Taking the first steps towards condition-based maintenance in the rail industry
Transportation maintenance managers are increasingly coming to realize that performing maintenance on a fixed schedule is wasteful. Many are therefore transitioning to a condition-based maintenance strategy. This paper describes a five-step process for successfully making that transition.
Asking the obvious question

In a meeting with a maintenance services supplier, a rail company’s maintenance manager described the scenario of his wife and her new car. He explained how the car displays messages on the dashboard regarding potential maintenance issues and suggests the appropriate response or action. It simultaneously sends a message to the dealer alerting them to the issue. “Why,” the manager asked, “couldn’t the same scenario play out with my signals, switches and other assets?”

Why not indeed? That rail network company is now far along in the process of deploying a condition-based maintenance (CBM) solution that is accomplishing just that.

Managers and engineers in a growing number of transportation organizations are realizing that successful CBM deployments result in lower maintenance costs with increased reliability. In fact, in 2019, Zpryme Research found that 72% of transportation industry survey respondents planned to implement a new asset maintenance strategy and system in the next 1-5 years¹.

The transition by transportation providers from time- or interval-based maintenance to CBM is accelerating. Resistance to the transition is eroding as the financial, performance and reliability benefits become clearer, and as the next generation of maintenance personnel, not steeped in the culture of interval-based maintenance, enters the field.

In this white paper, we will describe how transportation organizations are capitalizing on the increasing availability of digital asset data and improved communication infrastructure as they adopt CBM to optimize their maintenance efforts. We will describe a five-step process to transitioning to CBM, and identify common barriers to successful implementations and how those barriers can be overcome.

¹ Capitalizing on the digital revolution with connected asset lifecycle management for the transportation industry, Zpryme Research, April 2018
Facing change

Resistance to change

The appeal of CBM is that it is highly intuitive. For example, no homeowner will automatically repair or replace their roof after a fixed time interval. While the warranty may indicate the owner could expect 15 years of life, weather conditions and other factors will greatly shorten or extend actual life. Thus, homeowners will devote money, time and attention to a roof only when it begins to show trouble. Similarly, with equipment, actual duty levels and asset condition should drive specific maintenance schedules.

Regardless, many transportation operators continue to cling to an arbitrary – and often overly-cautious – time-based approach. There are a variety of reasons: Some appreciate the simplicity of a system that requires little more than a calendar or checklist to determine when it’s time to perform maintenance. Some believe the technology needed to do otherwise is too costly. And for many, it is a simple matter of tradition: They do maintenance the way they have always done maintenance.

Overcoming these barriers requires culture change, combined with a knowledge refresh on the technology available, its cost, and how it can be appropriately applied.

Creating the culture of change

The first incorrect belief to dispel is that CBM is a more expensive approach. “There is an upfront investment, which varies with the size and scale of the transit operator and the scope of their implementation,” says Matt Zafuto, SVP, Global Corporate Strategy and Business Development. “But the payback is fairly swift, typically in the one- to three-year range. According to our analysis, a catastrophic asset failure can cost up to 10 times the price of the equipment itself and have negative flow-on effects. Considering the fact that CBM is much more likely to identify problems prior to failure, the financial prudence of monitoring equipment health becomes even clearer.”

Mining, manufacturing and other markets have already embraced the fact that CBM enhances performance. “Many industrial operations have adopted a CBM approach,” says Sarah Anstee, ABB Transportation Segment Manager, “driven by the basic need to be more productive, cost-effective and competitive.”

Metrics related to CBM in manufacturing are impressive. The ARC Advisory Group reported that the cost of performing predictive maintenance could be up to five times less than preventive maintenance, and 10 times less than corrective maintenance, before factoring in downtime costs².

“The rail industry is early in the change process, but the transition to CBM is underway,” Anstee continues. In addition to regulatory pressures such as the US Federal Transportation Administration’s Final Rule, which carries imposed penalties for not developing and executing on state of good repair plans, transit operators are responding to the accelerating attrition of skilled technicians. “The transportation industry has started to see success with CBM in other industries, and those practices are increasingly migrating to other areas as operators strive to automate and simplify the maintenance process.”

Whether it’s a driver or the result of the shift to CBM, another essential cultural change well underway is the convergence of information technology (IT) and operations technology (OT). Functional silos within transportation operators are crumbling as IT and OT personnel increasingly work together to capitalize on the value to be garnered from organization-wide data streams. Data that was gathered in isolation by different functional areas of these businesses is now being consolidated and used to make smarter and more efficient maintenance and business decisions.
A five-step strategy for successful CBM

Once a transportation organization overcomes the cultural impediments to a CBM implementation, how do they prepare to embark on this new path? Rick Nicholson, VP of Global Digital Business Development for ABB Power Grids, offers a five-step framework.

Five steps to condition-based maintenance:
1. Assess your assets
2. Gather the data already available
3. Add new data collection/sensors
4. Aggregate the data
5. Analyze the data

1. Assess your assets

Certain maintenance strategies are better for certain assets than others. The optimal maintenance strategy is dependent upon a number of factors, including the cost of failure, the return on investment, and the full lifecycle cost of the asset.

For example, a piece of equipment that is not essential for operations may be best served by a reactive “run to failure” strategy. It may be more cost-effective to fix non-critical assets only in the event of a breakdown. However, if the cost of replacement is high, the impact of failure is significant, or if supply is limited and/or carrying inventory is expensive, a more predictive, condition-based maintenance strategy may be more appropriate.

Preventative maintenance is the most commonly used strategy today, where inspections and repairs are done at predetermined intervals (time or usage). While quite easy to set up, this strategy tends to be expensive, as it may potentially lead to over-servicing assets or not delivering service when needed, thereby resulting in costly failures.

To assess which strategy is most appropriate for an asset, you must consider information such as:
- Mean time between failures
- Mean time to repair
- Maintenance costs
- Impact of a failing or poorly performing asset

With this information in hand, a cost/benefit analysis can be performed to determine the ideal maintenance strategy for each of the different asset types.
2. Gather the data already available

Many organizations are sitting on a rich trove of asset health-related data with the potential to provide tremendous insight into the status of their assets.

“Transit providers are already collecting data to assess the condition of their equipment, even those that have no formal monitoring or data management system in place,” says Nicholson. “At every organization, operators and field technicians go out and look at sensors and operating conditions and record their findings in some kind of system. They already have the data. They just need to do something with it.”

“They have records about the kind of maintenance they’ve done in the past,” adds Daniel Simounet, Vice President, Transportation Sector, ABB. “What kind of system issues have happened? What’s the history of that equipment regarding number of operations, known problems and asset age? The asset history may be in many forms. When we’re asked to do equipment assessments, we often get a box full of paper records as the starting point. That’s all good data.”

Data gathering is something the operator can do as a low-cost first step towards a CBM system. What exists in their maintenance management system? Are individual engineers or maintenance managers already capturing data in homegrown repositories? The data collectors should throw their net wide and gather from the widest range of sources possible.

But while more data is always better, it’s not just about the quantity. “While it’s good to have as much asset information as possible, keep in mind that each piece of data isn’t equal,” says Anstee. “For example, the condition of the seats in a carriage isn’t as critical to an operator as the failure of a switch at a point. Although both assist in the overall view of the asset’s health, the failure of a switch is infinitely more important to the safe and efficient operation of a service than if a seat cover has a coffee stain. The algorithms used in the CBM analytics assign appropriate weights to the different assets, add metrics, and integrate them appropriately into an overall holistic view.”

IT can be a valuable partner in this effort, supporting the data collection, consolidation and organization. It can be a big effort to bring all the information back to one point, and a bigger effort to do that as a routine process. But a unified data repository is a foundational element of successful CBM implementations. As companies begin to seek out asset data, they often find that the answers to many questions about effective maintenance were there the entire time.

Unsurprisingly, manually collecting data on a regular basis often proves too time-consuming, and many agencies discover gaps in their asset health data. With that realization, they move to the next step and determine what sensors or monitors should be added in order to automate data collection and provide the total picture of the condition of their assets.

3. Add new data collection/sensors

As operators consider the best approach to deploying sensors, they should be guided by the experience of others who have already traveled that road.

“Customers tell us that any decision to invest in monitoring must be made prudently,” says Nicholson. “It’s not feasible or necessary for every component to be monitored. A cost/benefit analysis will point to specific needs for improved data collection in localized segments of the network, such as those critical to seamless operation or that represent reoccurring reliability issues.”

To this end, operators will invest in monitoring capabilities on assets whose failure would involve major repairs and service interruptions, hindering the lines’ performance. Other information gaps may be allowed to remain. For each class or type of asset, there are key operational metrics that can be readily monitored and that provide good indicators of asset condition and maintenance requirements.
“The business case still isn’t quite there to add sensors to an entire transportation network and all of the equipment found there,” observes Zafuto, “but that case is shifting with recent sensor developments. Customers have started focusing on the high value or high impact to service or safety parts of their networks and are now adding more sensors and data. Over time, we expect this to continue to accelerate.”

Falling prices, increased simplicity and greater reliability of sensors are spurring a growth in penetration. Further, the increasing availability of IP communications networks in facilities is making it easier to gather and collect data from these sensors, further driving their proliferation.

Sensor simplicity is a recurring theme in many successful CBM implementations. “One agency opted originally for very smart sensors,” Simounet recalls, “Those sensors turned out to be overly complex, so the crews ended up doing more labor because the sensors themselves required maintenance. Better to rely on simple sensors and put more of the intelligence downstream in the software performing the analytics.”

4. Aggregate the data

With the appropriate sensors in place, what’s needed next is the pipeline to gather and convey that data to an electronic database for consolidation, processing and utilization to create a complete and clear image of maintenance requirements.

Not only is it the basis for the organization’s CBM processes, this consolidated data also can be leveraged for supply chain management and other applications.

The cost and difficulty of data aggregation continue to decline as the communications networks required to interconnect them expand in both size and capability. Although mainly discussed as a consumer resource, the Internet of Things has taken hold in both consumer and industrial devices as more smart devices come online.

The scale and ubiquity of this new IP connectivity is demonstrated by IHS Markit research. According to IHS, there were 27 billion Internet-connected devices in 2017, and that number is projected to grow to over 125 billion by 2030.

The growth of transportation initiatives and the related communications networks continues to drive development of standards and protocols related to IP communication for industrial applications, ensuring consistent architecture and high functionality. Widespread IP communications, low processing costs and continued deployment of intelligent equipment provide a prodigious data stream, ready to be converted into actionable information supporting enhanced maintenance crew effectiveness.

“The final element is the analytical software that makes sense of the data to guide maintenance activities,” says Anstee. “Analyzing this data is no trivial task, considering the volume of information and the disparate sources and formats, but machine learning and performance algorithms are identifying correlations between seemingly unrelated points of data that would have been thoroughly impossible even three to four years ago.”
5. Analyze the data

Some organizations seek to extend the application of their existing asset management systems by repurposing them for CBM analytics. Unfortunately, those systems were originally designed to house relatively simple, planned maintenance programs, not dynamic CBM programs. Tasking these older systems with CBM is likely to result in overloading the system and under-utilizing the data collected.

Many transportation organizations have in-house experts who can define the basic rules or algorithms to drive the CBM system. Typically, though, this area is best left to experts who possess experience with equipment-performance models related to the targeted asset classes being monitored.

“Transit operators are typically staffed with very intelligent and experienced engineers,” says Simoumet. “What they often lack is extensive knowledge of switch or signal degradation and failure, and few of them have the analytical tools needed to create an optimal CBM plan. OEMs know the thousands of ways signals break and can apply that knowledge to predict issues with the customers’ assets.” That experience ensures that the analytics consider the best metrics to assess current asset health and predict potential issues.

“Selecting the right analytical tool is critical,” states Nicholson. “Operators need to select an open architecture solution that doesn’t lock them into a narrow range of sensor types or data formats. That way the sensors can be off-the-shelf and the processors generic. The power of the system resides in the algorithms processing the asset data. Most technology refreshes and capability enhancements can then be accomplished at the software level.”

Transportation organizations should understand that their CBM applications are not a “set-it-and-forget-it” proposition. The algorithms are moving targets that need regular updates to incorporate the most current asset experience.

Advantages of condition-based maintenance:
- Extend asset life
- Improve equipment reliability
- Enable root-cause problem solving
- Minimize maintenance spend
- Minimize overtime costs
- Minimize spare parts requirements
- Optimize maintenance intervals
- Improve worker & customer safety
- Reduce unplanned signal system outages
- Lower rolling stock downtime instances
- Reduce maintenance errors
- Simplify regulatory compliance and reporting
From baby steps to giant leaps

Deployment of a network-wide CBM system is a daunting task, deterring some organizations from launching this initiative. Nevertheless, many transit operators have tested the water and met with success by limiting their efforts to a narrow slice of their assets.

“You can’t start too small,” Nicholson believes. “You don’t have to take huge bites. Determine which assets to monitor based on the potential savings in routine maintenance or improvement in reliability. Based on their criticality, switches, signals and rolling stock are good places to start. They also tend to have existing service and performance history. It doesn’t take as many dollars as you might think to make a big improvement in reliability, so this is this best place to launch their CBM efforts.”

Nevertheless, some transportation providers have made a major initial commitment to their CBM systems. For example, Network Rail, owners of the UK’s rail infrastructure, launched a major initiative called Offering Rail Better Information Services (ORBIS) to boost the safety & efficiency of its railway infrastructure.

Network Rail wanted to reduce their risk by moving to a more proactive strategy of predicting and preventing asset failure before it had an impact on rail services. Having better information about their assets and their condition was the first step in this strategy as it allowed them to make more informed decisions when it came to managing and maintaining the network.

As a first step in this program, the company sought to establish a detailed catalog of its asset base – particularly switches and crossings. Network Rail enabled engineers and field maintenance workers to capture asset data with smartphones and tablets, and synchronize it with the company’s enterprise asset management system.

The new solution provided Network Rail with an accurate record of its asset data, which allowed the company to maintain and invest in its infrastructure more efficiently.
CBM successes

The benefits of CBM seem readily apparent, but are companies actually realizing those potential benefits? Many are.

**Real results**

According to the International Railway Journal, Network Rail has seen some impressive results from their condition monitoring efforts. In 2016-17, they reported 98 broken rails, a 90% decline from 1998-99, even though traffic levels increased by 50% during the same period. In addition, total incidents from non-track assets have fallen steadily from 30,596 to 20,595.⁴

Other large companies using CBM tools include several large rail network operators, large-scale utilities, global mining organizations and process companies. Analytics has enabled major electric utility American Electric Power to boost their reliability by enabling the remote assessment of network health from the boardroom to the control center. This ensures they have the foresight required to perform CBM on their equipment as well as deploy field crews to where they are needed ahead of faults occurring in identified potential problem areas. Where they are needed, these practices reduce downtime for operations, maintaining continuous high quality of service for their customers.

**Acquiring deeper knowledge**

Transportation organizations hungry for in-depth guidance on their transition to CBM can turn to many resources. It’s useful to note that CBM practices fall under multiple umbrellas, such as the more fundamental predictive maintenance approach and the more-encompassing asset performance management. Identifying literature and resources under any of these topics will prove helpful.

Industry events also present rich opportunities to learn more. The CBM concept is far from new, but it remains a topic of great interest and discussion. Many OEMs see the writing on the wall. They increasingly recommend CBM over time-based maintenance for newly-installed assets, and therefore offer customers training on this approach. This is despite the fact that some of those OEMs were in the business of providing scheduled maintenance services, and will try to migrate that service revenue stream to CBM.

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How prepared are you to move towards CBM?

A recent Zpryme report⁵ shows that most transportation organizations’ current solutions do not fully prepare them for an enterprise-wide view of asset health and maintenance. In fact, only 31% feel prepared or very prepared with their current solutions.

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⁴ Becoming a predict-and-prevent railway, International Railway Journal, May 2017
⁵ Capitalizing on the digital revolution with connected asset lifecycle management for the transportation industry, Zpryme Research, April 2018
Moving forward with CBM

Most major transportation providers are taking strides – albeit of different lengths – toward condition-based maintenance.

Successful implementations are being made and benefits are being realized at installations that range in scale from network-wide to single assets.

Regardless of size, every successful implementation begins with assessing your assets, capturing the data that already exists in the organization and deploying sensors to fill critical information gaps. The data must then be consolidated in a single database and should be made accessible to all functional areas in the organization to maximize its value throughout the operation. Finally, analytical software is required to identify issues, predict trends and generate highly efficient maintenance work plans.

Once CBM is in place, transportation operators can capitalize on the commonsense approach of servicing assets when they require it, not based on an arbitrary schedule. The bottom-line benefits are highly focused maintenance activities that ensure the highest possible asset reliability and life – and ultimately the safest, most efficient service for customers.