to be disappointed in the implementation, data received, and, ultimately the value. What differentiates the two?

In this paper, we will take a look at some of the most common issues and challenges that cause CBM deployments to fail.

CBM Defined
CBM is the next-phase culmination in the evolution of maintenance for strategic assets. In early years, it was common for organizations to maintain all of their equipment with a run to failure strategy. This approach might be appropriate for those assets that have little to no impact on production and, importantly, create no safety issues when they fail. However, for more strategically important assets, organizations progressed to a time-based preventative strategy with scheduled maintenance and overhauls. While effective in keeping assets operational, this approach incurs additional costs. Overall productivity drops throughout the life of the asset due to the duration of these scheduled maintenance events, overhaul and parts replacement actually “throws away” unused remaining operational time, spare parts inventory increases in order to facilitate this type of maintenance policy, and maintenance expenses in general increase with recurring scheduled maintenance.

It’s for these assets that CBM advanced: from failure- or time-based to condition-based.

CBM is a maintenance strategy in which asset managers actively supervise the health condition of assets to perform maintenance on time and only when needed. CBM uses sensors that are purposefully and strategically placed on assets to stream data to that quantifies the current health of the asset and provide insight into impending degradation in that health.

This approach provides an efficient, cost-effective maintenance method based on the tangible, current condition of each maintained asset. Equipment that is consistently in good condition does not need to be maintained as frequently. CBM anticipates assets reaching an age or profile that results in decreased efficiency due to changes in failure modes or frequency. CBM programs seek to decrease the number of maintenance events on assets over their lifecycle while reducing the risk of unplanned failures. CBM can provide enough lead time to optimize planned use of maintenance resources. The goal is to reduce unnecessary maintenance and anticipate scheduling of required maintenance to control lifecycle costs of maintenance.
The Three Levels of CBM

**Level I** CBM focuses solely on replacing or delaying scheduled maintenance until the asset, or component within the asset, signals that it is time for maintenance. This is a reactive approach to asset management as there is no prognostic capability, and thus not largely different from a run to fail approach. The sensors provide real-time information as to whether or not the asset needs maintenance now. While this approach often has the benefit of recognizing failure just before it happens and reducing the risk of catastrophic, this reactive take is not an effective maintenance strategy for mission-critical assets and does not save on costs in the long run.

**Level II** CBM begins to integrate prognostics. In its best form, Level II includes a diagnostic evaluation along with a mathematical prognostic element – *predictive analytics*. This approach enables asset managers to plan when maintenance will be needed based on an asset’s predicted symptoms, and what type of maintenance will be required. Level II starts bringing CBM’s promise to life: maintenance takes place only when required and the lifecycle cost of maintenance activity and materials is controlled. Asset managers see reliable advance indication of the maintenance needing to be performed so that maintenance planning schedules can be optimized and maintenance materials can be prepared.

**Level III** of CBM, the most complex, is connected to the supply chain. This level allows asset managers to further optimize maintenance schedules, perform maintenance only when necessary, and to right size inventory holdings over time that support asset maintenance. This level includes all the benefits of CBM Level II – and, in fact, is only possible to achieve by building upon a mature Level II program. Level III CBM adds the ability to optimize supply chains and warehousing of spare repair parts across a multi-tiered support infrastructure. The cost savings alone in right-sizing maintenance inventory for the entire organization delivers high ROI: asset managers can vastly reduce the amount of inventory they traditionally keep on hand, both for local operations and for organization-wide support, when they have enough lead time to get repair parts where they are needed, when they are needed. This represents a true just-in-time strategy realized.
The Challenges of CBM

The number of failed or successful CBM implementations is unknown and so is the resulting ROIs, yet most asset managers are familiar with one or more CBM projects that either failed or vastly missed their target ROI. Here are common pitfalls that derail CBM programs:

Poor sensor implementation

As sensors and the data they transmit are the core of any CBM program, poor implementation of these sensors will perforce inevitably wreak havoc on the initiative. What affects implementation?

Partial CBM coverage. While CBM programs can offer higher fidelity information about the health of a specific asset or component, in the majority of organizations, CBM covers just a small portion of asset components – and for those that are covered, only specific failure modes are targeted for monitoring. Implementing a complete sensor processing solution, one capable of accurately representing the complete asset health, is challenging. Even in the most comprehensive CBM programs, only between 2% and 20% of the components installed on assets are equipped for CBM.

Dysfunctional sensors and poor sensor placement. As CBM depends on sensor data, the placement and effectiveness of the sensor, whether embedded or temporary, plays a deciding role in any deployment’s success. In general, the revenue-generating, mission-critical assets that companies target for CBM are in motion, and in many cases, operate in harsh environments. As a result, oftentimes the placement of the sensor can be suboptimal or ineffective. This is especially the case of embedded sensors that require significant design attention to provide the necessary information for accurate, ongoing asset health assessments, as well as future prognostics on impending asset health problems.

Sensor technology and robustness as well as physical limitations of sensor placement are all significant factors that can limit the success of CBM programs.

False Positives & False Negatives. Health monitoring sensors can produce false-positive indications from time to time that cause an asset to be removed from operation for maintenance when maintenance is not actually needed. In cases of poor sensor implementation or faulty analytics, the rate of false positives may be high enough to cause an unacceptable level of unproductive maintenance events and increased maintenance costs.

False Negatives are just as serious: failures are missed producing a false sense of security that could return an organization to the unacceptable run to failure model — which could be drastically more expensive in multiple ways (damage parts and assets beyond repair, increase down time for repair, etc.)

Working with a CBM prognostics vendor that can detect, accurately account for, and compensate for these False Positives and False Negatives is key to any CBM implementation.
Lack of a holistic approach
Just as CBM must be deployed across a material segment of an organization’s assets to be effective, the CBM program itself must be part of a comprehensive approach to have the intended impact. Unfortunately, many organizations view CBM as a stand-alone initiative, and suffer the consequences.

Reactivity leads to initiative abandonment. Many companies start with CBM Level I, but as reviewed above, this is an ineffective maintenance strategy due to its reactive approach. It provides little insight on when to perform maintenance until breakdown. Lacking reliable warning of impending maintenance needs, required repair parts are still stocked as if the company were utilizing a time-based maintenance strategy. The only realized benefits to this CBM strategy is that hopefully the number of maintenance events demanded by the asset is lessened. Seeing no appreciable benefit from CBM, the organization abandons the initiative entirely, rather than moving on to more proactive level.

Data quality. For CBM to be most effective, it needs to be part of an overall strategy that leverages data from multiple systems, such as maintenance data systems (CMMS), Asset Management, ERP, Supply Chain, among others. As such, managing data quality should be part of the overall organizational approach and considered early in the product lifecycle as well as maintained consistently throughout the entire process. This is done using cross-functional, collaborative methods so that the information obtained in one system or lifecycle stage is available to relevant processes in other lifecycle stages. Information must be visible throughout an organization to ensure that any and all decisions requiring quality data are informed in a timely, efficient, and accurate fashion.

As part of an overall strategy, CBM can help the organization optimize its inventory strategy, seamlessly allowing it to take appropriate action from the CBM data. In essence, CBM may seem reactive due to the fact that a failure can still occur, but it is in truth proactive because analyzing the data allows asset managers to anticipate the failure ahead of time more accurately, therefore adjusting solutions more quickly.

When CBM is seen as an independent initiative separate from the other systems that drive the organization, it cannot deliver to expectations. Hence, companies either never escape from a time-based scheduled maintenance strategy, or quickly default back to it, as they see no benefit from their foray into CBM. Without reaching Levels II and III, most CBM programs lack the sophistication to forecast asset health, including future performance, asset maintenance, and asset repair parts. As a result, maintenance becomes reactive rather than proactive.

Data Overload
If implemented correctly, a CBM program generates a high level of data. While this data holds the key to unlocking the potential in CBM, it also brings its own challenges. Fortunately, these tend to be big data and predictive analytics issues that can be addressed with the right mix of skills and software.
Data Collection and Storage. There exist enormous challenges around the raw data generated from the sensors themselves. Collection and storage of such large amounts of data into a big data repository requires coordination and a sophisticated back end. Without addressing this part of the data collection equation, the organization is not able to leverage the full set of data for use in decision making.

Taking action on the data. Organizations that have made it this far have most likely started seeing some of the benefits of their CBM implementation: a much better view of their assets, their current health, and some level of visibility on upcoming maintenance. However, some organizations fail to take the next step by fully leveraging their data for accurate reliability analysis and failure prediction. Many existing sensors provide no directionality (trending) information. The lack of directionality, or ability to isolate a change in sensor readings to a particular component, allows for uncertainty in the feedback. So, although the organization has seen some benefit from CBM, it is not yet in a position to maximize the potential and avoid productivity loss along with the costs associated with it.

Predictive analytics can uncover savings using a wide variety of data sources. Sensor data should be married with other system data such as historical maintenance and operational data to be intelligently monitored, processed, and mined for valid diagnostics, prognostics, and predictions. The capability of the CBM prognostics to consume, clean, and harmonize all the data is key to producing high-fidelity prognostics.

Faulty Analytics. Organizations must consider what type of approach is best suited for them to predict their future maintenance needs. While many analytics solution providers claim to provide predictive analytics, their methods can vary greatly and each tends to focus on a very narrow subset of approaches to analytics. Organizations should consider the breadth of methodologies supported when assessing solutions. Even within the same industry, different organizations will require varied approaches to assessing sensor capabilities and developing advanced detection. CBM technology must be customized to deliver desired results. Successful CBM is rarely carried out with an off-the-shelf solution. An analytics solution that supports multiple, customized approaches has a much higher probability of success.

For organizations looking beyond CBM Level II prognostics and have an eye on CBM Level III for supply chain integration, there is an additional aspect to consider. They should consider an analytics platform that goes beyond over-simplified predictive analytics that determine future metrics solely on historical data and more advanced, accurate approaches that leverage simulation to allow asset managers to combine data from past events with anticipated future events to make the decisions that best improve production and usage goals.

The Path Forward
Organizations considering a CBM implementation must do so as part of a larger holistic approach to their asset management systems and processes. This includes everything from how
data is gathered, data integrity across systems, and how the resulting data is leveraged to deliver business value.

This last part is the key to ensuring that organizations can see the promise and ROI of CBM, instead of finding themselves with terabytes of data and no real answers. Making the best decisions about the future of assets requires the right tools. Predictive analytics technology can produce detailed models of the future based on a set of ever-growing data from the assets. The variety of these models and simulations is virtually limitless, allowing an asset manager to see changes in the bottom line as factors in their asset’s lifecycle are manipulated.

Once an organization has successfully implemented its CBM program, it can take the next step into comprehensive asset lifecycle modeling, in which mature CBM programs add greater value through a higher fidelity characterization of asset and component future behavior. Lifecycle modeling simplifies the data management process by constantly updating operating data, ensuring maintenance strategies and other key performance indicators are always up to date. Unlike traditional forecasting methods that make predictions by trending historical generic procurement data with no reference to cause future operations, and aging, lifecycle modeling enables planning based on the current condition of individual assets, component aging, planned usage, intended operating environment, logistics network already in place, and other support systems. This root-cause driven planning, coupled with near-reality modeling of assets, and support infrastructures enables a high level of accuracy years or decades into the future. Lifecycle modeling capabilities build value on top of CBM systems to form a more comprehensive approach that brings greater value while seamlessly integrating with mature CBM programs.

**Conclusion**

If implemented correctly, CBM programs can help organizations increase productivity while controlling the cost and time of maintenance of mission-critical assets without impact on their operations, users, or customers. However, organizations are counseled to understand going in what the challenges will be, and set up themselves and their CBM initiatives for success. Data about assets is only actionable if it’s understandable and usable.

In fact, in some instances, a CBM based maintenance strategy can increase capital expenditures initially, but the payoff of implementing such a strategy over the lifecycle of an asset grows over time with more productivity, squeezing the most out of assets and equipment. A well-designed CBM program overcomes initial costs through improved maintenance and supply strategies to maximize asset operational time and profit.

Ensuring that the CBM program is part of a comprehensive approach – one that puts CBM at the center of a data capture strategy – is a good place to start. Following that up with the tools to manage, understand, and leverage the data is critical.
Clockwork Solutions is a global leader in predictive analytics solutions for organizations with strategic, high-value fleets and assets with a focus on improving asset availability, reducing parts inventory, and controlling maintenance costs. With more than 30 years of experience delivering solutions for Fortune 500 enterprises across multiple industries and military organizations worldwide, Clockwork delivers a full range of solutions ranging from Extract-Transform-Load (ETL) data capabilities through to Condition Based Maintenance, Predictive Health Management, and full Lifecycle Management.

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