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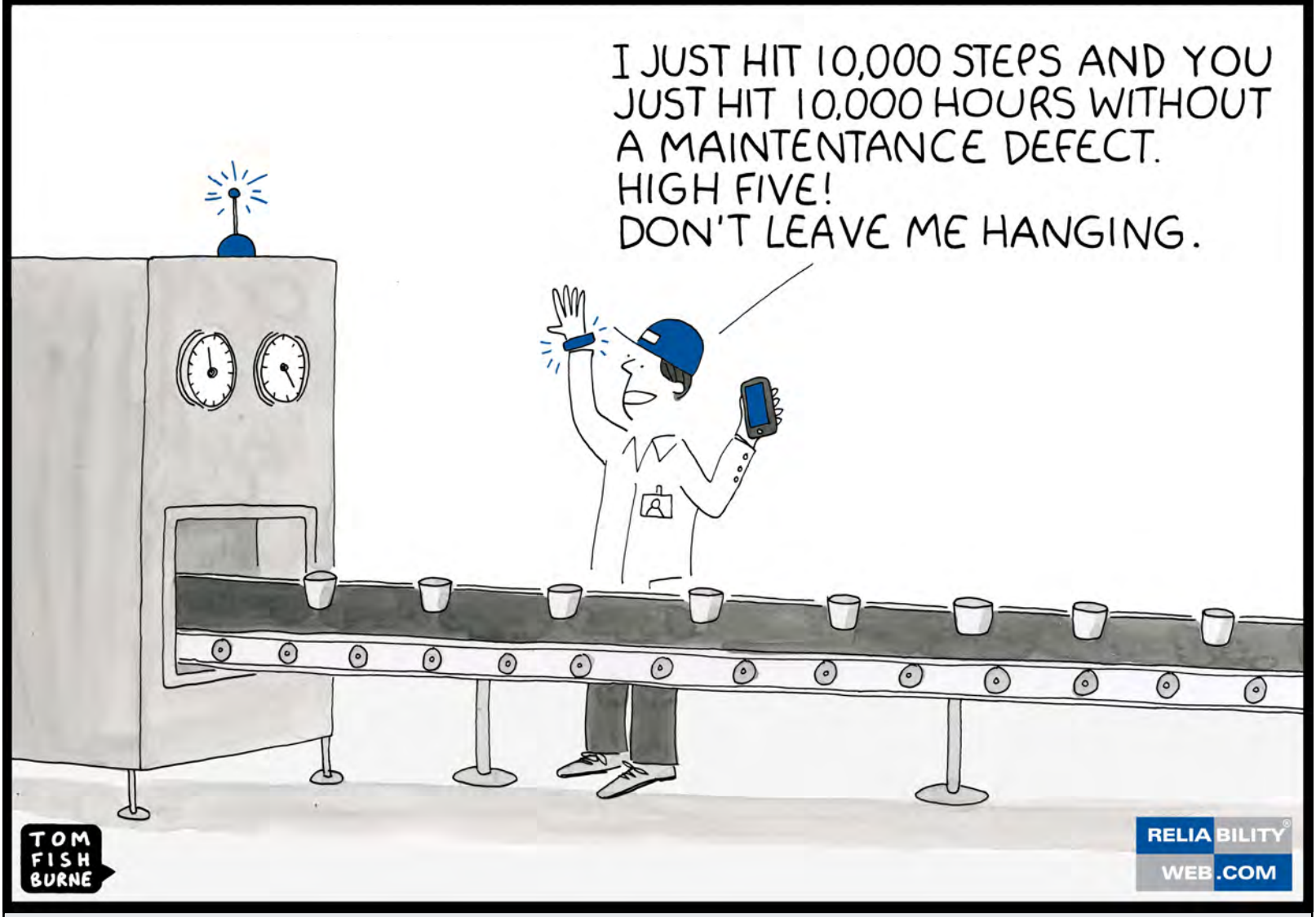

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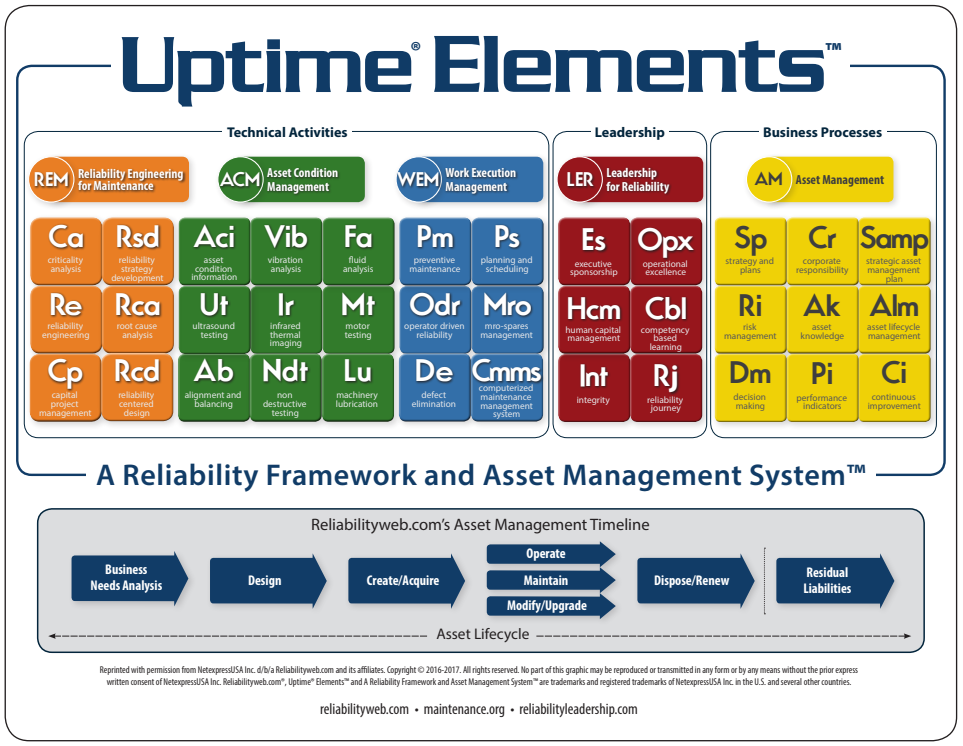

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STEVE JOBS' DREAM

Some of you may recall my dream about a dinner I had with W. Edwards Deming and Albert Einstein a couple of years ago. Well, it has happened again – just last night!

I was back in New York City, but this time with Apple co-founder, Steve Jobs.

I was telling Steve how good I feel about creating engaged and empowered teams through the work that has been done with Uptime® Elements™ – A Reliability Framework and Asset Management System™.

STEVE JOBS: *Your work is going to fill a large part of your life, and the only way to be truly satisfied is to do what you believe is great work. And the only way to do great work is to love what you do. If you haven't found it yet, keep looking. Don't settle. As with all matters of the heart, you'll know when you find it.*

ME: *I have found it, Steve. I really love the work I do with reliability, but I also know as I travel around the world doing very creative work, that the team at Reliabilityweb.com really creates that possibility. All the work I do is on their shoulders.*

STEVE JOBS: *Great things in business are never done by one person. They're done by a team of people.*

ME: *As this work advances, I feel like the world is dividing into two parts: those who want to cling to the ineffective maintenance paradigms of the past 30 years, and those who embrace a new context of reliability for everyone – with no one left behind. I must seem like a real troublemaker to some of these guys who "figured it out" a long time ago!*

STEVE JOBS: *Your time is limited, so don't waste it living someone else's life. Don't be trapped by dogma, which is living with the results of other people's thinking. Don't let the noise of others' opinions drown out your own inner voice. And most importantly, have the courage to follow your heart and intuition.*

ME: *There are a lot of people watching this new work, and a few have tried to copy it.*

STEVE JOBS: *Innovation distinguishes between a leader and a follower.*

ME: *That is a great point. Thank you. So, what keeps you going?*

STEVE JOBS: *For the past 33 years, I have looked in the mirror every morning and asked myself, "If today were the last day of my life, would I want to do what I am about to do today?" And whenever the answer has been "no" for too many days in a row, I know I need to change something.*

Remembering that I'll be dead soon is the most important tool I've ever encountered to help me make the big choices in life. Because almost everything - all external expectations, all pride, all fear of embarrassment or failure - these things just fall away in the face of death, leaving only what is truly important.

ME: *All the things I am reading about the Industrial Internet of Things (IIoT) and artificial intelligence (AI) are making claims that technology may solve the reliability issue.*

STEVE JOBS:*Technology is nothing. What's important is that you have faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them.*

It's not a faith in technology. It's faith in people.

ME:*Thanks for saying that, Steve. Coming from a technology visionary, that is very powerful. I might be crazy, but I am going to keep working with a focus on reliability leadership and create a future that was not going to happen anyway.*

STEVE JOBS: *The people who are crazy enough to think they can change the world are the ones who do.*

ME: *Hey, I should go now, but do you have any advice I can use to advance reliability and asset management in the world?*

STEVE JOBS: *Be a yardstick of quality. Some people aren't used to an environment where excellence is expected.*

And one more thing…

Warm regards,

Terrence O'Hanlon, CMRP
About.me/reliability
CEO and Publisher
Reliabilityweb.com®
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LER

RELIABILITY

IN THE NEWS

POLARIS Laboratories Customer Summit

More than 70 maintenance and reliability professionals from around the country gathered in Indianapolis, Indiana for the 3rd annual POLARIS Laboratories® Customer Summit: Connected Performance. This year's event took place November 1-3 and included presentations focusing on topics from telematics to data integration to oil analysis compliance. These presentations featured practical, real-life industry advice and experiences to build and maintain an effective maintenance program.

Xcelerate 2017

Fluke Corporation hosted close to 400 attendees at the annual Xcelerate Conference held at the Sanibel Harbour Marriott Resort in Fort Myers, Florida, November 7-9. Fluke Corporation presented the Fluke Accelix platform and attendees got hands-on experience at various integration demos throughout the conference. Attendees walked away with valuable insights and tools that will help them along the path to maintenance management success. Dave Reiber, Senior Reliability Leader, Reliabilityweb.com, among other maintenance and reliability experts, presented educational best practices sessions and participated on insightful industry panels. The agenda was rich with CMMS training, Fluke Reliability Solution sessions, lively networking events and more!

Asset Management Roundtables

Reliabilityweb.com® is facilitating three "by invitation only" industry-focused asset management roundtables and one executive asset management roundtable in 2018. These events focus on the strategies and approaches to create a culture of reliability and safety through cross-functional collaboration for improved asset performance across the whole asset lifecycle. Asset management and reliability-focused peer discussions for executives of public and private industrial organizations will explore the challenges and solutions to improved organizational performance.

Rail Asset Management
April 4-5, 2018 • San Francisco, CA

Life Sciences Asset Management
May 2-3, 2018 • Allentown, PA

Water Asset Management
July 11-12, 2018 • Washington, DC

Executive Asset Management
Sept 6-7, 2018 • Honolulu, HI

Qualified corporate maintenance directors, reliability leaders and asset managers can email assetmanagement@reliabilityweb.com to request an invitation.

Executive Operational Certainty Roundtable October 2017

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MTA Reliability Community of Practice

Reliabilityweb.com® recently supported the Metropolitan Transportation Authority (MTA) Reliability Community of Practice (CoP) with a highly interactive, one-day Reliability Leadership workshop led by Terrence O'Hanlon, CEO. Over 250 participants from NYCT Subways, NYCT Buses, Metro North Railroad, Long Island Railroad and MTA Bridges and Tunnels attended.

MTA is the largest public transportation system in the world and has created an Enterprise Asset Management system based on ISO55001 and Uptime® Elements™ – A Reliability Framework and Asset Management System™.

Bentley YII 2017

Bentley's Year in Infrastructure (YII) 2017 Conference was held in Singapore and was a global gathering of leading executives in the world of infrastructure design, construction, asset management and operations with over 1,500 professionals attending. The *Be Inspired Awards* recognized top performers from around the world. Reliabilityweb.com CEO, Terrence O'Hanlon, co-chaired the Infrastructure Asset Performance Summit, a highly interactive executive-level roundtable meeting designed to address current and future solutions with a forward strategy view.

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3:15pm-3:45pm

THURSDAY, DEC. 14

9:30am-10:00am
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JOURNEY TO RELIABILITY EXCELLENCE

Justin McCarthy

IMC 2017 The 32nd International Maintenance Conference

Speaker

Opx operational excellence

Uptime Awards

2017 Best Leadership in Reliability

Mercedes-Benz U.S. International (MBUSI), an SUV and sedan plant in Vance, AL, was undergoing some organizational changes in August 2011. Ken Hayes had rotated through several senior management positions throughout Mercedes and was returning to maintenance and engineering after eight years managing body and assembly production operations. He was dissatisfied by a lack of growth in the maintenance systems and decided to benchmark other Daimler facilities to see if there were practices he could apply at MBUSI. Realizing maintenance challenges were very similar in the other plants, he searched for a different approach.

Three years later, in October 2014, the organization was decentralizing and preparations were underway for a major model update. Ken, now responsible for maintenance strategies plant-wide, requested Justin McCarthy (author of this article) as maintenance strategy engineer, who would be responsible for looking at better approaches. Justin was a fairly new maintenance engineer, which made him a perfect fit for defining a new system. Ken wanted someone fairly new to avoid falling back into past bad habits. He called a two-hour meeting with his maintenance managers from each of the shops – body, paint, assembly, facilities and central standards – to start defining a vision of what maintenance excellence could look like. Despite the fact that each shop worked to build the same cars, it was painfully evident that the estimated 350 maintenance technicians and engineers were following different processes. The only thing the managers seemed to agree on was that the maintenance organization was too busy putting out fires to truly solve anything. Maintenance needed a completely new system!

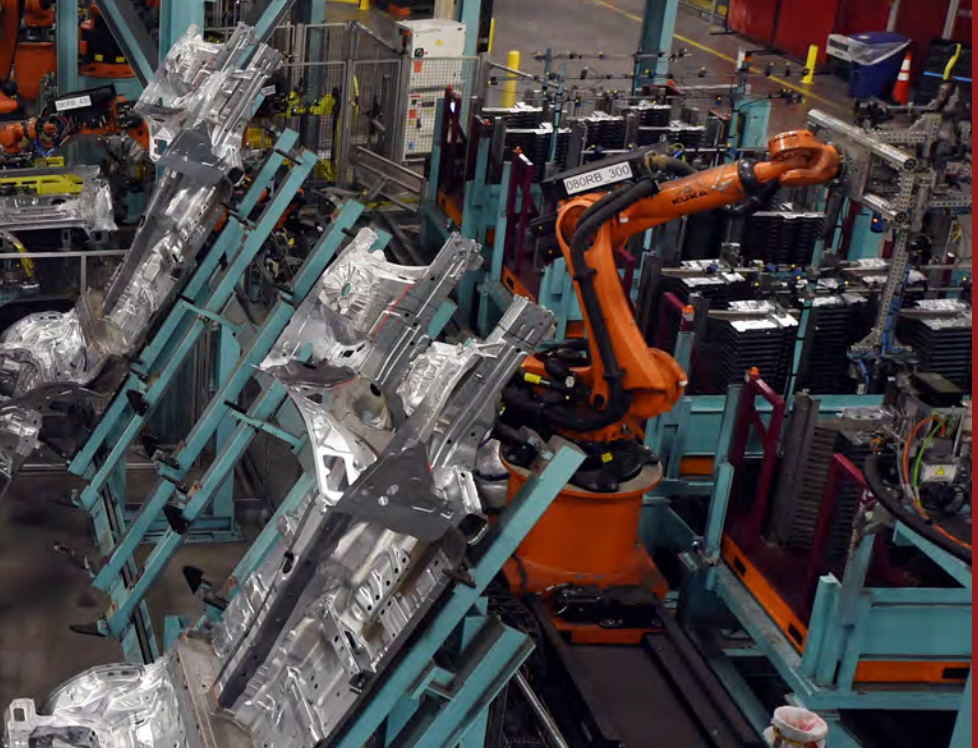
Ken quickly established a maintenance war room and made the two-hour managers meeting a weekly staple. Through perseverance, the group continued to debate what the vision should be. Even though all agreed that maintenance needed a change, it was an uphill battle to convince the managers to believe it could be done. So many times while brainstorming maintenance utopia, one or another of the managers would interject with reasons why it couldn't change. Any time Ken heard, "But that's the way it's always been…," he would passionately explain: "There's a lot of power in this room! If we can agree on a path forward for our dream and justify it, we will have all the resources we need to make it happen." He began hanging change management banners to brand his war room.

It was probably six months of discussions before the managers truly accepted that they could change the way they do business! Finally, they agreed on a vision statement: "Become the Benchmark Maintenance Program by Adopting a Proactive Mind-Set Through Evolution Not Revolution."

In March 2015, Justin participated in a reliability "boot camp" that explained what reliability is, why maintenance should care about it and how to implement a reliability program. One of his teachers was Ramesh Gulati, who wrote the book on reliability. Justin convinced Ramesh to visit Mercedes to meet with Ken. The fact that Ramesh's vision aligned so closely with the group's convinced the managers that they were on the right track.

The team needed to understand what a world-class maintenance program looked like. They benchmarked close to 20 plants across the

Figure 1: Branding in the maintenance war room



> **Become the Benchmark Maintenance Program by Adopting a Proactive Mind-Set Through Evolution Not Revolution.**

U.S. and Europe. And they didn't just limit themselves to the automotive industry. They visited aerospace and chemical processing plants, refineries and pharmaceutical manufacturers, they even shadowed the maintenance manager of a theme park! They learned that every maintenance department faces similar challenges and none had truly figured them all out. The biggest takeaway was that the best programs had adopted a reliability-centered mind-set at all levels of the organization.

All managers went through reliability training and immediately began funneling technicians, engineers and even colleagues from other departments through a three-day reliability boot camp. Feedback from the classes was interesting; most agreed this was how maintenance should be, but few believed these changes would ever happen at MBUSI. They'd seen too many unstable "flavor of the month" initiatives flame out after losing management support.

In the face of this adversity, Ken decorated the war room wall with more banners to remind the team that this was a long-term journey. The banners read: "The Greatest Danger in Times of Turbulence Is Not the Turbulence, It Is to Act with Yesterday's Logic;" "If You Always Do What You've Always Done, You'll Always Get the Same Result;" "Sharing Knowledge Brings Obligation;" "Train the Organization;" "The First Step Toward Change Is Awareness, the Second Is Acceptance and the Third Is Desire;" and "Follow the Process."

The maintenance managers took this feedback to heart. They realized that the emotions, past struggles and reluctance to change would be the biggest challenges in changing the mind-set of the organization. To show how serious they were about this dream, the maintenance managers sponsored their first certified maintenance and reliability professional (CMRP), hired a computerized maintenance management system (CMMS) specialist with a reliability background to optimize its SAP system and began hosting monthly maintenance meetings attended by every technician to share plant updates and reliability news. They piloted a kitting program that became popular with technicians and tested vibration sensors that prevented a major breakdown. Ken recognized the importance of divorcing these changes from past failed initiatives. His mantra became: "It's not what we do….it's how we do it." Presentation slides were branded, tools looked different, words from past initiatives were excluded from managers' vocabulary and managers ensured that maintenance technicians got to present the quick wins to upper management.

The scope of the program laid out by Ken and the maintenance managers was massive. Their quick wins created some momentum, but to get upper management's full support, they still needed to financially justify it. In October 2015, Ken hired a group to complete a three-week assessment of the maintenance organization. The findings this group reported to the upper management team were even more hopeful than expected. The maintenance department was the best they'd seen at reacting quickly, but there was a major opportunity to increase efficiency and substantially reduce costs by adopting a proactive system. This got the attention of the chief financial officer! Ken and his team's quick wins showed upper management that the maintenance team would support the new system and now they were convinced there was significant financial justification. All that remained was to put together a plan to achieve sustainable results.

The maintenance managers defined and prioritized seven initial "work packages" based on potential benefit and the culture's readiness to adopt them. Ken quickly realized that this program was becoming an "elephant" to be eaten one bite at a time. For lack of a better term, this nebulous reliability transformation had been called "Maintenance 2.0." But, in formalizing the program, Ken and the team announced it would be called the Maintenance Excellence and Reliability Program or MERP.

Figure 2: A team-developed quick win: a kitting program

> The message was clear: MERP is not any one person's program, it's everyone's program.

Despite the fact that 170 people had been trained during the three-day reliability class, the maintenance technicians still reacted negatively when MERP was announced. Many even believed it was secretly a head count reduction initiative! Some very clever interpretations of the acronym emerged: "Maintenance and Engineering Reduction Program," "Make Everyone Regret Participating," "Maintenance Engineers Resort to Prayer" and Ken's favorite, "Mercedes Executive Rewards Program." It was clear that if the group wanted to achieve its vision of adopting a proactive mind-set through evolution instead of revolution, the maintenance teams needed to be involved in defining the new standards. So, up went another banner: "Participation at All Levels."

Based on the organization's current resourcing situation, the group decided to support three work packages at once: criticality, problem-solving and planned maintenance execution. The team used its reliability training and best practices from benchmarking to define a high-level framework for these three work packages. Each package was assigned a maintenance manager as a sponsor and a cross-functional team of technicians and engineers with representation from each shop. These teams would design sustainable processes and standards to fit the framework. Finally, an engineer from each work package team was selected to be team leader and plant-wide standard holder. Each work package lead received a week of off-site reliability engineer training before enrolling in eLearning courses specific to his or her work package.

To manage all this change, remove roadblocks, identify and mitigate risks, and communicate progress plant-wide, the maintenance managers formed a program management office (PMO). The PMO was responsible for engaging with each work package team, escalating issues to appropriate managers and reporting progress monthly to upper management. Upper management agreed to support this plan and formed a steering committee that includes the chief executive officer, chief financial officer, each shop's vice president and Ken.

Finally, the program's structure was set! In July 2016, the three cross-functional teams were pulled from their day jobs and committed 100 percent of their time to MERP. The teams were initially apprehensive. They required regular assurance that neither immediate results were expected of them nor were they being held to a timeline. The manager-sponsors worked closely with their team to provide structure. First, they facilitated a charter definition for each work package. The teams listed their short-, mid- and long-term goals before outlining the tasks needed to achieve these goals.

Immediately, the teams recognized the benefits of working cross-functionally. They learned a lot by comparing practices between the shops, which ultimately resulted in more robust processes designed to work anywhere in the plant. The group did not want this to be another top-down program, so participation was encouraged to drive buy-in. The message was clear: MERP is not any one person's program, it's everyone's program. Ken would pop in on these discussions to provide support and reassurance, while ensuring that each team followed the vision. The group noticed a very positive reaction; the teams took complete ownership and developed pride for the work they had accomplished.

Pulling resources from the floor also created a lot of stress for those who had to pick up the slack. Ken countered this by generating excitement for MERP. He hosted an interactive fair in the plant's atrium with predictive maintenance tools to demonstrate the benefits of a proactive system. He created *MERP Monthly*, a monthly newsletter for sharing MERP updates with maintenance and engineering plant-wide. MERP hard hat stickers and challenge coins were distributed to participants. Trifold brochures explaining the purpose of the work packages were placed in all engineering offices and maintenance team centers. An article was written in the company's newspaper highlighting the vision and status of MERP. Ken made sure to attend every monthly maintenance meeting and training session to address questions and spread passion for the vision. He even convinced the chief executive officer to express his excitement for MERP during the quarterly all-teams meeting.

Over the next three months, the teams developed sustainable world-class maintenance tools and processes, specifically for MBUSI's

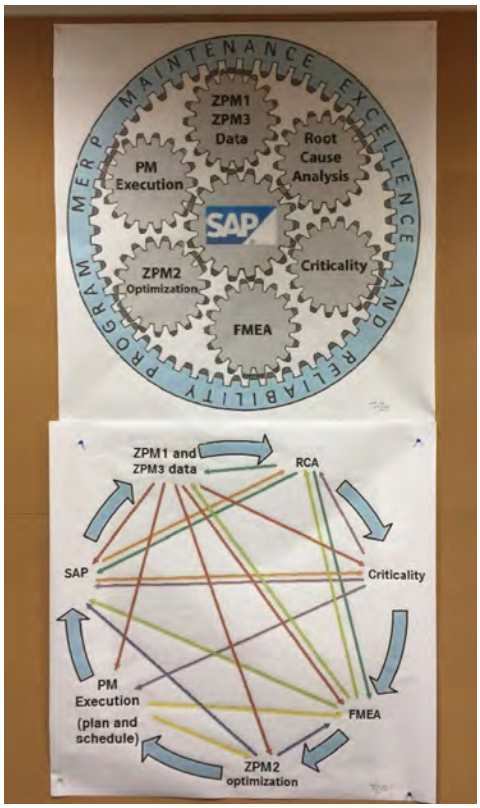


Figure 3: MERP's gear logo illustrates how intertwined the tools are

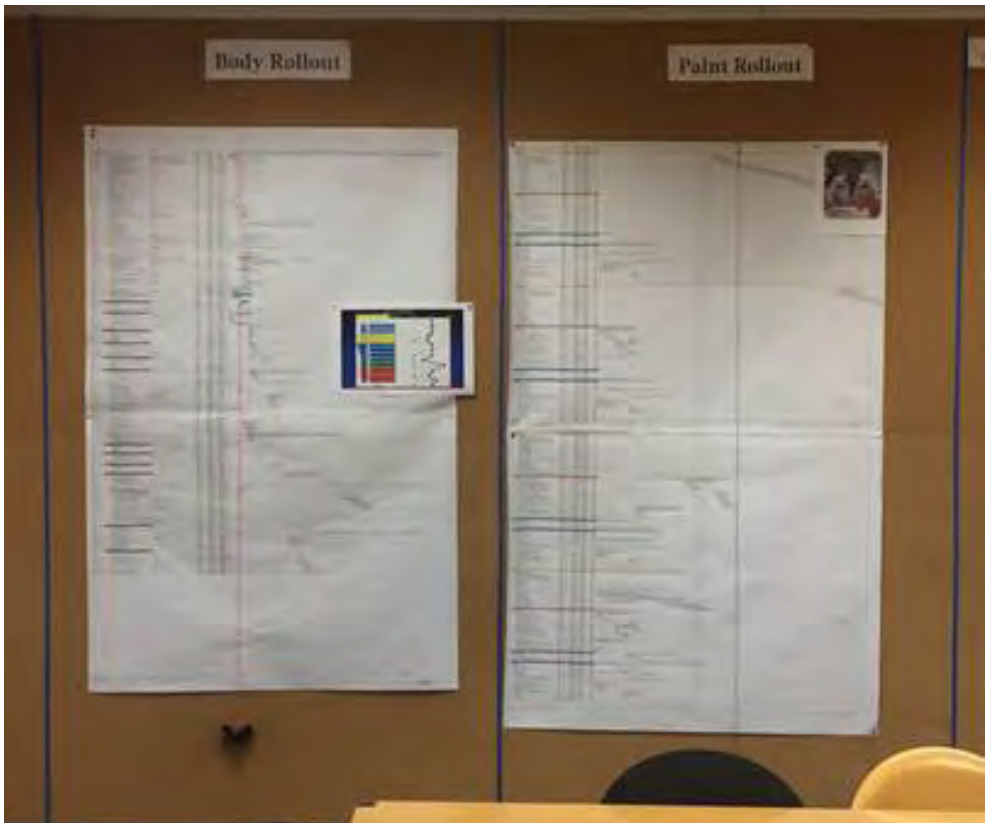


Figure 4: Each shop's MERP rollout plan

culture and "DNA." The criticality team designed criticality matrices to quantify which assets are most important to the goals of the business. Next, team members created a comprehensive failure mode and effects analysis (FMEA) template that assigns a risk weighing for every potential failure mode on a critical piece of equipment. Their equipment maintenance plan tool converts results from the FMEA into an ideal task list for maintaining a piece of equipment, including time-based preventive maintenance (PM) actions, operations tasks and predictive checks. Finally, their PM optimization dashboard suggests tweaks to PM frequency. The team involved maintenance technicians throughout to collect input and gut check their ideas.

The problem-solving team completely revamped the plant's approach to problem-solving. Its root cause analysis scorecard ranks problems based on criticality and several other factors to focus efforts on the most important problems. This new process limits an engineer to two problems at a time so he or she can concentrate on fully solving a couple of problems rather than attempting to "bandage" many. The team's problem-solving tools enable an engineer, with the help of a cross-functional team, to consider every potential cause of a problem and financially justify proposed countermeasures. Additionally, the problem-solving team defined a breakdown management process so maintenance teams would be more effective at managing breakdowns.

MBUSI has scheduled outages every weekend. It's vital that this time is used as efficiently as possible because it's typically the only opportunity to maintain equipment! The planned maintenance execution team optimized the work planning process. Every job to be completed, no matter if it's done by maintenance, a contractor, or another

department within MBUSI, must be requested through SAP at least two weeks in advance. This ensures appropriate maintenance support on weekends and gives planners the time they need to plan and kit all maintenance jobs.

Each new tool was reviewed by the PMO and other work package leads before being finalized. The group found that each tool seemed to rely on tools from other packages. This created the system!

By November 2016, the three work package teams were ready to test their tool to ensure they would all work together. The MERP steering committee decided to do the pilot in the body shop's underbody zone since this area of the plant was struggling the most. The teams received a lot of feedback from the floor during the pilot. For example, the criteria for triggering the problem-solving team's breakdown management process were initially confusing, so the team redesigned its breakdown management notepad to serve as both a process map and a reporting tool. The primary goal was to eliminate waste while adding value to the maintenance organization. The team focused on keeping the tools simple and effective.

The group noticed a shift in maintenance's attitude plant-wide. Questions about whether management was committed to the program almost disappeared and most technicians were more curious about how the changes would affect their daily job. One of the vice presidents shared that he was stopped by someone who said, "MERP is successful because……." That was enough said!

By February 2017, Ken and the team were convinced that the MERP tools were ready to be rolled out to the rest of the plant. Each maintenance manager collaborated with the work pack-

> MERP is part of daily business for almost every maintenance technician and engineer at MBUSI and the plant is already realizing gains.

age leads to create a rollout and training schedule for their shop. Since each work package team had cross-functional representation from each shop, now each shop had a technician-trainer who was intimately familiar with each work package.

A standardized training plan was critical for a successful rollout. First, everyone affected by the rollout received high-level training to explain the goals of MERP, followed by more detailed training for each work package. Specific tool training was given based on job role. Currently, the plant is eleven months into the rollout and two-thirds of the way through the training plan. MERP is part of daily business for almost every maintenance technician and engineer at MBUSI and the plant is already realizing gains. To date, 409 people have been through the three-day reliability class and 263 through the two-day root cause analysis class. The plant now has 13 CMRPs and one brand new certified reliability leader (CRL).

MERP will not be finished when the three work packages are rolled out. Today, the group is actively supporting five new work packages: storeroom, predictive maintenance, technical training, SAP and an autonomous maintenance work package that involves the operations department. With the overwhelming support received from upper management, the group will create a legacy of the benchmark maintenance program through evolution, not revolution.

MBUSI Quality and Environmental Certifications:

- Certified to the International Organization for Standardization (ISO) Quality Management Systems standard: ISO/TS16949:2009
- Certified by TUV Management Services to ISO14001 – Environmental Management Systems, Certificate Registration No. 12 104 11297 TMS

***Justin McCarthy** has been with Mercedes-Benz U.S. Int'l for 4 years. He spent 1 year as a maintenance engineer in the SUV assembly shop before transitioning into plant-wide maintenance strategy. As the program manager for the Maintenance Excellence and Reliability Program (MERP), Justin is thrilled with the team's progress and excited for the future of maintenance at MBUS. www.mbusi.com*

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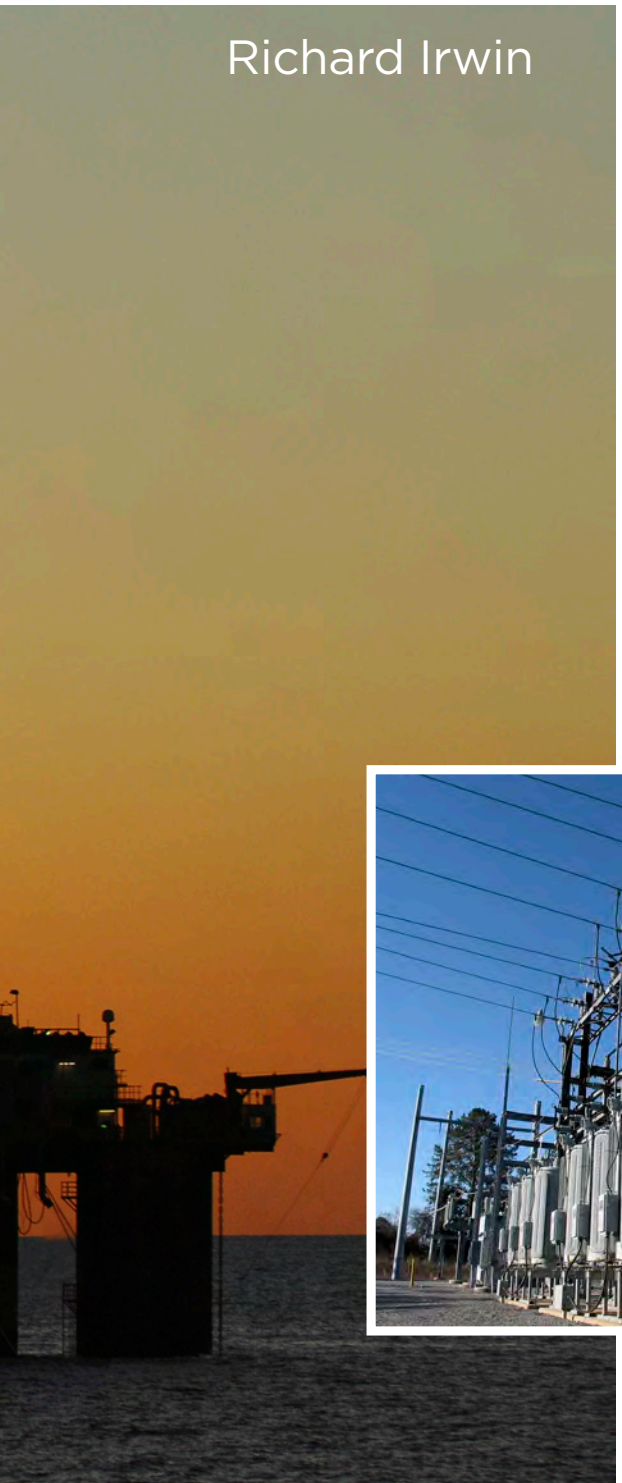
PREDICTIVE MAINTENANCE AND MACHINE LEARNING:

REVOLUTIONIZING RELIABILITY

Figure 1: PdM is one of the main benefits across all industries, particularly oil and gas.

"Machine learning is paving the way for smarter and faster ways to make data-driven decisions in predictive maintenance (PdM)."



Richard Irwin

One of the goals of reliability is to identify and manage the risks around assets that could fail and cause unnecessary and expensive downtime. Organizations know it is important to identify areas of potential failures and rate them in terms of likelihood and consequence. They also have put in place good reliability strategies and have implemented proactive, condition-based maintenance programs. But now, machine learning is helping maintenance organizations get to an elevated level of situational intelligence to guide actions and provide early warnings of impending asset failure that previously remained undetected. Machine learning is paving the way for smarter and faster ways to make data-driven decisions in predictive maintenance (PdM).

While machine learning has been researched for decades, its use in applying artificial intelligence (AI) in industrial plants and infrastructure asset operations is now advancing at a rapid pace. This influx of using machine learning is due to the growth in big data, the expansion of the Industrial Internet of Things (IIoT), the availability of computing power to number crunch this increase in data, as well as the need for superior predictive and prescriptive capabilities required to manage today's complex assets. While machine learning has typically been linked to such industries as transportation and banking (think self-driving cars and fraud monitoring, respectively), there are many uses for machine learning and PdM within the industrial sector. This article focuses on some of the principles within machine learning and the industries primed to take advantage of its application to maximize the benefits machine learning brings to improve situational intelligence, performance and reliability.

But first, it is important to point out that there are many options and techniques available to gain more insight and make better decisions on the operation and performance of your assets. It all comes down to knowing what the best fit is for your needs and what type of data you are using. Data comes in many shapes and sizes and can consist of time series, labeled, random, intermittent, unstructured, and many more. All data holds information, it's just a case of using the right approach to unlock it. This is where algorithms used within machine learning help decision makers.

Figure 2: Machine learning can help the smart grid get even smarter

6 Questions to Ask Before Investing in Machine Learning

It is important to understand the complexity involved with machine learning before you make a decision on what is appropriate for you and your organization. Here are some questions to consider before implementing machine learning:

1. **What do you want your data to provide** Question your data. What do you need to know, what are you looking for exactly? What do you want your data to tell you? What aren't you seeing that you hope the data can provide?
2. **Is your data clean?** Make sure your data is available, ready and validated. The more data the better and the more accurate the outcomes will be.

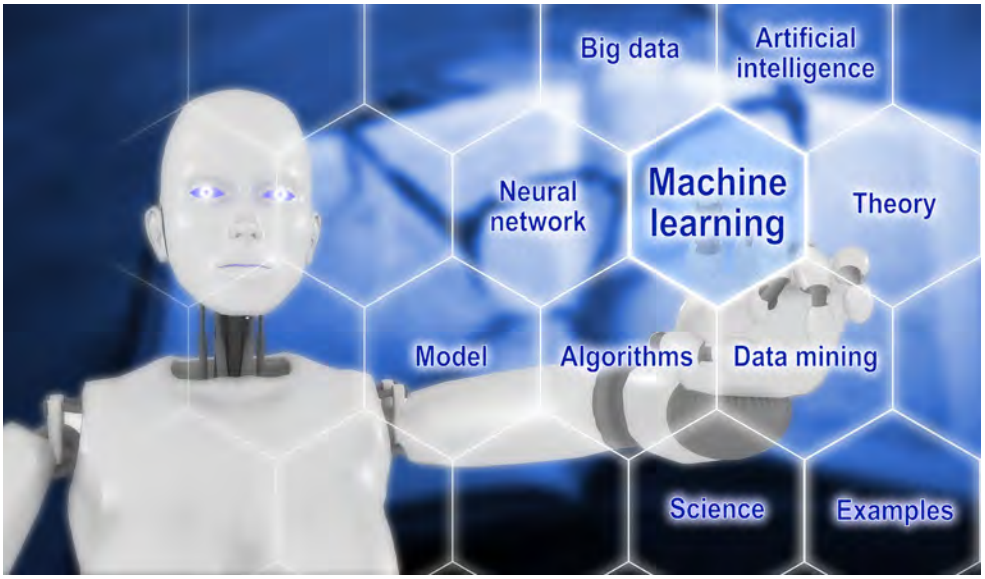


Figure 3: Machine learning is comprised of many different data science techniques

3. **Do you have enough data?** For accurate predictions, machine learning needs lots of historical data from which to train, then it can be applied to data in real time.
4. **Which machine learning platform should you choose?** Choose your machine learning platform carefully and consider interoperability.
5. **Should you hire a data scientist and how will this individual be integrated into the organization?** With machine learning, there might be a need for a data scientist or analyst, but this individual should not be locked in a dark room.
6. **Can you share the data output?** Knowledge gained through machine learning shouldn't be applied to just one project at a time. Its scalability means it can and should be incorporated across the whole enterprise, delivering insight into any area rich in data. Plan to get the most out of machine learning.

The Route to Deeper Understanding

Machine learning makes complex processes and data easier to comprehend and is ideal for industries that are asset and data rich. In any industry, the ability to recognize equipment failure and avoid unplanned downtime, repair costs and potential environmental damage is critical to success. This is even more relevant in today's turbulent times. With machine learning, there are numerous opportunities to improve a situation with PdM and the ability to predict critical failures ahead of time.

PdM is one of the most relevant areas where machine learning can be applied within the industrial sector. Predictive maintenance is a failure inspection strategy that uses data and models to predict when an asset or piece of equipment will fail so proactive, corrective actions can be planned in time. PdM can cover a large area of topics, from failure prediction and failure diagnosis to recommending mitigation or maintenance actions after failure. The best maintenance is advanced forms of proactive, condition-based maintenance. With the combination of machine learning and maintenance applications leveraging IIoT data, the range of positive outcomes and reductions in costs, downtime and risk are worth the investment.

Whichever path is chosen, the benefits machine learning can offer to big data are just being brought to fruition. Opportunities are rapidly developing, with productivity advancements at the heart of the data rich industry in which you work. Here are some examples leading the way in this fast-moving digital transformation.

Electric Power – Electric utility companies are affected by aging assets, increasing energy demand and higher costs. The ability to recognize equipment failure and avoid unplanned downtime, repair costs and potential environmental damage is critical to success across all areas of the business. Machine learning is augmenting the smart grid to better leverage and gain insight from the IIoT, with an enormous number of connected assets spread across a large network. With transformers, pylons, cables, turbines, storage units and more, the potential for equipment failure is high and not without risk, so predicting failures with data and models is the new answer to keeping the network running smoothly.

Oil and Gas – In the oil and gas industry, the ability to recognize equipment failure and avoid unplanned downtime, repair costs and potential environmental damage is critical to success across all areas of the business, from well reservoir identification and drilling strategy to production and processing. In terms of maintaining reliable production, identifying equipment failures is one of the main areas where machine learning will play an important role. PdM predicts when an asset or piece of equipment will fail so maintenance can be planned well ahead of time to minimize disruption. With the combination of machine learning and maintenance applications leveraging IIoT data to deliver more accurate estimates of equipment failure, the range of positive outcomes and reductions in downtime and the associated costs means it is worth the investment.

Water Utilities – Water companies also face the same challenges of an aging infrastructure, rising costs, tighter regulations and increasing demand. They also share the same benefits that machine learning offers, such as identifying equipment failure before it happens, but not just to predict a failure, but also to identify what *type* of failure will occur. Other machine learning benefits in the water industry include meeting supply and demand with predictive forecasting and making smart meters "smarter" to help curb waste, such as during water shortages.

Manufacturing – Manufacturing has been the main industry mentioned alongside machine learning, and for good reason, as the benefits are very real. These benefits include reductions in operating costs, improved reliability and increased productivity — three goals that relate to the holy trinity of manufacturing. To achieve them, manufacturing also requires a digital platform to capture, store and analyze data generated by control systems and sensors on equipment connected via the IIoT. Preventive maintenance (PM) is key for improving uptime and productivity, so greater predictive accuracy of equipment failure is essential

"…reductions in operating costs, improved reliability and increased productivity — three goals that relate to the holy trinity of manufacturing."

Figure 4: A PdM plan provides unprecedented insight regarding your assets

with increased demand. Furthermore, by knowing what is about to fail ahead of time, spare parts and inventory can use the data to ensure they align with the prediction. Improving production processes through a robust condition monitoring system can give unprecedented insight into overall equipment effectiveness by regularly and consistently monitoring air and oil pressures and temperatures.

Digitization and Transformation With Machine Learning

Early adopters of machine learning are already reaping the benefits of PdM in the speed of information delivery, costs and usefulness. This gives them more information and insight to make smarter decisions. Some of these early adopters are also combining machine learning with other digitization technologies, such as visualization dashboards, cloud-based IIoT data, analytics and reality modeling, for an even more model-centric, beneficial process. The result is a complete solution for operations, maintenance and engineering.

Having a PdM plan in place powered by machine learning will give you unprecedented insight into your operation and lead to significant benefits in efficiency, safety, optimization and decision-making. The digital transformation for industry is now at a tipping point, with technologies all converging at the same time. A PdM approach to reliability and asset performance means root cause analysis (RCA) could become a thing of the past. In its place will be machine learning, which takes into consideration the whole history of failures and identifies the signs of failure in advance.

Richard Irwin *is a Senior Product Marketer for Bentley System's Operational Analytics service. He has over 10 years' experience working within the analytics industry. In his role, Richard works with the sales and industry teams to coordinate marketing opportunities across a wide variety of industries applicable to AssetWise. www.bentley.com*

MACHINE LEARNING CASE STUDY

This case study demonstrates the application of various machine learning techniques within a processing plant.

THE PROBLEM

A steel manufacturer routinely shuts down operations to perform maintenance on its assets, which is very costly. The steel output can sometimes warp or crimp during the production process as it travels through different stages. These failures only can be corrected every six months, as well as monthly for smaller fixes, during planned and very expensive maintenance that involves long periods of downtime.

THE GOALS

The goals the steel manufacturer wants to achieve are:

- Reduce defects and locate root cause;
- Identify key variables that matter the most;
- Prioritize assets during shutdown.

THE SOLUTION AND ACTION PLAN

It was determined that machine learning could help the steel manufacturer meet its goals.

The first part of the machine learning process was to sort the data into a self-organizing map using neural networks to organize data into 10 distinct classes based on parameters of the steel, such as thickness and weight, as it entered each manufacturing stage. Other techniques included decision trees to learn the pattern of data and identify which features were important in those patterns; asset health prioritization to provide ranking; asset health indexing to determine the health of the assets; principle component analysis to reduce the dimensionality of the data; and clustering and anomaly detection, which highlights how each stand deviates from its normal operating mode.

What developed was a method for dealing with different types of products, the ability to identify the top variables associated with production defects and a process for applying anomaly detection to equipment in an industrial plant.

RESULTS

It was shown that these processes could reduce the need for extensive analysis of equipment and give operators better tools and more insights to make maintenance decisions. A significant amount of time is spent locating the cause of the issues and performing maintenance. The new algorithm can be run before planning the shutdown and it can identify which stand to prioritize during shutdowns through analysis of the asset anomaly charts. Focusing on assets that are the most at risk optimizes the shutdown, as it is only conducted for a limited time.

Ri
risk management

Jack Pouchet

WORLD'S MOST CRITICAL INDUSTRIES

Study Reveals Valuable Lessons

What's worse, a disruption in a major city's rail system or extended downtime in a cloud data center?

The answer, of course, depends on your perspective. If you're one of thousands of people who use the rail system to get to work and you can't afford to miss a day, that disruption is no small matter. But, if your business relies on the Cloud and you're losing thousands of dollars for every minute of downtime, you might consider your situation more serious than that of the stranded commuters.

Since the impact of downtime depends on perspective, it's difficult to compare one situation to another. Still, that doesn't mean something isn't a worthwhile undertaking.

Vertiv, which designs, builds and services critical infrastructure for applications for data centers, communication networks, and commercial and industrial facilities, conducted a study to rank the world's most critical industries. The study was aimed at raising awareness of the role critical infrastructure plays in every aspect of people's lives.

The Process

The first step in the nonscientific study was assembling a team of global infrastructure experts with expertise that spanned a variety of industries. Then, this team developed a list of more than 20 industries that are subject to disruption and could be considered critical to the people that depend on them.

Next came one of the most interesting challenges in the process: determining how to quantify criticality. The team compiled a list of 15 criteria that could be used to evaluate the impact of a disruption in a particular industry, factoring in everything from lost revenue and recovery costs to the amount

> Since the impact of downtime depends on perspective, it's difficult to compare one situation to another.

of frustration downtime causes users to how heavily the industry prioritizes availability.

These factors were then weighted based on their impact and severity. The outcome of this exercise was a criticality rubric (see Figure 1) that each team member used to score each industry. These scores were compiled and an average score for each industry was calculated, which became the basis for the ranking.

Seven of the industries evaluated had a score of at least 600, which was established as the threshold for the Vertiv report, *Ranking the World's Most Critical Industries*, available at VertivCo.com/MostCritical.

Vertiv Criticality Rubric

CRITERIA	YOUR SCORE 1 = NOT APPLICABLE 5 = VERY APPLICABLE					WEIGHT
	1	2	3	4	5	
Unplanned downtime's impact on human health						30
Financial impact - unplanned downtime causes lost sales and opportunity						20
Societal order depends on availability (i.e. downtime causes disruption to day-to-day life)						20
Potential environmental impact of unplanned downtime						10
Immediacy of impact - an outage takes a toll right away						10
Cost of recovery - repairs, affected asset replacement, alternate measures required during downtime						9
Significant portion of the affected company's/affected affiliates' resources depend on availability						9
Ripple effect (unplanned downtime takes out other systems, within or outside the initially affected organization)						9
Likely scope (local, regional, national, global) of effects of unplanned downtime						8
Subjective industry criticality ranking (please rank this industry based on your own experiences and knowledge and for those you scored 4 or 5, explain why you think this industry is extremely critical)						8
Impact of reputational damage caused by unplanned downtime in competitive marketplace (in the most extreme cases, this reputational damage could extend beyond the affected organization/company to the whole industry)						7
Lack of availability may not cause societal disruption, but it causes frustration and angst (i.e. when video streaming goes down on a Friday night or your social media game is not available for a morning public transportation commute)						7
Unplanned downtime brings the risk of high media/public outrage						7
Probable duration of impact (operational, not reputational)						5
Industry's prioritization of availability (do businesses in this industry spend significant time and resources to ensure their own availability?)						5

Figure 1: Criticality rubric used in the study

The Results

Some of the top seven ranked industries certainly come as no surprise. Utilities, for example, ranked number one. Electricity is still the foundation for much of the economy and a widespread disruption in electrical power has the broadest consequences of any industry analyzed in the study.

This could change in the future as heavy power users, such as data center operators, deploy micro grids and increase their adoption of alternative energy. In fact, the report highlights alternative energy as an emerging industry that will grow in criticality as it evolves from its current role as a supplement to the grid to a viable alternative to it. However, even looking 10 years out, it seems likely the vast majority of people and businesses will continue to depend on the grid and utilities will remain at or close to the top of the list.

Utilities was followed by mass transit, telecommunications, and oil and gas production, all industries that scored high on multiple heavily weighted criteria.

Cloud and colocation services ranked fifth in the study. This was a little surprising to some team members due to the fact that the cloud market is still relatively new and still in a rapid growth stage. In a very short period of time, cloud and colocation data centers have become critical hubs in the digital economy, supporting a vast array of businesses and services people depend on daily. And, based on their current growth rate, their influence can be expected to grow in the coming years.

Another rapidly emerging industry that made the list was smart cities, which ranked seventh behind defense. While the smart city vision has not been fully implemented, the study team saw the concept advancing rapidly in many areas of the world, with the consequences of downtime being hugely disruptive. Interestingly, smart cities will use Internet of Things (IoT) technologies that will likely be dependent on the Cloud, further elevating the criticality of cloud and colocation providers.

Most Critical Industries Ranking:

7. Smart Cities (605)
6. Defense (613)
5. Cloud and Colocation Services (614)
4. Oil and Gas Production (626)
3. Telecommunications (634)
2. Mass Transit (643)
1. Utilities (712)

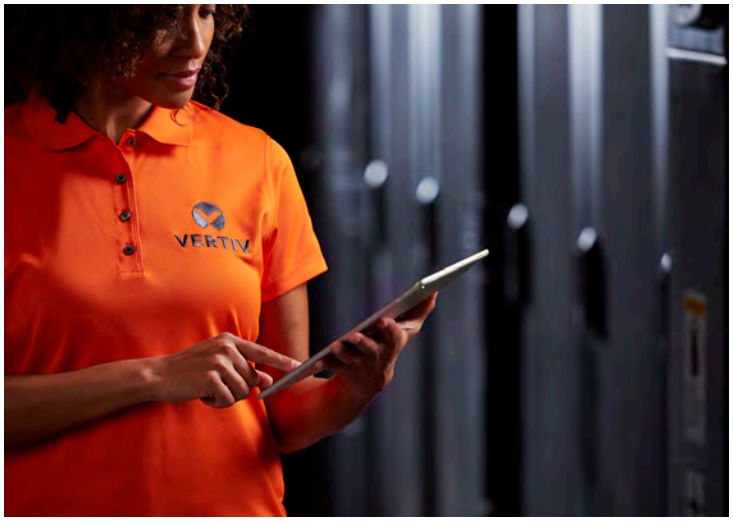


Figure 2: Cloud data center

The Lessons

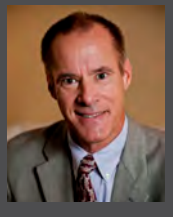
The process of ranking industries proved as valuable as the end results for those involved in the study.

The discussions leading up to the ranking provided each team member with a deep appreciation for the various impacts of downtime across industries and the measures taken within each industry to prevent it. For example, a team member who works with large data center operators, including those supporting social media platforms, was able to provide perspective on the growing role these platforms are playing as critical communication channels that people depend on for much more than news about family and friends, as well as how seriously those platforms take availability.

Team members also came away from the process with a better appreciation for how effective, in general, current critical infrastructure systems are in preventing downtime. It was necessary to consider worst-case scenarios in evaluating various industries, but these scenarios are surprisingly rare. Yes, you may recall high-profile disruptions in virtually every industry, but when you consider the complexity of the systems involved and the always-on demands of today's world, the critical industries identified in the report are doing a good job of earning the trust of the people who depend on them.

That being said, the increase in digitization and the resulting interdependencies across critical industries are a little startling when taken in total. The effect of this extends the impact of downtime in almost every industry. Disruptions in the electrical grid ripple across all industries; delays in rail and air transport disrupt commerce; and downtime in a colocation facility extends across multiple businesses and shuts down the streaming video service people turn to for relaxation after a hard day's work.

Industries across the spectrum must continue to invest in the technology, processes and services required to keep critical systems operational. Industries may never be able to eliminate all natural disasters or human error, but with proper planning and investment, they can achieve a world where critical technologies always work.



Jack Pouchet *is the Vice President of Market Development and Energy Initiatives at Vertiv Co. Jack works closely with major OEMs, large data center owners and operators, and leading mission critical engineering firms to help define, architect, and create opportunities for advanced power and cooling technologies that improve day-to-day business and operational efficiencies. www.vertivco.com*

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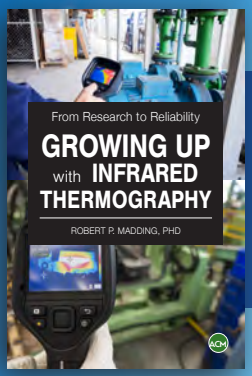

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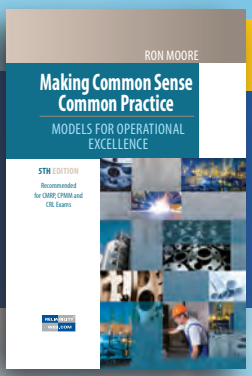

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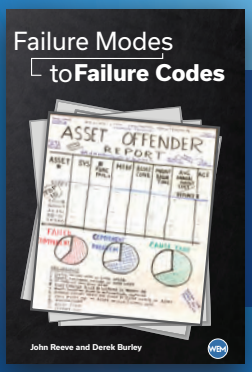

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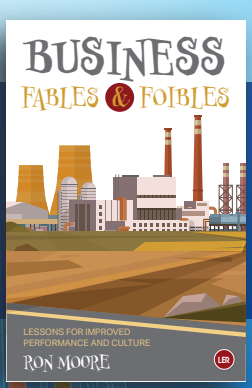

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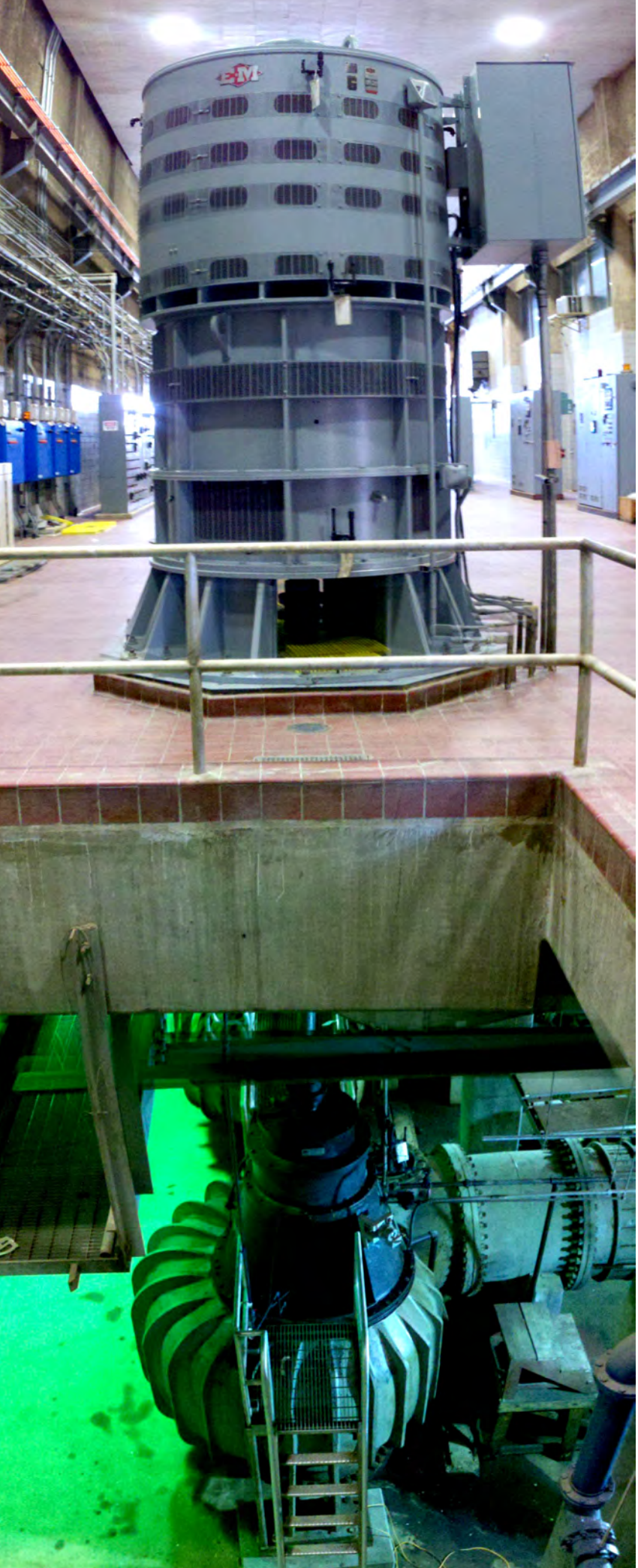
machinery lubrication

DEPLOYING AN ENGINEERED LUBRICATION MANAGEMENT PROGRAM

at DC Water's Blue Plains Advanced Wastewater Treatment Plant

Phillip Higgins and Jason Kopschinsky

IMC 2017 The 32nd International Maintenance Conference Speaker



DC Water's Blue Plains Advanced Wastewater Treatment Plant is the largest advanced wastewater treatment plant in the world. It covers 153 acres and has a capacity of 384 million gallons per day (MGD) and a peak capacity of 1.076 billion gallons per day. This massive facility, commissioned in 1937, consists of hundreds of rotating assets that must operate efficiently to effectively support the needs of customers in a multi-jurisdictional area.

In recent years, DC Water's Equipment Reliability Group focused efforts on improving overall equipment reliability through effective lubrication management. With thousands of rotating assets, equipment reliability is a critical issue, as many of the machines have been in service for nearly 30 years.

The Old Business as Usual

As with many large organizations, the lubrication program evolved from a time when lubrication management was not well defined or documented. Historically, lubrication management has been the responsibility of the individual mechanic or millwright completing the work. Generally, anyone who needed oil or grease could order any type or amount of lubricant to complete the task at hand. The result was an excessive amount of new, unused oil and grease stashed in every corner of the plant. The goal was to have easy access to lubricants at the point of use, which is critical in a plant the size of Blue Plains. However, with little to no oversight, this practice quickly created an environment in which misapplication, poor quality control and a host of other poor practices resulted in inflated up-front lubricant costs, followed by unexpected downstream reliability issues.

DC Water has a long history of using oil analysis to guide the maintenance program. One of its first efforts was to implement an internal oil analysis program that utilized a benchtop minilab for immediate results and quick action. As with many organizations with a huge amount of grease-lubricated equipment, technicians know early on that their grease selection and application practices need to be improved. The Equipment Reliability Group believed DC Water was not getting sufficient product life from bearings and there was either over or under lubricating. The fact was incorrect amounts of grease were being applied to most bearings based on industry accepted guidelines. The next action was to investigate and implement an ultrasonic greasing program to add much needed precision to the mechanical reliability program.

Although these efforts are typical of world-class programs, the team soon realized the efforts were not addressing the root causes of some of their most common problems. Although an oil analysis program was helping to assure quality in lubricants, the technicians often didn't get the right information necessary to make decisions on equipment maintenance. Additionally, though its ultrasound program was adding precision to the grease program, the team suspected the technicians weren't always using the correct or optimal lubricants in all applications.

Benchmark Assessment

Even after the team's initial efforts, there was a consensus that the lubrication program still had plenty of room for improvement. Like many others before them, they really didn't know where to start. Wanting to learn best practices, they sought professional help to support their improvement program with a site-wide benchmark assessment of the lubrication program.

The assessment documented how DC Water approached lubrication. The assessment covered three days and was divided into 10 areas of lubrication, including:

- Equipment Maintainability and Contamination Control;
- Lubricant Storage, Handling and Dispensing;
- Lubricant Application Practices;
- Oil Analysis Basics;
- Oil Sampling Practices;
- Training and Education;
- Lubricant Purchasing, Selection and Quality Assurance;

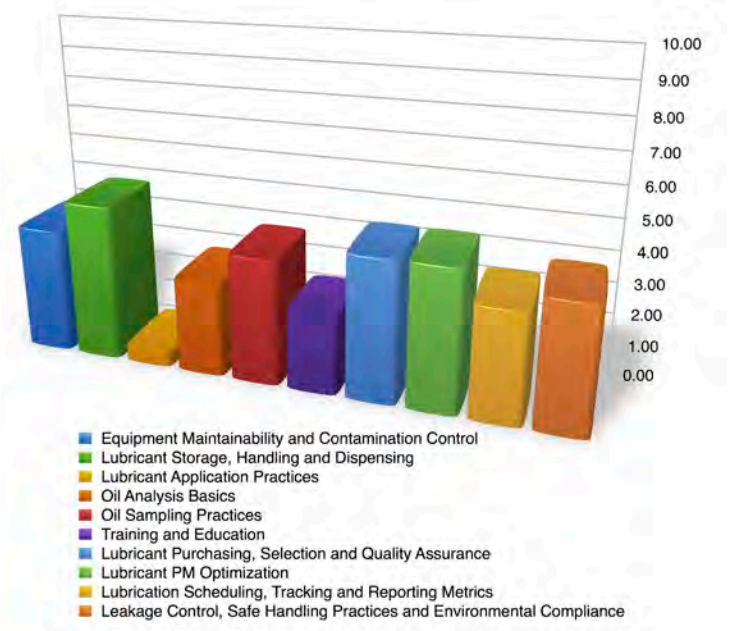


Figure 1: Benchmark of 10 key areas of lubrication

- Lubricant PM Optimization;
- Lubricant Scheduling, Tracking and Reporting Metrics;
- Leakage Control, Safe Lubricant Handling Practices and Environmental Compliance.

The team conducted and documented inspections in every area of the plant regarding the 10 key areas of lubrication. Based on the information gathered, a grade in each area was awarded with a maximum score of 10.

The assessment's results were largely as expected. Even though an oil analysis program was underway, the reports only told the team that it hadn't really made a consistent effort in areas like contamination control and storage and handling. Most of the equipment was still equipped with original equipment manufacturer (OEM) air filters that were allowing moisture and small particles to enter freely into the equipment. They also treated the new lubricants as clean and dry and ready for immediate use. The contamination from these two practices was noted in the analysis, but there was no comprehensive strategy to address the issues.

While they felt the correct condition-based volume of new grease was being added based on the use of ultrasonic feedback, they still were not seeing the life span projected for the bearing systems. A detailed asset by asset audit was not conducted during this assessment, but it was noted that some lubricant selections were clearly incorrect. The most apparent examples were the extreme pressure (EP) grease selected for use in electric motors and the use of another EP2 grease used in couplings. These greases did not have the correct base oil viscosity or additive packs needed for the selected components.

The Impact of Lubrication on Machine Reliability

There are several ways maintenance organizations can learn about the impact lubrication has on machine reliability. Conferences, published articles, collective team experience and training all provide conduits for knowledge transfer. However, few catalysts illustrate the impact as bluntly as equipment failure.

Over the years, many experts have attempted to quantify the cost of lubrication in their plants. The biggest challenge is calculating assumptions on the lubrication program because most organizations don't typically collect and trend lubrication-specific data. Some studies suggest that in extreme cases, plants will lose up to 30 percent of their annual maintenance budget to the downstream effects of poor lubrication. On average though, the figure is closer to 10 to 15 percent, which is still a significant number. A plant with a $10 million annual maintenance budget is expected to waste $1 million to $1.5 million through poor lubrication practices. The problem is many organizations do not know how to properly identify what poor lubrication actually is.

Poor lubrication can be defined as any of the following:

- Over lubrication;
- Under lubrication;
- Wrong lubricant (e.g., base oil, additives, thickener type);
- Poor or nonexistent contamination control;
- Poor storage and handling practices;
- Incorrect application methods;
- Poorly trained technicians.

Many in the industry are not informed enough to identify poor lubrication practices because they don't yet know if they are over or under lubricating, using the wrong oil or grease, or not properly addressing contamination or storage.

For generations of technicians, the focus in maintenance has been on trying to anticipate when a machine or component was likely to fail and what the consequence (e.g., downtime, cost, safety) of that failure would be. There was little attention given to the root cause of those failures. When evaluated on a cost-benefit basis, approximately 50 percent of PM tasks have essentially no value. Activities, like time-based oil drains, calendar-based filter replacements and high frequency lubrication preventive maintenance, are all merely guesses and most of the time, fail to add any value. In fact, many of these activities are detrimental to the health of the lubricant and, ultimately, the machine.

For example, on the surface, a task as simple as adding a little too much grease to a bearing a little too often can have significant effects down the road. Over greasing a bearing results in added visits and more product than necessary, so there is a cost associated with the labor and the material. The ex-

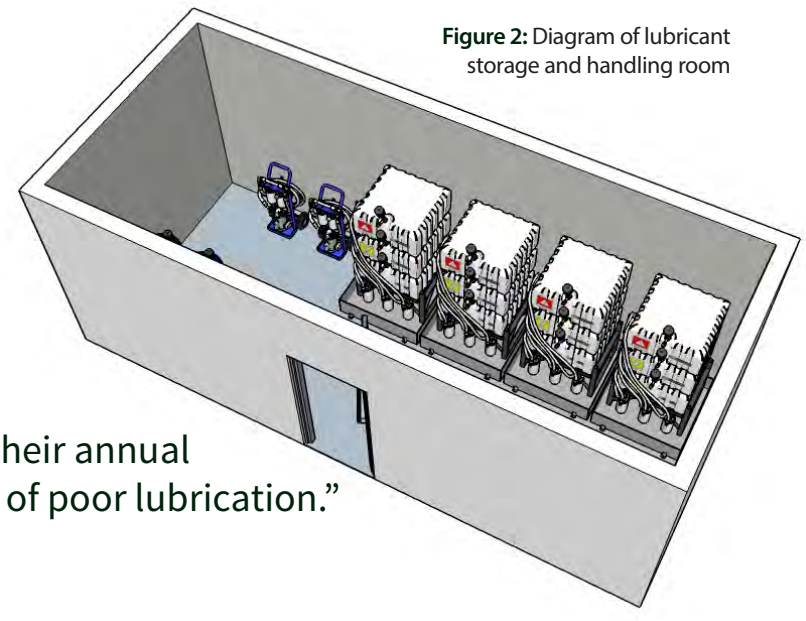


Figure 2: Diagram of lubricant storage and handling room

"…Plants will lose up to 30 percent of their annual maintenance budget to the downstream effects of poor lubrication."

Figure 3: DC Water's lubricant storage

cessive grease envelops the bearing, insulating it so it holds in more heat. This additional heat leads to the rapid onset of oxidation, which creates by-products that can damage the bearing's surface and reduce its overall useful life span. If a bearing is over greased today with the wrong grease, it's unlikely it will catastrophically fail tomorrow. However, instead of that bearing running trouble free for 15 years, perhaps the life of the bearing has been reduced to five or six years. When you start to add up the lost productivity of that bearing, the cost of the replacement and the potentially hundreds of examples like it in the plant, the financial impact really adds up.

The First Step

As a result of the assessment, the Equipment Reliability Group realized its approach to lubrication was potentially costing a significant amount. Even though the group had been progressive in its program over the years, it was still relying on estimates and projections with respect to the lubrication program. It was clear an overall plan based on actual data was needed.

One of the primary deliverables from the initial assessment was the development of an action plan. The action plan was a task list of nearly 50 discrete items that detailed improvement possibilities in each of the 10 key areas of lubrication. One area in which the group knew needed improvement was lubricant storage and handling. The team learned that if it didn't get lubricants into a condition suitable for in-service use in the storage area, it had little chance of achieving this in the plant environment. The group also learned that in order to mitigate the risk of additional equipment contamination during oil changes and top offs, technicians needed to prefilter the new lubricants. As a general rule, oil should be filtered to two ISO codes cleaner than the target cleanliness of the component for which it is intended. This will account for practices in the field, such as small volume top offs, that cannot be avoided and may potentially allow contaminants to enter the system.

DC Water was able to design a fully functional lubricant storage and handling room, with equipment designed to make the job more efficient and effective. The technicians realized that by making improvements in how they store and handle their new lubricants, they were able to improve in other areas, as well. They knew their new oil was free of dirt and water and several times cleaner than the oil in service. This adds important context when reviewing oil analysis reports. All the potential noise from dirty makeup oil was removed, allowing them to focus on real root causes when they saw a potential increase in solid contaminants or water.

The Next Step

The assessment identified some things DC Water was doing very well and some things that needed attention. The assessment's recommendations included implementing several practices that hadn't been previously considered. DC Water started to leverage what it did well and focused on implementing some of the new recommended practices.

The next step was to make sure technicians were using the correct lubricant in the correct place. Though the entire plant isn't very old relative to most industrial plants, the lubricants in use have changed over time. This happens for a number of reasons: plants change lube suppliers, lube suppliers add and remove products from their product line, errors in selection and OEMs not providing enough specific details to select the optimal lubricant.

DC Water engaged professional assistance to collect the data needed to determine the right lubricant in the right amount and frequency and provide a complete lubrication policy. This included plans for each asset class on how best to make minor modifications so that maintaining equipment from a lubrication standpoint and controlling contaminants were easier and more effective.

Progress Toward World-Class: Where DC Water Is Today

Lubrication programs are ever-changing. As the demand on equipment changes and machinery and lubricants age, DC Water must adjust its lubrication program accordingly. With this understanding, DC Water continues to move toward world-class lubrication while consistently evaluating the lubrication process from cradle to grave.

Since implementing the program, the Equipment Reliability Group has been able to identify some quick fixes. For example, identification of equipment with significant leakage problems has become easier with a well managed program. Additionally, knowing what an ideal lubricant volume and consumption look like plant-wide makes it far easier to maintain a realistic inventory of lubricants. These examples, along with many others, help explain the ongoing cost of the lubrication program, which will improve accuracy when forecasting budgets in the future.

As DC Water continues down the path to world-class, it plans to improve on benchmarking by creating key performance indicators (KPIs) from oil analysis data entered into its computerized maintenance management system (CMMS). The plan is to use this data to better understand asset life expectancy of equipment in its normal operating context. Optimizing PMs, more efficient planning and scheduling, and identifying root causes and failures earlier to minimize the impact are all additional benefits DC Water is looking forward to realizing.

A wastewater treatment plant of this magnitude has a vast amount of rotating assets that require many different types of lubrication tasks. DC Water's Equipment Reliability Group (manager Phil Higgins, Gerald Wheeler, Edward Blankenship, John Adams and Coralynn Smith) works relentlessly at designing and implementing a lubrication program that uses industry best practices and produces tangible data that will support and justify its efforts to increase the asset's life span.

With any lubrication program, it's extremely important to approach it as a journey without an end. DC Water will continue to introduce new technologies to its mechanical reliability program as it fine-tunes its lubrication program for continued success.

A special thank you to Phillip Higgins, former Reliability Manager at DC Water, for his contribution to this article. Phillip has retired from DC Water since the writing of this article.

Jason Kopschinsky, *CMRP, is the Director, Reliability Services at Des-Case Corporation. Prior to joining Des-Case, Jason spent over a decade coaching clients in asset reliability and lubrication management. Prior to joining Des-Case, Jason worked at Noria Corporation and Trico Corp. www.descase.com*

Pm
preventive maintenance

The Technology for Better Preventive Maintenance Procedures

Eric Morgan

The goal for maintenance managers is simple: Oversee the successful installation, repair and upkeep of the facility's assets for smooth operations and on track budgets. This goal is certainly obtainable in an ideal setting where inventory is always in stock, technicians are continuously efficient and assets are always running.

Now, let's enter the real world, where downtime is a daily occurrence and overtime hours seem unavoidable. This scenario doesn't have to be the norm if you're able to proactively manage workloads, breakdowns and inventory. And, it doesn't have to be an out of reach possibility with the correct strategy implemented for less reactive maintenance.

Does your organization only service assets once they break down or are headed for a complete system replacement? If so, you're operating in a purely reactive maintenance landscape. However, in today's era where people crave instant access to information and results, the "if it ain't broke, don't fix it" way of reactive maintenance simply doesn't make the grade anymore.

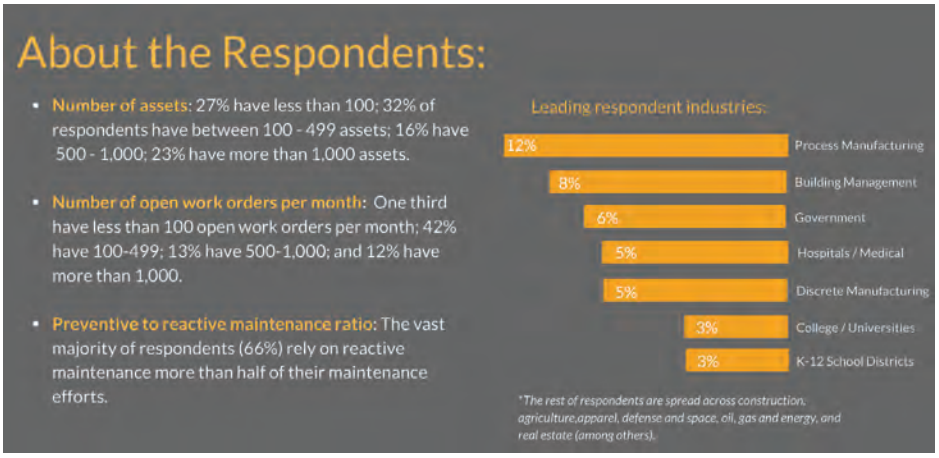


Figure 1: A portion of Maintenance Connection's 2016 report that indicates 66% of survey respondents rely heavily on reactive maintenance; at right, the top industries of respondents

Not a mind reader? No problem. You don't have to have any special skills to predict an asset breakdown before it happens, thanks to the help of preventive maintenance (PM) enabled by a computerized maintenance management system (CMMS). It's a one-stop technology solution for better maintenance procedures.

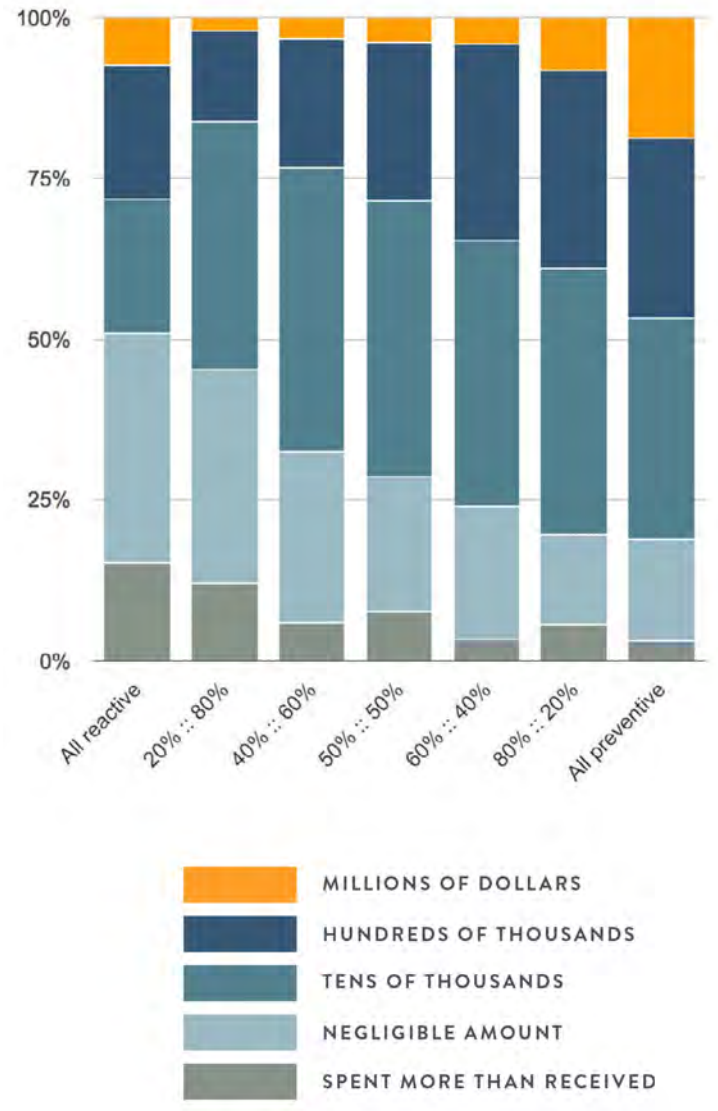


Figure 2: Graph from Maintenance Connection's 2017 State of CMMS Report shows preventive maintenance is a strong driver of ROI, as the more preventive an organization is, the more CMMS ROI it witnesses, with some completely preventive organizations saving millions of dollars

Does your organization only service assets once they break down or are headed for a complete system replacement?

The Benefits of Preventive Maintenance

Often times, facilities get stuck with reactive procedures because it's all they know. While work is getting done across the board, technicians are scrambling to manage work orders, overtime hours are stacking up due to emergency service requests and equipment, with multiple breakdowns, isn't reaching its full life span potential.

The solution for organizations stuck in the reactive landscape of the past is to implement a PM schedule. PM schedules present these benefits facility-wide:

- Cost savings due to less downtime;
- Fewer machine breakdowns or operational downtime;
- Better technician scheduling and less overtime hours and manual labor needed to complete daily tasks;
- Longer asset life with fewer breakdowns;
- Fewer large-scale repairs;
- Improved response time to fulfill work order requests.

Overall, PM schedules help facilities proactively manage breakdowns before they happen for more accurate budgeting, less unexpected downtime and fewer interruptions in the production schedule, just to name a few.

CMMS and Preventive Maintenance: A Cost Saving Partnership

While you may agree that the benefits of PM are clear, a study by Maintenance Connection (Figure 1) finds that only 34 percent of survey respondents were operating in a preventive environment. That translates to more open monthly work orders and other issues, like decreased reliability, slower response times and a higher likelihood for downtime.

While implementing PM across your facility may seem like a daunting task filled with manual data entry and years from ideation to fruition, it doesn't have to be. With the help of a CMMS, PM schedules are simple to program and organize all assets into one hub.

The best CMMS solutions have specific features that make PM implementation simple. Among the functions that can be performed are:

Pm
preventive maintenance

> …What maintenance manager doesn't want to see higher ROI from technology usage or better cost savings on overall budget with PM?

- Using auto-triggered work orders for more accurate technician scheduling;
- Setting up system-generated notifications for upcoming PM tasks;
- Creating a list of estimated inventory needs for any PM requests in the near future to avoid inventory stockouts;
- Adding instructions on work orders for technicians to efficiently complete requests;
- Pulling data on historic repairs to better understand what assets may be underperforming;
- Setting up seasonal schedules based on past downtime data;
- Scheduling technicians proactively to avoid breakdowns;
- Cutting back on unplanned downtime and overspending with increased asset and technician efficiencies.

If you're still wondering if a CMMS investment coupled with a PM strategy is right for your facility, consider the following: In an updated report by Maintenance Connection released in 2017 (Figure 2), data from 1,000-plus maintenance professionals uncovered that preventive maintenance is a strong driver of CMMS adoption in terms of return on investment (ROI). In fact, the report states that 73 percent of facilities that have a preventive to reactive ratio of 50 percent or higher see significant cost savings, ranging from tens of thousands to millions of dollars from CMMS-enabled PM schedules.

Measure PM Success with CMMS KPI Dashboards

In addition to the CMMS features, also consider the benefits of reporting on a CMMS. Creating a key performance indicator (KPI) dashboard is another component of PM success and decreased machine downtime.

The best dashboards go beyond just the health of your assets to also measure KPIs, like technician availability and response rates, for faster, more efficient PM procedures.

Specifically, consider the following factors as you build out your KPI dashboard into a comprehensive view of your overall maintenance performance:

- Average time between failures;
- Number of emergency work orders;
- Percentage of work orders in a backlog;
- Ratio of PM vs. corrective or reactive maintenance;
- Percent of overtime, preventive and corrective labor;
- Total unplanned downtime;
- Total annual maintenance time;
- Average annual downtime;
- Quarterly or annual number of failures;
- Percent of work orders by type;
- Average service request duration;
- Maintenance cost per head count.

With these KPIs, you'll be able to pinpoint how much manpower, time and inventory is dedicated to a single work order, or over the span of time, like a quarter or year. From there, this sort of information can be applied to data backed decision-making to help you narrow down the exact cause of maintenance emergencies, identify underperforming assets or personnel and ward off breakdowns before they occur.

After all, what maintenance manager doesn't want to see higher ROI from technology usage or better cost savings on overall budget with PM?

Using a CMMS to Find Maintenance Solutions

No matter your industry, company size, number of technicians, or asset management budget, a CMMS can be the solution for a variety of maintenance problems.

For instance, it can be a solution for:

Asset management: Simplifies asset management by tracking work order history and maintenance cost, and organizing all assets by location, building, floor, etc.

Work order tracking: Creates a snapshot of work order statuses and defines and assigns tasks to open technicians.

Reports on historic data: Collects real-time data on your maintenance health, like overdue work orders, backlog hours and average completion time.

Inventory and cost tracking: Automates the inventory process to alert you when levels are low, automatically generates reorders and tracks all inventory costs.

Field tasks: Provides mobile functionality, increasing team productivity from anywhere and updating work order status from the field.

If your facility is looking to improve its daily maintenance operations, save money, reduce downtime and extend asset life, it may be time to take the plunge and invest in a CMMS.

Eric Morgan *is the CEO of Maintenance Connection, an industry-leading CMMS provider. Mr. Morgan has more than 30 years of experience in information technology and Software as a Service (SaaS). Morgan has a strong track record of accelerating growth of the businesses he leads, and served as the president and CEO at three enterprise-level software companies.*
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A chain is only as strong as its weakest link. Many businesses address this issue by focusing efforts on identifying and strengthening the weakest link. But, is this the best solution? Rather than accepting the existing chain with its weaknesses as given, reconfiguring or redesigning the whole chain can potentially eliminate the weakest link altogether.

This is the reasoning behind product value management (PVM), a holistic approach that can help asset managers redesign assets to boost performance without adding lifecycle costs or complexity.

Consider this scenario: The cargo on a steel train is too heavy, so the train's wheels spin in place. This leads to wheel damage that requires additional maintenance, downtime, and labor and material expense.

How would you solve this issue? A traditional redesign approach would focus on just the wheel to mitigate the issue. PVM takes a broader view, one driven by data across the entire asset and not just the problem component. Instead of focusing on just the wheel, asset managers look to develop alternating current (AC) traction motors that enable trains to carry heavier loads with fewer locomotives while also increasing mean time between failures and service intervals. This reduces maintenance times and total cost of asset ownership. The result is a 15 to 25 percent reduction in asset lifecycle costs.

The Challenge and the Solution

The main challenge for asset managers is to continually improve asset performance while also reducing maintenance and lifecycle costs. A product redesign approach can play a pivotal role in meeting this challenge by identifying ways to improve asset performance and efficiency without adding cost.

How Does PVM Work?

The success of PVM depends on its thorough application across three crucial steps: assess the cost of ownership of critical assets by analyzing maintenance data; identify which critical assets should be redesigned using a value-based approach; and convene both internal and external parties (e.g., suppliers, customers) to collaborate on the redesign.

Let's take a more detailed look at each of these steps.

1 Analyze maintenance data to assess the cost of ownership of critical assets

The impact good asset design can have on maintenance operations is huge. That's why understanding the total cost of maintaining assets is critical to determining asset performance.

Take passenger railroad cars' wagon doors, restroom doors and toilets, for example. Asset managers can look at data to identify how servicing these systems can be combined with other maintenance work so they always function when the train car is in use. While a train can still run with nonfunctioning doors or toilets, a passenger rail company's image strongly depends on those systems working. How can these systems be designed to provide customer-expected functions while not requiring additional maintenance attention?

The first step in data analysis should focus on maintenance records, including frequencies, servicing times, performance data after 30, 60 and 90 days, mean time between failures, etc. Mainte-

nance times can expose inefficiencies and provide insight on equipment redesign opportunities.

Asset managers need to understand the product performance data to support a redesign based on facts instead of anecdotes. This is just as true for the core systems that allow an asset to run, as it is for systems that impact noncore systems that can drive value to the broader organization.

2 Identify critical assets to be redesigned through a value-based approach

To identify which critical assets should be redesigned, all business units, functions and organizational levels need to be brought into one room to discuss the detailed performance data. The resulting asset after redesign should be a product that performs the essential functions at the lowest lifecycle cost without sacrificing quality or delivery requirements.

Here is a real-life example: The chief operating officer of a major railway company once asked: "How is it possible that it takes us six hours to disassemble a restaurant railcar to access the coffee machine and change a failing part?" While the asset manager knows it takes six hours to replace the part, the supplier may think it only takes 30 minutes. Or, even worse, maintenance requirements may not be considered at all when designing the coffee machine.

To establish a thorough redesign process, asset managers need to stop relying solely on in-house knowledge. Instead, they should look outside their organizations to leverage asset performance data with strategic suppliers and/or customers to drive product improvements. PVM provides the opportunity to look at improvements from a 360-degree angle.

3 Convene both internal and external parties to collaborate on the redesign

Each part of the supply chain tends to operate in a silo. For a successful asset redesign, it is vital to break down those silos and get different functions to work together with external perspectives. This ensures asset redesign benefits from both cultural and functional perspectives.

Collaborative work with external partners needs to follow a structured approach so no one is confused during the process. Asset managers, a cross-functional internal PVM team and suppliers should collaborate on asset redesign based on function analysis, performance teardown, benchmarking, design for service and design for manufacturing.

Together, team members should challenge the basic assumptions behind the product's servicing and maintenance strategy. This requires a cultural change in most engineering-driven organizations, where the engineering teams will need to change their role from solution providers to challenge describers and solution evaluators. Open innovation platforms can provide an additional forum for subject matter experts with a variety of backgrounds to develop out of the box redesign ideas.

Working with Suppliers

So how do you convince suppliers to work with you on the redesign of critical assets to improve reliability and efficiency? You have to create a financial win-win situation, where both parties are motivated to work together and makes clear you will not endanger the supplier's margins. Use your asset performance metrics, not to just complain to suppliers, but to highlight performance issues that you can address together.

Approach suppliers with a structured development plan to establish a relationship of trust that demonstrates your offer is not just lip service. It should be clearly stated that PVM is not a sourcing exercise; the goal is a redesign of the asset, not a cost reduction for existing asset components. And, as with any collaborative approach, measures to ensure accountability and sustainability should apply to all parties, not just suppliers.

After the new design features have been developed, create a solid business case with fixed offers from suppliers. Once it has been confirmed that costs can be reduced, the new ideas should be implemented quickly. In the end, not only does leveraging PVM lead to a more competitive, cost-effective product to go to market, it can also help asset managers build a robust product redesign strategy and supporting organization. PVM delivers improvements beyond asset performance by growing a culture of collaboration, driving greater competitiveness in the global market and laying the groundwork for next generation innovations.

For time strapped asset managers who may not have a lot of internal clout and deal with a lack of good data, this may all seem like a steep hill to climb. But ultimately, taking a more value-based, hands-on approach will help streamline day-to-day maintenance operations. Rather than using asset performance metrics to prove to your boss you're doing a good job, use them to improve your own job. PVM provides the steps to achieve that goal.

***Andreas Doerken** is a Senior Vice President with Argo Consulting. He specializes in product value management (PVM). Andreas manages operations excellence projects in all European countries, the United States and Asia in industries that include industrial manufacturing, petrochemical, automotive, pharmaceuticals, and target and portfolio companies of private equity firms. www.argoconsulting.com*

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vibration analysis

IDENTIFYING BEARING FAILURE AT AN EARLY STAGE

Detecting wear, imbalance and misalignment of rotating parts within machinery is critical to its health and overall performance. This can be achieved by implementing a variety of proven techniques. Vibration analysis, for example, uses accelerometers to detect potential problems with industrial equipment caused by incorrectly aligned, loose, or unbalanced rotating parts.

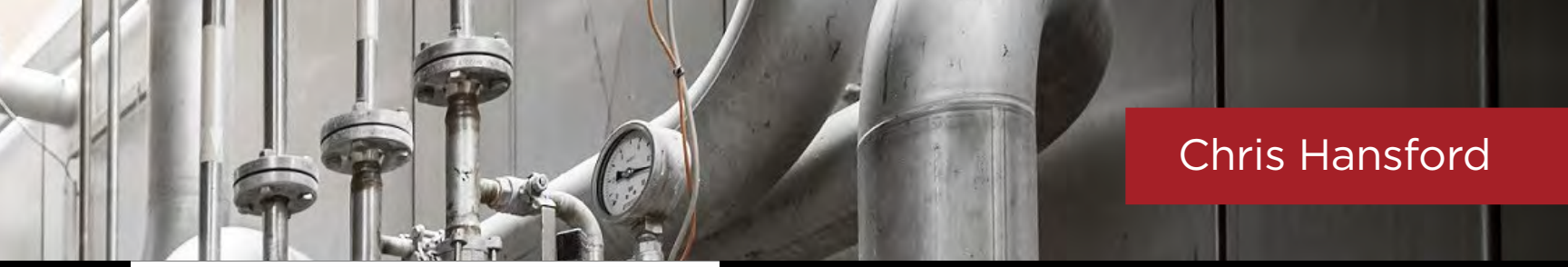
These techniques tend to be most effective during the later stages of the wear cycle, when damage has already begun to occur. In the early stages of wear, however, when vibration signals are of low intensity, it can be difficult to separate the wear signature from underlying and background machine frequencies.

THE SOLUTION

Instead of waiting for wear rates to progress to a later stage – at which point the machinery's performance is likely to be declining while the potential for unscheduled machine downtime will be increasing – maintenance and production engineers can take advantage of a signal processing technique called acceleration enveloping.

This enables engineers to overcome the limitations of conventional velocity spectrum measurements and detect the failure of, for example, rolling element bearings at the earliest possible stage. Then, the rate of wear can be monitored and maintenance work planned accordingly.

In practice, what tends to occur is a defect in a rolling element causes repeated impact events that generate resonant frequencies in the surrounding machine surfaces, causing it to ring. Although the amplitude of the ringing signal decays between impacts and becomes part of the overall vibration signal of the machine, it nonetheless affects the natural resonance response of the machine at the impact frequencies.



Chris Hansford

> ...Acceleration enveloping progressively filters out unwanted parts of the vibration spectrum until the signal of the bearing defect can be isolated from the noise around it.

Vib
vibration analysis

Using a high performance accelerometer, acceleration enveloping progressively filters out unwanted parts of the vibration spectrum until the signal of the bearing defect can be isolated from the noise around it. The signal is then clearly identifiable.

This information can be easily collected from the accelerometer using a data collector, ready for review and interpretation by a specialist. An informed decision then can be made on whether or not maintenance work is required immediately or can be planned as part of routine schedules.

ACHIEVING SUCCESSFUL RESULTS

While acceleration enveloping in many ways is the ideal option for detecting bearing failure, it has a number of potential limitations that must be taken into account before being implemented. The first consideration for plant engineers is the suitability of each machine, because acceleration enveloping isn't fit for use with any and all machines. The technique detects faults involving repetitive, metal to metal interactions, which means anything that masks this, such as gaskets or dampers, may reduce its effectiveness.

However, where an application is deemed to be suitable, several factors help to ensure better results. First of all, in order to measure the low-level signal, accelerometers must be selected carefully and in the proper frequency range to suit the needs of the particular machine or application.

Figure 1: Accelerometers must be mounted securely on a clean and solid base and as close to the component being monitored as possible

Once specified and ready for use, accelerometers should be correctly mounted on a flat, clean surface in close proximity to the component being monitored to guarantee consistent results. Poor mounting reduces the reliability of results and can make collected data redundant, preventing the correct decisions and appropriate actions from being taken.

Once accelerometers have been installed and calibrated, data readings should be taken at regular intervals over a period of time to allow accurate trend analyses to be produced. This allows a steadily deteriorating condition to be identified, for example.

It is important to understand that the information provided is not a simple yes/no answer and requires some skill and experience to interpret. For example, the amplitude of a worsening condition can actually reduce over time as the imperfection becomes slightly smoother.

The potential benefits of acceleration enveloping are clear, but it would be unwise to rely on the technique alone. Implementing it as part of a wider monitoring and analysis regime can be far more effective, helping plant engineers to safeguard the health, performance and productivity of all the assets under their care.

> "...Data readings should be taken at regular intervals over a period of time to allow accurate trend analyses to be produced."

ACCELERATION ENVELOPING IN ACTION

According to the Global Wind Energy Council (GWEC), 268,000 wind turbines were in operation at the end of 2014, with an average of 8,000 separate components per turbine. Of these, a large number are associated with the drivetrain, which is considered the major cause of extended downtime. Wear in gearboxes and bearings, in particular, is known to cause problems. Regular vibration monitoring can prevent these issues from occurring, eliminating the need for expensive repairs.

The complexity of a typical wind turbine, however, does present a challenge for vibration monitoring. For example, the main turbine, gearbox and generator often have more than 15 rolling element bearings installed, while the gearbox incorporates a series of stages, each with multiple gears. These components generate unique vibration signatures with different amplitudes and frequencies, which can be difficult to isolate from each other and can be masked by noise from surrounding systems.

This is where acceleration enveloping can play a crucial role, enabling vibration analysts and maintenance engineers to separate vibration signatures and identify the changes in signal conditions, which can indicate increasing wear.

To be effective, acceleration enveloping requires the use of multiple accelerometers fitted to all key rotating parts. These include the main bearings; planetary, intermediate and high speed gear stages; the generator, both inboard and outboard bearings; and ideally, the nacelle traverse and axial movements.

In each case, several critical factors must be considered. In particular, each accelerometer must be mounted securely on a clean and solid base, and as close as possible to the component being monitored. Normally, standard M8 mountings are used.

It is also important to collect data consistently to enable any change in operating conditions or trends over time to be accurately identified at the earliest possible stage.

Chris Hansford *is the Managing Director of Hansford Sensors, a leading manufacturer of accelerometers and ancillary equipment. Chris is a qualified electromechanical engineer with over 30 years' experience in the vibration monitoring industry. www.hansfordsensors.com*

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LANGUAGE

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VALUES

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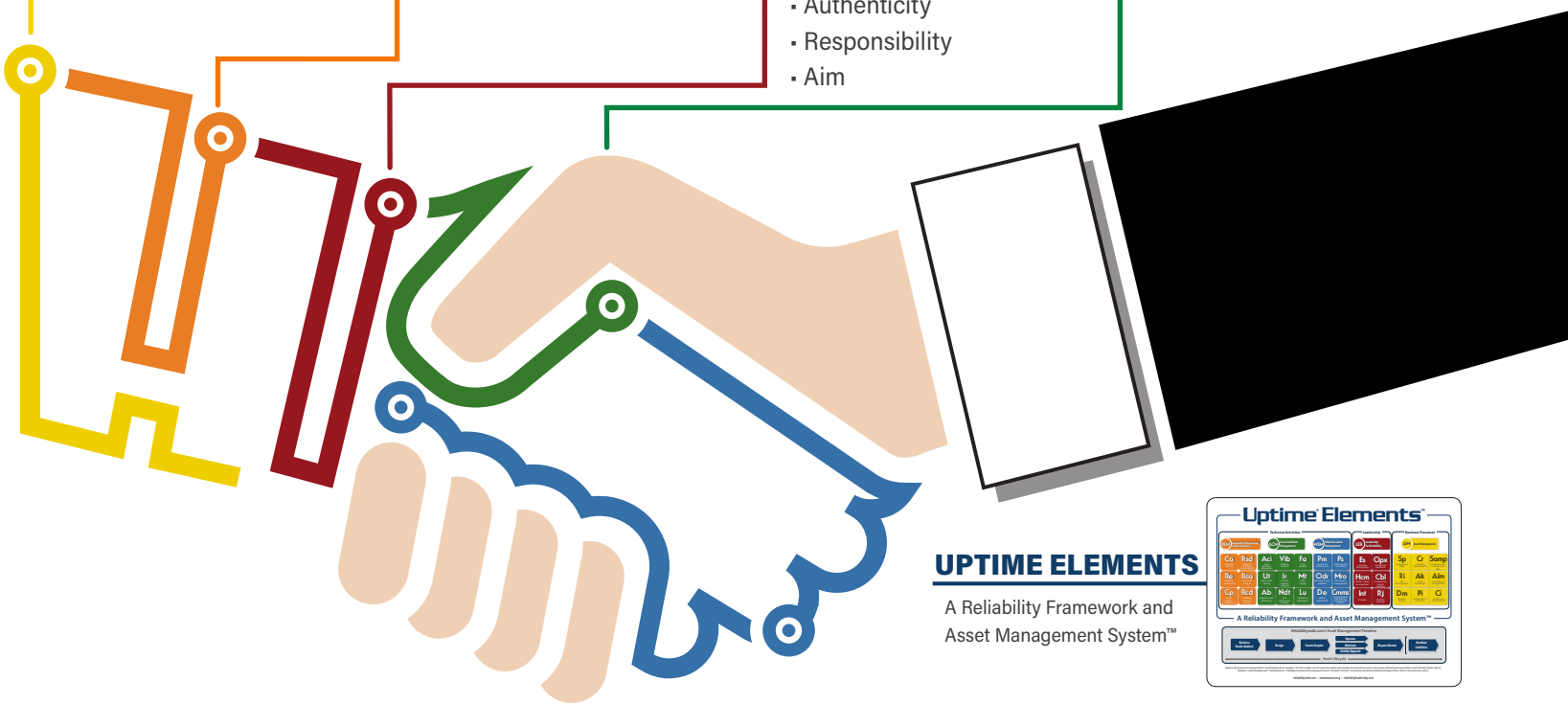
- Integrity
- Authenticity
- Responsibility
- Aim

ECO-SYSTEM

A community that shares the goal of advancing reliability and asset management through interaction, support and sharing.



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COST REDUCTIONS

WITHOUT LOSSES TO EQUIPMENT EFFECTIVENESS AND ASSET INTEGRITY

Doug Robey

Maintenance and reliability teams, programs and practices seem to be a constant target for cost reductions, but this brings up an important question: How can it be accomplished without losses to equipment effectiveness and asset integrity?

When companies implement overarching programs to reduce equipment failure, it isn't always apparent where the problems and root causes exist because the programs often attempt to address everything at once. Some immediate returns and benefits are realized, however, these programs often do much more than is actually required. An example includes following the original equipment manufacturer's guidelines without taking into account or adjusting for site specifications and equipment layouts.

> …The reality is most organizations go beyond what is needed to achieve that result.

Although immediate improvement to equipment uptime is attained, the reality is most organizations go beyond what is needed to achieve that result. The same results can be gained *and* improved on further by adding another step beyond the implementation. That step is analyzing RCM and planned maintenance effectiveness and identifying opportunities for cost savings and optimization.

A planned maintenance optimization approach starts with a detailed program analysis to identify gaps and select key metrics to target for improvement.

The optimization also can identify best practices that already exist within an organization to share for widespread use. This means looking at high performing areas, analyzing the differences between those areas and others, and then implementing a program to disseminate those best practices across an organization. Essentially, you are ensuring time and money are spent in the correct and *best* places, while also removing and inspecting unnecessary and repeat tasks, and getting the maximum impact out of your effort. *The right activities at the right time*!

As an example, one organization specializing in chemical destruction implemented RCM and planned maintenance programs. Although working to great results, the programs started to become difficult to maintain, facing cost overruns. The organization started an RCM and planned maintenance optimization approach, which largely consisted of a detailed program analysis to identify gaps and define and implement cost-effective solutions.

The planned maintenance optimization started with a review of the company's practices, analyzing information from the following:

- Computerized maintenance management system (CMMS);
- Spare parts lists;
- System design description and vendor documentation;
- Planned maintenance item (PMI) workshop;
- Visual inspections of equipment;
- Walk-throughs;
- Interviews with site personnel.

This analysis identified significant opportunities, categorizing many tasks on the company's PMIs as non-value-added. These included inspect-

ing couplings on pumps, manually lubing bearings and chains, and checking fasteners for tightness.

Through this process and analyzing the history of equipment and design specifications, many tasks were aligned more appropriately with equipment needs and design specifications, ensuring the right activities are performed at the right time. Many PMIs deemed non-value-added were confirmed through empirical data.

By reducing and removing unnecessary and repeat tasks and aligning them to a more effective timeline, the amount of planned work is more efficient and effective, saving time for other tasks and duties.

As a result of the optimization, this company improved asset availability by 52 days, along with several other positive impacts.

To determine if your organization might have some of the same issues and to explore opportunities for cost savings, consider a quick exercise by answering the following questions about your organization to achieve *current situation clarity*.

What is your total cost of maintenance?
- Labor, parts, freight, storage, etc.

What is the cost of unreliability?
- Cost and impact of business losses

What is the percentage of reactive work relative to total maintenance workforce hours?
- What is the percentage of planned maintenance workforce hours relative to total?

Where are the major delays and problem areas?
- What are the root causes?

If any of these questions are worrisome, consider taking steps to address what might be causing the problem. Instead of trying to fix all the problems at once, focusing on a specific set of gaps through a detailed program analysis can uncover significant opportunities for cost improvements while maintaining the efficiency and effectiveness of the initial programs.

Implement a program, such as a planned maintenance optimization approach, and keep three things in mind:

1. **Focus on Gaps**: Development or annual evaluation of reliability and maintenance strategies should be focused on closing key gaps: where you are compared to where you want to be.
2. **Gain Outside Perspective:** An ever-present need exists for organizations to revisit and refocus on gaps. Although some organizations have been able to do this internally, remember that an outside perspective is valuable.
3. **Apply Best Practices:** Knowledge of best practices is not often widely known internally, but is critical to an organization's rate of progress.

Conclusion

By implementing a planned maintenance optimization approach and focusing on gaps, gaining an outside perspective, and applying best practices, teams can effectively reduce the costs of their maintenance reliability programs while also finding opportunities for improvement.

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A planned maintenance optimization program starts with a detailed program analysis to identify gaps and select key metrics to target for improvement.

The Case for PREDICTIVE MAINTENANCE *on an Aging Infrastructure*

Saar Yoskovitz

During the early morning hours of Wednesday, July 12, 2017, the skies opened up in Racine, Wisconsin, and over seven inches of rain poured onto the ground for several hours. At the Racine wastewater facility, which is accountable for purification and disposal of sewage and wastewater from over 200,000 people before pouring them into Lake Michigan, all hands were on deck.

As a result of the flash storm, the facility was faced with 106 million gallons of water in a 12-hour period, three times more than its designed capacity flow of 36 million gallons per day. When dealing with such considerable storms, which happen a handful of times a year, all the machines in the facility have to work at 100 percent capacity—there is no room for error. When you hear the words "unsung heroes," reliability engineers should be included on that list. It is through their efforts that systems like the one in Racine keep floodwaters and impact to life and limb minimized.

During a recent visit to the Racine WasteWater Utility plant, Keith Haas, the facility's general manager, pointed out that the plant has had zero days of unplanned downtime since 1970. That's *zero* incidents in over 45 years. Even more surprising is that most of the facility's equipment, which largely consists of pumps, has been there since the 1970s, as well.

How do plant workers reconcile the aging equipment with 100 percent reliability and uptime? Through the use of advanced technologies that enable them to predict malfunctions before they occur.

A Tale of Two Cities: Failed Pumps in New Orleans

Wastewater facilities, whether private or government owned, are responsible for the seemingly easy task of supplying to the general public reliable power, running water and sewage disposal. What many people often overlook is the monumental task of keeping such systems running. That's millions of machines working in unison to deliver services that everyone relies on each and every day. All it takes is one failure at the wrong place to remind people of their dependence on these critical systems and their importance.

Much has been written about the nation's aging infrastructure and many are discussing various ways to overcome the issue. Unfortunately, in early August 2017, the city of New Orleans, Louisiana, suffered a massive blow as a result of its critical infrastructure's inability to perform.

Reminiscent of Racine's July 12 storm, New Orleans was slammed by a massive rainstorm, resulting in eight to 10 inches of rain in a matter of hours. People were evacuated from their homes and neighborhoods after homes were damaged due to widespread flooding across the city. The difference between the storm's impact in Racine and New Orleans rests on 16 critical pumps. Those particular pumps in New Orleans, which are responsible for pumping water from storm drains to nearby bodies of water, happened to be off-line due to planned maintenance and unexpected malfunctions on the day the storm hit. That means 16 pumps had the ability to uproot and disrupt the lives of over one million people.

The lesson learned is clear: No facility can afford to have its critical equipment that powers businesses, cities and lives suffer from downtime.

Figure 1: City of Racine wastewater facility, Wisconsin

Figure 2: Flooding in New Orleans from Hurricane Katrina back in 2005, but flooding continues to hit the city during heavy rainfalls

Figure 3: Mechanical diagnostics enabling PdM at a wastewater facility

> No facility can afford to have its critical equipment that powers businesses, cities and lives suffer from downtime.

Enter Predictive Maintenance

In the past three decades, a new paradigm for maintenance has emerged in high-end industries—predictive maintenance (PdM), also known as condition-based maintenance. The practice involves a shift from the more commonly used calendar-based preventive maintenance approach toward treating machines based on their actual, real-time condition. PdM works by analyzing current and historical mechanical data, aiming to detect a malfunction in its earliest stages before any real damage occurs so repairs can take place before machines are taken off-line at critical or unplanned moments.

Take, for example, a simple screw that needs tightening on a piece of equipment. If a technician is alerted to a loose screw, he or she could simply tighten the screw immediately at nearly no cost. However, if gone unnoticed, that simple malfunction could result in the machine tearing off its shaft and failing during a big production push, or in the case of the New Orleans pumps, during an unexpected deluge.

A U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Federal Energy Management Program report finds that by taking a predictive approach to maintenance, repairs become easier, simpler and cheaper by up to 90 percent. Predictive maintenance also helps eliminate

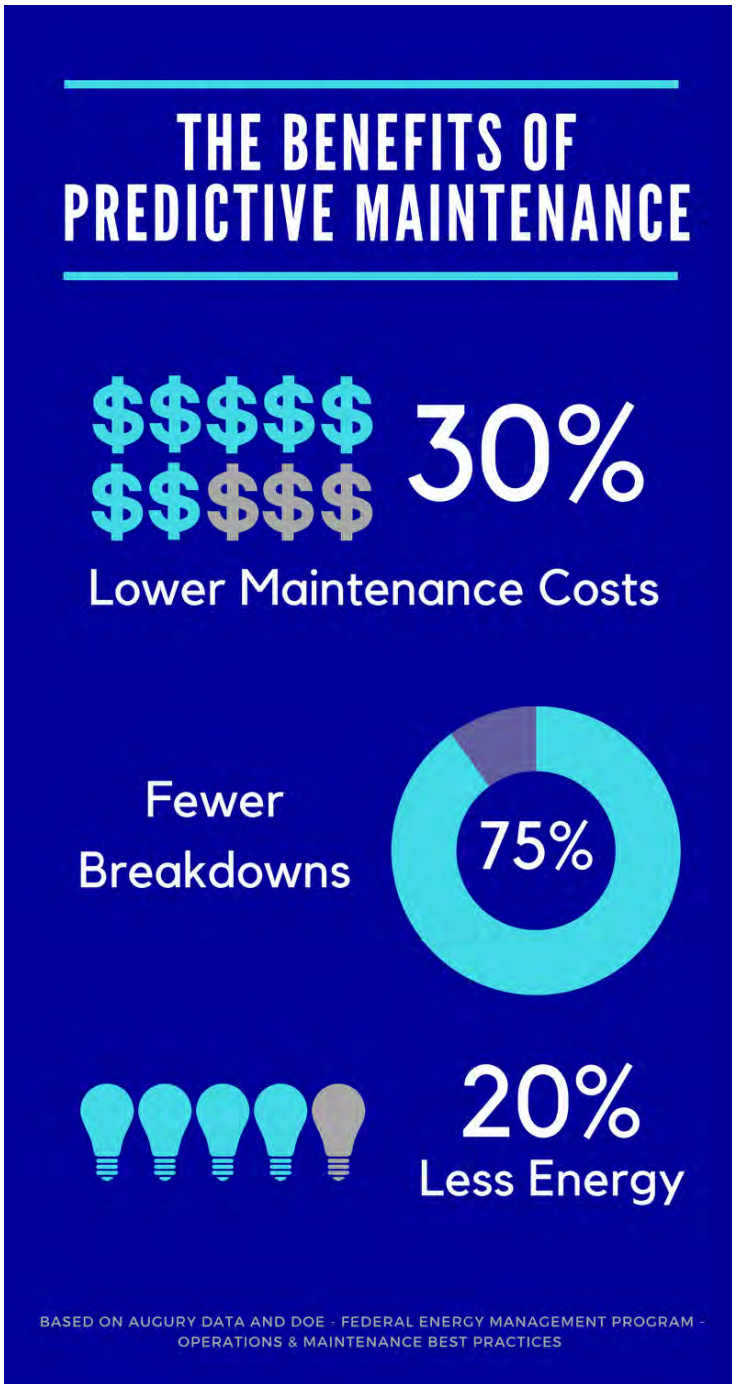

Figure 4: PdM benefits

critical malfunctions by up to 75 percent and enables the facility to plan repairs for a more convenient time and be ready with spare parts.

Embracing the Cost-Effective, Efficient, Smart Future of Maintenance

Until recently, PdM has been used almost exclusively on very expensive industrial equipment in high-end markets. The practice had not trickled down to auxiliary equipment, such as pumps, fans and compressors, that form the foundation for much of the infrastructure people rely on. The reasons may be that with legacy PdM technologies, expensive sensors have to be purchased and installed on every machine to be monitored, trained technicians are required to operate the equipment and results are slow and expensive, both in cost and processing power. But, all that has changed with the arrival of cheap sensors, increased Internet connectivity, cloud-based storage and computing, and mobile devices.

By leveraging modern technologies and using the same types of sensors, processors and network chips typically found in smartphones, machines are coming on-line and becoming "smart" with continuous diagnostics. And like any other computing technology, the costs of these platforms are going down constantly, to a point where their use on auxiliary equipment already shows a sizable return on investment.

The proliferation of connected sensing technology allows cloud-based diagnostics solutions to collect data from one machine, compare it to other similar machines from around the world, pinpoint the exact problem and offer possible solutions. Over time, these ever growing malfunction dictionaries will provide insights into the inner workings of machines that have not been available until now using traditional tools. Similar to the impact the stethoscope and X-ray imaging has had on modern medicine, continuous diagnostics is transforming the face of machine maintenance and operations.

When you take into account the current cost of implementation and operation of PdM technologies, it becomes obvious that organizations are past the point where they can afford hesitation in adopting new technologies for their aging infrastructure. At the pace at which people live and the rate of human productivity and dependence on machines, organizations should be tapping into such technologies to keep their systems and infrastructure running smoothly.

Saar Yoskovitz, *an avid entrepreneur, has extensive experience in machine learning, signal processing algorithms, and system architecture. Prior to founding Augury, Saar worked as an Analog Architect at Intel. Saar holds a B.Sc. in Electrical Engineering and a B.Sc. in Physics from the Israel Institute of Technology (Technion).*
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NO MORE SPREADSHEETS:

Amir Datoo

Microsoft Excel® is an amazing tool. Yet, it has its limitations and flaws for engineers who aren't trained in computer programming.

The main problem with spreadsheets for managing maintenance programs is human error. No matter how fastidious you are when creating a spreadsheet, a single line of data that is entered incorrectly, or worse, an inaccurate user-defined formula, can have huge implications down the road.

In fact, "What We Know About Spreadsheet Errors," a study by Raymond Panko of the University of Hawaii's College of Business Administration that was published in the *Journal of End User Computing*, found that 88 percent of spreadsheets contain errors. He warns:

These error rates are completely consistent with error rates found in other human activities. With such high cell error rates, most large spreadsheets will have multiple errors, and even relatively small 'scratchpad' spreadsheets will have a significant probability of error.

When it comes to maintenance, these small errors can add up quickly.

Think of a multimillion dollar maintenance project. A maintenance manager unwittingly enters a few incorrect cost estimates. Decisions are made based on the calculations resulting from this incorrect data and, as a result, machinery is not maintained when it should be.

Or, the equation for failure probability is not quite right. According to the spreadsheet, a major piece of equipment isn't likely to fail anytime soon, so you delay maintenance. Whoops. The equipment fails and the whole plant needs to shut

THE NEW PARADIGM IN ASSET STRATEGY MANAGEMENT

down. The downtime costs tens of thousands of dollars a day.

Yes, Excel can be used to create links between different sheets, develop hierarchical relations and create simple pivots. It can even run complex Monte Carlo simulations for determining probabilistic likelihoods of asset failure. It's flexible and easily adaptable. But, can your organization afford the risk of compounding errors due to incorrectly entered data or a flawed formula?

Making Sense of Work Management

As any maintenance engineer or manager knows, work management is a critical piece of the maintenance puzzle. It's all about evaluating your equipment, deciding what you need to do with it, scheduling the work, completing the work and, finally, reviewing your actions.

You'd be hard-pressed to find an organization that doesn't have a good work management process in place. Additionally, a raft of enterprise software systems exist to help manage the activity.

Yet, these enterprise systems fall short in one crucial area: Asset Strategy Management. Reliability analysis is not built into the tools, so organizations fall back on spreadsheets to manage things like predictive failure analysis, failure mode and effects analysis and reliability simulations.

The good news? Implementing an Asset Strategy Management (ASM) solution removes the inconsistent outcomes from asset strategies and drives continuous reliability improvement. ASM helps to answer the "what" and "when" of maintenance and is proving to save money, dodge downtime and improve overall business performance.

Key Benefits of Asset Strategy Management

The use of an enterprise ASM solution over spreadsheets offers huge value to any organization.

First, as a structured solution, you know it has gone through rigorous rounds of testing by experienced programmers. Formula errors simply don't exist.

What about human error? An ASM solution helps you avoid user input errors through data validation and verification. You set up business rules and logic that immediately flag any errors that have been made. For example, there's a common field called system condition. You can set the field as mandatory, meaning a user must enter a number to progress to the next field. You can even stipulate what number(s) it can be.

ASM also delivers huge efficiency gains. With spreadsheets, it can take almost three years to develop a reliability management strategy. But, using an enterprise ASM software tool, complex reliability strategies for that same organization can be up and running in six months.

Efficiency is also found in a reduction of files being used. If you're using spreadsheets to manage maintenance schedules, it's common to have a different spreadsheet at each site. A change that needs to be deployed globally requires a huge effort and carries a risk for errors. When data is consolidated into one ASM system, changes can be made singularly and globally.

Reliability studies also seamlessly interact with the computerized maintenance management system (CMMS) without version issues and/or loss of data.

Perhaps the most significant benefit of an ASM solution is its ability to facilitate risk-based decision-making. Spreadsheets do no provide real-time analytics to guide informed decisions. But, with the right ASM system in place, all the key metrics you need to make those business-critical decisions that could make or break your business are at your fingertips.

In Summary

If you are currently trying to manage your asset strategies in spreadsheets as your enterprise tool, you may already be experiencing challenges with collaboration and large data storage. You may have also experienced the effects of errors that can exist within these systems or, perhaps, you don't have visibility into where errors are lurking or how significant they are. Errors can potentially lead to poor decision-making, compromising equipment availability and reliability, or worse still unknown exposure to critical risk. As an alternative, consider increasing reliability and decreasing downtime costs by using a software solution that is fit for purpose and can handle the needs of a collaborative, enterprise level organization.

"Implementing an Asset Strategy Management (ASM) solution removes the inconsistent outcomes from asset strategies and drives continuous reliability improvement."

Amir Datoo, *CRL, CMRP, is a Technical Manager at ARMS Reliability. He is involved in the development of enterprise asset strategy management software and associated reliability and implementation software, as well as provides technical support and governance for reliability projects. www.armsreliability.com*

Ut
ultrasound testing

Part II of II:

ULTRASOUND FOR SAFETY...

IF NOT FOR ANYTHING ELSE!

Jim Hall

In Part I (Oct/Nov 2017 *Uptime*), the focus was about the use of ultrasound and SAFETY. Hopefully, it spurred a discussion in your facility as to how this technology, no matter its age or origin, can be a life-saver. This technology can truthfully claim that it has been around longer than any of you have been alive. Yet, it is still a most valuable technology in many, many ways.

Part II focuses on ultrasound for reliability maintenance and presents real-life situations as to why electrical workers and infrared thermographers should use ultrasound as a complementary technology.

Figure 1: Corona seen through a corona camera, with the dots representing ionized gas surrounding the anomaly; Ultrasound detected corona through the closed doors of the cabinet

Figure 2: Horizontal flame box of a boiler

Figure 3: Coal fired power plant with nine tanks of hydrogen gas

Figure 4: Step-up transformer nitrogen blanket leak

Enhance Safety With Ultrasound

The ultrasound applications presented in both parts of this article are tried-and-true. Despite this, many electrical workers/technicians and infrared thermographers still need convincing to learn to use ultrasound as part of their electrical inspection. So, here it is in a nutshell: Making ultrasound a complementary technology to your electrical inspection might just be the difference in you going home safely today. Yes, those are strong words, but they need to be written. They are based on years of experience from what is known today compared to what was known before NFPA 70E, the Standard for Electrical Safety in the Workplace from the National Fire Protection Association (NFPA), was being practiced. In short, the use of ultrasound for electrical inspection is strongly advised.

Ultrasound for electrical inspection of switchgear and substations to detect and locate arcing, tracking and corona discharge is still one of the least understood. In some cases, it has been easy to ignore.

Every industrial plant and power generation and utility provider have electrical applications where ultrasound should and can be used religiously. If you still need convincing, arrange for an ultrasound demonstration to scan electrical switchgear and substations with plant workers to demonstrate the use of ultrasound and how it can detect and locate electrical anomalies that disturb the atmosphere around it with either an arc, partial discharge, etc.

Corona, with its by-products of nitric oxide, carbon, ultraviolet light and ozone, all together provide a continuous decay of the apparatus, hardware, or connections. Well within the range of the ultrasonic translator/receiver, it can be easily detected. Once found, the trick is to convince oneself to doing something about the findings. If you have a connector or piece of hardware that is continually being decayed, looking to find ground, would you allow this to continue? How severe is it? If corona is present, it is severe.[1] The number of decibels one detects is not the severity, but more to do with how close you are to the anomaly.

Figure 1 is the result of only detecting two to three decibels when scanning the doors of a closed 7,200V phase to ground, 12,470V phase to phase cabinet. The sounds of corona discharge prompted an immediate inspection of the electrical cabinet. Once opened, a plastic shield was directly behind the doors between the exterior of the cabinet doors and the stress cones. When energized, corona can be heard some 40 feet away and another six to seven decibels higher was also noted.

Note: *The number of decibels one detects is not the severity, but more to do with how close you are to the anomaly.*

A week later, a corona camera was used to video the damaged stress cones and associated hardware. The damage was not confined to one area, but multiple locations within the cabinet. This could have become a catastrophic failure. The cabinet was located on a small college campus walkway with lots of daily foot traffic within only a few feet of the cabinet.

> “Making ultrasound a complementary technology to your electrical inspection might just be the difference in you going home safely today.”

Ultrasound Safely Inspects Boiler Horizontal Flame Box

On one particular day in a high-rise building in Los Angeles, California, the facility maintenance team had to use two hands to open the boiler

> *Almost 70 percent of all electric power generators over 60 MW worldwide use hydrogen cooling.*

room door due to a strong pull of negative air from inside the room. In other words, the room was evacuating a large amount of air in the room to a "safe" working range and to lower the effects of carbon monoxide in the room. Ultrasound was being used in the room for leak detection of the compressed air supply lines. Fortunately, the first thing detected was not compressed air supply leakage, but leakage from several bolts of the boiler's horizontal flame box (Figure 2).

Using the ultrasound instrument and a rubber cone in front of the receiver allowed for identifying each of the leaking bolts. It was also apparent that some of the loose bolts had broken torque-stripe. Once the bolts were replaced, it was evident the leakage situation was resolved because it only took one hand to open the door into the boiler room.

Ultrasound Safely Finds Hydrogen Gas Leaks in Power Generation Plants

Back in 2009, an article written by Nancy Spring[2] stated, "According to John Speranza, vice president, hydrogen product sales, Proton Energy Systems, *almost 70 percent of all electric power generators over 60 MW worldwide use hydrogen cooling.*" The article went on to explain that there are two ways to fill the generator's hydrogen demand: have it delivered in cylinders or make it on-site. "Hydrogen gas inventory becomes the chief safety concern because of the potential energy in hydrogen," said Speranza.

For example, Speranza said a standard portable cylinder filled with hydrogen at 2,400 psig is equivalent to 35 pounds of TNT in terms of explosion potential. A 12-pack of cylinders represents 420 pounds of TNT and a typical tube trailer, 5,585 pounds of TNT.

Hydrogen is an effective way to cool the generator and allows power plant operators to get a lot more megawatts out of a smaller generator (Figure 3).

Do you have hydrogen at your plant? If yes, hopefully you have gas specific detectors and leak detectors. However, over the years, several technicians have found that ultrasound detects a hydrogen leak at a distance. Ultrasound also can locate a hydrogen leak around a generator's seal.

At a power generation plant in Southern California, a group of Level 1 ultrasound technicians had left due to attrition and the ownership of the plant was changing. The plant had been unsuccessful in locating an ultrasound instrument on-site and after local services also failed to locate a nitrogen blanket leak, an ultrasound instructor was called in to locate the leak on a step-up transformer (Figure 4). It was found within 45 seconds. Additional inspections were conducted, including the switchgear and surveying for hydrogen leaks around the access plates of the generator/turbine. About 12 hydrogen leaks were found. Why so many, you might ask? Simply because of environmental conditions thwarted the use of a specific gas detector to sniff and detect the hydrogen leaks.

These environmental conditions were caused by the Santa Ana winds of Southern California. Their ferocious, both for allergies and for detecting gas leaks, such as helium or hydrogen in open spaces. However, an ultrasound detector detects turbulence, no matter what the air or gas. With the use of a liquid wetting solution that amplifies leaks, a thin film of this surfactant can be sprayed onto the bolt and bolt heads and detect bubbles popping from bubbles so small they were very hard to see with the naked eye. The sound, very much like rice cereal popping in milk, was detected in areas surrounding the bolt heads and flanges (Figure 5). The hydrogen leaks detected by ultrasound could have been detected by a specific gas detector had the winds not been blowing.

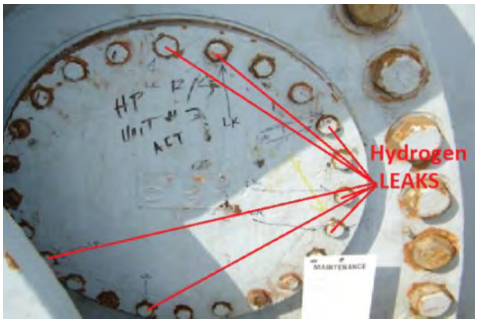

Figure 5: Hydrogen leaks around generator access plate found with ultrasound and wetting solution

Evaluate Your Ultrasound Inspection Program

Hopefully, the real-life examples in this article give you pause in understanding how much passion ultrasound users, the practitioners of ultrasound for reliability maintenance, have when using these instruments to keep people, facilities, and the environment safe.

Take some time to look at your ultrasound inspection program and do the following:

- Reevaluate the storage and handling of gas cylinders;
- Reevaluate the feasibility, both from a financial and safety perspective, as to whether to replace hydrogen tanks with on-site hydrogen generators;
- Determine whether you are practicing proper boiler inspections in accordance with the American Society of Mechanical Engineers (ASME), the Occupational Safety and Health Administration (OSHA), or the National Board of Boiler and Pressure Vessel Inspectors (NBBI) codes;
- Verify that you are utilizing ultrasound instruments with the proper safety ratings (e.g., FM, ATEX, etc.);
- Get your technicians trained in the use of ultrasound if they are not already.

There are so many applications where ultrasound can be used if technicians are trained in its proper use. As the slogan goes: Safety First. Safety is everyone's responsibility and the use of ultrasound can ensure that safety.

Ultrasound for SAFETY… If not for anything else!

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Jim Hall, *CRL, is the Executive Director of The Ultrasound Institute (TUI). Jim has been in the ultrasonic market for over 25 years and has trained many Fortune 500 companies in the use of airborne ultrasound, including the electrical power and generation, pulp and paper, automotive and aviation industries. Jim has been a contributing writer for Uptime® magazine's ultrasound segment since the magazine's inception. www.theultrasoundinstitute.com*

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Dick Hyatt

INCREASING UPTIME

Through a Service Relationship Management Approach

Although the Internet of Things (IoT) has the ability to provide organizations with an astounding amount of data to help increase uptime, reduce total cost of ownership and improve operational efficiencies, companies are not using this data to its fullest potential. In fact, according to a report by McKinsey & Company, most IoT data remains unused. The small amount of data that is being used is generally applied only to anomaly detection, with little ongoing, sustainable value being achieved.

In reality, companies *can* successfully use IoT sensor data to accurately track the overall performance and utilization of their assets and tools. This data can be aggregated to identify issues and even predict failures before they happen.

Achieving this long-term sustainable value is only possible when sensor data can be made actionable and easily shared in a timely and efficient manner among the various members of the service supply chain. In this respect, an IoT sensor in and of itself is not an enabler, but really an enhancement to the service event management process.

Effective service management requires a well coordinated effort across the service supply chain. The service supply chain is a complex web of data, people (internal and external), technology and process required to ensure effective, timely and efficient service and repair of commercial assets. Unfortunately, these teams and the required information are often disconnected when an incident occurs. An enormous amount of time is spent tracking down paperwork (e.g., maintenance histories and schedules, warranty information, etc.), sending e-mails and making phone calls, all before any type of repairs take place.

Better Collaboration and Efficiency Through Service Relationship Management

Implementing a closed loop service relationship management (SRM) approach ensures the right people have the right information at the right time. SRM enables the in context collection of sensor data and information from other third-party applications and shares that information in real time with key members of the service supply chain. This eliminates antiquated, complicated and inefficient methods in favor of a system that promotes instant collaboration through the connection of people, processes, information and systems.

SRM systems are cloud-based software platforms that enable the service supply chain to communicate and share in context information to make better, faster and more informed decisions. This approach has proven to reduce problem identification time by more than 70 percent, lower service and repair times by as much as 50 percent and improve the likelihood of the correct repair by more than 90 percent.

How Companies Use SRM to Drive Uptime

While most transportation companies have used telematics to monitor location and driver behavior, these connected assets are also increasingly being used to report on vehicle health and performance. Sensor data on engines and other key components, plus location information, can help kickoff a process to track, manage and measure service events.

Traditionally, capturing vehicle health, engaging the right internal and external personnel, scheduling the best available repair location by hours of operation, proximity, parts availability, services offered, etc., and gaining access to the information required to correctly and efficiently repair a vehicle has been a time-consuming, manual and stressful process.

If the fleet and its service supply chain are using an SRM system, however, this process suddenly becomes a lot less complicated. The manager is notified when a high severity event occurs and receives information regarding the likely cause, plus a suggested repair plan. This information, along with the asset's location, nearby preferred providers, service history and details about warranties, campaigns and any outstanding recalls, is all aggregated and shared.

> "SRM enables members of the service supply chain to engage with each other in real time based on IoT sensor data and other information."

The entire service supply chain can now easily access details on the vehicle's overall performance and maintenance histories, much as a doctor would when seeing a new patient's medical records. With a better understanding of the issues, the team is more prepared to make the appropriate repairs, decide how to manage the driver and delivery load, and get the necessary technical or warranty-related support from the truck's original equipment manufacturer. Ultimately, the truck spends less time in the shop and more time on the road.

The same principles can be applied to any commercial, industrial, or manufacturing assets or equipment that rely on continuous operation. Sensors can provide valuable data on temperature, pressure and other factors that may impact the performance of the asset/equipment. This in context data can be captured across the supporting service supply chain through an SRM system to ensure maximum asset availability.

Enhancing Efficiencies Through a Cloud-Based System of Engagement

In the 2012 *Forbes* article, "The Move from Systems of Records to Systems of Engagement, Josh Bersin writes about the distinction between "systems of record" and "systems of engagement." He defines systems of record as "ERP-type systems we rely on to run our business…traditionally designed for people who have no choice but to use them." Meanwhile, systems of engagement are "systems which are used directly by employees…they 'engage' employees."

When Bersin wrote his article, organizations were on the cusp of a transition from systems of record to systems of engagement. Now, organizations have reached the point where data can be used to drive new levels of productivity and efficiency.

The ubiquitous nature of cloud platforms has made it possible for everyone in the service supply chain to get access to the information they need, when and where they need it. They can use this information to make better decisions, work more efficiently and keep things running.

SRM enables members of the service supply chain to engage with each other in real time based on IoT sensor data and other information. SRM makes this data actionable and intelligent and puts the right information into the hands of the right people at the point of service. In doing so, it drives value to the company's bottom line by enhancing efficiencies and increasing uptime.

Dick Hyatt, *President and CEO of Decisiv, has more than 25 years of experience building, managing and growing early stage technology companies. Hyatt is responsible for all aspects of building a world-class team of industry and technology experts and delivering high-quality, profit-improving products and services leading to long-term customer satisfaction. www.decisiv.com*

Aci asset condition information

The Industrial Internet

DISRUPTIVE INNOVATION READINESS

IMC 2017 The 33rd International Maintenance Conference
Speaker
John Murphy

If you search the Internet for information on asset management, the Internet and Industrial Internet of Things, digitalization, business trends and business reengineering, you'll find a considerable increase in the number of articles with headlines heralding or promising significant and "disruption" or "disruptive" change.

> It's wiser to focus on how to extract value from what you have and spend time creating the vision of where you want to go on the digital journey.

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PC Computing	Tablet Computing

Businesstheory.com, **Apple's New iPad: A Disruptive Innovation by** Tim Mojonnier

Usually, people consider disruption a BAD thing, but these headlines speak to goodness and of something better. What does disruption mean in this context? Certainly, let's hope, the chairpersons and chief executive officers of organizations know and have devised elaborate long-term plans to leverage this cure-all for their organizations' prosperity!

Well, no, sorry, wrong, they don't and they haven't.

There is so much confusion, misinterpretation and misapplication of the disruption term in the business leadership community, and more so in the industrial community. Too often, the word disruption promotes a product or is used as visual "bait" to gain interest and access for product demonstrations. After all, you don't want to be the one to miss the big opportunity, do you?

At other times, disruption becomes confused with innovation, reengineering and continuous improvement.

Technically, when discussing disruption in a business sense, it's really about "disruptive innovation," a term of art coined by Clayton Christensen, the Kim B. Clark Professor of Business Administration at Harvard Business School. In his book, *The Innovator's Dilemma*, Christensen describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors.

On the consumers' side, they've experienced and have come to expect disruptive innovations. Take examples like the evolution from rotary dial to smartphone; desktop to tablets; and the shift from store-based boxed movies to algorithmic streamed movies while sitting in the comfort of your home.

It's important to highlight, as Christensen points out, that each of these product or service examples took a lengthy period to occur and have been usually generated by start-up companies.

So, where are the disruption examples in the industrial world? Where are they on the factory floor? In the maintenance and repair process?

Many would have you believe that the Industrial Internet of Things (IIoT) is the disruptive innovation. Others, this author included, say NO.

Certainly, many wonderful changes are occurring in the industrial space. There's increase usage of sensors/condition-based monitoring capabilities; robotics/automation continues to expand; and a few original equipment manufacturers that both sell software **and** manufacture assets/products are doing a bang-up job connecting and making them smart. But, smart doesn't mean disruptive.

The dictionary meaning of innovation is *something new or a change made to make a product or service better*. IIoT is innovation. It's business process reengineering, its improvement, it's certainly change, but it does not yet meet the rigor of Christensen's definition of disruptive innovation:

> *"a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors."*

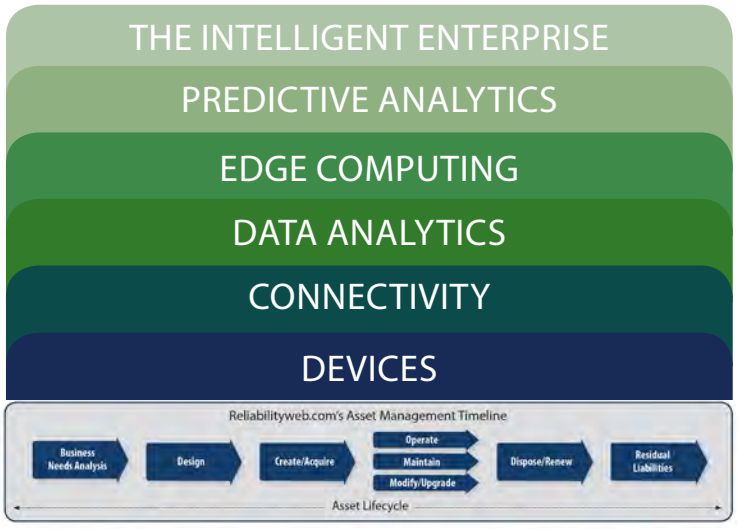
No significant displacement has occurred in the industrial space, but in fairness, aspects of IIoT over an extended time may morph into disruptive change. There are indications that certain products are beginning the Christensen criteria journey, such as drone-based digital inspection or machine learning/AI, but IIoT is not yet the disruptive panacea often lauded. Someday, but not today.

Organizations on the chase to find disruptive innovation need to stop and refocus. Finding the next GREAT thing is too problematic. It's wiser to focus on how to extract value from what you have and spend time creating the vision of where you want to go on the digital journey. Too many companies don't have a digital vision, a culture of neither innovation nor continuous improvement. Too many companies do not embrace the principles of reliability that *Uptime* magazine sponsors. Living these fundamental business principles are foundational requirements for any successful digital transformation with the innovations IIoT offer.

Tell your organization to forget the technical definition of disruptive innovation and replace it with a simpler one:

CHALLENGING THE MAINTENANCE STATUS QUO WITH SMART DIGITAL CAPABILITIES

Once you've accepted this mantra, then your journey into the digital IIoT can begin, with your strategy embracing your company's AIM and culture. Think of it as of smart maintenance practices infused with smart digital solutions tied to achieving short and long-term organizational goals. It's the convergence of the practical with the possibility within the industrial space.



The bottom line is this: The industrial space, generally, isn't ready for disruptive product innovation. That's going to come from the outside, possibly from the consumer sector, as the line between consumer and industrial processes blurs even more. More worrisome is that the industrial space is not more prepared for the IIoT, with too many companies lacking strategy, culture and capital plans.

The opportunity for the industrial sector is massive, but more organizations need to wake up to the realization that digital/IIoT, innovation and reliability engineering are the true keys to organizational success.

John Murphy *founded Gallatin Management Services in 2016 and recently joined Reliabilityweb.com as Senior IoT Leader. For 34 years prior to starting Gallatin, Mr. Murphy was Chief Mechanical Officer – Engineering and Strategy at CSX, a leading freight transportation company. www.reliabilityweb.com*

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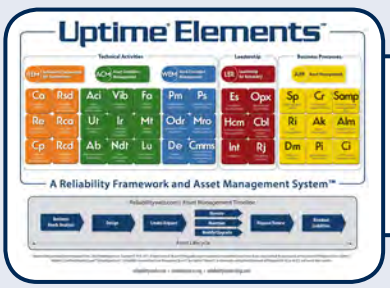

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PREDICTIVE MAINTENANCE OR DETECTIVE MAINTENANCE?

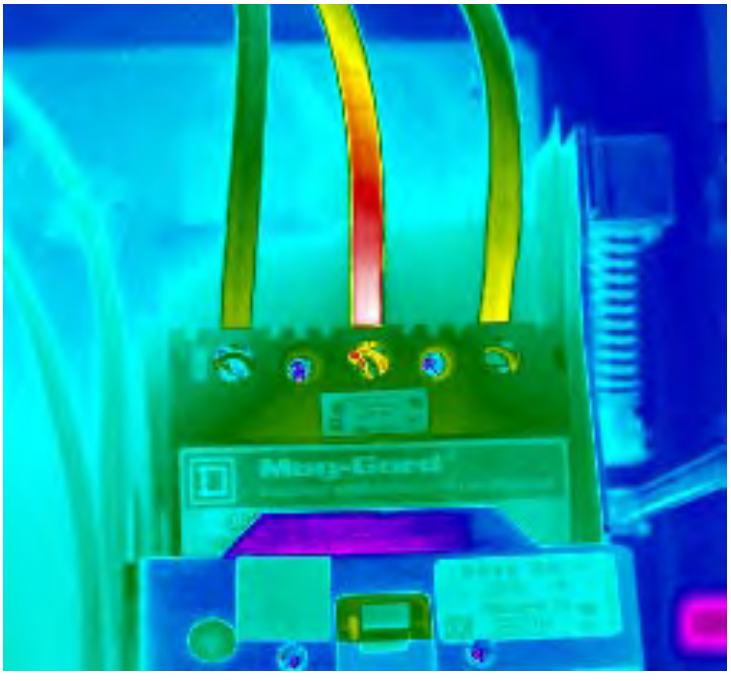
IMC2017 Speaker Joel Levitt

Are you a big believer in oil analysis, vibration analysis, infrared and the use of various kinds of ultrasound? Are you in favor of the tons of new technologies that let you look into aspects of a machine and see its condition in new ways?

How about predictive maintenance (PdM)? If you think it's hogwash, snake oil, you're not alone. Only in the last year or two, using big data analysis and Watson-like tools, is any of PdM providing predictions worth the paper they are printed on. So, what is the problem? The problem is with imprecise language. The problem is when words are recruited to mean something different than what they actually mean. When you say something where the meaning is not what the words mean at closer look, you will (intentionally) confuse people.

Is infrared scanning really as its dictionary meaning of "relating to or having the effect of predicting an event or result?" Think about it from your experience – you can predict a failure from a scan, but the scan itself is in no way a predictive.

Figure 1



> **"So, what is the problem? The problem is with imprecise language."**

Perhaps the name of predictive maintenance should be changed to detective maintenance. What is it that you are actually doing? Let's take a look at an infrared picture (see Figure 1). Sure, you could argue that the middle wire will fail. It might be true, but it is not accurate.

What if it is said that infrared is a way to detect issues that could lead to problems? So, Figure 1 is actually a condition that might lead to problems. Therefore, you have successfully detected potential problems with no bogus prediction involved.

How many times have you faced down meetings where your toes were held to the fire, so to speak, because a prediction from your predictive maintenance didn't turn out? Executives love it when the maintenance folks scream the sky is falling because their predictive gear says it.

Consider that scenario versus you have detected an anomaly and plan to investigate, fix it, watch it, sit on it, whatever. It sounds more credible, doesn't it?

Someday soon, there really will be predictive maintenance systems that will text you, "Get out of the area if you want to live" or something equally clear.

***Joel Levitt**, CRL, CPMM, is the Director of Reliability Projects for Reliabilityweb.com. Mr. Levitt has 30 years of experience in many facets of maintenance, including process control design, source equipment inspector, electrician, field service technician, maritime operations and property management. He is a leading trainer of maintenance professionals and has trained more than 17,000 maintenance leaders from 3,000 organizations in 25 countries in over 500 sessions. www.reliabilityweb.com*

So let's vote now, predictive or detective?

AM

Q&A

KEEP NEW YORK MOVING.

That is the corporate mission and overall vision of the Metropolitan Transportation Authority (MTA). So what does it take to keep the largest city in the United States up and running?

According to Mildred Chua, Vice President & Chief Financial Officer for MTA Bridges and Tunnels, "I believe that best practices in asset management will enable our organization to use our infrastructure to provide safe and reliable service to our customers. By managing our physical assets well, not only are we able to work toward ensuring high performance for our bridges and tunnels, but we are also able to realize the goals of maximizing our revenues while optimizing the cost of delivering our services."

Q: Could you briefly describe the asset management culture at MTA and your role in it?

As the largest transportation agency in the world (comprised of five operating agencies), MTA is an asset intensive organization with a diverse asset base, ranging from rail, transit, buses, bridges and tunnels. The combined value of our assets is estimated at $1 trillion!

I am the Vice President and Chief Financial Officer for the agency, MTA Bridges and Tunnels (B&T), which operates the tolled bridges and tunnels in New York City. I am also the program sponsor for the agency's enterprise asset management (EAM) initiative.

Asset management is a core value and way of life at MTA. We have been managing our assets, either acquired or built, from the very beginning and our workforce serves as proud stewards of our assets, regardless of which operating agency they work for. Our employees have an almost heroic quality about them – thriving on the satisfaction that at the end of every day, they are contributing to fulfilling MTA's mission of keeping New York moving.

In spite of a strong asset management culture, our current practices lack consistency across MTA's agencies. While we have been successful at maintaining our assets in a state of good repair, there is always much more work to do to bring us into alignment with corporate goals, customer expectations and, of course, the international standards for asset management – ISO55000. Therefore, we have been in the throes of implementing an EAM program across all of the MTA agencies since 2013, with an emphasis on establishing a comprehensive management system to formalize and provide a structured framework for our already sound asset management practices.

Q: You have been active in encouraging the advancement of asset management, what drives you to be so passionate about the topic?

My expertise is in finance, investment planning and budgeting, so, of course, asset management is extremely important from a finance point of view, specifically from a total cost of ownership perspective. But, my passion for asset management is deeply rooted in my natural curiosity to understand the drivers behind situations and not simply accepting things at face value. I love exploring options and possibilities from multiple perspectives beyond the financial realm and arriving at results that are more holistic and comprehensive. Business case development and the evaluation of alternatives to select best value options are an integral part of my skill set, along with my inclination toward the use of data to enable evidence-based decision-making.

Given my role at MTA B&T, I have a unique perspective and understanding of the challenges and successes across multiple disciplines through visibility gained from our strategic and financial planning process. This provides opportunities to integrate varying perspectives to achieve efficiencies and better value for our investments, as well as help people understand the value they bring to the table, regardless of their background and expertise.

Q: Can you give us an example of how diversity has played a role in the current MTA asset management journey?

There are many ways to look at diversity. First, it is about consideration of all different perspectives beyond engineering and maintenance, extending participation to include administrative functions, such as finance, procurement, human resources and IT. Second, diversity is about inclusion in the workforce and reflecting healthy representation of gender, age and ethnicity. Last, but not least, there's diversity across the MTA family. We are five operating agencies that have uniquely different businesses (e.g., rail, transit, buses, bridges, tunnels), yet we align ourselves under a common goal for asset management across the MTA enterprise. I think all of these perspectives on diversity have played a major role in MTA's asset management journey.

As an example, our enterprise asset management programs involve projects that touch all departments and encompass three major work streams (people/culture, business process, and systems and data) that are integrated to work in concert to enable comprehensive implementation efforts. When we implemented our recently completed program for cashless open road tolling (ORT), we were inclusive of every department and all levels of the organization to meet the accelerated schedule on budget and to the satisfaction of our customers.

It is noteworthy to mention that when the EAM program was launched MTA-wide, all of the agency's program sponsors were women who happen to have significant expertise in investment planning, budget and finance. I think this says a lot about the ultimate goal of the program for MTA: to realize efficiencies and achieve that optimal balance of CAPEX and OPEX when making decisions regarding investments to maintain our asset base in a state of good repair throughout its lifecycle.

This is a true reflection of the many ways diversity is very much at play at MTA, not only in asset management, but across all aspects of the business.

Q: What can other organizations learn from encouraging diversity in their asset management journeys?

Encouraging diversity as part of our asset management journey has, so far, enabled better integration of uniquely different perspectives into a common goal that aligns us both strategically and tactically across our organizations. Diversity allows us to transcend the traditional asset management mind-set of reliability engineering and maintenance to become all-inclusive of every discipline in our agency.

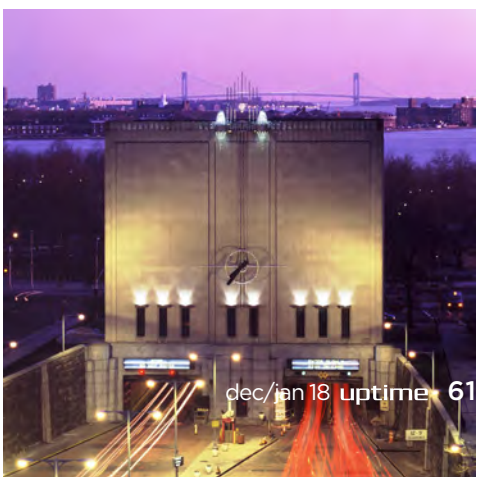
It is through our organizational efforts to encourage diversity at MTA B&T that we have been able to bring everyone together to envision an enterprise approach in managing our assets. We are most proud of our vision statement for asset management, which simply states: "Every Crossing Counts." These three simple words succinctly capture our mission statement of providing efficient, safe and reliable service to our customers and generating surplus revenues to subsidize mass transit operations.

We use the vision to inspire and help our employees understand that while we may view the world through different lenses, each and every one of us at MTA B&T has a role in making "every crossing count" for ourselves, our customers, the MTA family and the New York region. We keep New York moving by making every crossing count!

Q: What are the barriers to diversity and how can we overcome them?

One of the barriers in achieving diversity is the lack of good communication within teams and workgroups, as well as between management and staff. This can be a substantial challenge when there is a high variance in employee backgrounds, especially if differing predispositions and cultures exist because they often result in different forms of expression that are easily misunderstood if communication channels are not open. Really effective communication establishes trust and rapport, helps you to act on risks and opportunities, and promotes productivity and alignment. To improve communication, leaders must lead by example and demonstrate empathy and mutual respect.

Resistance to change is another barrier that is slightly different as it pertains more to the momentum of an organization's culture. Diversity affects organizational norms by creating the need for flexibility and evolution toward a broader culture—a need that is sometimes met with resistance. Resistance builds a wall around a group and creates silos that promote less communication and further isolation. To overcome resistance, you must be able to answer the question often asked by resisters to change: "What's in it for me?" Then, proceed with implementing a planned approach to change in a way that allows people to



understand and realize the social, environmental and financial benefits desired from the change, as well as their own personal benefit.

Q: Can you give an example of diversity in action?

One of the goals of MTA B&T's EAM program is to establish a reliability-centered maintenance (RCM) community of practice, with a focus on embedding the principles of asset management and reliability within the culture and mind-set of the organization. EAM implementation requires participation from all disciplines. However, most of the technical expertise required for asset management lies in the areas of engineering, maintenance and operations. In order to provide opportunities and encourage women in these departments and throughout the agency to participate in the EAM program implementation, MTA B&T established a formal outreach effort to recruit interested staff to join the Women in Reliability and Asset Management (WIRAM) community to increase participation of females from all disciplines across the organization. As participation increases, we expect to see more application of EAM knowledge and principles into daily routines and projects.

Q: Where do you see women in reliability and asset management in 5-10 years?

EAM is cross functional, multidisciplinary and, essentially, a diverse arena where anyone and everyone with the interest and desire can find a calling for themselves personally and professionally. As more women enter into professions in the STEM areas of science, technology, engineering and math, I think there will be more opportunities for exposure to and engagement in reliability engineering, maintenance and EAM. I am particularly encouraged as I am seeing younger generations entering our workforce (a lot of them are young women) with open minds and a thirst to learn many different things beyond their areas of expertise. EAM thrives in this type of mind-set.

My goal as the sponsor for EAM is to build a community of practice, not just for WIRAM, but for asset management in general. In our agency, we have begun to expose all of our new employees to the principles of asset management and reliability as part of their orientation process. Also, we were able to build momentum for our program when we implemented ORT at all of our crossings within one year and we are beginning to experience positive outcomes from using EAM principles to support our ORT implementation efforts. Many women at MTA B&T participated in this important initiative and as they continue to practice EAM principles and share/transfer their knowledge and experience to the next generation of asset managers, I am confident we will see an increasing level of participation among women, as well as better proficiency and higher maturity for EAM, not only at MTA, but in the industry as a whole.

Q: Can change management play a role in encouraging women in reliability and asset management?

Absolutely! Change management is key to successful implementation of anything new, innovative and transformational, like our EAM program. MTA's change management team seeks to facilitate a change in behavior by providing employees with the knowledge, skills, attitudes and desire necessary to embrace the principles of asset management and their eventual application in their daily routine. Training programs are available on this subject and there are regular communication channels where EAM news is shared across the MTA family on a regular basis.

I was encouraged to join WIRAM by a number of women across MTA who have experienced the benefits of this special community of practice and learning environment. As the EAM program sponsor for MTA B&T, I am also the first woman to join from my agency and have found it rewarding to participate and share ideas and knowledge with women around the world who share the same passion as I do for enterprise asset management. I have since begun to recruit my sister EAM practitioners in my agency to join this movement. I am thankful for the opportunity to be a part of the WIRAM family.

Q: What is your advice for young engineers hoping to pursue this career?

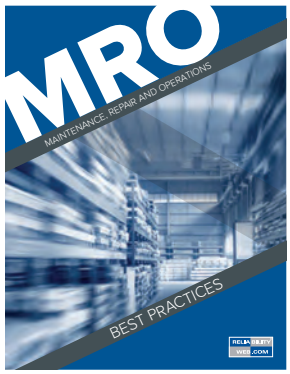
This is an interesting question since I am not an engineer myself. But, my advice for the young engineer or anyone who has aspirations to pursue an asset management career is to remember that asset management is much more than engineering, reliability, maintenance, or systems. It takes a special mind-set to be a good asset management professional. You must rise above your own perspective and have an interest in listening, understanding and considering all different points of view and how they contribute, add value, integrate and connect to achieve holistic outcomes.

The real value of asset management is realized in properly integrating and coordinating diverse sets of activities across the organization to achieve maximum performance, efficiency and alignment of the operating environment with corporate goals and objectives. This means not only being comfortable in dealing with a range of uniquely different disciplines, but also helping people across the organization understand and value the contributions from all perspectives and mind-sets beyond their own. I don't think there is any college major or curriculum that teaches students how to achieve this mind-set, as it is learned primarily through exposure to the diversity of thought out there, coupled with a personal commitment to embrace an enterprise asset management philosophy.

My personal mantra is: "Let events unfold and embrace the possibilities." EAM is a discipline geared toward building a solid foundation, then allowing the principles to take root and blossom, enabling those who have the desire to seize the opportunities for improvement to proceed on the path of continuous improvement and best practices.

Maintenance TIPS

Key Performance Indicators for the MRO Storeroom: Stock Levels



The stockroom makes a service agreement with maintenance to stock certain parts in quantities adequate to supply maintenance needs. A stock out occurs when the stockroom runs out of a stocked part when it is needed. The measurement of this service agreement is stocking level.

Different parts should have different stocking levels. A common part available locally is less critical to hold than a long lead time OEM replacement part on a critical asset.

Key performance indicators (KPIs) flow directly from the AIM of the organization. They are a subset of performance indicators (Pi), which may or may not be "key" indicators. KPIs are the few measures that keep you in action with your continuous improvement (Ci) effort.

How do you measure this inventory when most of the well-established KPIs were developed to manage the inventory of retail stores, not storerooms? If you segment the inventory appropriately, you can use these traditional metrics.

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A Mechanical Condition or a Lubrication Condition?

When monitoring your bearing lubrication with ultrasound, it is important to watch for very high values in your condition indicators (total RMS and Peak values). After applying grease, both values should decrease proportionately. This is a sign the bearing was under lubricated. If the total RMS value lowers and the peak value stays relatively the same, then the bearing has a mechanical condition that is generating impacts.

SDT • (905) 377-1313 • www.sdtultrasound.com

Have You Considered Making the Internet of Things Part of Your Asset Performance Strategy?

Like it or not, the Industrial Internet of Things (IIoT) is changing the way you use information, which means it is changing the way you make decisions. Are you ready for it? The IIoT makes getting good asset information urgent, which means you need to start planning now. As volumes of data grow, how will you manage to make decisions on proactive corrective actions required to keep your assets running safely and reliably? For better asset performance and better operational control, IIoT is an opportunity to make better information-driven decisions. In fact, IIoT has the potential to make our everyday work lives better – for maintenance professionals, reliability leaders and asset managers.

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Avoid Information Overload

As more machines come online, facility managers are inundated with vast amounts of data pouring in from various sources. Avoid information overload by ensuring your solutions have the capability to condense data into useful insights via automated analytics.

A successful maintenance reliability organization is one that is able to derive a holistic view from the constant influx of seemingly unrelated data. Facilities that do so gain a better understanding of their assets and the ability to prevent failures from occurring repeatedly. As a result, these organizations operate more efficiently, safer and more reliably.

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For other Maintenance Tips and great information, visit: www.reliabilityweb.com.

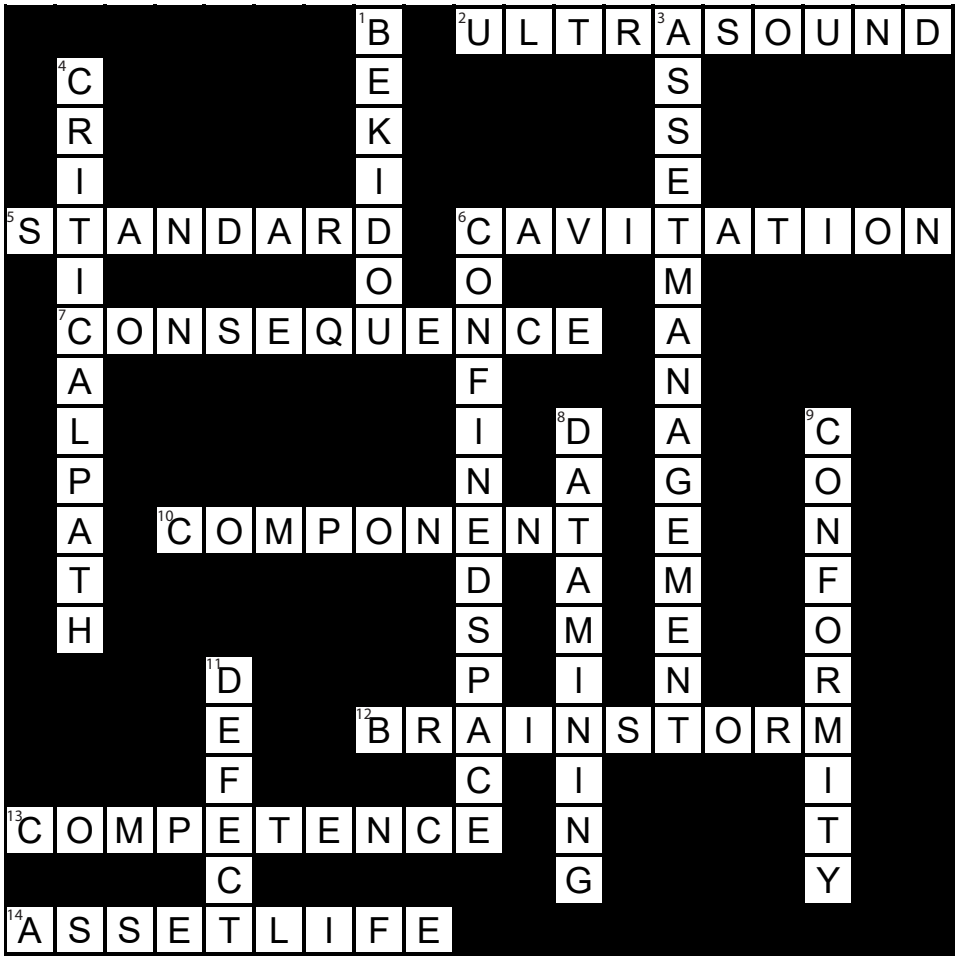
uptime® Elements™

Crossword Puzzle

Created by Ramesh Gulati

ANSWERS

OCTOBER/NOVEMBER ISSUE



ACROSS

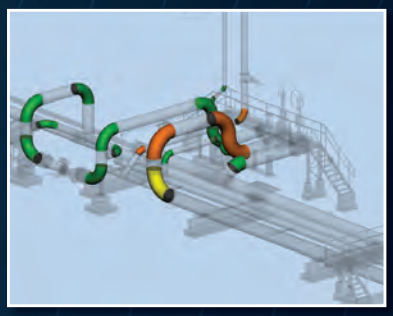
2. The use of sonic technology to discover asset problems
5. An established norm or requirement, generally presented in a formal document that establishes uniform technical criteria, methods, processes, or practices
6. A phenomenon that occurs when the absolute pressure in a pump intake line is reduced below the vapor pressure of the liquid
7. Something that follows from an action or condition
10. An item or subassembly of an asset, usually modular and replaceable, sometimes serialized depending on the criticality of its application, or interchangeable with other standard parts
12. A basic problem-solving tool that uses unbiased ideas of group members to generate a list of possible options
13. The ability to apply knowledge and skills to achieve intended results
14. The period from an asset's conception to its end of life; Also referred to as cradle to grave (two words)

DOWN

1. A Japanese word for output optimization
3. An organizational process to maximize value from an asset during its life (two words)
4. The series of activities in a project network diagram that determine the earliest completion of the project (two words)
6. An area with limited access and a potential respiratory hazard requiring a special permit to enter (two words)
8. An information extraction activity whose goal is to discover facts contained in databases (two words)
9. Fulfillment of a requirement
11. A condition that causes deviation from design or expected performance and leads to failure

Your Roadmap to Operational Readiness and Superior Asset Performance

Assess risk based on failure severity, likelihood scores and confidence assessment.



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