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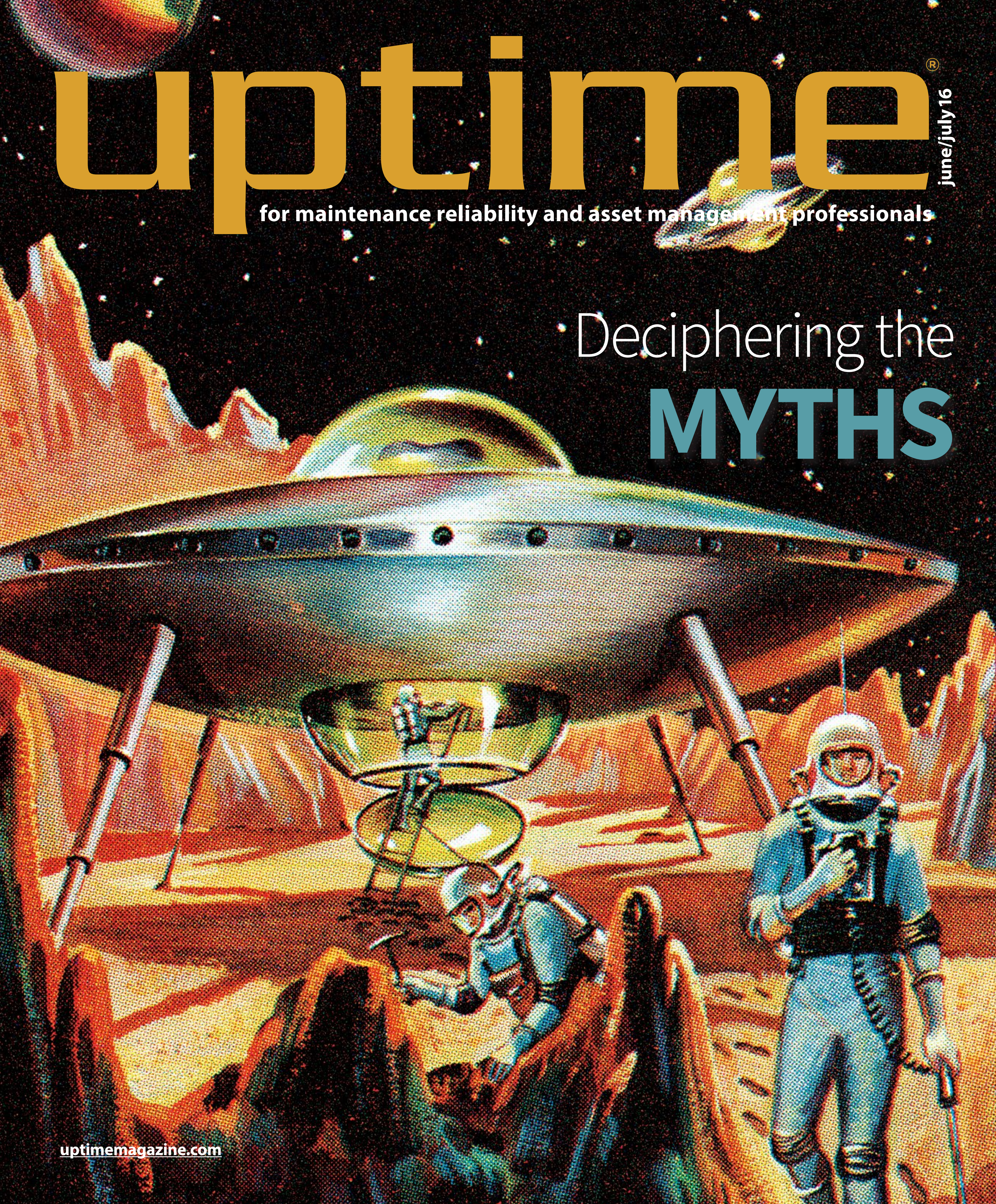

Deciphering the MYTHS

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Reliability Excellence for Managers	General Managers, Plant Managers, Design Managers, Operations Managers and Maintenance Managers	Build a business case for Reliability Excellence, learn how leadership and culture impact a change initiative and build a plan to strengthen and stabilize the change for reliability. CMRP exam following Session Four.	SESSION 1 DATES: Aug 9-11, 2016 (CHS) Mar 21-23, 2017 (CHS) (Sessions 2-4 dates are available on the website)	12 days total (4, 3-day sessions) 8.4 CEUs	$5,995
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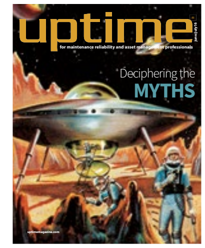
Contents

june/july 2016



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ON THE COVER
Can you find the Uptime logo on the cover? uptime

Features

16

20

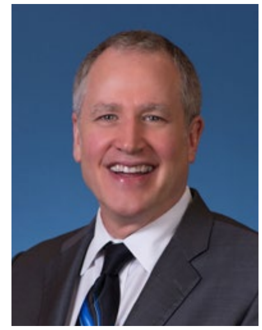
42

46

50

Elements

Editorial



Why Reliability?

For the past 30 years, I have attended hundreds of maintenance, reliability and asset management conferences and sat through thousands of presentations. In almost all cases, these presentations focused on the "how-to."

Reliabilityweb.com has published over 150 how-to books on these topics and there are another 2,800 books published on the topics of maintenance, reliability and asset management. Almost all of them go straight to the how-to. There are many professional, high quality maintenance and reliability certifications that deal in the how-to realm as well.

Our research at Reliabilityweb.com amplifies the claim by business consultant Ken Blanchard that 70 percent of change and improvement efforts fail. More specifically, Reliabilityweb.com research shows that more than 70 percent of reliability improvement efforts fail to generate sustainable business success.

It seems as if there is no shortage of how-to information related to maintenance, reliability and asset management. So, how is it possible that we already have all the answers related to how-to and yet most companies still do not have the level of reliability they desire?

People often ask the core differences between the Certified Reliability Leader (CRL) and other leading maintenance reliability certifications. I would reply that the other certifications deal in how-to and the CRL deals in *what* and *why* without entering the realm of how-to.

Please do not get me wrong – there is a time when how-to is vital for successful improvement; however, our core belief is that too many leaders use it as a starting point, dooming the improvement program to lackluster results or outright failure.

Cynical training companies sell the same how-to knowledge over and over again, knowing that chances for successful change are slim to none.

Our experience shows that by starting with *why* and following with *what*, you empower and engage stakeholders in your organization who can enable reliability and, at the same time, also disable reliability. People who work in production, purchasing, IT, HR and senior management need to be recruited as an army of reliability leaders to create any real change in your organization.

So, take a sip of coffee or tea as you read this, then sit back and ponder this: Why Reliability?

After you begin to answer that question for you and your team, please join Reliabilityweb.com as we proudly borrow from one of the presidential front-runners:

Let's Make *Reliability* Great (Again)

Sincerely,

Terre O'Hanlon

Terrence O'Hanlon, CMRP
About.me/reliability
CEO and Publisher
Reliabilityweb.com
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RELIABILITY® IN THE NEWS

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HIGHLIGHTS from the CRL Chronicles…

The Certified Reliability Leader training has been on the road and has visited the following organizations and events:

- ✓ Austin, TX ~ ARMS Reliability Summit
- ✓ Louisville, KY ~ Reliable Plant Conference
- ✓ Las Vegas, NV ~ The RELIABILITY Conference
- ✓ Bonita Springs, FL ~ Inauguration of eMaint's New Office
- ✓ Fort Myers, FL ~ Reliability Leadership Institute

Terrence O'Hanlon, CEO & Publisher, Reliabilityweb.com and Uptime Magazine, and Florida's Governor, Rick Scott, talk reliability at the eMaint office inauguration

WIRAM Women in Reliability and Asset Management

WIRAM hosted a dinner and group meeting with maintenance reliability professionals at The RELIABILITY Conference in Las Vegas, Nevada, on April 11th. Highlights from the evening included inspiring presentations by Nadia Clark (Elise Resources), Elizabeth Minyard (CH2M Hill), Gail Petersen (FORTIG) and Charli Matthews (Empowering Pumps) who all shared their experience and wisdom with the group.

Left to right: Elizabeth Minyard, Nadia Clark, Maura Abad, Charli Matthews and Gail Peterson

Reliabilityweb.com is proud to announce:

The 2016 Work Execution Management Process Manager's Guide

Coming…July 2016

Read more in the Q&A, page 62-63.

Brian Gleason, President & CEO of Des-Case, and Terrence O'Hanlon

Des-Case Hosts Annual Distributors Conference

On May 2-4 Des-Case Corporation hosted their annual Distributors Conference in Nashville, Tennessee. This event allows Des-Case to thank their distribution partners for all their support and contributions, as well as provide them with in-depth training on industry and application-specific solutions and product demonstrations. Among the topics and activities covered was a customer case study, a holistic approach to lubrication best practices, a plant tour, and a presentation on understanding your target market given by Reliabilityweb.com's CEO, Terrence O'Hanlon. Attendance was represented from 15 different countries, providing a unique global dialogue and presence.

2016 Upcoming Certified Reliability Leader Events

CRL Workshop and Exam

- **June 20-24**
  Uptime Elements
  Fort Myers, FL
- **August 17**
  MaRS (SMRP Houston)
  Galveston, TX
- **September 12-16**
  Uptime Elements
  Fort Myers, FL
- **September 21-23**
  Cincinnati MSD
  Plant Tour
  Cincinnati, OH
- **October 10-14**
  Uptime Elements
  Fort Myers, FL
- **December 13 and 16**
  IMC-2016
  Bonita Springs, FL

International Workshops*

- **June 23**
  Edinburgh, UK
- **September 7-8**
  Asset Performance Summit
  Amsterdam, Netherlands
- **November 20-21**
  Abu Dhabi, UAE

*Request your invitation: crm@reliabilityweb.com

Maintenance TIPS

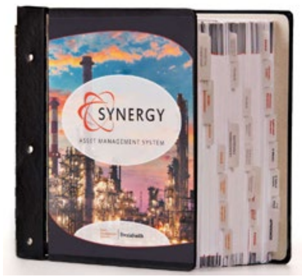
New Oil Does Not Mean It Is Clean Oil

Preventing contamination in lubricated equipment starts with new oil. While the concept that new oil is not clean may be shocking to some, it stands to reason when you consider the number of times a lubricant is transferred before it's put into a machine. For example, when a lubricant is delivered to a bulk tank it may be dispensed from a tanker truck. If the transfer process is not a closed system, then airborne particulate may enter the lubricant and storage tank. The same concept applies when a lubricant is dispensed from the bulk storage tank to a transfer container or satellite storage area. To minimize this risk of contamination, an enclosed transfer system is desirable. This is achieved through addressing storage and handling practices, component modifications, and transfer protocol at every point in the plant lubrication system.

Des-Case Corporation • (615) 672-8800 • www.descase.com

The Right Foundation for the Asset Management Operation

Asset management operations need structure, strategy, and standardization to thrive. A management system provides all three. It is a comprehensive program, a set of policies and practices, that governs all aspects of equipment and infrastructure management.



Asset management systems coordinate people, practices and technology to achieve business goals. They provide the holistic perspective and strategy needed to manage large maintenance operations.

Start with a strong foundation. Establish a management system for your asset management operation.

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Don't Forget to Routinely Inspect Belts

It is easy to install new belts on equipment and forget about them until problems arise. It is important that preventive maintenance (PM) be set up at proper intervals to inspect belts for wear, damage and proper tension.

A few things that should always be inspected during these PM's are:

- Wear in the grooves for V-belts, using a sheave gauge and following supplier recommendations. Rusted or pitted sheaves should be replaced. Otherwise, belt damage/wear and premature failure can easily result.
- Shiny grooves. These can indicate heavy wear.
- Corrosion on the sheave and especially in the grooves. Corrosion will build up and rapidly wear the belt and result in premature failure. Sheave should be replaced if corrosion is found.
- Replace all belts and never a single belt. Mixing old and new belts results in the load not being shared evenly and could easily lead to damage, premature belt failure and sheave wear.
- Ensure that the sheaves are properly aligned. Misalignment will result in premature wear and damage.

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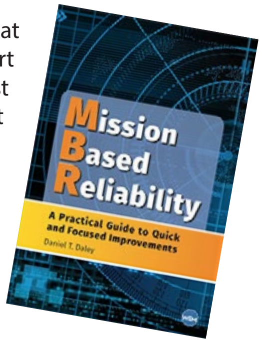
Elements of Focus in Mission Based Reliability

While there are a significant number of elements that might be subjected to pre-departure testing as a part of mission-based reliability, it is important to test those that really need testing and ignore those that do not. If too many things are added to the list, operators performing the checks will become insensitive to the tests and treat them with little concern. Expertise in administering and executing MBR will come when participants can accurately distinguish the various shades of gray.



Daniel T. Daley • Mission Based Reliability
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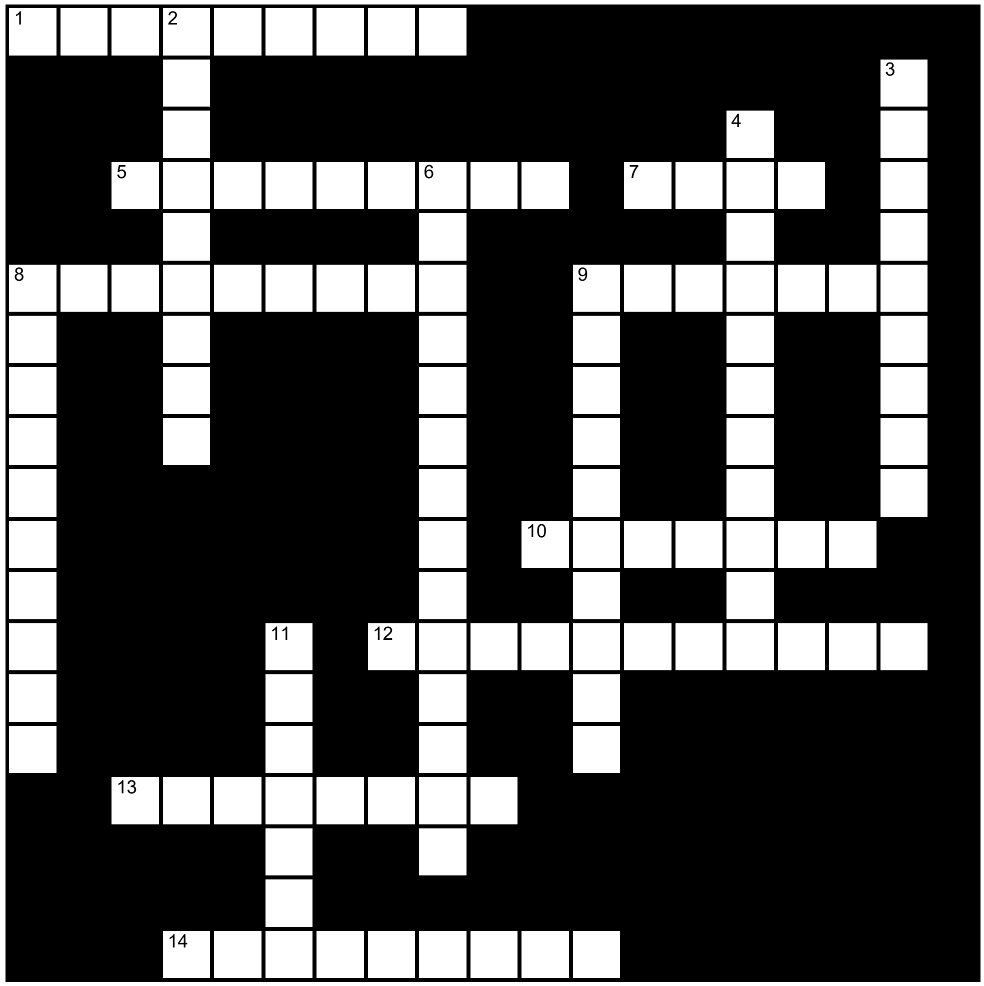
uptime® Elements™

Crossword Puzzle

Created by Ramesh Gulati



ACROSS

1 Adjusting the distribution of mass in a rotating element to reduce vibratory forces generated by imbalance

5 A standard measurement or reference that forms the basis for comparison

7 A discrete piece of information used as a basis for reasoning, discussion, calculations, communication, and further processing for making decisions

8 The elapsed time from the start of an activity / process until it's completed

9 All work waiting to be done

10 A Japanese word for Output Optimization

12 All activities, both value-added and non-value-added, required to bring a product or service from raw material state into the hands of the customer

13 A condition in which one of the feet on a machine does not sit flat on the base

14 A structured, pre-prepared form (list) for gathering and recording data to ensure right and safe operation

DOWN

2 The period from an asset's inception to its end of life

3 A quality of being honest and having strong moral principles

4 A person or organization that can affect, be affected by, or believe to be affected by a decision or activity

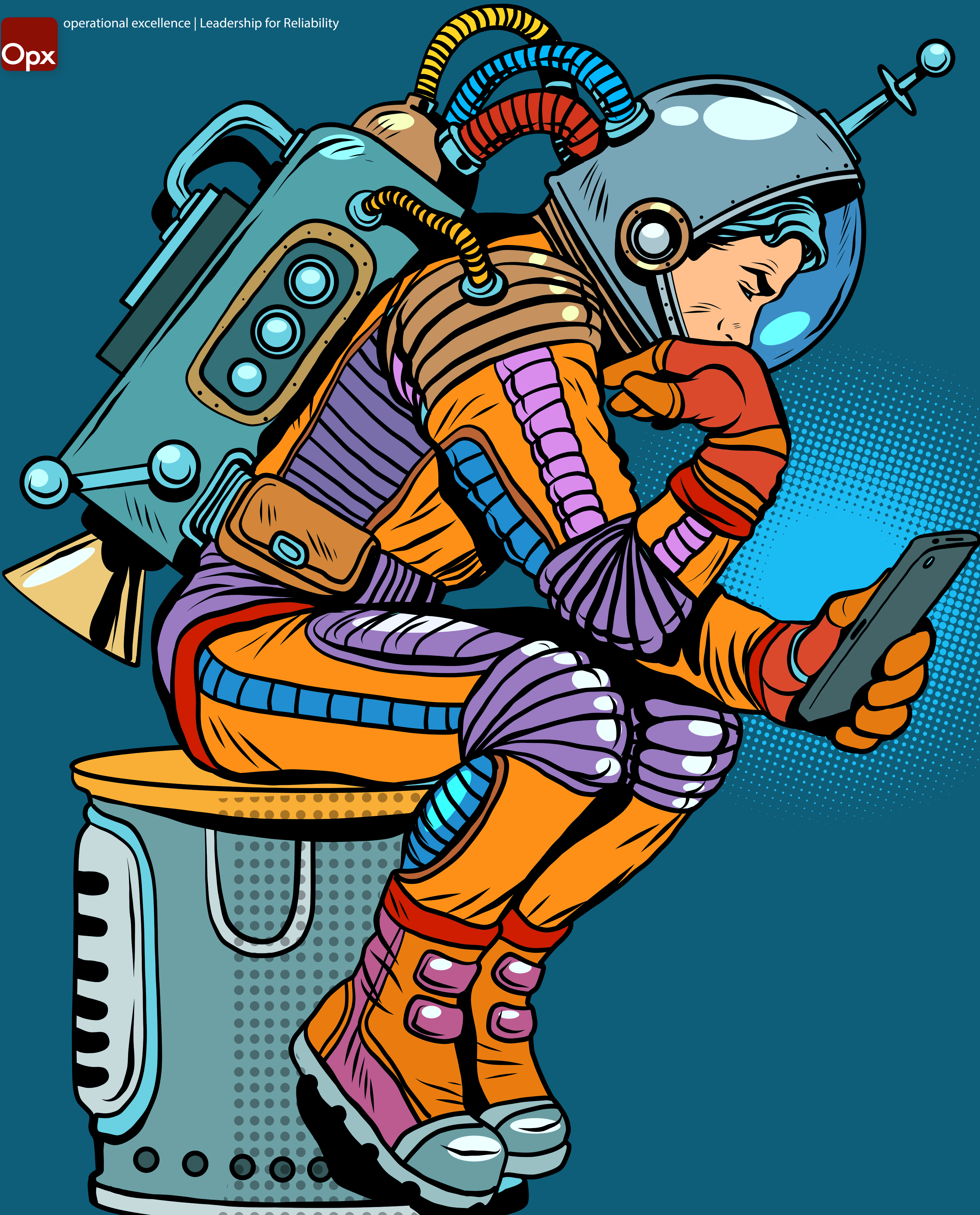
6 An iterative process used to optimize preventive maintenance (PM) intervals

8 Knowledge, skills and abilities required to perform a task safely and consistently

9 A point of congestion in a system that occurs when workloads arrive at a given point more quickly than that point can handle them, creating a longer overall cycle time

11 A common set of values, beliefs, attitudes, perceptions and accepted behaviors shared by individuals within an organization

See page 64 for answers.



Deciphering the MYTHS

Some Observations on Improvement Tools and Strategy

by Ron Moore

It's not easy trying to convince people to use a more comprehensive approach to achieve reliability and operational excellence objectives. Managers need to focus less on maintenance and more on operations, design and procurement. Eliminating the defects in these areas will naturally result in fewer failures, lower costs, higher production and, not surprisingly, a far more efficient and effective maintenance organization. If you focus mainly on maintenance, you will only do work that you shouldn't be doing in the first place more efficiently. But if you focus on the other areas, working as a team aligned to a common purpose while giving an appropriate level of attention to maintenance, you will be far more successful in having a reliable plant. This article attempts to convince people to apply this comprehensive approach by addressing certain myths.

Myth #1

Having an excellent maintenance program will provide excellent plant and equipment reliability.

THE REALITY

Of course, you need excellent maintenance to take care of the equipment and the best plants do indeed have excellent maintenance programs. However, their reliability was not primarily driven by maintenance. It was driven by an operations-led reliability program, supported by excellent maintenance, with the two functions working in partnership toward operational excellence.

The Society for Maintenance and Reliability Professionals (SMRP) defines reliability as the probability that a plant or equipment will perform a required function without failure under stated conditions for a stated period of time. Although equipment is included in this definition because it is part of the plant's production process, the emphasis should be on the plant's ability to perform, with the equipment being a subset of that performance. Using the plant's performance or operational reliability as measured by asset utilization (AU) or overall equipment effectiveness (OEE), Figure 1 shows the breakdown of losses from ideal that most plants have.

As you can see in Figure 1, 67% of losses from ideal production are not caused by equipment issues, but rather by product and process changeovers, rate and quality problems, raw material quantity and quality issues, production planning, so-called short stops, market demand, etc. Maintenance does not control any of these issues. Moreover, when you do a root cause analysis on the balance of losses, or the 33% related to equipment failures, you typically find that about two-thirds or 22% of them are due to poor operating practices or, in some cases, process or equipment design. That leaves only about 11% of the losses from poor maintenance practices. Maintenance controls very little of the plant's capability to produce quality product in a timely manner. Reliability should be looked upon as plant or process reliability and capability, not equipment reliability or availability. They are very different issues. And you should review your data to see how it compares and act accordingly. Incidentally, in a recent survey of 100 maintenance professionals, only 4% said their reliability program was operations led. What does this imply about their probability of success?

Charlie Bailey, vice president of operations for Eastman Chemicals before his retirement, said it best many years ago: *"Reliability cannot be driven by the maintenance organization. It must be driven by the operating units…and led from the top."* A more simplistic view is: *Expecting maintenance to "own" reliability is like expecting the mechanic at the garage to "own" the reliability of our cars.* Moreover, given the aforementioned data, it bears reinforcing that: *If you focus on maintenance, you will only do more efficiently much work that you should not be doing at all.*

Myth #2

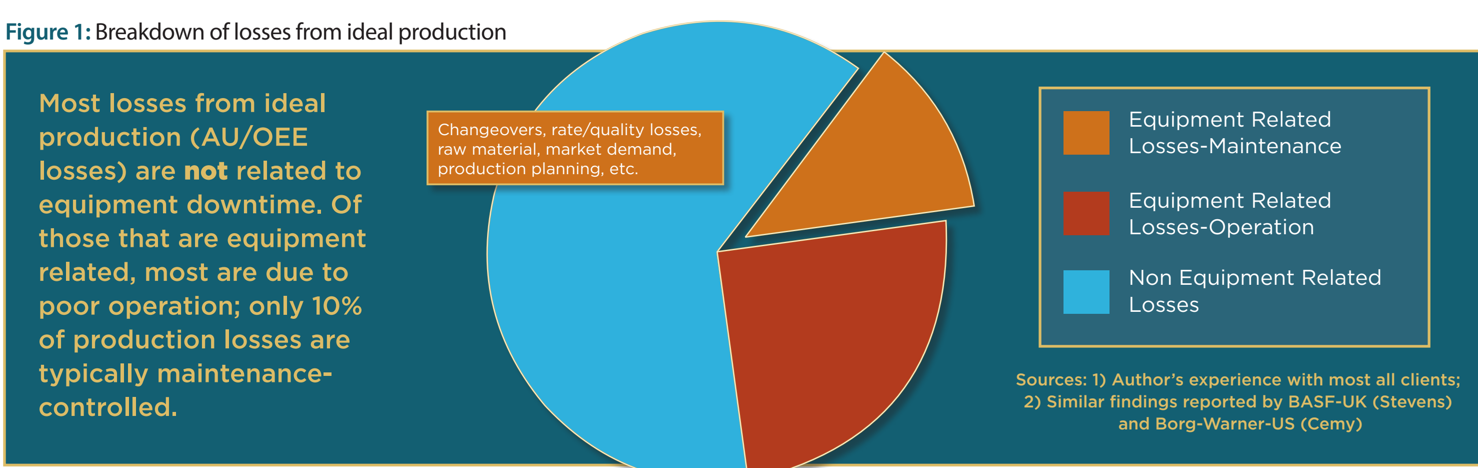
Doing reliability-centered maintenance (RCM), root cause analysis (RCA), Six Sigma, or some combination of the three, will solve most problems in operating plants.

THE REALITY

These are all excellent problem-solving and strategy support tools and their use is strongly encouraged. However, while Myth #2 is true in theory, experience shows that it falls far short in practice. Consider the fact that many, if not most, industry experts say that these tools/initiatives either fail completely or fail to deliver the expected result or some initial success 60 to 90% of the time, or have some initial success, and then slowly fade away into oblivion with the organization returning to its original state. Here are some of the reasons why this happens.

- Initiatives using these tools typically involve only about 3-5% of the workforce. Yes, some plants have trained all their people in Six Sigma or some other technique, but afterward, it is not put into practice by the vast majority of them. With the learning half-life of classroom instruction being about a week, that so-called learning is down to nearly zero a month later. As most training experts know, that learning comes from doing what you have been taught and, ultimately, from teaching others. So, if you only have 3-5% of the workforce actively using these tools, what happens to the other 95-97%? It matters little to them. Experience shows the leverage for organizational success is in engaging the 95-97% to do all the little things right and getting them to use simple problem-solving tools to address the problems that trouble them most. If you want to understand the problems with the work, ask the workers. Engaging the entire workforce in process improvement is the key to success.
- It is often difficult to get the right people in the room to do a proper RCM, RCA, or Six Sigma analysis. If you don't have adequate information for the analysis, it is doomed to failure. Or, you may get the analysis done, but it is one that requires additional resources to actually implement its recommendations. According to RCM experts, you need to budget five times the analysis budget to actually get the changes made that will support better performance. Otherwise, the analysis ends up as a book on a shelf, awaiting action that rarely comes.
- Senior level managers in plants (e.g., site managers, production and maintenance managers) change every two to three years. Each new one brings a different perspective and values the tools differently. As such,

Figure 1: Breakdown of losses from ideal production



this churning of management leads to varying views on what's important, what tools to use and what results are expected, not to mention the dynamic of the management team and the lack of sustainability. Most shop floor people recognize this and become "we-be's," as in, "we'll be here when you'll be gone; you're just another manager passing through." As a result, they are often reluctant to take these initiatives or tools seriously, making them far less successful. Therefore, constancy of purpose is essential.

- Senior executives within a given company will often approve these initiatives, thinking that success will come from them if they just hold people accountable. Unfortunately, these same executives then walk away, having checked off that box and moving on to the next initiative or issue. Achieving reliability and operational excellence through the proper application of tools also requires constancy of purpose, a comprehensive approach and, most importantly, executive sponsorship. That is to say that permission is not the same as sponsorship. Sponsorship requires active engagement in the process, talking about it, demanding it, measuring it, rewarding it and supporting it with appropriate resources. Far too often, executives appoint, for example, a reliability manager and expect reliability to happen. What most have really done is appoint and grant permission, without all the other attributes previously noted. Eventually, the reliability manager gets frustrated and quits, or asks for a transfer, only to be replaced by another who, unless the individual is really resilient, will likewise leave after a couple of years.

Myth #3

Appointing a reliability manager will assure reliability and operational excellence.

THE REALITY

This is no more likely than appointing a safety manager to assure safety. Like safety, reliability requires active engagement by everyone – leadership, management, supervisors, shop floor and contractors, and by all functional groups working in cross-functional teams to eliminate the problems causing the extra costs, lost production and safety hazards.

The safety manager cannot make the plant safe. This person can support plant safety with tools, training, facilitation, measures, etc. Safety is everyone's responsibility. Likewise, the reliability manager cannot make the plant reliable. This individual can support reliability with tools, training, facilitation, measures, etc. But reliability is everyone's responsibility. More importantly, even critically, reliability is the foundation of safety because an unreliable plant is less safe. Data demonstrates that a reliable plant is a safe, cost-effective and environmentally sound plant. Executives should adhere to this mantra and support engaging everyone in practicing reliability accordingly. As noted previously, executives typically provide permission, not genuine sponsorship, and that is a huge mistake. Permission will not result in the desired outcome of a reliable, safe and cost-effective plant.

Myth #4

Total productive maintenance (TPM) is mostly about getting operators involved in maintenance.

THE REALITY

While operator care tasks are an integral part of TPM – which, by the way, should be called total productive manufacturing according to author and founder of the TPM system Seiichi Nakajima – it is far more than operators doing preventive maintenance. TPM is, according to workplace educator Bob Williamson, the original equipment improvement process in the Toyota Production System and it is comprehensive. The basic principles of TPM are:

- Maintenance is about maintaining plant and equipment functions; that is, preventing breakdowns by eliminating defects that create the process and equipment failures. Unfortunately, in U.S. and western companies, maintenance is too often about repairing equipment, that is, "fixing stuff" after it breaks. But Masaaki Imai, an organizational theorist known for his work on quality management, had it right when he said that the 5S methodology is a prerequisite for doing TPM. Klaus Blache, director of the Reliability and Maintainability Center at the University of Tennessee, also notes that properly implementing 5S first will double the probability of a successful lean manufacturing effort.

  In western cultures, when equipment is new, it is as good as it will ever be. In a so-called TPM culture, when equipment is new, it is as bad as it will ever be, or said differently, the current state of the equipment is always its worst state, relative to its future. You are going to constantly improve it.
- TPM calls for measuring all losses from ideal production capability (e.g., 24-7), or overall equipment effectiveness. Knowing all losses from ideal helps prioritize resources and analysis so the focus is on managing actual losses, not any specific number. If you manage your losses, OEE will be what it is optimally supposed to be.
- TPM calls for restoring equipment performance to a like-new condition or better. Half fixes and patches are discouraged. TPM calls for training and developing people to improve their job skills so they can eliminate defects and variation using improved skills and knowledge.
- TPM calls for new equipment management and *maintenance prevention in the design*. If you eliminate or facilitate stopping the defects and failure modes in the design, life is so much easier.
- TPM calls for the effective use of planned, preventive and predictive maintenance, making the work more efficient and effective.
- And finally, TPM calls for operator care and involvement in maintaining equipment, that is, avoid the defects and failure modes, or monitor them so you can detect them early and manage them. But, TPM is more than just operator care, it is all the aforementioned integrated into a comprehensive approach.

Myth #5

Planning and scheduling are nearly the same and better planning will improve reliability.

THE REALITY

Planning and scheduling are often used interchangeably, however they are totally different functions. As manufacturing excellence consultant Bill Schlegel observed, it should be called planning, *then* scheduling. Planning is about developing the work scope and identifying the resources, parts, tools, etc., while scheduling is about identifying a time slot when the resources are available to actually do the work that has been planned. They are two separate functions and should be treated as such.

Moreover, better planning will not improve reliability substantially. So many organizations focus on improving planning and scheduling, and that's not a bad thing. But, if you eliminate the defects that create the work, then the planning becomes so much easier to do and to improve. Of course, you need good planning and scheduling to effectively manage the assets, much the same as accounting needs a good accounting system to manage finances. But, having a good accounting system won't do you much good if you can't close the orders and deliver the product that drives the business. And having a good planning and scheduling system won't do you much good if you're overwhelmed by reactive, unplanned work!

Myth #6

Asset management is about doing better maintenance management.

THE REALITY

Asset management is about managing all the assets, people, processes and, of course, physical assets to create value for the organization. It, too, requires a comprehensive approach that incorporates more than just managing physical assets. Specifically, it includes the business requirements of the assets over the coming 5-10 years and the roles of production, operations, design, capital projects, procurement, stores and, of course, maintenance. The key is to clearly define each role in managing all the assets to minimize losses and risks, and most importantly, add value to the organization. All the functional areas must be aligned to the strategy and goals, and work together to that end.

THE APPROACH TO TAKE

All these myths beg the question: What approach should you take? A recommendation, though not perfect, is provided in Figure 2.

At the top of the figure, the inverse triangle begins with long-term thinking, while recognizing the need to survive in the short term. Next is process mapping where value is added or waste is incurred, followed by continuous engagement of employees and suppliers in improvement. Once you have this in reasonable condition, then move on to tools.

It is strongly recommended to begin with kaizen principles, such as using 5S to help detect and eliminate defects and establish discipline and order; having standard work to assure consistency in work processes; having managers and supervisors "go and see" where the problems are and how they can help remove these problems and obstacles for their people; implementing quick changeovers to minimize production downtime; using visual systems to help make it easy for the shop floor to detect problems; and, in general, implementing waste elimination practices and continuous improvement through structured improvement time or kaizen events. The first few steps provide organizational readiness and capability, which is a culture of discipline and basic care, along with long-term thinking and engagement of all employees. Experience shows that if you apply so-called kaizen tools first, you will solve a lot of problems directly and simply, and allow the more advanced tools to be more focused on the difficult problems. By doing so, these tools will be more sustainable for your continued success.

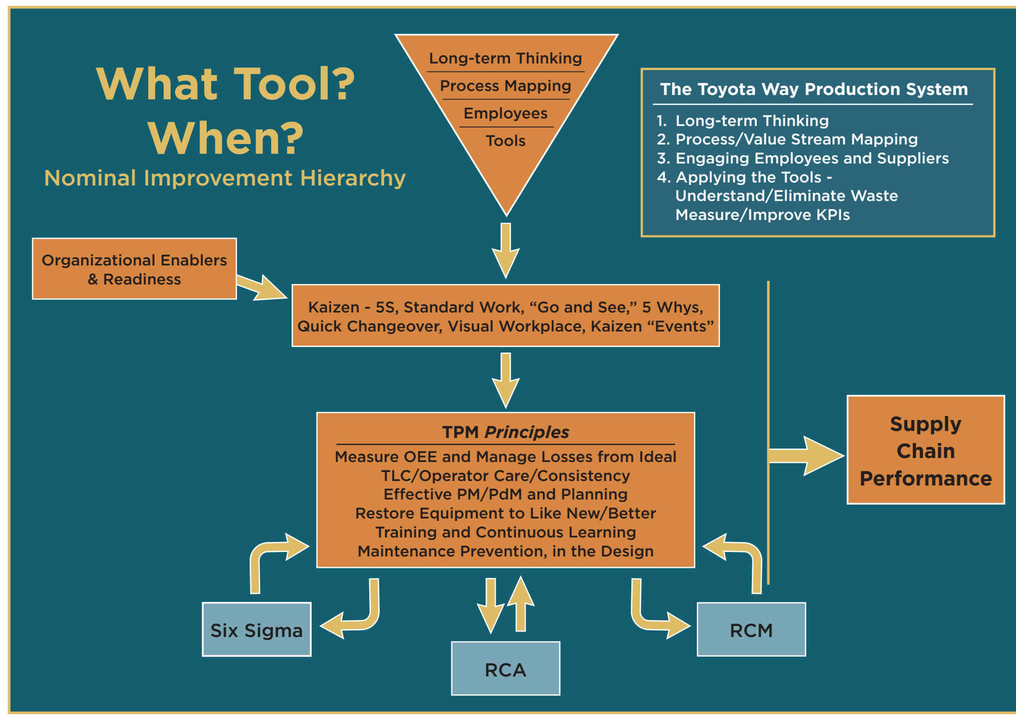


Figure 2: Improvement tool hierarchy

Next, use TPM principles for measuring and, most importantly, managing all losses from ideal. TPM also should be used for operators taking care of their equipment and assuring consistency of operation; effective preventive and predictive maintenance and planning and scheduling; restoring equipment performance to like new or better when doing maintenance; maintenance prevention in the design stage; and continuous training and learning.

Once these are embedded into the organization, you're more likely to be ready to apply and sustain the results of some of the more advanced tools, like Six Sigma, RCA and RCM. Doing these first without organizational readiness and discipline will more likely lead to their failure, as experienced by 60-90% of the people who did so. Finally, if you do all this well, you're far more likely to have excellence in supply chain performance.

CONCLUSION

Experience shows that it's essential to have reliability and operational excellence led from the top. Executive sponsorship is essential, and recall that simple permission is not sponsorship or leadership! You must have a good production and maintenance partnership, which includes clear goals and expectations that are reasonably achievable. To support this partnership, there must be *shared* KPIs for reliability and business results in the annual management appraisal and bonus system. And finally, and as important as all the rest, you must have a shop floor engagement process for defect elimination, including a support structure, the use of cross functional teams and structured improvement time.

Hopefully, this helps in getting you thinking about using a more comprehensive approach to achieve your reliability and operational excellence objectives.

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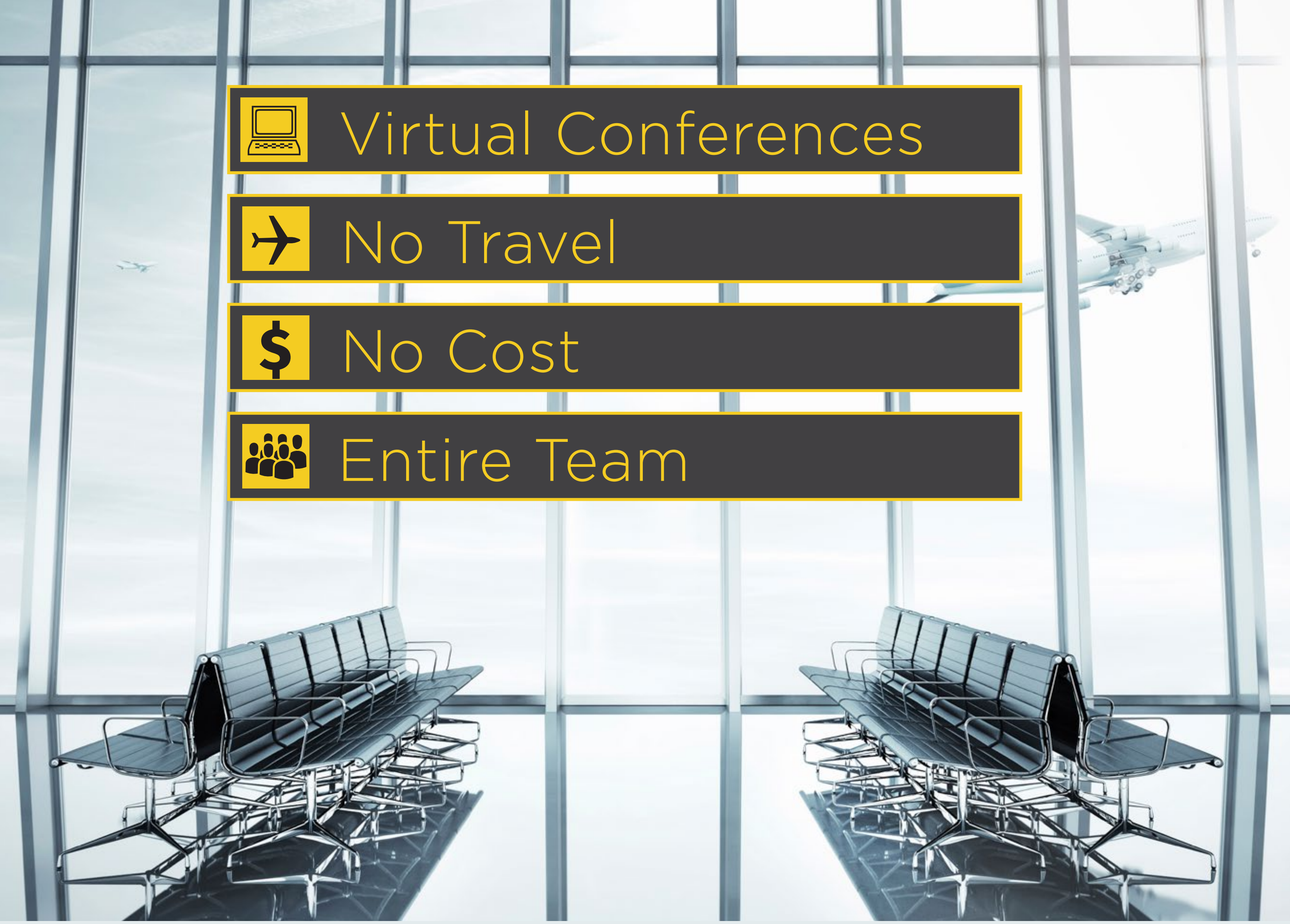
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Even Data Centers Need PM OPTIMIZATION

by Dr. Klaus Blache

YOU NEED PM OPTIMIZATION IF:

- Your PM tasks add minimal or no value;
- There is insufficient wording or clarity on your PMs;
- Decisions are being made without sufficient information;
- You are performing the wrong kind of PM tasks;
- PM tasks cause as many problems as they fix due to lack of accessibility, modular replacement, visual controls, training, etc.;
- You can't get your predictive and condition-based maintenance tasks done because all you are doing are reactive repairs;
- PM tasks don't seem to be effective;
- PM intervals are too short or long.

PM optimization is a systematic process to get the best equipment reliability. This is done by identifying and improving on weaknesses in maintenance performance and frequencies. PM optimization is a process, a series of questions or a guiding decision matrix, that helps make your preventive maintenance (PM) more efficient and effective. It enables the optimization of resources, while instilling best practices.

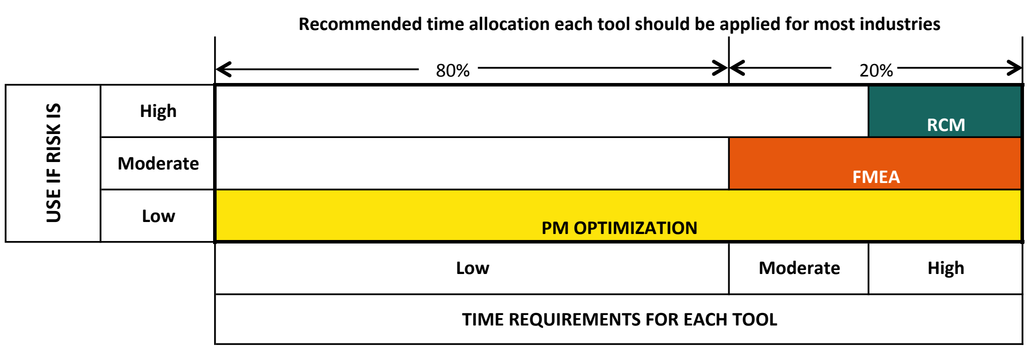


Figure 1: PM tasking improvement tools

Table 1 – Comparison of Five PM Optimization Studies

	1 John Schultz Industrial Equipment	2 Steve Turner Coal Mine	3 Steve Turner Coal Mine	4 Klaus Blache Data Center	5 Klaus Blache Data Center
Number of PM Tasks	20,000	964	>300	793	200
Results of PM Optimization:					
Eliminate the Task	8%	21%	8%	49.90%	24.00%
Use Task As Is	10%	38%	52.40%	14.80%	38.50%
Change Task to:					
PdM/Condition-Based	32%		13.00%	*	
Extend Task Intervals		23%	4.00%	*	
Reduce Task Intervals		6%	0.30%	*	
Add New Task		12%	7.70%	22.70%	
Change Role/Responsibility (Assign to Operator and Lubrication, Outsource Service, Reengineer, Further Analysis Needed)	47% 3% Other		14.60%	12.60%[6]	37.50%
	100%	100%	100%	100%	100%

Sources

1. Moore, Ron. *Selecting the Right Manufacturing Improvement Tools: What Tool? When?* Fort Myers: Reliabilityweb.com, 2011, p. 251.
2. Turner, Steve. "PM Optimization Case Studies at Two Coal Mines." ReliabilityWeb.com download
3. Ibid
4. Blache, Klaus. "Data Center PM Optimization Study, 2014."
5. Blache, Klaus. "Data Center PM Optimization Study, 2015."
6. 12.60 percent also includes items marked with*.

You can do PM optimization as part of a comprehensive reliability-centered maintenance (RCM) implementation, a full or shortened version of a failure mode and effects analysis (FMEA), or by itself. The extensiveness of your analysis should be guided by the risk and severity of failure consequences.

However, with high internal competition for scarce resources, most organizations have small finite time available to do a full RCM and/or FMEA analysis. As such, the recommendation is to focus 80 percent of your time available for continuous improvement on PM optimization and the other 20 percent on FMEA and full RCM investigations.

RCM may be your guiding philosophy, but how many weeks or months are you willing to set aside for RCM and FMEA projects each year? If the risks and potential consequence of failure are high, as in the aerospace industry, you do it. But for most industries, it's a decision between reliability goals and bottom-line financial results.

Many of the maintenance tasks come from the original equipment manufacturer (OEM) and are often required to maintain warranty. Many others are added to respond to emergency repairs and avoid similar situations. A large number are still there only because they are being carried over from some past issue, reasoning, or justification that is no longer valid.

Table 1 compares the outcome of five PM optimization efforts from different industries. The first study is based on industrial equipment, the next two studies are from mines and the final two are from two different data centers.

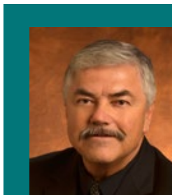
"The extensiveness of your analysis should be guided by the risk and severity of failure consequences"

The infrastructure of data centers (e.g., pumps, fans, cooling tower, transformers, compressors, air handlers, fire protection, filters, power supply, etc.) is just as ripe for improvements as most other industries. There may be some facilities that would not benefit much from PM optimization, but those have not been found as yet.

Although the data findings were collected in varying categories, the studies have been compiled to enable some comparisons. The reasons for the differences are the age of the equipment (e.g., just being commissioned versus being in use for a long time), type of industry, team member backgrounds and level of experience, focus of the optimization initiatives and so on. All these factors guided the failure modes, strategy discussions and decisions.

As the data findings show, PM optimization is a useful tool in all types of industries, such as manufacturing, process, mining, utilities and yes, even data centers.

For those interested in data center focused reliability there is the "R&M Data Center BootCamp", which is at UT with one or more days at the Oak Ridge National Laboratory's Supercomputing Complex. http://rmc.utk.edu/events/data-denter-boot-camp/



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Evaluation of Medium and High Voltage Machines with Motor Circuit ANALYSIS

by Howard W Penrose

Low and high voltage motor circuit analysis (MCA) methods have existed since the 1950s, with low voltage MCA technology becoming commercially viable in the 1980s. Since the mid-1980s, MCA technologies have become more prevalent as part of predictive maintenance and motor diagnostics programs across all industries. While the descriptions of these technologies are high and low voltage, they describe the types of outputs from the instruments, not the types of electric machines tested. This article explains the concurrent application of low and high voltage MCA on 4160 volt induction machines through 13.8 kV synchronous motors.

The technologies studied include:

- Amprobe 5 kV Insulation Resistance Tester (AMB55) for insulation resistance, polarization index, dielectric absorption, dielectric discharge, rotor test and capacitance to ground.
- ALL-TEST PRO 5™ for resistance, inductance, impedance, phase angle, current/frequency response, insulation resistance, capacitance to ground and dissipation factor. Other than resistance and insulation to ground testing, the circuit tests are frequency based.
- Electrom iTIG II D12 for resistance, inductance, impedance, phase angle, capacitance, Q-factor, rotor influence test, insulation resistance, polarization index, dielectric absorption, high potential test, surge comparison testing and PD surge.

The goal of the study was to determine how the test results and findings compared between technologies, as well as their accuracy. Each of the technologies studied is designed for field application, as well as in the original equipment manufacturer (OEM) and service industries. The low voltage MCA devices are relatively lightweight across all voltages, while the high voltage instruments increase in size and weight as the voltage and machines being tested increase.

4160 Volt Induction Motor

The types of motors tested in the study were open, drip proof (ODP), varied in size from 300 to 4500 horsepower, 900 to 1800 RPM form wound induction and synchronous machines. Each machine had power factor correction capacitors that need to be disconnected for either low or high voltage testing. While testing can be performed at these leads, since the tests would evaluate the cables and motors in parallel, the motor leads were disconnected in order to evaluate the motor insulation system only.

The first machine evaluated was an ODP 300 horsepower, 885 RPM, 4160 Vac, form wound electric motor that had some visual level of contamination. While no specific test results indicated the contamination was an issue, the unbalanced partial discharge (PD) levels may be an early indicator of insulation degradation.

The low voltage MCA results in Table 1 show a balanced winding with good insulation resistance results.

Table 2 and Figure 2 are the low voltage and high voltage MCA tests. The data was balanced with the exception of PD, which was measured in picocoulombs and unbalanced. Off-line PD tests involve trending and/or comparison of phases or like motors to determine if there are changes or unbalances. In this case, the average PD from other machines was under 20,000 pC and relatively balanced. Therefore, it was determined that a polarization index and insulation resistance profile (IRP) reading would be performed. The motor also passed a surge test, indicating that any issues are early in nature and should be trended, or the motor should be removed, cleaned and put through a short cycle vacuum pressure impregnation (VPI) to fill in any cracks or surface voids.

The IRP was performed at 2500 Vdc and resulted in only a few small capacitive discharges. Therefore, the final conclusion was to plan an overhaul within the next three to six months.

Figure 1: A 300 horsepower, 885 RPM, 4160 Vac, form wound motor

Table 1 – Low Voltage MCA Test Results (ATP5)

	T1-T2	T1-T3	T2-T3
Resistance (Ohms)	1.15	1.15	1.15
Impedance (Ohms)	43.7	43.8	43.7
Inductance (mH)	69.5	69.7	69.5
Phase Angle (degrees)	81.2	81.2	81.1
I/F (percent)	-46.8	-46.9	-46.8
Insulation Resistance (1000V)	>999 Megohms		
Capacitance	35.7 nF		
Dissipation Factor	1.13%		
Test Frequency	100 Hz		

Table 2 – High and Low Voltage MCA Tests (iTIG)

	T1-T2	T1-T3	T2-T3
Resistance (Ohms)	1.1530	1.1528	1.1526
Impedance (Ohms)	369.3	369.0	367.9
Inductance (mH)	58.47	58.43	58.26
Phase Angle (degrees)	84.2	84.3	84.3
Q Factor	9.85	9.93	9.89
Partial Discharge (pC)	24460	16306	16306
Insulation Resistance (1000V corrected to 40°C)	8,333 Megohms, 0.03 uAmps		
High Potential Test	10,300 V, 1.54 uAmps		
Capacitance	0.128 nF		
Capacitance D Factor	0.437		

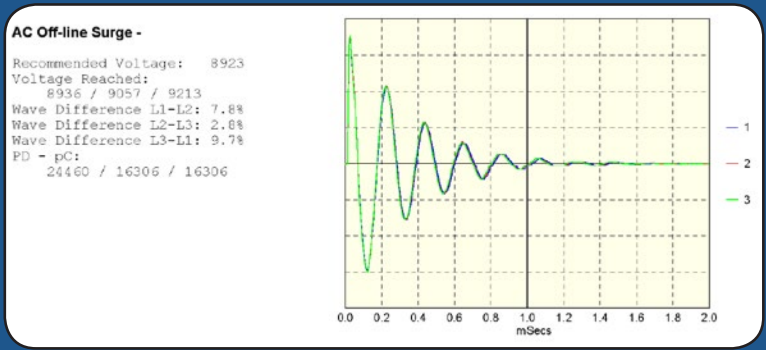

Figure 2: Surge comparison test and PD test of the 300 horsepower motor

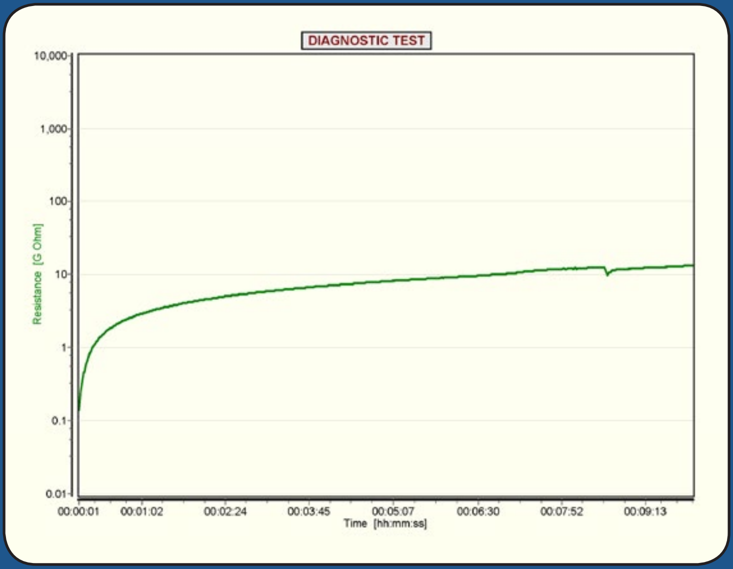

Figure 3: IRP with small discharges starting at about seven minutes, indicating an aging insulation system

Table 3 – High and Low Voltage MCA Tests Stator (iTIG)

	T1-T2	T1-T3	T2-T3
Resistance (Ohms)	0.7195	0.7186	0.7204
Impedance (Ohms)	519.2	437.7	437.7
Inductance (mH)	81.23	68.77	76.42
Phase Angle (degrees)	79.4	80.8	79.9
Q Factor	5.35	6.19	5.62
Partial Discharge (pC)	21,742	10,871	8153
Insulation Resistance (1000V corrected to 40°C)	25000 Megohms, 0.01 uAmps		
High Potential Test	0.62 uAmps at 11,000 V		
Capacitance	0.051		
Capacitance D Factor	-0.701		

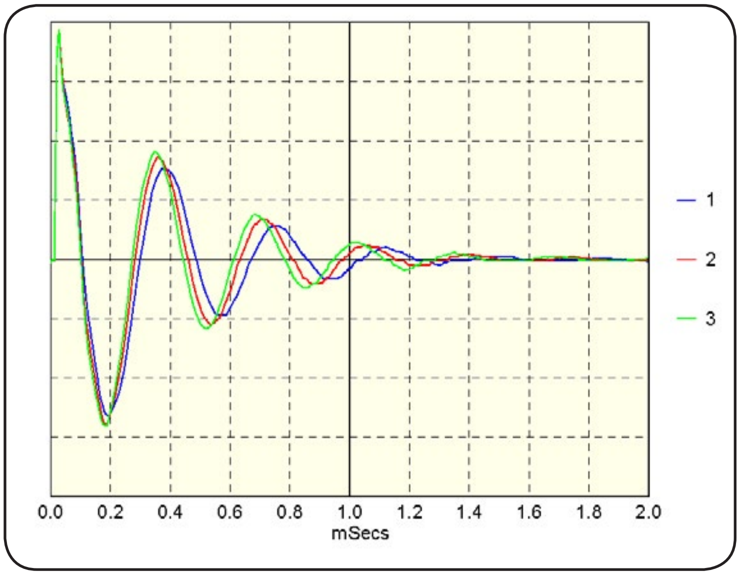

Figure 4: Surge test results show unbalance due to rotor position

13,800 Volt Synchronous Motor

A series of 4500 horsepower, 1800 RPM, 13.8 kV synchronous motors were evaluated as part of the study. It was determined that the rotor would be evaluated with an insulation resistance test prior to performing any other testing. As the values appeared to be relatively low, the team decided to use low voltage MCA and IRP to evaluate the rotor.

Since there were surge arresters in the machine connection boxes, they were disconnected. Additionally, the rotor leads were disconnected for testing both the stator and the rotor to reduce the influence the rotor had on the stator and to protect the rotor electronics. When possible, both the low and high voltage MCA devices are able to adjust for rotor position. In the case of these machines, such an effort was not time-effective.

The condition of the stator was known to have moisture and oil contamination and there was corona and partial discharge problems with the windings. The PD unbalance, shown in Table 3, would be expected from these conditions.

The stator had been tested four months prior to using low voltage MCA, allowing for a comparison between the previous and present data. Table 4

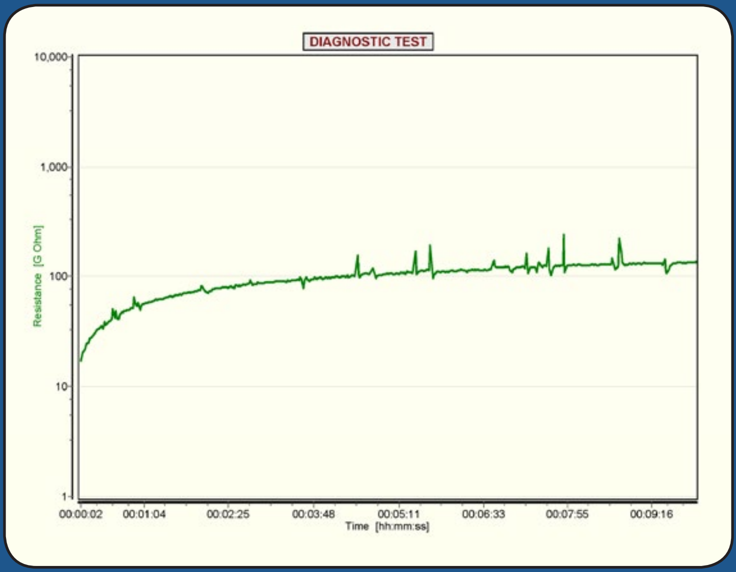

Figure 5: IRP of rotor at 500 Vdc indicating aged insulation system

Figure 6: Rotor four months later after the motor was idle for several weeks

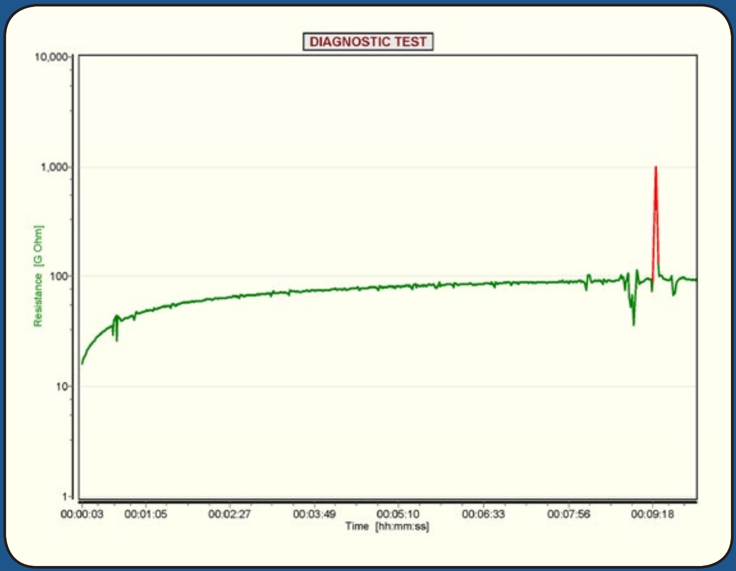

Figure 7: Rotor after attempting to start the machine

Table 4 – Low Voltage MCA Test Results on Stator 4 Months prior (ATP5)

	T1-T2	T1-T3	T2-T3
Resistance (Ohms)	0.726	0.727	0.724
Impedance (Ohms)	55.4	54.3	54.7
Inductance (mH)	88.2	86.4	87.1
Phase Angle (degrees)	78.7	76.8	76.6
I/F (percent)	-47.1	-46.2	-46.0
Insulation Resistance (1000V)	>999 Megohms		
Capacitance	170 nF		
Dissipation Factor	1.38%		
Test Frequency	100 Hz		

Table 5 – Low Voltage MCA Test Results on Rotor Comparison Between Present and 4 Months Prior (ATP5)

	Present	Prior	Difference
Resistance (Ohms)	0.171	0.153	0.018
Impedance (Ohms)	42.0	45.8	3.8
Inductance (mH)	33.4	72.9	39.5
Phase Angle (degrees)	70.9	63.4	7.5
I/F (percent)	-41.2	-39.1	2.1
Insulation Resistance (500V)	727 Mohms	>999 Mohms	Reduced
Capacitance	9.60 nF	9.80 nF	0.2
Dissipation Factor	1.12%	1.23%	0.11
Test Frequency	100 Hz	100 Hz	N/A

represents the data taken the first time and Table 5 is the second set of data used to determine how quickly there is degradation of the insulation system in order to make reliable time to failure estimations.

Previous data identified some issues with the condition of the rotor insulation. While there are conditions with the stator, in this case, the rotor is the weakest part of the chain. Additional work was performed to evaluate the condition of the rotor insulation.

The changes, in particular where inductance and impedance are concerned, identify the potential for a winding short in the rotor. Additional testing would be necessary to confirm the condition of the rotor.

The increase in discharges in Figures 5, 6 and 7 indicates the synchronous motor rotor is rapidly decaying. The reasons for degradation were found following the second round of testing, with those findings outside the scope of this article.

The challenge in this case is that the high voltage MCA device could potentially "finish off" the rotor, thus removing the decision to continue operating the machine from the user. In this case, the use of low voltage MCA and IRP was invaluable because the problem was found and the user had the option of continuing usage without the potential of finishing off the insulation system.

Conclusion

The use of low and high voltage MCA testing provided similar results. One of the primary differences was found with the synchronous motor rotor, where high voltage tests may have finished off the insulation system. Another concern was the need for a "booster" to meet the surge and high potential voltages necessary for the 13.8 kV system. The use of 11,000 volts versus the 18,500 volts that should have been used was based on previous predictive maintenance tests. In both cases, the high voltage MCA device required access to an outlet with a reasonable output voltage. The instrument used for this study has a built-in power conditioner that reduces the impact of power quality issues on the test results.

> "Since the mid-1980s, MCA technologies have become more prevalent as part of predictive maintenance and motor diagnostics programs across all industries."

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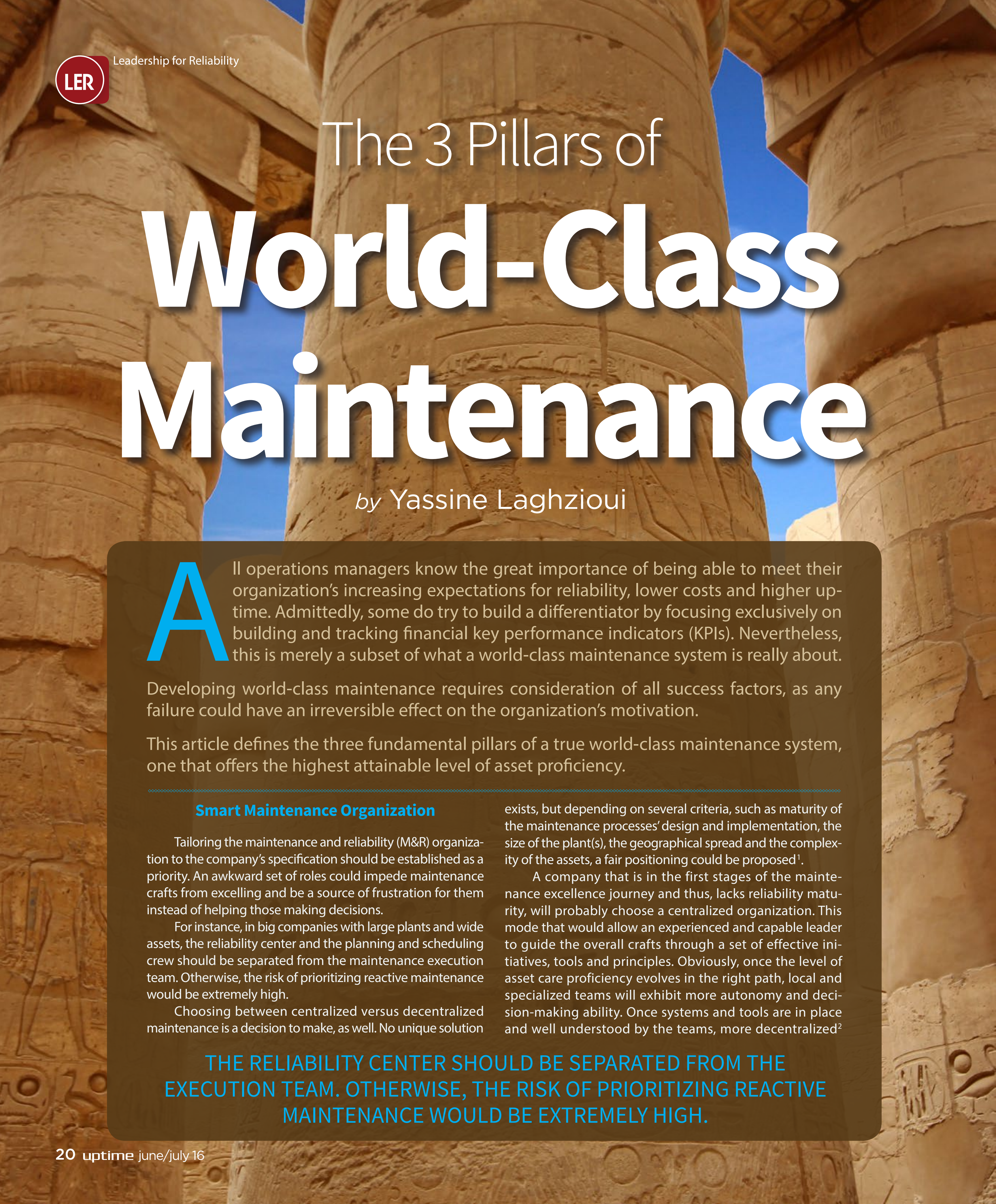

The 3 Pillars of World-Class Maintenance

by Yassine Laghzioui

All operations managers know the great importance of being able to meet their organization's increasing expectations for reliability, lower costs and higher uptime. Admittedly, some do try to build a differentiator by focusing exclusively on building and tracking financial key performance indicators (KPIs). Nevertheless, this is merely a subset of what a world-class maintenance system is really about.

Developing world-class maintenance requires consideration of all success factors, as any failure could have an irreversible effect on the organization's motivation.

This article defines the three fundamental pillars of a true world-class maintenance system, one that offers the highest attainable level of asset proficiency.

Smart Maintenance Organization

Tailoring the maintenance and reliability (M&R) organization to the company's specification should be established as a priority. An awkward set of roles could impede maintenance crafts from excelling and be a source of frustration for them instead of helping those making decisions.

For instance, in big companies with large plants and wide assets, the reliability center and the planning and scheduling crew should be separated from the maintenance execution team. Otherwise, the risk of prioritizing reactive maintenance would be extremely high.

Choosing between centralized versus decentralized maintenance is a decision to make, as well. No unique solution exists, but depending on several criteria, such as maturity of the maintenance processes' design and implementation, the size of the plant(s), the geographical spread and the complexity of the assets, a fair positioning could be proposed[1].

A company that is in the first stages of the maintenance excellence journey and thus, lacks reliability maturity, will probably choose a centralized organization. This mode that would allow an experienced and capable leader to guide the overall crafts through a set of effective initiatives, tools and principles. Obviously, once the level of asset care proficiency evolves in the right path, local and specialized teams will exhibit more autonomy and decision-making ability. Once systems and tools are in place and well understood by the teams, more decentralized[2]

THE RELIABILITY CENTER SHOULD BE SEPARATED FROM THE EXECUTION TEAM. OTHERWISE, THE RISK OF PRIORITIZING REACTIVE MAINTENANCE WOULD BE EXTREMELY HIGH.

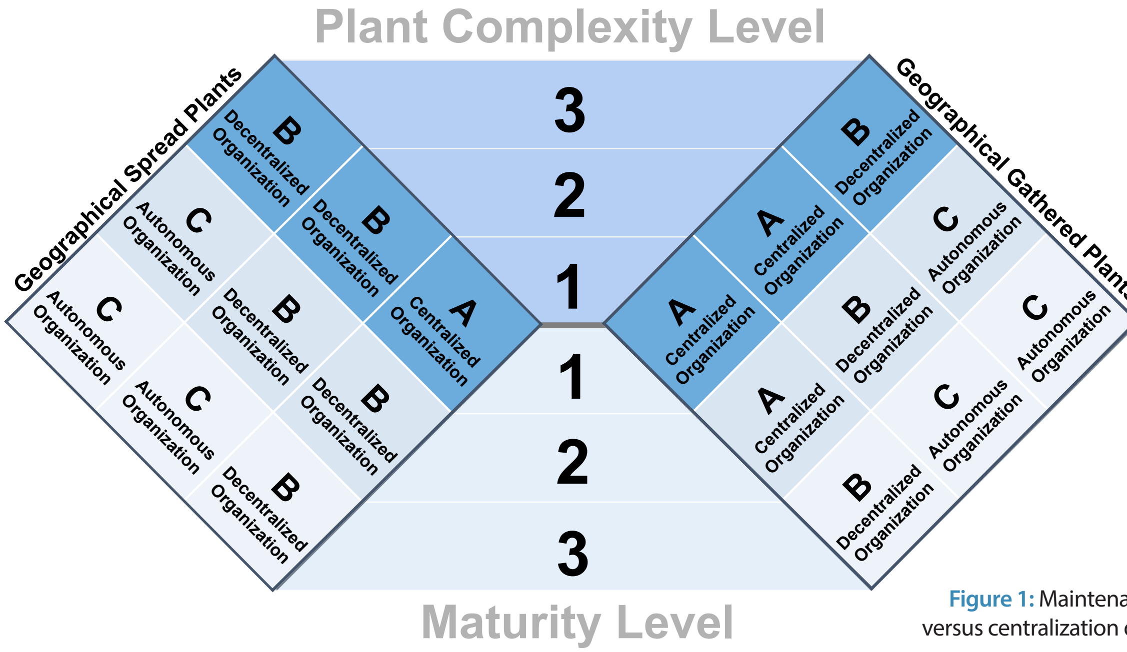

Figure 1: Maintenance decentralization versus centralization decision support matrix

and empowered maintenance units will drive improved performance for the whole organization.

An optimal organization happens when the reliability culture reaches the highest level – all maintenance work is preplanned on a long horizon. The ownership of resources and assets is no longer an issue. This is called an interdependent autonomous organization, which is based on devolution where every unit self-learns and spontaneously shares best practices and common data sets with other maintenance units from across the whole company. This type of organization adapts its objectives, focusing on customer expectation without missing the company's high-level strategies and policies.

Figures 1-4 illustrate a simplified methodology to decide which of the organizations is more likely to achieve world-class maintenance on each stage of maturity.

Comprehensive Performance Tracking System

The widely known adage, "You can't manage what you can't measure," is very accurate for asset management. Moving forward in the maintenance excellence path requires having the appropriate dashboard with gauges showing the correct measures.

However, evaluating maintenance effectiveness is not an easy task to perform. A rich and interesting body of material has been developed by maintenance professionals in the past decades, yet only a few companies can state they are tracking maintenance performance as they really want and need. Here is a list of requirements that must be embraced and integrated to ensure achieving maintenance performance management (MPM) that leads to world-class maintenance:

Data acquisition: Without sufficient and accurate data, there is no point in analyzing awkward metrics based on estimated records. The problem is not only about the necessity of getting the precision for performance improvement, but more about the risk of impacting crafts' confidence and then lowering the likelihood of change success. For instance, the workforce will simply think that the KPIs displayed on the meeting room wall are there for reasons other than helping them improve their performance.

Ensuring good data acquisition entails implementing a set of incentives, ongoing operational discipline, and well configured and utilized computer maintenance management system (CMMS) software.

- Incentives could include providing modern and powerful tools, such as wireless tablets, laptops and smartphones, which reduce the time of entering data and improve its accuracy.
- Operational discipline is an essential ingredient to ensure data accuracy and timeliness. It requires clarifying responsibilities and accountability of each member of the organization regarding whom, when and by which means a set of information will be recorded.
- Adapted CMMS software is extremely important to deal with the huge amount of data that maintenance crafts and assets generate each day. Choosing a system that matches the company's culture and work practices and has an intuitive user interface increases the likelihood of implementation success and thus the convenience of collected data.

KPIs and metrics: To professionalize maintenance performance management, it is necessary to identify a dashboard that leads to the levers that will create the most value, help make efficient decisions and highlight problems that are worth the time and resources to solve.

Here are some questions where the answer "yes" means that a set of maintenance metrics is controllable and worthy:

- Does it show every opportunity for maintenance performance improvement?
  Tracking performance improvement opportunities should be achievable when a dashboard emphasizes when and where creating additional value is possible.
- Are the measures calculated in a standardized way through both periods and entities?
  There is nothing worse than comparing non-comparable indicators to draw conclusions and engage efforts in a misleading way.
- Does the set cover the lifecycle value of maintenance work?
  Immediate efforts for cost savings and increased productivity need to be designed in accordance to a long-term assets management consideration.

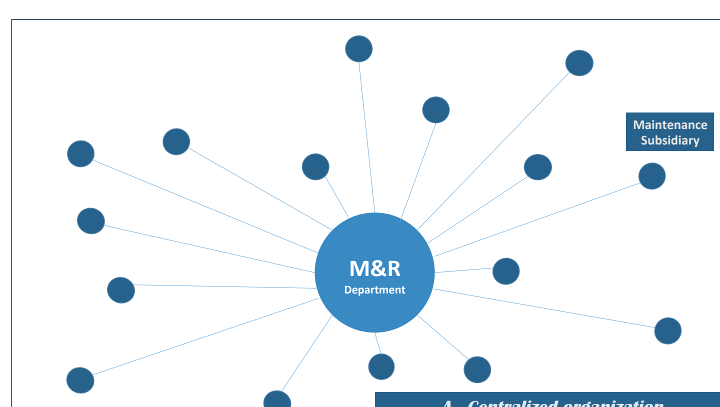

Figure 2: Centralized maintenance organization: Decision-making authority is transferred mainly to the M&R department

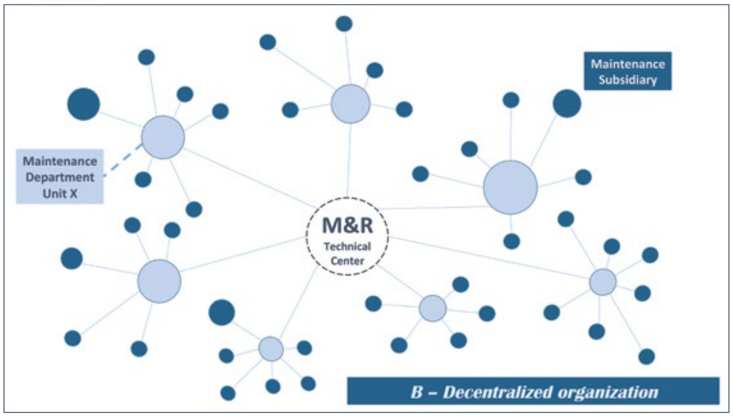

Figure 3: Decentralized maintenance organization: Decision-making authority is partially owned by local teams; the M&R technical center serves both an audit and a knowledge sharing function

A basic and more direct example is that postponing a preventive maintenance shutdown would instantly increase production and significantly decrease the costs. The consequences of this shortsighted decision would not take long to manifest themselves.

- Does analyzing the data allow maintenance crafts to keep moving forward in terms of practices enhancement?
  When pursuing better work quality, more challenging scheduling, or higher inspection effectiveness, it's important to plan improvements without asking, "Who hasn't done their job." Instead, ask, "How can we get better." A good framework of indicators that highlight workflow optimization potential more than maintenance workers' mistakes would greatly help. Accountability without accusation is critical for improvement.

A Well Designed and Implemented Maintenance Work System

The third pillar is about designing an optimized and standardized way to do maintenance. This way of maintaining the assets should depend on the standards, processes and procedures of maintenance. The combination of these elements, when rigorously applied, provides the maintenance and reliability system.

Here is a simple, but effective, two-step approach for achieving a world-class M&R system:

#1 – Build a tailored and powerful set of standards and methods.

The quickest and easiest way is to bring in an existing set of tools, change the logo and communicate it to maintenance crafts. However, this is not the smartest way, merely because all the new material will be rejected just as the human body will reject a strange organ, even a healthy one.

These are the success factors to consider when building an M&R system for your company:

- Involve everyone, from senior managers to the shop floor. This will make available a great amount of knowledge, expertise and enthusiasm, and lower the risk of resistance in the implementation phase.
- Identify the M&R foundations. Even if the system is tailored to company specifications, the worldwide known principles that lead to maintenance excellence remain the same, such as maintenance work management and reliability-centered maintenance.
- Think big, but start small. Preparing written standards and processes requires investing considerable time and effort. It is wise to focus first on a manageable scope while still being ambitious.
- Avoid unjustified complexity. Tools and standards should be as simple as possible. In other words, the more efforts you make to drive too much precision and unnecessary complexity into your system requirements, the poorer the quality of your maintenance system will be.

THE MORE EFFORTS YOU MAKE, THE POORER THE QUALITY OF YOUR MAINTENANCE SYSTEM WILL BE.

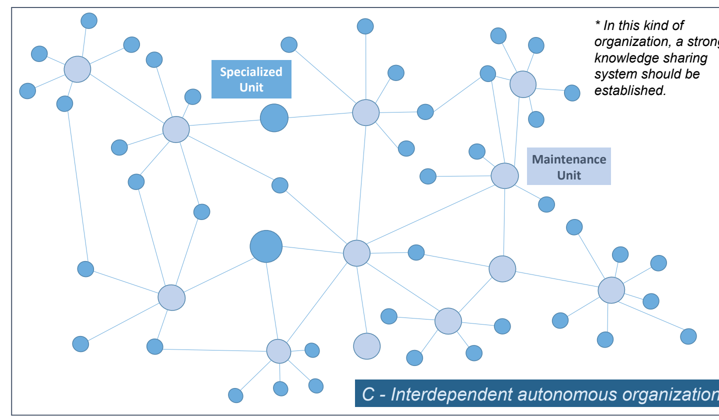

Figure 4: Independent and autonomous maintenance organization: Decision-making authority is completely owned by local teams

#2 – Enable M&R system execution consistency.

This is, in fact, one of the most challenging issues. The cultural and behavioral changes of the key players of the maintenance organization are a condition for success with any maintenance system implementation. Alignment of all members of the team, from top management to the most junior craft, is essential. Everyone should know their role and the value of their contribution to the overall maintenance effort. Senior leadership must ensure this alignment and have the vision and persistence to support it, especially as it first begins.

As far as the whole maintenance workforce is concerned, the right way to do maintenance should be categorically known as the way given by the M&R system.

Being persistent, showing the success, avoiding directive and autocratic management style, and adopting a leadership position are some good ingredients for success.

Developing a consistent change management plan is no longer a nicety, it is a necessity.

Notes

1. This model is proposed as a decision support tool. Other criteria, such as corporate culture and human resources capacities, should be taken into account before reorganization.
2. A decentralized and interdependent organization does not necessarily mean dividing all resources among the units. An approach that allows the possibility to share them depending on the value-based prioritizing criteria should be set. Obviously, this would not be possible in a non-mature maintenance system.

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Content:
The Missing Piece of the
Asset Information Pipeline

by Tracy Smith

Good information is the holy grail of asset management. Everyone is looking for complete, accurate and up-to-date information to make informed business decisions that will improve asset performance, reduce risk and lower costs.

In this quest, many asset-intensive organizations have invested heavily in asset information systems (e.g., EAM/ERP/CMMS) over the last 20 years. Yet, despite considerable expenditure, organizations complain that benefits have been slow to materialize and are difficult to measure. Managers say they still can't access the information they need.

If everyone is after it, why is good information still so hard to get? What is missing?

Good asset management information is a product of several things. You often hear people, process and technology cited as key information drivers. That's true, but there is a fourth piece that is essential for creating good asset management information, yet it is often overlooked. That piece is **content**.

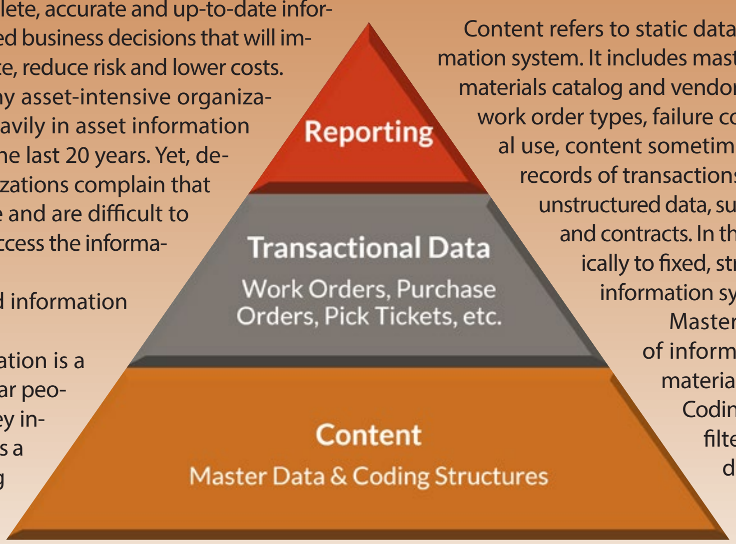


Figure 1: Layers of data in an asset information system

What Is Content?

Content refers to static data structures that are stored in the information system. It includes master data, such as the equipment master, materials catalog and vendor master, and coding structures, such as work order types, failure codes and equipment classes. (In general use, content sometimes includes transactional data, such as records of transactions conducted in the software system, or unstructured data, such as documents like manuals, drawings and contracts. In this article, however, content refers specifically to fixed, structured data that is preloaded into the information system.)

Master data provides a standardized library of information about an organization's assets, materials, vendors and other business objects. Coding structures are used to sort, group and filter data. These two types of content are distinct, but they share a key characteristic: both are *loaded into* the system as opposed to being *created by* the system.

An asset information system contains several layers of data. These include content, transactional data, and reports generated by the system from this data. Content is the bottom layer, the base on which transaction records and reports are built.

Content is foundational because it must be referenced when the system completes other tasks. Thus, developing good content is crucial if you want to pull useful information out of your software.

Content and the Information Pipeline

Content interacts with people, process and technology to create transactional data, such as work orders, pick tickets and purchase orders. Each time a transaction record is created, the system must reference existing system content. Work orders are created on equipment records, for example, and parts are issued from a materials catalog.

As transaction records are created, the system builds up a history of information about asset-related events. This transactional data is the basis for performance measurement and analysis. Mean time between failures (MTBF), equipment failure analysis, reorder point analysis and many other analytical tools rely on transactional data for their insights.

In addition to its role in creating transactional data, content also plays a key role in reporting, analytics and system usability. That's why bad content is so lethal to good information; content is the starting point for everything the software system does.

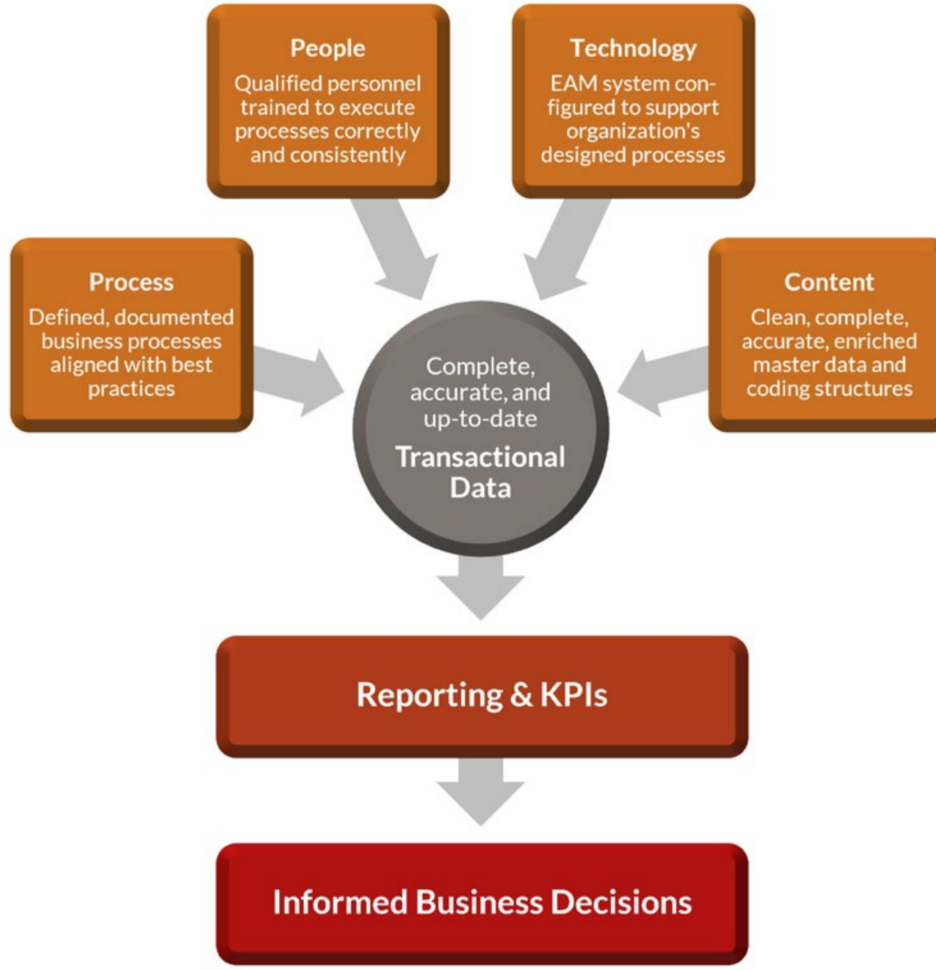


Figure 2: The asset information pipeline

Content Challenges

Many organizations spend too little time developing content for their asset management software. This omission can manifest itself in several ways:

- Master data is incomplete, contains duplicate entries, has spelling or syntax errors, or does not follow standard naming conventions across the organization.
- The equipment master hierarchy is not structured for costs to roll up properly.
- Coding structures do not exist, or if they do, the code sets are incomplete or poorly designed.

Challenges such as these create major problems for system use and performance. Missing information, duplicate entries and bad codes wreak havoc with transactional data. They make it hard to locate records, forcing users to slowly scroll through the database to find the information they need. They also create problems with downstream information output. A poorly developed set of problem and failure codes, for example, makes it impossible to analyze the specific reasons for equipment failures.

In short, if you don't get your content right up front, it will cripple your ability to pull rich, actionable information from the software system.

Content Solutions

Because content is so critical, content development activities, such as building an equipment master and establishing work order coding structures, should be a fundamental step in every asset information system implementation. With that in mind, this section provides guidelines for developing several key types of content.

Equipment Master

The equipment master is the table that contains all of a site's equipment records. Most asset management software allows for different levels of equipment:

- **Systems** are collections of positions and/or assets that work together to deliver a required business function or service. (A wastewater collection and treatment system is a good example.)
- **Positions** identify a location in which an asset resides. Positions are in the engineering realm and are identified on piping and instrumentation diagrams (P&IDs). Position naming convention normally describes what the position does, for example, "Pump (A) for Crude Unit Charge System."
- **Assets** are maintainable physical objects, such as pumps and compressors. Assets are the base unit of equipment information and the smallest tracking unit for capital investments. A useful method for describing assets is the noun, modifier, attribute, value system, as shown in Figure 3.

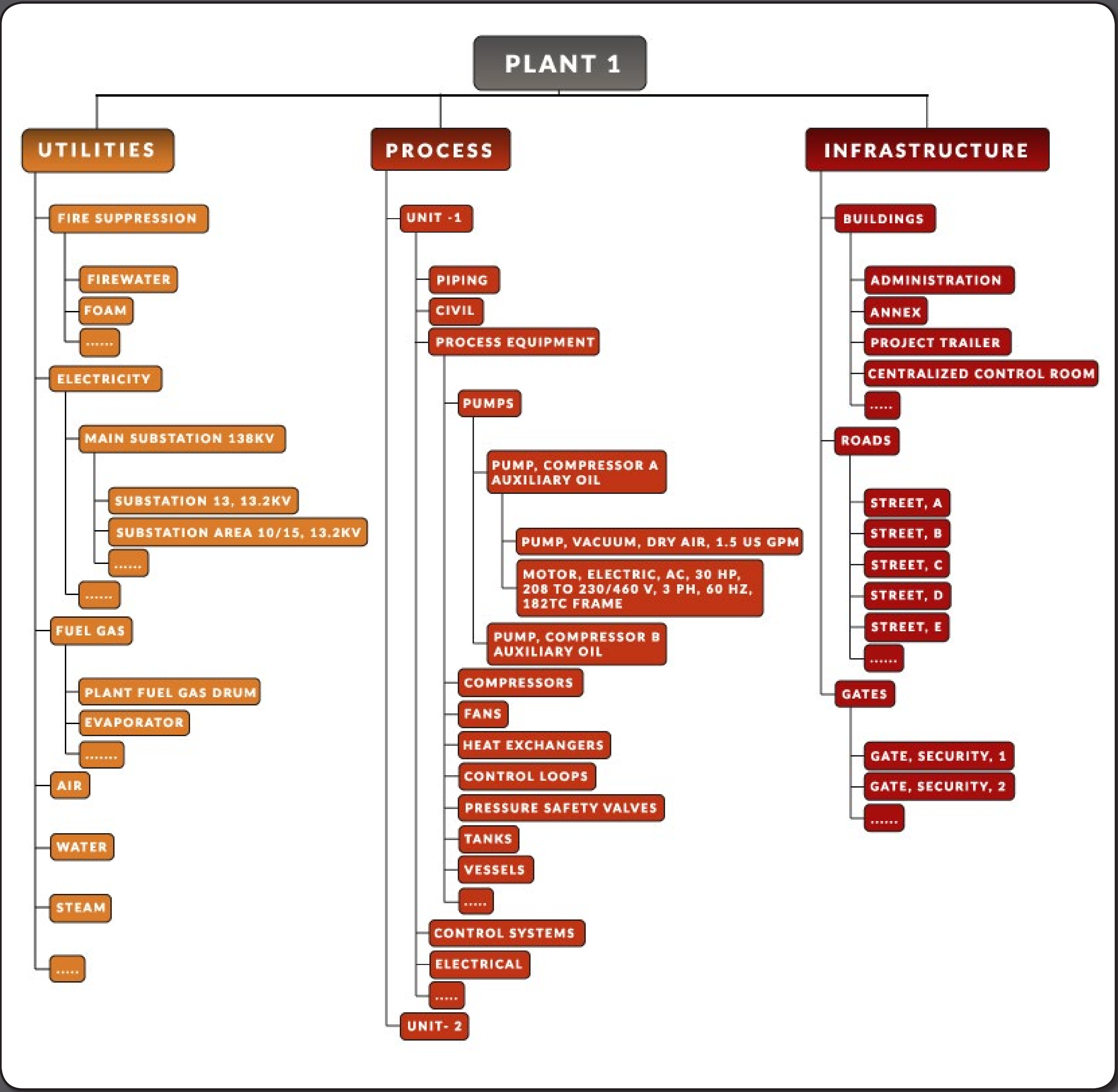
PUMP, VACUUM, DRY AIR, 1.4 US GPM, 3500 RPM, LIQUID RING, BN 139010
PUMP, VACUUM, DRY AIR, 1.5 US GPM, 3500 RPM, 2 HP MOTOR, LIQUID RING
PUMP, VACUUM, DRY AIR, 1.5 US GPM, 3500 RPM, 3 HP MOTOR

MOTOR, ELECTRIC, AC, 30 HP, 208 TO 230/460 V, 3 PH, 60 HZ, 182TC FRAME
MOTOR, ELECTRIC, AC, 25 HP, 208 TO 230/460 V, 3 PH, 60 HZ, 184T FRAME
MOTOR, ELECTRIC, AC, 25 HP, 208 TO 230/460 V, 3 PH, 60 HZ, 182T FRAME

Figure 3: Noun, modifier, attribute, value naming system

Most asset management software supports the development of an equipment hierarchy. An equipment hierarchy is a logical way to break down the plant's systems, engineering positions and assets. A well-designed hierarchy supports cost roll-up. For example, if the equipment hierarchy has been

Figure 4: A sample equipment hierarchy



Item No	Description	Class	Commodity	UNSPSC Code	UNSPSC Description
10001	ADAPTER, PIPE, 1/2", FEMALE, SCH 40, PVC	ADAPTER	P.V.F. (PIPE, VALVE, FITTING)	40142332	PIPE ADAPTERS
10002	ADAPTER, PIPE, 1", FEMALE, SCH 40, PVC	ADAPTER	P.V.F. (PIPE, VALVE, FITTING)	40142332	PIPE ADAPTERS
10003	ADAPTER, PIPE, 1", MALE, SCH 40, PVC	ADAPTER	P.V.F. (PIPE, VALVE, FITTING)	40142332	PIPE ADAPTER
10004	GLOVES, MEDIUM, 9.75" LG, WHITE, B GRADE GRAIN GOATSKIN, ELASTIC BACK	GLOVE	INDUSTRIAL SUPPLIES	46181500	SAFETY APPAREL
10005	GLOVES, EXTRA LARGE, 9.75" LG, WHITE, B GRADE GRAIN GOATSKIN, ELASTIC BACK	GLOVE	INDUSTRIAL SUPPLIES	46181500	SAFETY APPAREL
10006	BEARING, ROLLER, SPHERICAL AND TAPERED BORE, SINGLE ROW, 80 MM ID, 170 MM OD	BEARING	BEARING & P.T.	31171505	ROLLER BEARINGS
10007	BEARING, ROLLER, SPHERICAL AND TAPERED BORE, 100 MM ID, 215 MM OD, 47 MM WD	BEARING	BEARING & P.T.	31171505	ROLLER BEARINGS
10008	BEARING, BALL, DEEP GROVE, SINGLE ROW, 65 MM ID, 120 MM OD, 23 MM WD	BEARING	BEARING & P.T.	31171504	BALL BEARINGS
10009	BEARING, BALL, DEEP GROVE, TAPER, SINGLE ROW, 75 MM ID, 130 MM OD, 25 MM WD	BEARING	BEARING & P.T.	31171504	BALL BEARINGS
10010	RELAY, GENERAL PURPOSE CONTROL, 24 VDC COIL, 250 VAC, 10 A CONTACT RATING	RELAY	ELECTRICAL	39121515	GENERAL PURPOSE RELAYS
10011	RELAY, GENERAL PURPOSE CONTROL, 120 VAC COIL, 250 VAC, 10 A CONTACT RATING	RELAY	ELECTRICAL	39121515	GENERAL PURPOSE RELAYS

Figure 5: A sample extract from a materials catalog

structured properly, the costs to maintain a certain pump will be rolled up to the engineering position and system to which that pump belongs.

Materials Catalog

The materials catalog contains records for all the materials the organization purchases. Some of these materials are managed in the storeroom, while others are purchased on demand for specific jobs.

Implementing a clean, structured catalog makes it easy to find parts and develop purchase agreements. Reducing mean time to repair (MTTR) and item costs are big money savers for an organization. As the saying goes, the dough is in the MRO.

Entries in the materials catalog have certain required fields. Each of these fields is used for a different purpose and has different data requirements.

- **Item Number** should be dumb and sequential. (Leave the intelligence for the other fields in the database.)
- **Description** must be clean without unnecessary syntax and standardized. It must employ a noun, modifier, attribute, value approach.
- **Class** provides a way to group items for enhanced searching and reporting.
- **Commodity** provides high-level grouping for vendor spend analysis.
- **The United Nations Standard Products and Services Code (UNSPSC)** is an open, global, multi-sector standard for classifying products and services. It enables facility-wide visibility of spend analysis, cost-effective contract development and full exploitation of electronic commerce capabilities.

Equipment Class	Problem Code	Failure Code	Action Code	Cause Code
Blower, Centrifugal	Corrosion	Air Intake Dirty	Inspected	External Factor
	Knocking	Bearing Worn	Replenished / Recharged	Design
	Leaking	Blade Eroded	Calibrated / Adjusted	Operational
	Efficiency Loss	Blower Corroded	Cleaned / Serviced	Maintenance
	Overheat	Blower Eroded	Overhauled / Rebuilt	
	Seized	Blower Seized	Replaced Equipment	
	Turbine stall	Control Drift	Modified	
	Vibration	Out Of Balance		
		Packing Worn		
Fan	Bearing Pedestal cracked	Bearing Pedestal Cracked	Inspected	External Factor
	Blade bent	Bearing Scored/Overheat	Replenished / Recharged	Design
	Corrosion	Blade Bent	Calibrated / Adjusted	Operation
	Enclosure damaged	Drive Faulty	Cleaned / Serviced	Maintenance
	Overheat	Fan Blade Imbalance	Overhauled / Rebuilt	
	Vibration	Fan Corroded	Replaced Equipment	
		Fan Enclosure Damaged	Modified	
		Fan Hub Cracked		
		Shaft Bent		
Pump, Reciprocating	Low performance	Bearing Noisy	Inspected	External Factor
	Overheat	Coupling Slipping	Replenished / Recharged	Design
	Cavitating	Valve Worn	Calibrated / Adjusted	Operation
	Foundation cracking	Seal/Gasket Leaking	Cleaned / Serviced	Maintenance
	Seized	Ring Worn	Overhauled / Rebuilt	
	Vibration excessive	Plunger Worn	Replaced Equipment	
	No Flow		Modified	
	Leaking			
	Knocking			

Figure 6: A Selection of problem, failure, action and cause codes

Reliability Codes

Reliability codes (e.g., problem, failure, action, cause) are the heart of asset reliability reporting. They allow users to generate reports on the cost and frequency of different failure types for different pieces of equipment. See Figure 6 for examples of these codes.

- **Problem codes** define the specific problem with a piece of equipment. They are best associated with a specific class of equipment, such as pumps, motors, heat exchangers and so on.
- **Failure codes** further define what failed on the piece of equipment, allowing deeper analysis to be conducted on the part or component that failed.
- **Action codes** identify the action the maintenance technician took to rectify the equipment issue. These codes are general in nature and apply to all equipment classes.
- **Cause codes** are used to further describe the reason "why" the asset was underperforming. They are not intended to identify the exact cause of the problem, but are captured to provide a starting point from which root cause analysis can proceed.

Other Content

There are many other types of content to develop in addition to those listed, including both master data (e.g., preventive maintenance, vendor, standard jobs, etc.) and coding structures (e.g., work order classes, how found, maintenance technician delay, etc.). Understanding what each does and how each can help is fundamental to creating great asset management information.

Conclusion

In order to make good business decisions, decision makers must know how often a piece of equipment has failed, whether critical parts are being stocked, how much preventive maintenance is being completed on time and so on. Without good content, it's impossible to come up with reliable answers to such questions. Thus, although it can take time and effort, content development is essential to getting the information you need.

If the content in the system is poorly developed, system performance will suffer, no matter how much you invest in software or practices. People, process and technology are important, but don't forget about content. It just might be the piece you're missing.

Tracy Smith *is the principal of Swain Smith, a full-service asset management consulting firm. Tracy has 18 years of experience optimizing asset management practices and technology for organizations around the globe. He is a member of the Institute of Asset Management and an active participant in the U.S. Technical Advisory Group that helped develop ISO55000. www.swainsmith.com*

10 Components of a Successful VIBRATION PROGRAM

by Alan Friedman

Right Tools and Right Data

Part 4 of this series focuses on the importance of selecting the right tools for your goals and collecting the right data at the right time.

With any job, you need the right tools. In the case of vibration analysis and other condition monitoring (CM) technologies, it is important that the goals of the program are well understood (right goals) and the tools match the skill levels of the people who will use them (right people). Sadly, most people purchase the tools before understanding their goals and the technology. Many programs end up being limited or defined by the capabilities, or lack thereof, of the system that was purchased.

There are many different uses or applications for vibration analysis and just as many different tools on the market. So, the best place to start is by understanding your goals. Vibration analysis can be used for troubleshooting, acceptance testing, structural analysis or resonance testing, process monitoring, simple alarming, etc. Each of these applications requires tools with different capabilities.

A common goal of vibration analysis is to enable condition-based maintenance, so that is the goal for the purpose of this article, along with the features to look for in a tool. Condition monitoring is a process of taking the same data on the same machines day after day, month after month and year after year, and looking for changes. Imagine you are in the hospital and a nurse wakes you up to take your blood pressure. Now, imagine you are late for a doctor's appointment. You burst into the waiting room and the nurse calls you back right away, sits you down and takes your blood pressure. Are the readings going to be the same? Does the difference mean there is something wrong with your heart? The answer to both questions is "no."

One aspect of "right data" is repeatable measurements. The machine must be running at the same speed and load each time it is tested for trends to be meaningful. From a personnel or right people point of view, it means the person collecting the data is doing it the same way every time, which implies data collection is a standard procedure, which further implies it is a

Read Part 1: Right Goals   Read Part 2: Right People and Right Leadership   Read Part 3: Right Goals and Right Follow-Up and Review

Figure 1: 10 components of a condition monitoring program

1. Right Goals	**Having clearly defined and achievable goals that may evolve over time.**
2. Right People	**Having the right people in the right roles with the right training.**
3. Right Leadership	**Inspiring continuous improvement.**
4. Right Tools	**Having the right tools and technology to help reach the goal.**
5. Right Understanding	**Equipment audits, reliability and criticality audits, FMECA, maintenance strategies, etc.**
6. Right Data Collection	**Collecting the right data at the right time to detect anomalies, defects or impending failures.**
7. Right Analysis	**Turning data into defect or fault diagnoses.**
8. Right Reporting	**Turning data into actionable information and getting that information to those who need it at the right time and in the right format.**
9. Right Follow-up and Review	**Acting on reports, reviewing and verifying results, benchmarking, auditing and improving, etc.**
10. Right Processes and Procedures	**Tying together: people, technology, information, decision-making and review.**

low skilled job. From a right tools point of view, it means the data collection unit doesn't need a big screen and a million features, it simply needs to be able to take a preloaded standard test. A simple, robust data collector with fewer buttons and features might be more than adequate to meet the need and more suitable for a lower skilled employee.

Wireless sensors and systems are becoming more popular due to reduced sensor costs, better wireless communications, unlimited data storage and ease of installation. An important question to ask is: Is the sensor smart enough to know when to take a good reading? To save battery power, most wireless sensors "wake up" at a predetermined time, take a reading and then go back to sleep. If your machine is variable speed or load, what are the chances it will be in the right condition when the sensor happens to wake up?

Because they are battery powered, wireless sensors might be limited in the data they can collect. It takes more processing power and memory to take higher quality data. Transmitting larger amounts of data also lessens battery life. In order to keep prices down and maximize battery life, most wireless sensors on the market today are limited in the data they can collect, compared to what is routinely collected with portable systems.

Right data means that the data being collected is adequate to detect the defects you are trying to find. "Right understanding" refers to understanding how the asset fails and what indicators it gives when it enters a failure mode. These are the indictors you are trying to measure, therefore, right data and right understanding are directly linked. For example, a root mean square (RMS) overall reading is probably not an adequate indicator if your goal is condition-based maintenance. Likewise, a sensor that only measures up to 2,000 Hz is not adequate to detect a defect in a gearbox that generates vibration at a frequency of 7,000 Hz.

You need to know what you want to measure and you need to make sure you are measuring it accurately.

Condition monitoring is based on trending repeatable data and looking for changes. If you have good software, it should be able to detect these changes for you. When people are shopping for a system, they tend to focus on the data collectors, even though most of the full featured data collectors on the market can easily take the standard tests required for condition monitoring. It is more important to focus on the software and its alarm or diagnostic capabilities. Consider how good the software is at turning data into an alarm, an alarm into a diagnosis and a diagnosis into a report with actionable recommendations.

A benefit of wireless sensors is they can test the machine more frequently, perhaps every hour instead of once a month. For example, if you have 1,000 machines with an average of six sensors on each machine, each collecting five different measurements once per hour, that's 30,000 unique graphs to analyze each hour. Who is going to analyze all this data? If, as previously noted, you are not even certain that all of the data is good data, then you are really in trouble! Assuming your system is intelligent and collects good repeatable data (which is NOT the case for most of the wireless sensors on the market today), you will still need very good software with intelligent alarms or diagnostic features to let you know which machines have problems.

Most vibration analysts today do not have alarms set on most of the equipment in their database because most of the main vibration software programs have archaic alarm features that do not work so well. Too many false positives cause users to ignore the alarms and too many false negatives (machines that fail without triggering alarms) cause users to not trust the alarms. There is also a big difference between an alarm (this piece of data is in the "red") and a diagnosis, such as "moderate free end motor bearing wear." For wireless systems and the Industrial Internet of Things (IIoT) to be successful with vibration monitoring, data needs to be right data and improvements need to be made in automated diagnostics (i.e., right analysis and right reporting).

Here is something to try if you already have a system to see if you are using it correctly, or if you are buying a system, use it as the best approach. First, ask for a field engineer, not a salesperson, to demo the system for you. Set the individual up in a conference room with a grinder or desk fan on a table. Next, ask the field engineer to configure the grinder or fan in the software as if it was a real machine in the plant, taking all of the data types one would normally measure. Set up more than one test point and more than one measurement axis to make it more realistic. Then, ask the field engineer to load a route (the machine test configuration defined in the software) into the data collector and test the machine. Based on this data, ask the field engineer to build alarms or baselines in the software, utilizing all of its alarm features on each data type. Next, put a piece of duct tape on the fan or add a screw or some gum to the grinder rotor to create an unbalance (be careful!). Test the machine again and upload the data to the software. Here is the key point: See if the software tells you the machine is out of balance or in alarm, but not by looking at the data manually, rather via an automated report. If it doesn't, then look at the data manually to verify there was a change. It could be the fan was out of balance and the duct tape balanced it. If so, move the tape and try it again. The goal here is to see if the alarms or diagnostics work, not to see if you can manually view the difference in the graphs.

Ask the field engineer to configure the grinder or fan in the software as if it was a real machine in the plant

If the new data looks different, but the software does not say it is in alarm or out of balance, then tweak the alarm until it does. This is what you want to be able to do with the actual machines in your plant. When and if you get the software to say it is in alarm, add some more tape, test it again and see if the software says it is a higher severity level. When and if you get that to work, take the tape off and put a coin under one of the feet of the machine to simulate a different fault. Test it again and see if the software says it is in alarm. If not, tweak the alarm until it does. When you are happy with the results, return the machine to its original state and test it again. The software should say it is healthy. When you add duct tape again, it should say it's out of balance, in alarm, etc.

Next, run the machine at a slightly different speed, if possible, to see how the software handles it, or tell the software the machine is running at a slightly different speed than it actually is. Even AC induction motors that are not on variable frequency drives (VFDs) can vary in speed by a few percent from test to test. This is a huge issue because most of the fault indicators are related (or not) to the motor shaft speed. Therefore, the software needs to know or be able to determine the motor speed if it is going to be able to give a correct diagnosis. A slight variation in running speed should not trigger an alarm, nor should it cause the alarms to not function correctly.

At each of these steps, write a report. How hard is it to turn the data or your analysis into a report? How easy is it to edit or add comments to the report? Is the last report available and visible when you are analyzing newer data? Can you easily add a note that says, "the machine has been repaired" and see it in the machine history? Can you easily see the history of what has happened, such as no fault, moderate unbalance, serious unbalance, foundation looseness, or no fault? Can you easily make this report available to someone else, preferably without printing reams of paper?

The bottom line is this: If it takes all day or if the field engineer cannot make the software come up with the right answer when testing a simple machine sitting on a table with known problems, then it isn't going to work in your plant with real machines. Again, you already know what the problem is, so the point isn't to manually analyze the data and come up with the fault. The point is to automate the process and fine-tune the alarms until you feel you can rely on them.

There are hundreds of different vibration monitoring systems on the market and even more sensors. All of the hype around the IIoT is attracting new companies into the wireless sensor market and big data companies are promising advanced analytics. When assessing which tools to use, it is important to understand your goals and the equipment you are monitoring. It is also important to understand the people who will be employing these tools, along with their level of education and training. Right tools facilitates and supports the 10 components of a successful program.

Right data is about being sure the tools are configured and utilized correctly in order to get high quality data that accurately measures the specific fault indicators you are looking for. There are a lot of technical details that come into play when determining if an instrument, like a data collector or sensor, is actually measuring what you want it to measure. These details are related to both the limitations of the equipment itself and to how it is configured and used. It is a good idea to get an unbiased opinion before making a big purchase, not just to rate the equipment, but to make sure the equipment is appropriate for the users and the application.

Why would someone pay $1,500 for a camera when there are other cameras available for $100? Because they are not the same. That said, the $100 camera might be perfect for what you need it for and the $1,500 camera will still take rotten photos if you don't use it correctly.

Right tools and right data are only a part of the puzzle. In order to have a successful program, you need to have all 10 components in place: Right goals, right people, right leadership, right tools, right understanding, right data collection, right analysis, right reporting, right follow-up and review, and right processes and procedures.

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Bristol-Myers Squibb Journey

Part 1

Initial Implementation and Prioritizing of Uptime Elements
(Dec/Jan 2016 p. 30)

Part 2

Aligning a Framework Within Our Sites
(Feb/Mar 2016 p. 26)

Part 3

The Central Team's Effort Aligned to Our Strategy
(April/May 2016 p. 22)

Part 4

Journey to 200 CRLs

A Journey to Shape Reliability Excellence at **Bristol-Myers Squibb**

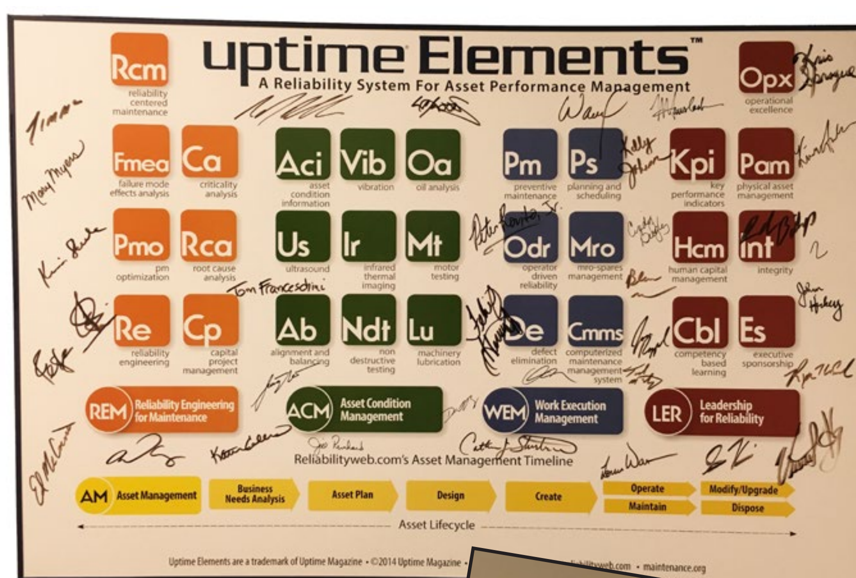
by George Williams and Robert Bishop

This fourth installment shows how the Bristol-Myers Squibb Company (BMS) was able to train and certify more than 200 employees as certified reliability leaders (CRLs) in just one and a half years. The series began in *Uptime's* December/January 2016 issue with the initial implementation of Uptime Elements at BMS. The second installment in the February/March 2016 issue explained the alignment of the framework with the sites, while the third installment in the April/May 2016 issue covered the role of the central corporate strategy. These all supported the culture that led BMS to 200 CRLs.

Journey to 200 CRLs

The first facilitated CRL exam was held in October 2014 at BMS's annual reliability excellence conference. This exam resulted in 28 CRLs across seven sites, planting the seeds for BMS's journey to 200 CRLs. Each of the sites acquired an appreciation for the value of the CRL education and an appetite quickly developed to spread this experience to others in the organization.

Like many companies, BMS begins each new year with the development of objectives. These discussions begin at the top of the company and cascade downward throughout each organization. Objectives are separated into categories and each objective is aligned through a line of sight back to the overall company goals. For reliability excellence, 2015 brought with it some key objectives associated with growing the culture across not only the reliability centric positions, but across functional areas. The Uptime Elements and CRL training and certification offered a fantastic opportunity to do just that. So embedded in the central team's objectives was a goal to reach an additional 50 CRLs across the BMS manufacturing network. While this was a documented goal, the central team informally set a goal of 100 CRLs across all of BMS.



Why was this a goal for the central team? Put simply, reliability comes from people. The CRL process allows for the removal of silos and increases the understanding of other departments and functions. It develops and demonstrates a minimal level of understanding across the framework relating reliability to BMS employees and their roles in it. It facilitates conversations about improvements that can be made to systems related to asset management and develops a sense of ownership in equipment reliability across functional boundaries. The development of CRLs is a mechanism to nurture the BMS culture.

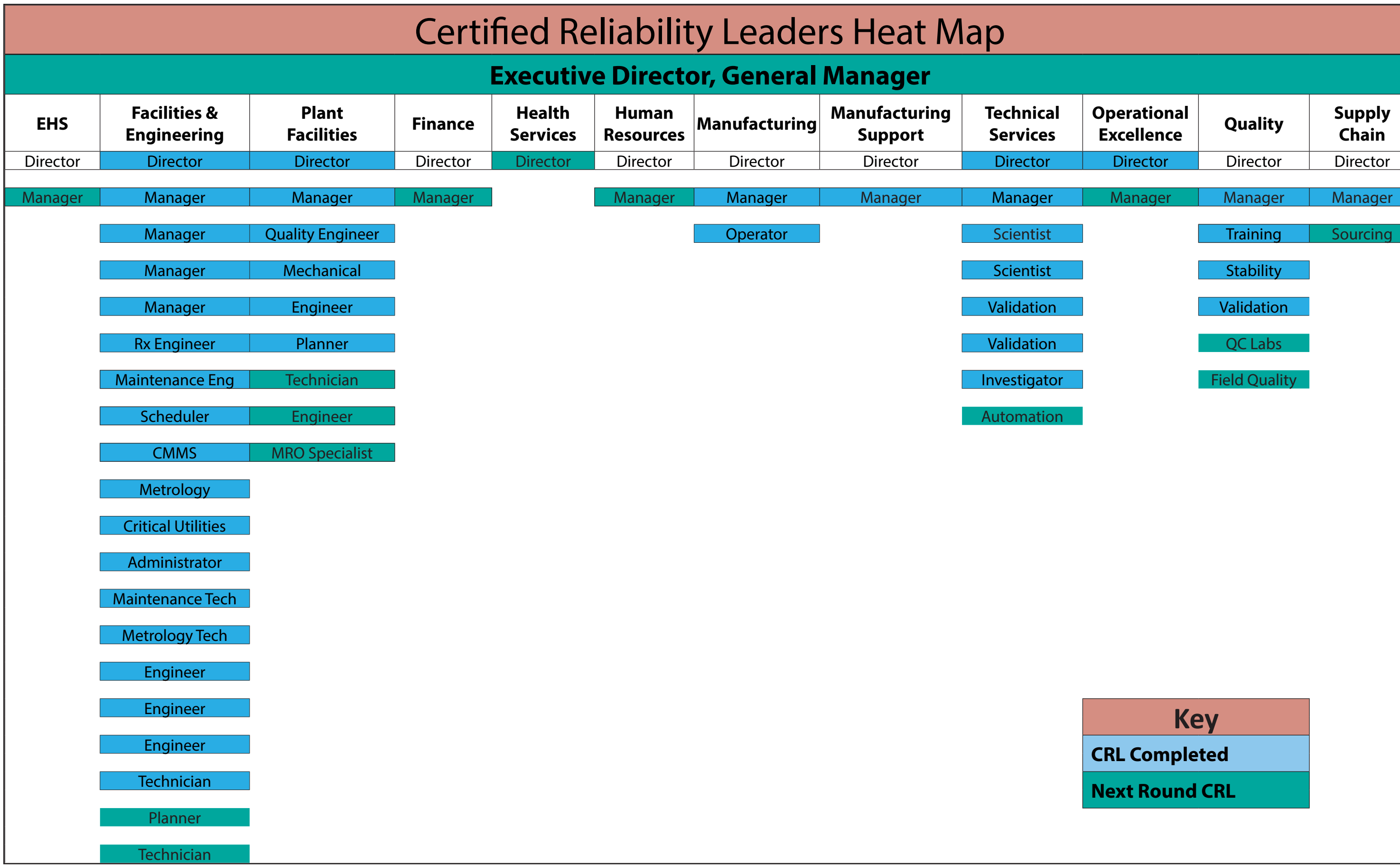
To help facilitate this process, BMS joined the Reliability Leadership Institute (RLI). RLI offers an organization access to many benefits, including the Uptime Elements learning management system, which includes access to the body of knowledge in PDF, audio books and videos. Users log in and are guided through each passport and its knowledge checks. Additionally, the organization commits representatives to participate in the RLI community as board members, implementation and benchmarking champions and learning managers. These groups meet regularly to discuss goals, achievements, lessons learned and opportunities to expand on the current framework.

The first step in BMS's development of CRLs was to provide access to the RLI learning management system to anyone interested in learning more about reliability. As people began to utilize the training materials, a strategy for training and certifying BMS employees was needed. With the same goal across many sites, it was decided to certify an internal employee for the training delivery and exam invigilation. The next step in the strategy was to coordinate visits to a dozen sites and fill rooms with people willing to take the course and sit for the exam.

It's no easy task to have a production site commit to filling a room with personnel for reliability training, especially when they are needed to execute the daily mission and particularly if reliability is not something they would define as their core role. So began the efforts of e-mails and phone conversations to gain alignment on why this was an important effort and why the sites should invest their time in this training.

Honestly, for BMS, this was not as difficult as you might think. BMS employees get it; they understand that at the core of who BMS is as a company, its employees have to operate and maintain equipment in order to deliver to BMS patients. The sites recognized that the CRL was not just for maintenance reliability individuals. Many departments were engaged, including operations, manufacturing support, quality, training, validation, engineering, supply chain, metrology and more. Not only was the central team able to gain commitment for the courses, but several sites required multiple sessions to accommodate the number of people interested.

As summer approached, the central team finalized travel plans and prepared to



live out of hotel rooms for a while. George Williams, CRL, CMRP, the facilitator for these sessions, scheduled each session as a one-day overview to include the exam. This was by design to help ease the burden of having many key people in training simultaneously. Individuals were encouraged to utilize the online content prior to the overview sessions and exam.

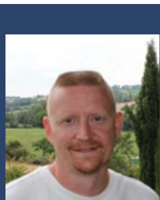
The first site to host a CRL overview discussion and exam brought 12 people together for an all-day interactive training followed by the exam. This allowed for conversations relevant to the site's unique situation. This format was very effective and became the platform rolled out at other sites. Over the next few weeks, three other sites hosted similar events, all with their own unique approaches.

One site expanded this even further and built an eight-week program. There was a kickoff meeting to explain the process, resources and expectations. This was followed by several lunch and learn sessions that were spaced strategically to make sure the group would stay on track. In addition to preparing for the exam, the lunch and learns were designed to facilitate conversations, encourage opportunities and build relationships.

[Put simply, reliability comes from people]

The framework provided a path to outline the journey, but didn't prevent deeper discussions or the typical sidebar conversation. Each was supplemented with a video on a topic directly related to the framework. As the end of the program approached, there would be a concentrated, all-day training for the group, followed a day or two later with the exam. This format produced a 95 percent passing rate and has resulted in a culture tipping point in the direction of reliability across functions.

Each individual brought a unique viewpoint to the discussion, specific knowledge and questions, but each left with a common language and understanding of the framework. It was this benefit that was realized and allowed BMS to achieve the 200 CRLs. Now, it's time to see where the journey goes from here. Perhaps someday, the CRL process will be part of onboarding each new employee.



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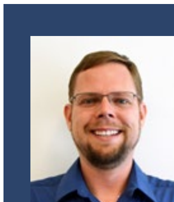

Robert Bishop, CRL, CMRP, *is a Manager Maintenance and Reliability for BMS, Syracuse. He has an undergraduate degree in Mechanical Engineering from the University of Rochester and an MS in Bioengineering from Syracuse University. Rob has worked for BMS for over 9 years, supporting equipment in several roles. He is an early adopter and loves to improve systems and our culture. Rob has the IAM Certificate for ISO55000. www.bms.com*

DOES IT REALLY MATTER?

by Carl Fransman

A lot has been said and written about predictive analytics. Most of the attention focuses on applying forecasting techniques to the domains of marketing and security. More recently, however, the rise of machine generated data (e.g., M2M, Industrial Internet of Things, Industrie 4.0, etc.) has opened a new playground for data scientists.

What exactly is at stake? To really understand this, one has to take a step back and look at the changing business environment. Increasingly, competitive markets have led companies to stray away from the traditional, "I'll sell you something and when it breaks, I'll sell you more" model. In this model, clients bought equipment and when the equipment broke, they had to buy spare parts, maintenance, etc. In a weird way, vendors actually benefited from machines breaking down, especially in B2B markets.

But then, buyers finally did the math and understood why this was not a healthy relationship, even less so when one was tied to a specific vendor. Out of this awareness, a new business model was born: servitization. Products are being repackaged as a service that includes maintenance, spare parts and some sort of performance commitment. The commitment is on the output, not just on speed of intervention as is often the case with simpler service level agreements (SLAs). With this type of commitment, when equipment is down, the provider doesn't make money (or less money, or in some cases, even pays fines). The provider's incentive is to keep the equipment running as much as possible. The easiest way to do so would be to make equipment that simply doesn't break. Well, that would be utopia, wouldn't it? But, there's an economic reality to count with and beyond a certain point in mind; it's just not economically sound to keep improving equipment quality.

With predictive analytics, one combines machine data with external data, such as schedule, environmental factors and anything that may influence the equipment's reliability.

The other way is to make the equipment as reliable as possible while making sure it performs when it should. This would be a scheme where the provider makes money when the client runs the machine; it just shouldn't break when it's scheduled to run. Sounds simple enough. First came the maintenance schedules with preventive maintenance more often than not still defined by the equipment provider. Then came periodic analysis of equipment performance, which allowed a refinement of the maintenance schedules. And now, finally, comes predictive analytics.

With predictive analytics, one combines machine data with external data, such as schedule, environmental factors and anything that may influence the equipment's reliability. Even the person operating the equipment should be factored in. Complex algorithms are then derived to use all this data and come up with some sort of prediction as to the state of the equipment. And, unfortunately, that's where most of these projects stop. There are some clever data scientists that may come up with so-called "smarter" maintenance schedules that seem to work well at first, but later seem to be totally off the charts. An intermediate step has been to develop diagnostic solutions that use the machine-generated data to alert operators of an upcoming failure. Unfortunately, these warnings come too late to really allow for scheduled intervention. Their main benefit is limited to speeding up the reaction time and, at best, the diagnosis of what's causing the problem.

So, do predictive analytics really matter? Yes, well applied predictive analytics allow timely, planned intervention. And that's where the true value of predictive analytics lies. It turns unplanned events into planned ones. One of the main misconceptions of this technology is that it will lower the number of events. It really doesn't, however, it changes the event (i.e., a failure) into another type of event (e.g., a maintenance activity, a part replacement, etc.).

Therefore, the really important outcomes are whether you know what will happen, how confident you are that it will happen and how much time you have between the warning and the event.

The WHAT...

is really straightforward, or is it? Well, it's actually more refined than one may think. Let's say you know Machine A will fail next week. Sounds good enough? But if that machine is a big, complex piece of equipment, one may still be looking for a needle in a haystack to find what caused the prediction. Wouldn't it be better if the failure forecast could be made to the level of subassemblies or even individual parts? Well, the capacity to do so depends mainly on availability of data, capability and capacity to interpret the data.

The WHEN...

determines how much time you get before the event occurs. Obviously, the more heads-up one gets, the more time one has to schedule an intervention without or with minimal disruption to the production schedule. Also, and this is where things get really interesting, a longer lead time for predictions may allow one to group maintenance activities that, while not lowering the number of events, will lower the total production downtime.

The CONFIDENCE...

(or precision) really impacts whether or not one decides to act upon a prediction. There is no linear relationship here. For example, would you react to a prediction saying a part will fail on an asset and this failure would result in a safety issue? You probably would, but at a way lower confidence level than for a prediction that would result in a quality deterioration of manufactured products.

So, in order to avoid predictive analytics from being no more than an intellectual exercise for data scientists, the key is to use the outcome of the prediction for two things: act and optimize. Without action, the forecasts can't have any real operational impact and only serve the purpose of comforting oneself as to how good you are at predicting certain outcomes. While this has its value, it's best to leave it to academics. In business, one shouldn't care about the tools, methodologies, techniques, etc., only about the outcome! Optimization is where the real value comes from because reactive interventions without optimization are nothing more than reacting before things happen. Introducing better scheduling, grouping, root cause analysis, etc., turns these interventions into proactive events that may result in longer uptime, better adherence to forecasted production schedules, lower maintenance costs, etc.

The quality of the predictions will have a huge impact on the potential value derived from them. But, the true value of predictive analytics lies not with the predictions themselves, but rather in knowing what to do with them!

__Carl Fransman,__ Managing Director for EMEA at Predikto, has over 25 years of international management experience in high technology industries. He holds a number of board mandates in technology companies and the nonprofit sector. His previous experience includes management roles in technology and the manufacturing sector. www.predikto.com

Can't We All Just Get Along?

Melding the Worlds of Production and Reliability

by Paul Llewellyn

"Can't we all just get along?" As the fifth child of eight, I remember my mother saying that quite often. Having four older brothers, it really never happened where we just all simply got along.

Now as an asset reliability educator, I travel around the country providing in-plant training for operators and maintenance personnel. During these training sessions, often times I am reminded by the folks who spend the majority of their day inside these American manufacturing facilities, that I must be living in a different world.

"Everything you are saying about asset reliability sounds great, but we are charged with getting product out the door. We don't have time to do all the best practice things you are talking about."

I completely understand this sentiment. I really do. However, we must find a way to meld our two worlds.

The world of production throughput, asset uptime and maintenance cost reduction must learn to get along with the world of lubrication reliability, predictive and preventive maintenance, and reliability-centered maintenance. So, how can this task be accomplished?

First, recognize that it does not happen on its own. To become world-class in your reliability-centered maintenance program, you must work hard to make it happen. You must have buy-in from the same hardworking people who are charged with production throughput. You must have buy-in from upper management so they can support the people with the grease guns in their hands.

You also must believe that by bringing these two worlds together, your performance in delivering product to the end user will actually improve and, ultimately, your job will be easier and your company more profitable.

It stands to reason that if you can keep clean and dry the lubricants you rely on to run interference between two opposing moving metal parts, then you can improve the life of the oil and certainly improve the life of the asset.

Where to Begin

Within plants, there are many opportunities for simple improvements that, in the long run, and sometimes in the short run, will pay back many times over.

The lubricant storage area is always a great place to make major improvements. Ask yourself this question: If the oil in your lube room meets the specifications for the oil in your personal vehicle and the company says it's okay for you to take what you need, would you use it? Most people would say no. Then the question is: Why use that oil in the plant's assets that you are relying on to make a profit?

Replace your drums that have open bungs and rags stuffed in them with an oil containment system that allows the stored oil to be filtered when filled and filtered again when being used to top off a gearbox or hydraulic system.

Get rid of the galvanized open-top transfer can, the repurposed cutoff two-liter soft drink bottle, the bucket and the funnel. Replace them with color-coordinated, closed-top oil containers.

Avoid potentially costly cross-contamination mistakes. Place a color-coded lubrication chart on the wall in the storage room so everyone knows which oil and grease goes with which piece of equipment.

Figure 2: An individual drum, set up with a desiccant breather, color-coded ID tag and quick connects so oil can be filtered upon removal or filtered while still in the drum, demonstrates a best practice

Identify everything with color-coded labels or tags so the trail is seamless from lube room to equipment. Take the guesswork out of which grease is your multipurpose lithium complex grease and which one is your polyurea electric motor grease by using color-coordinated clear tube grease guns.

Next, take a look at the equipment. Can you outfit gearboxes and hydraulic systems with desiccant breathers to keep moisture and particulates at bay? Is there a need for a bottom sediment and water bowl to check the clarity of the oil and look for water and remove it? Can you replace the standard, flat sight window with 3-D sight glass so you can see from any angle and know for sure that there is oil in the system and at the correct level?

Does the reservoir size warrant quick-connects so kidney loop filtration can be performed when oil analysis shows the oil is still good, but is dirty and needs a good cleaning?

How do you decide which assets need oil analysis? Is it based on asset criticality, reservoir size, or both? What ISO cleanliness code has been

⇦ **Figure 1:** Lube room "before" images show what not to do; storage and transfer methods in use in these lube rooms are an open invitation to contaminants that degrade lubes before they even reach your equipment

Figure 3: These lube room "after" images show best practice methods for storage and transfer of lubricants; great care has been taken to ensure that the lubes stay clean and dry, and to eliminate the risk of cross-contamination

set as your goal and what alarms and limits are you measuring to determine whether or not to filter the oil or change it? Are you changing good oil, therefore costing the company unnecessary expense with downtime, labor and oil disposal costs?

Are maintenance personnel and operators receiving the necessary training so they fully understand the detrimental effects of contaminated oil? Are you part of the problem because you don't know what you don't know, or are you part of the solution when discussing world-class lubrication and asset reliability because you are trained to recognize poor lubrication practices and do something about them?

Bringing Worlds Together

The world of getting widgets out the door and the world of lubrication reliability best practices can and do get along, and it is always for the betterment of production efficiency and profitability for the company. It is rare to find a facility operating poorly where reliability-centered maintenance and lubrication best practices are the norm rather than the exception.

Don't wait years to bring reliability and production throughput together.
It's just too costly to keep them apart!

__Paul Lllewellyn__ is the Asset Reliability Training and Education Manager at Lubrication Engineers, Inc., with prior roles within the company as general sales manager and corporate sales manager. Paul is an STLE-certified lubrication specialist (CLS) and has earned MLT I, MLT II and MLA II certifications.
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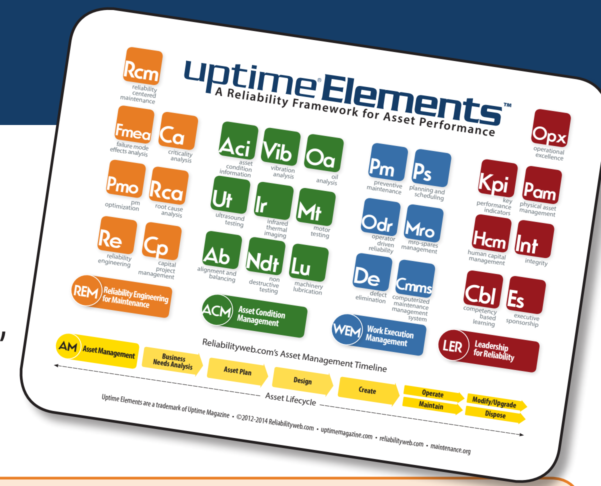

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armsreliability.com | bentley.com | blueskyreliability.com | nexusglobal.com | peopleandprocesses.com

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lelubricants.com | ludeca.com | sdthearmore.com | theultrasoundinstitute.com

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AM – Asset Management

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Asset and Maintenance Managers: Key Decision

Asset and maintenance management are becoming increasingly complex tasks. Those responsible must make decisions about the condition of equipment and machinery that can have an impact on the operation of the entire plant. So, it is not at all surprising that they are constantly trying to improve their asset management and maintenance strategies. There are numerous methods and tools available to help companies and managers make decisions regarding their maintenance concepts. Nowadays, it is possible to interpret data to allow foresight into the future condition of the assets. And it is not only about optimizing maintenance management technology. Rather, the entire decision-making process of asset management and the maintenance staff is under scrutiny.

Do Asset and Maintenance Managers Predict the Future?

Asset and maintenance managers carry a lot of responsibility in their companies. All their thought processes center around making the right choices for their machines and equipment. Complete operational strategies are dependent on these decisions. However, the basis for these decisions has only changed slightly in the past, while the assessments that those responsible must make increase in complexity.

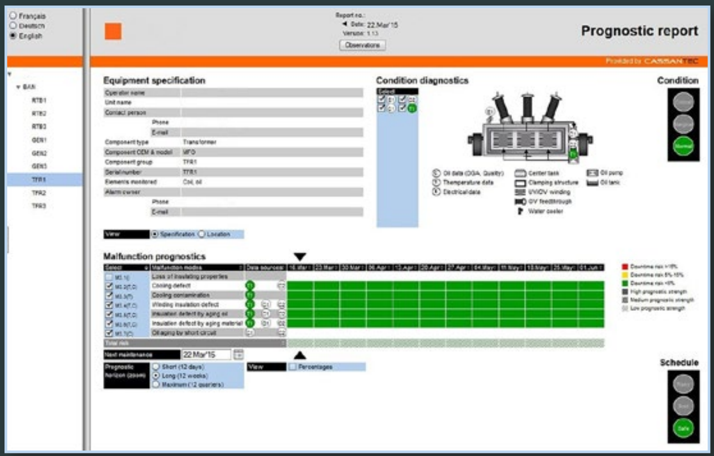
Basically, asset and maintenance managers make decisions that affect future events. In other words, they more or less predict the future of the plant and equipment. Even if they have a specific maintenance plan, they must often decide, based on their experience, when the next maintenance date should be and expect that everything runs smoothly and nothing goes wrong until that date. At the same time, it is also their responsibility to decide how extensively and in what order the equipment will be maintained at the next scheduled intervention date.

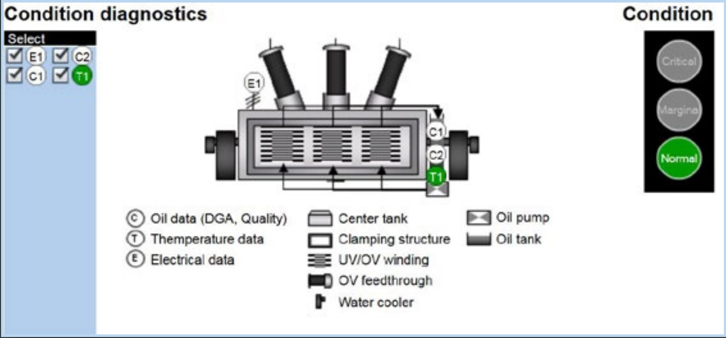
Because of this immense responsibility, asset and maintenance managers should ask themselves three questions when faced with making a new decision:

1. Does my decision affect the future?
2. How do I reach this decision?
3. What resources and information do I use to reach this decision?

In most cases, the answer to the first question is "yes." But for the second question, decision makers are confronted with probabilities and possibilities for the future that they play through in their minds. Being able to rely on information other than one's own gut feeling improves the quality of the decision. Hence, a prognostic tool can prove to be very useful in making such future-oriented decisions.

With tools like condition monitoring, maintenance managers receive information about the current state of the equipment. With this information, immediate work can be scoped and scheduled depending on the urgency and importance of the respective pending measure. The aim is to make sure the maintenance manager's decisions are based on solid facts; however, very often decisions are suboptimal because necessary data-based information regarding future equipment condition is missing.





by Moritz von Plate

Makers

Foresight into the Future of Plants Thanks to Condition-Based Prognostics

Even advanced diagnostic or predictive analytics tools are not able to give explicit information about the future. Therefore, asset and maintenance managers only have the option of choosing between a compromise based on their own experience and the recommendations of the manufacturer. They must, more or less, follow their own gut feeling. In order to provide decision makers with useful information, this information gap must be closed. So far, data-based information about the future of a plant is not available. A look at the development of maintenance techniques, however, shows this gap is steadily closing.

> “So, based on data, companies can optimize their previous maintenance plan”

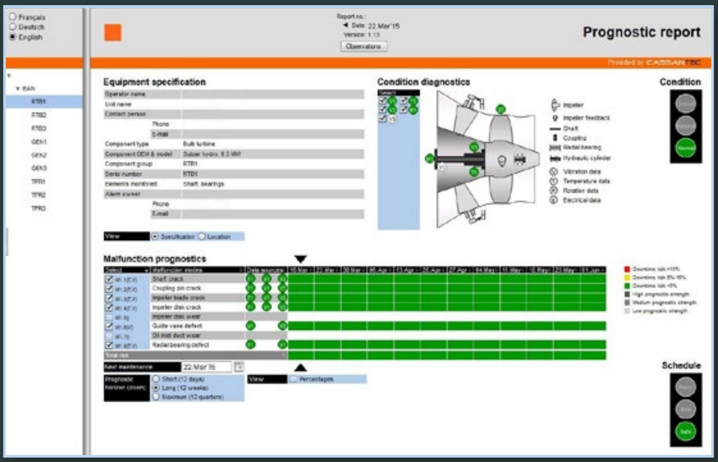
Progress in Maintenance

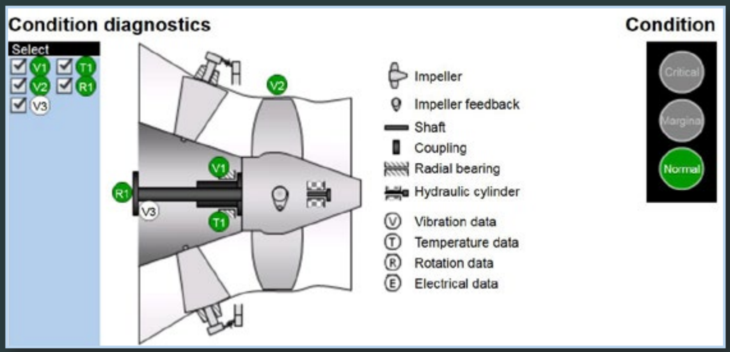
The tremendous value of asset management and maintenance for a company is well-known. In order to exploit their full potential, the industry is steadily developing relevant methods. The trend is moving toward intelligent maintenance.

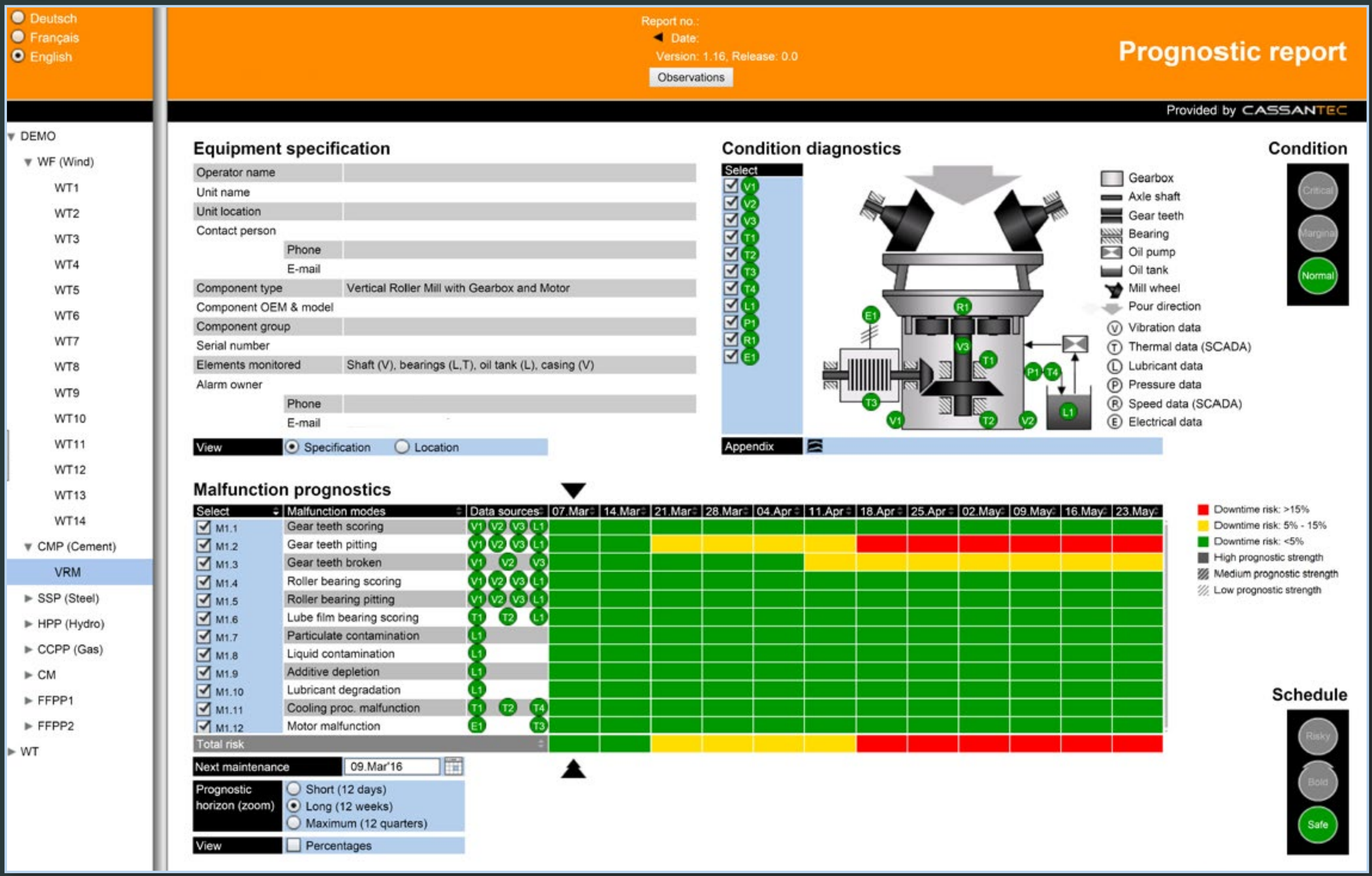
Reactive maintenance, where maintenance engineers repair any faults as soon as they occur, is considered the oldest and best known maintenance strategy. However, this first generation of maintenance methods does not address equipment condition systematically and is not based on data. This method may still be useful for components that are not critical to the business and whose failure would cause only minor financial loss. Companies should resort to other measures for components whose failure can cause significant costs and are critical for the entire production. Increasing connectedness of components and equipment and constantly rising demands on availability are forcing companies to rethink their approaches.

Particularly in industrial plants, many companies have replaced first generation maintenance with a second generation. They have introduced preventive maintenance (PM), which calculates mean time between failures, and use this as the basis for a regular maintenance cycle. This method, in which data analysis plays only a subordinate role, is relatively easy to organize and produces better results in terms of availability of equipment than the reactive approach. However, this approach quite often leads to maintenance being executed prematurely when it is technically not yet warranted. Furthermore, PM does not systematically prevent failures and downtime.

With the ongoing digitization of plants and processes, a third maintenance generation in which data plays an increasingly important role is emerging. Most companies strive to introduce such condition-based maintenance. The basis for it is provided by condition monitoring data gathered on individual components. Condition monitoring analyzes this data, ideally in real time, to help avoid immediately impending malfunctions or damages.







Next Step: Condition-Based Prognoses

Using mathematical models, companies can use the same data from condition monitoring for condition diagnoses and condition prognoses of components and entire plants. Diagnoses and prognoses together provide the basis for condition-based maintenance. This method makes it possible to schedule maintenance when it is technically necessary and economically sensible. Companies implement condition-based maintenance, which is provided either online or off-line, based on the utilization of sensor data and central data analytics. These prognostic solutions provide asset and maintenance managers with the foundation of right information upon which they can make optimized decisions. They get a prognostic time horizon of the component's and plant's condition for weeks, months and sometimes even years. At the same time, some prognostic tools provide information about the risk of the possible malfunction. Red, for example, means a high risk of over 20 percent, yellow, a lesser risk of between five and 20 percent and green, a risk of less than five percent (see figure above). Now, asset and maintenance managers are able to make transparent decisions about the remaining useful life of components and the entire plant according to the individual situation and the decision maker's risk appetite.

All available data sources are tapped, with no new sensors required. In addition, asset and maintenance managers obtain a fleet view on all components, such as pumps, turbines, or boilers.

This information makes it possible for asset and maintenance managers to understand when in the future a malfunction will occur. This way, costs can be reduced and plant availability increased, particularly by avoiding unplanned downtime. So, based on data, companies can optimize their previous maintenance plan, consequently leading to an optimized operating strategy.

Making Better Decisions

Asset and maintenance managers are key decision makers in companies, yet the previously used tools for deciding on the right asset and maintenance strategy are inadequate. Rather than changing the way decisions are made, it is advisable to upgrade the tools that are used to make those decisions. Developments in asset management and maintenance show that the data necessary for such prognoses already exists in most companies. Now is the time to use the latest mathematical models to exploit this data more comprehensively for one's own asset management and maintenance strategy.

Moritz von Plate *has been the CEO of Cassantec, a company specializing in prognostics for industrial facilities, since 2013. Before joining Cassantec, Mr. von Plate was the CFO at Solarlite, an EPC contractor for concentrated solar power plants, and worked for seven years at the Boston Consulting Group, focusing on industrial goods and financial services industries.*
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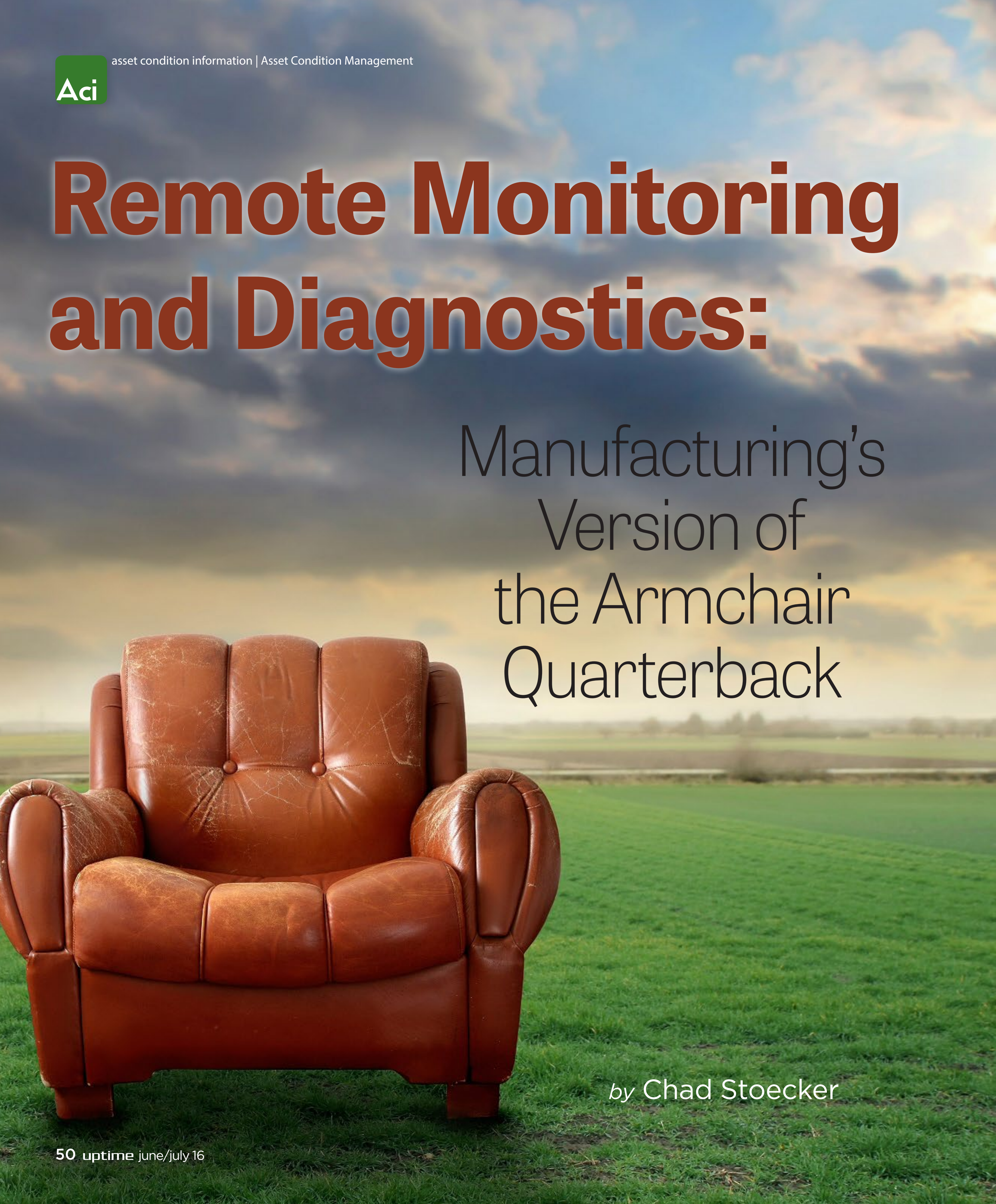

by Chad Stoecker

In any industrial environment, and particularly those with geographically distributed and remote assets and operations, reliable monitoring can be a challenge. Catastrophic equipment failure can occur without warning and, in some cases, go for long amounts of time without being noticed. The oil and gas industry, among other industries, was quick to recognize the benefits of remote monitoring and diagnostics (RM&D), as oil and gas companies have very expensive equipment deployed in disparate locations around the world. These difficult operating conditions make topflight monitoring and diagnostics systems crucial to ensuring that workflow operations can continue without interruption.

With remote asset monitoring, organizations are able to source valuable operations data, leading to valuable insights to drive informed decisions and better manage desired outcomes. The more workflow data a company can capture and analyze, the better it can understand its system and equipment performance and identify areas for improvement.

Here are a few real-life examples of how implementing a RM&D solution makes industrial organizations more efficient with better resource allocation and avoided downtime.

Wise Resource Allocation

In today's economic environment, with industries like oil and gas facing particular pressures, facility performance and reliability have never been more critical. No business can afford the interruptions in productivity when a piece of equipment or system goes down. Constant on-site monitoring of a facility's oil and gas workflows naturally drains valuable manpower resources, leaving fewer workers available to focus on the core business.

Off-site or remote asset monitoring increases overall efficiency by saving time and reducing expenditures so organizations can put their valuable resources elsewhere. In many circumstances, on-site staff may be limited, but RM&D allows organizations to automatically receive information on all assets, such as patches, updates and equipment upgrades, with less legwork. Workflow databases are consistently updated and important business applications are continually tracked without the need for 24/7 manual processing.

Catching Problems Before They Occur

Outside of scheduled maintenance, which at best is an estimate of when maintenance should actually occur, operators generally are only able to diagnose and resolve problems after there has been a failure. Now, RM&D platforms with predictive analytics, driven by the connected machines of the Industrial Internet of Things (IIoT), allow operators to see when their assets will fail before they actually do. Asset diagnostic technology is able to rapidly convert vast amounts of raw data into actionable intelligence for operators by automatically identifying anomalies. This simplifies the often overwhelming amount of data sets being streamed from equipment and alerts staff to potential failure.

For example, a team was running RM&D for a gas customer when an increase in the primary seal gas inlet flow to the drive end on a reinjection compressor was detected. Over the course of 60 days, consistent monitoring of the seal supply flow to the drive end showed a steady increase. After alerting the customer to the increase, the team inspected the valves that control the inlet flow to the high pressure stage drive end seals. It was determined that a valve was abnormal due to a faulty response signal from the valve positioner. But as a result of early notification, along with daily monitoring and regular updates, the customer was able to review the seal gas control system and identify the inlet flow control valve requiring calibration and testing. After making an adjustment to the valve, the inlet flow returned to a normal operational range, saving the customer approximately $360,000 in avoided downtime.

Predictive maintenance also can be custom designed for a company's specific system, built from regular observation and recordkeeping that can reveal trends and uncover anomalies. For instance, when equipment is commissioned, a facility may create a pump health log to use as a baseline for alarms and required maintenance triggers during the lifetime of the system. This dashboard allows an organization to spot trends and identify unusual operations that could create problems in the future, so it can adjust its overall maintenance schedule accordingly and maximize its workflow uptime.

A Holistic View

Asset managers use a variety of software tools and systems to do their jobs, often working with the same or related data, but at off-site locations. Asset diagnostics systems automatically filter workflow data and allow industry operators to monitor all systems in one view, regardless of location. This integration also extends to workflows that include multiple users in their execution and allows workers to perform this process on their own. Employees are now armed with a holistic snapshot of operations at all times, empowering them to make better, more informed decisions, 24/7.

For example, a customer needed to monitor a remote engine using a 360 degree, holistic view of all the engine data. A decrease in firing temperature was noticed and the customer was alerted to this discrepancy. Due to the early notification, the customer scheduled a planned maintenance trip to the remote platform to inspect the engine. After inspection, the maintenance technician replaced the spark plugs and was able to return the engine to a normal combustion pattern before serious damage was done.

RM&D platforms' holistic view of data from various databases is crucial to ensuring that process and manufacturing plants, often some of the most dangerous work environments, are safe for workers. With direct access to data, ranging from material safety data to real-time equipment and environmental monitoring, workers are armed with the information they need to ensure safety for themselves and their colleagues.

No business can afford the interruptions in productivity when a piece of equipment or system goes down

Conclusion

These examples show how RM&D technology platforms have turned from a "nice to have" to a "must-have" for industrial companies to remain competitive and safe. Complete automation of data collection and data analysis ensures the seamless execution of machine maintenance, regardless of location, increasing the uptime of operations.

RM&D platforms continue to prevent millions of dollars in lost productivity by identifying issues before they occur, keeping systems online and helping organizations more efficiently allocate internal resources in an increasingly competitive digital and global economy.

Chad Stoecker *is a Manager at the Industrial Performance & Reliability Center of GE Digital, where he oversees a global team of customer reliability engineers to deliver a high value monitoring solution to power, oil and gas, mining and aviation clients. Mr. Stoecker, an accomplished engineering professional with over 10 years in the automation and asset monitoring industries, holds a Master's Degree in Mechanical Engineering from Oklahoma State University.* *www.geautomation.com/products/industrial-performance-reliability-center*

Standards' Interoperability Breaks Silos in Operating Facilities

by Gary Mintchell

Problems for maintenance reliability professionals in asset-intensive industries begin long before the plant is running. The root of a problem typically begins in the engineering and design phase, well before construction begins.

Name one of your biggest headaches when something goes down at 2 a.m. More than likely it entails having ready access to engineering details of the unit, component, or asset you're working on. Documents in PDF format exist from engineering, procurement, construction (EPC), but what confidence does anyone have that the data is accurate as to what was built? Further, what is the confidence level that any engineering changes during the time in operation were fed back through a revision management system into the document you now have while trying to fix the problem?

The problem in operating facilities no longer lies in getting data. Nor is there a problem of not enough IT and data standards. The problem is that so much data resides in silos of applications and databases. These may all comply with one data standard or another, but those standards often actually conflict with each other.

Data residing in the engineering silo may or may not match the data in the operations and maintenance systems. Furthermore, various engineering, operations and maintenance reliability systems may not be properly connected to each other or the sensors providing them with real-time data.

The Internet of Things (IoT) and more powerful databases may provide floods of additional data, yet managers are still searching for information that will aid decision-making and improve performance.

In a nutshell, the problem is a lack of interoperability in both IT systems and operations and maintenance systems. John Palfrey and Urs Gasser, writing in *Interop: The Promise and Perils of Highly Interconnected Systems*, said, "Higher levels of interoperability can lead to systemic efficiencies. The greatest beneficiaries of interoperability are often business operations that use it to streamline their processes and manage costs."

> *"Name one of your biggest headaches when something goes down at 2 a.m."*

Silos

Owners/operators recognize that they are in a bind. Custom integration of data horizontally across the horizontal plant lifecycle does not work in the long run, not to mention its expense. Instead, owners/operators have turned to technology suppliers, but the solution requires a larger industry effort.

A plant information system consists of many sub-systems. Data should flow seamlessly from system to system. But there are roadblocks in the system. The problem is both IT interoperability (i.e., getting the data to flow) and system-to-system interoperability (i.e., getting the entire facility operations to work together).

The formation of the OpenO&M Initiative was driven by this need to achieve interoperability among open standards that, at the same time, allows for use of commercial off-the-shelf software and solutions from the various technology suppliers. Founding members included the International Society of Automation (ISA, 88 and 95 committees), the Manufacturing Enterprise Solutions Association (MESA) International, MIMOSA and the OPC Foundation. Other organizations that joined in the work include Fiatech, POSC Caesar Association and the Professional Petroleum Data Management Association.

OIIE to the Rescue

The work has culminated in the open industrial interoperability ecosystem (OIIE). This ecosystem explains how the various standards are used together to support systems, communications and applications interoperability employing a system of systems approach. It builds upon existing standards and describes how to make them work together.

The OIIE is well-documented and available for use by technology providers, suppliers and owners/operators.

The OIIE simplified systems architecture represents the framework for developing an enterprise architecture that employs a system of systems interoperability. The foundation of an interoperability architecture is standards and the OIIE uses a portfolio approach in leveraging both international and industry standards. The selection of standards is based on their capability to meet the industry specified requirements, as well as levels of industry adoption and community engagement.

The OIIE prescribes the use of standards for several important components, including:

- An information message bus to provide middleware-based data transport/conveyance;
- Information and message models for representation of messages and service inputs/outputs;
- Reference data for consensual interpretation of information;
- A service directory to register ecosystem applications, manage service of record and exchange service endpoint and transport configuration;
- An asset interoperability register that includes the system of record for systems of records, datasheet definitions management and mapping, and the asset management of change log;
- An object registry that maintains identifier mappings between internal application identifiers and canonical identifiers used as part of standard information models.

Standardization of these components allows industries to collectively reduce capital, operating costs and risks because the software required to support the OIIE (e.g., software adapters) can be written and, more importantly, maintained by software suppliers rather than owners/operators.

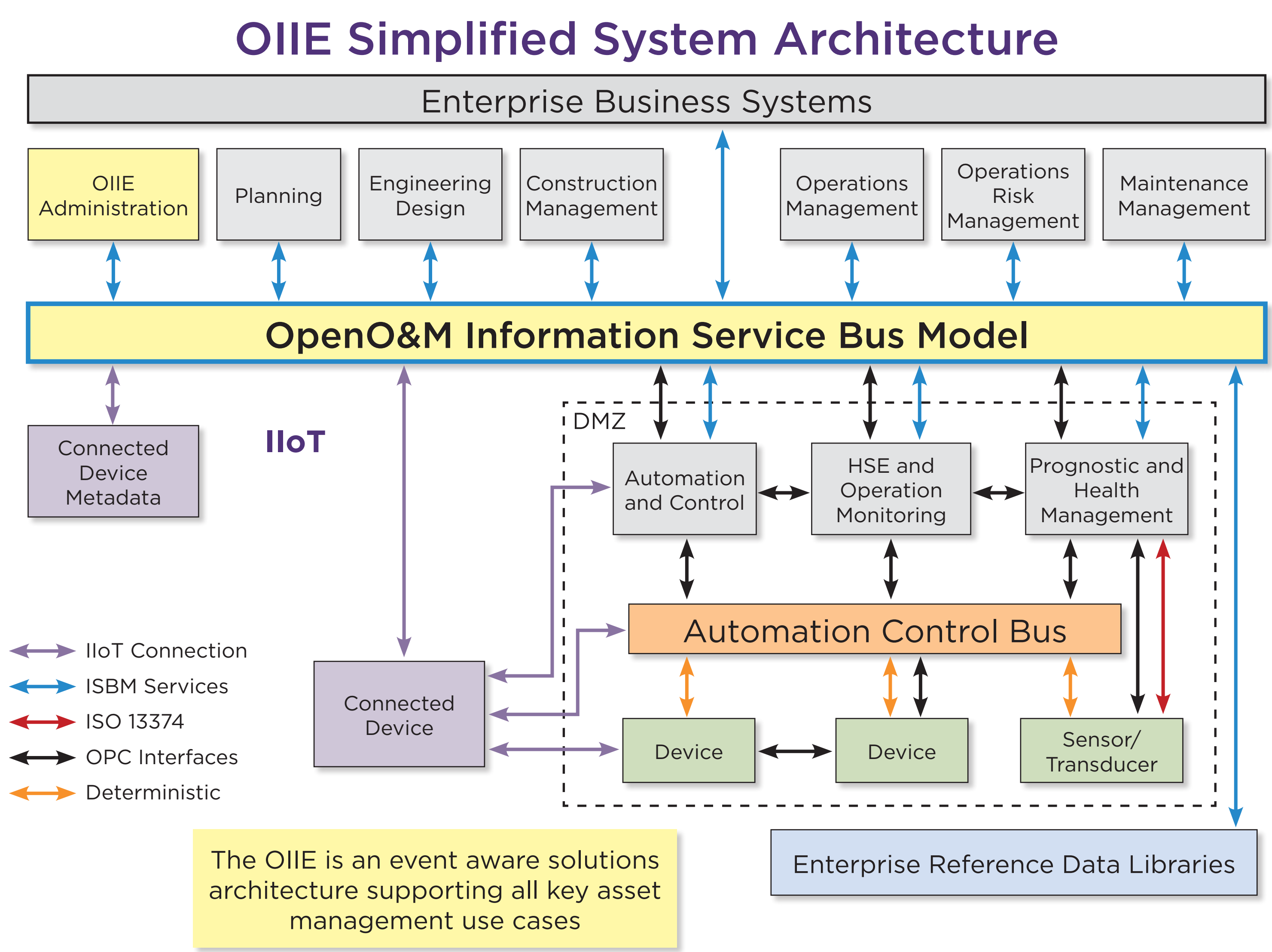

Figure 1: OIIE simplified systems architecture

Reduce Capital and Operating Costs

The centerpiece of the OIIE systems architecture is the OpenO&M web services information service bus model (ws-ISBM), also described in ISA95, Enterprise-Control System Integration standard. The ws-ISBM specification can handle the arbitration for Level 3 related activities, and is, in fact, a series of open application programming interfaces (APIs). Equally important are the OIIE administration tool specifications, which provide the basis for application and supplier neutral ecosystem administration, which is critical to establishing and maintaining an interoperability ecosystem. The OIIE administration tool specifications include the MIMOSA service directory and structured digital asset interoperability register (SDAIR), in addition to the OpenO&M common interoperability register (CIR).

Notably, the business process itself is not standardized by the OIIE. No attempt is made to require either proprietary application software or a plant's business process to conform to a standard.

OGI Pilot Demonstrates Success

So, does this actually work?

Twelve technology suppliers, universities, standards organizations and owners/operators worked together to construct a pilot of a debutanizer project. The oil and gas interoperability (OGI) pilot, an example of the OIIE, demonstrated the feasibility in action of a continuous hand over from design to operations and maintenance (O&M) of a debutanizer.

Eleven use cases were developed and five actively demonstrated:

- Capital project hand overs to O&M;
- Recurring engineering updates to O&M;
- Field changes to plant/facility engineering;
- Enterprise product data library management;
- Asset installation/removal updates;
- Preventive maintenance triggering;
- Condition-based maintenance triggering;
- Early warning notifications;
- Incident management/accountability;
- Automated provisioning of O&M systems;
- Enterprise reference data library (RDL) management.

Many individuals and organizations have contributed to the development and trial implementation of the OIIE. This model does not destroy any existing standards or even individual suppliers' products. By using the ws-ISBM for arbitration and the OIIE administration, organizations move many steps forward to the dream of interoperability through rules for both information management and O&M management.

The dream of live, accurate data for the engineers and technicians who keep the plant running at 2 a.m. is much closer.

Gary Mintchell, *founder of The Manufacturing Connection, followed up a 25-year manufacturing/IT career with a second career in media, becoming the voice of automation. He is now an independent writer, analyst and consultant in manufacturing/production technologies and strategies.*
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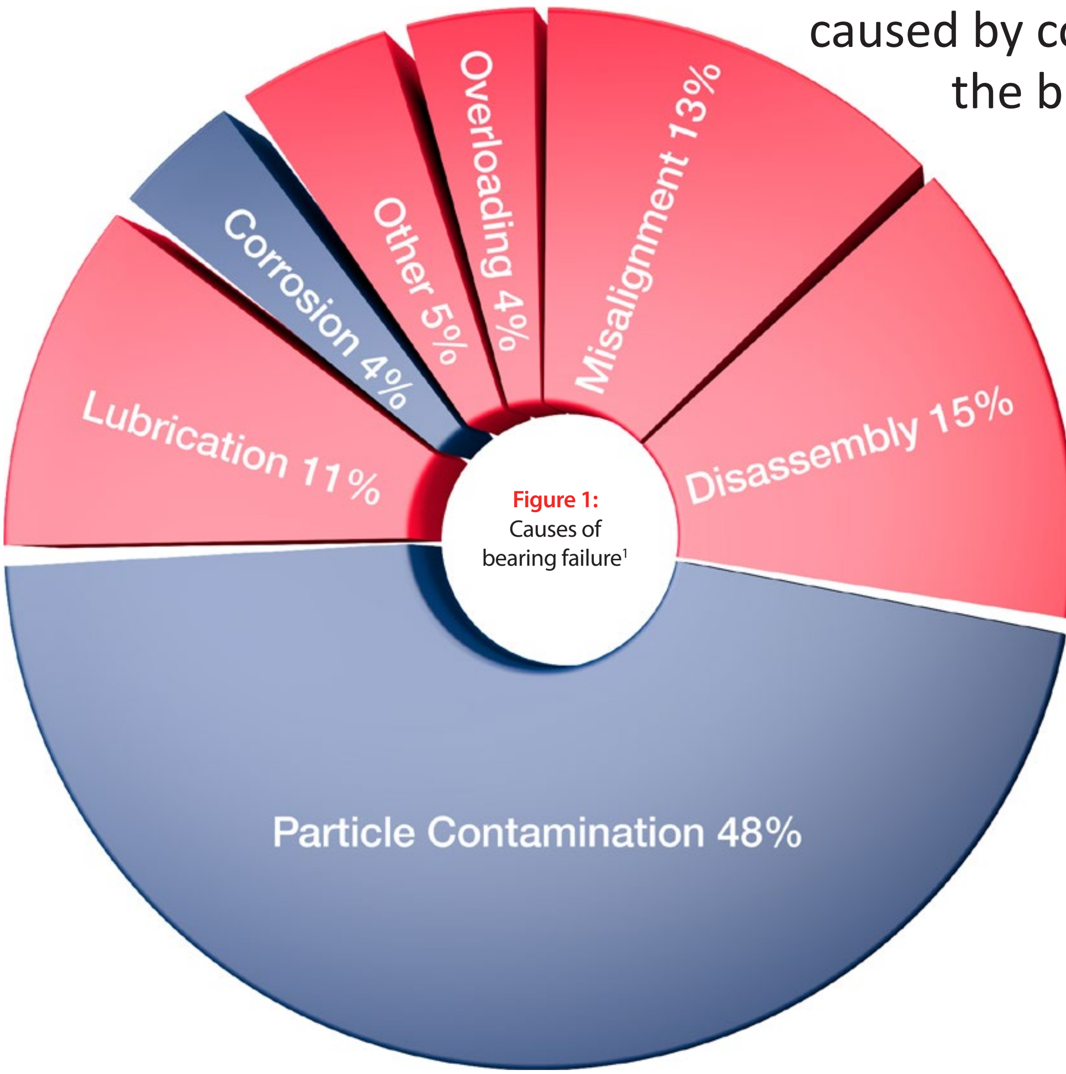

Figure 1: Causes of bearing failure[1]

52% of ALL bearing failures caused by contamination of the bearing oil

48% from particle contamination

4% from corrosion caused by liquid contamination

How to EXTEND

Bearing Life

by Dr. Chris Carmody

"The reliability of rotating equipment is almost inevitably linked directly to bearing life, and it is estimated bearing failure is responsible for almost 21 percent of these equipment failures."

– Heinz P. Bloch, P.E., 2011

Research into bearing failures[1] shows that just over half of them are a result of contamination of the bearing oil (Figure 1). Clearly, it is essential to ensure that this is minimized and, if possible, eliminated to achieve the optimum bearing life necessary to improve equipment reliability.

One of the significant contributors to bearing oil contamination is the bearing enclosure breathing process required by rotating equipment. When equipment rotates, the bearing housing heats up and the oil/air mixture inside expands, which is then forced through the seal (Figure 2). A problem arises when the equipment cools because the oil/air mixture cools and contracts, sucking air from the external atmosphere through the bearing seal back into the housing (Figure 3). If bearing seals are to work effectively, they must facilitate this "breathing cycle" in order to extend bearing life.

Labyrinth Design

Advanced labyrinth bearing protection seals have been developed that offer dust tight protection against both solids and liquids. These seals are also non-contacting in operation, which addresses the problem of lip seals relying on surface contact with the shaft to form the seal, which results in damage. The labyrinth design overcomes this issue while preventing bearing oil contamination because it incorporates patented dynamic lift technology to protect against the breathing issues that contribute to 52 percent of all bearing failures. This technology uses the centrifugal force of rotating equipment to open a temporary micro gap. By allowing the expansion of the oil/air mixture in the bearing housing, it enables the equipment to breathe (Figure 4). However, when the equipment is not rotating, this micro gap is closed, ensuring no contaminants enter the bearing housing and cause premature bearing failure (Figure 5).

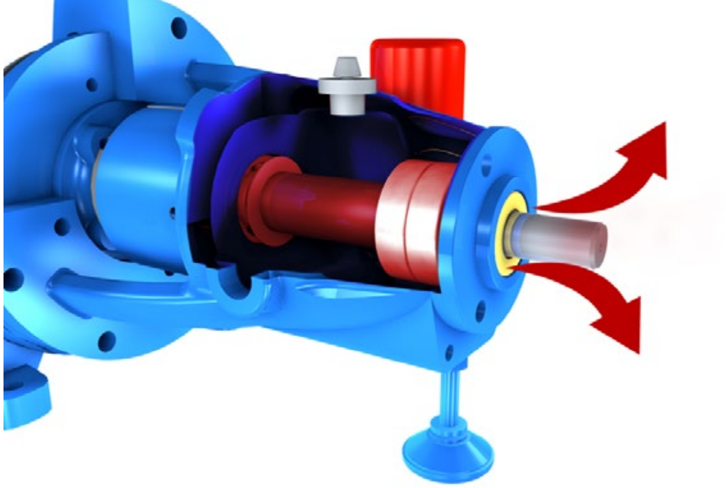

Figure 2: As the equipment rotates, the bearing housing heats up and the oil/air mixture inside heats up, forcing air through the seal

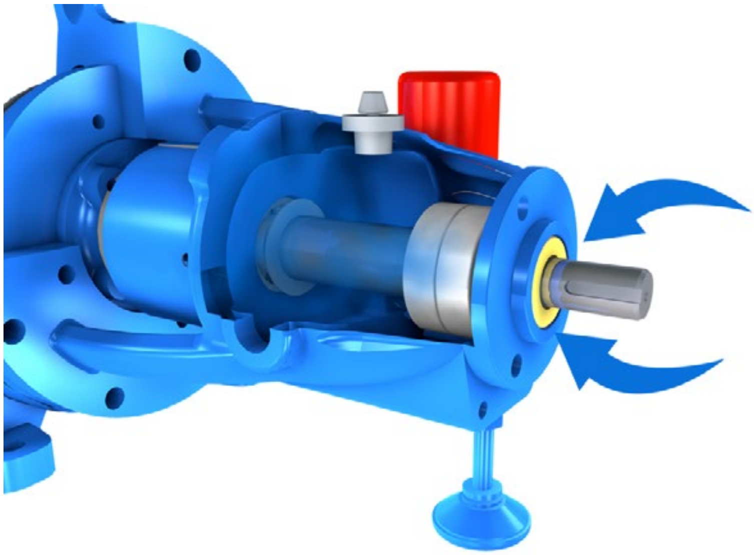

Figure 3: As the equipment cools, the oil/air mixture contracts, sucking air from the atmosphere through the bearing seal into the housing

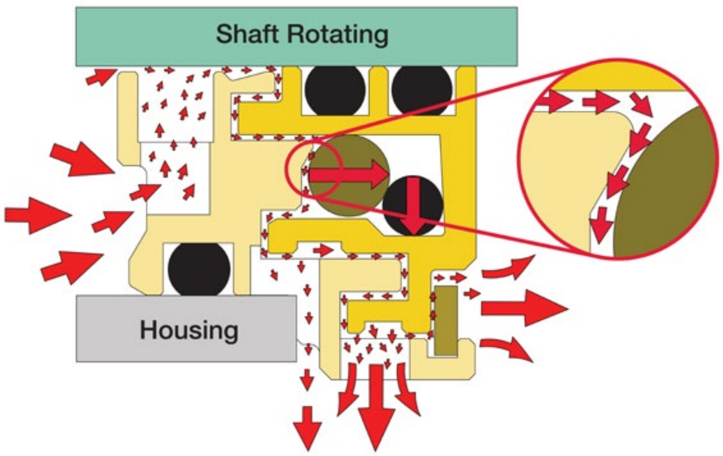

Figure 4: Centrifugal force creates a temporary micro gap, which expands the oil/air mixture in the bearing housing, allowing the equipment to breathe

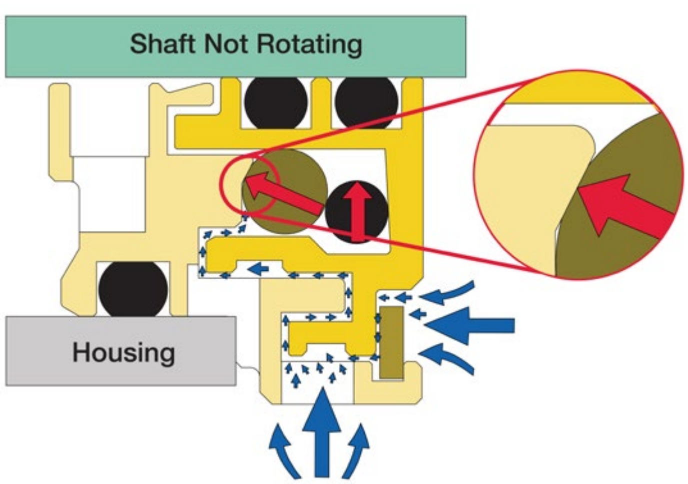

Figure 5: When the equipment stops, the micro gap immediately closes

Rated to IP66 of the ingress protection code, a labyrinth design bearing protector seal is capable of reducing water contamination in the bearing oil from as high as 83 percent to just 0.0003 percent, compared to lip seals[2], even when exposed to high pressure water jets. The range is ATEX certified for use in explosive environments and a number of special designs make it suitable for a wide and varied range of applications.

It is also designed with a thinner cross section and seal length than other devices, which means it can be retrofitted on more equipment without having to carry out modifications. Furthermore, the design enables it to be positioned differently on the shaft, meaning shafts already damaged can be fitted with the labyrinth design without replacing the shaft.

Accelerated life test research[3] shows that with a stop-start cycle of four times a day, the average life expectancy of the labyrinth design was over 10.5 years. The research also shows that by using Weibayes, an established statistical technique, the average life expectancy also was in excess of 10.5 years. However, because such statistical data only can be modeled with failure data and since no product of this type has ever failed, the results have to be viewed as conservative.

Figure 6 shows the effect of water contamination on a continuous digester that was originally fitted with inadequate bearing protection. The moisture contained in the atmosphere was able to penetrate into the bearing

Figure 6: Water contamination on a continuous digester prior to a labyrinth design bearing protector seal being installed

housing. This was enough to destroy the bearings. Independent research[4,5] shows that water contamination as low as 0.002 percent (20ppm) in some oils can reduce bearing life by as much as 48 percent. The challenge for maintenance and engineering professionals is to reduce this contamination and provide an effective method of sealing the space between the bearing housing and the drive shaft.

Conclusion

An increasing number of engineers are upgrading to modern labyrinth bearing protectors because they eliminate bearing oil contamination from both dust and moisture. They are also easy to fit, avoiding shaft wear, and are relatively inexpensive. Furthermore, Weibayes research and accelerated life tests have shown that the average life expectancy is in excess of 10 years, offering the opportunity to significantly extend the life of bearings on rotating equipment.

References

1 Bloch, Heinz and Budris, Allan. "Pump User's Handbook: Life Extension, Third Edition." Lilburn: Fairmont Press, 2010.

2 AESSEAL Internal Test Results

3 Carmody, C. and Rea, C. "Predicting product life expectancy of the LabTecta bearing protector." *Sealing Technology*, Volume 2014, Issue 8: pp. 8-12.

4 Schatzberg, P. and Felsen, I.M. "Effects of water and oxygen during rolling contact lubrication." *Wear*, Volume 12, Issue 5, November 1968: pp. 331-342.

5 Cantley, R. "The Effect of Water in Lubricating Oil on Bearing Fatigue Life." *ASLE Transactions*, Volume 20, Issue 3, 1977: pp. 244-248.

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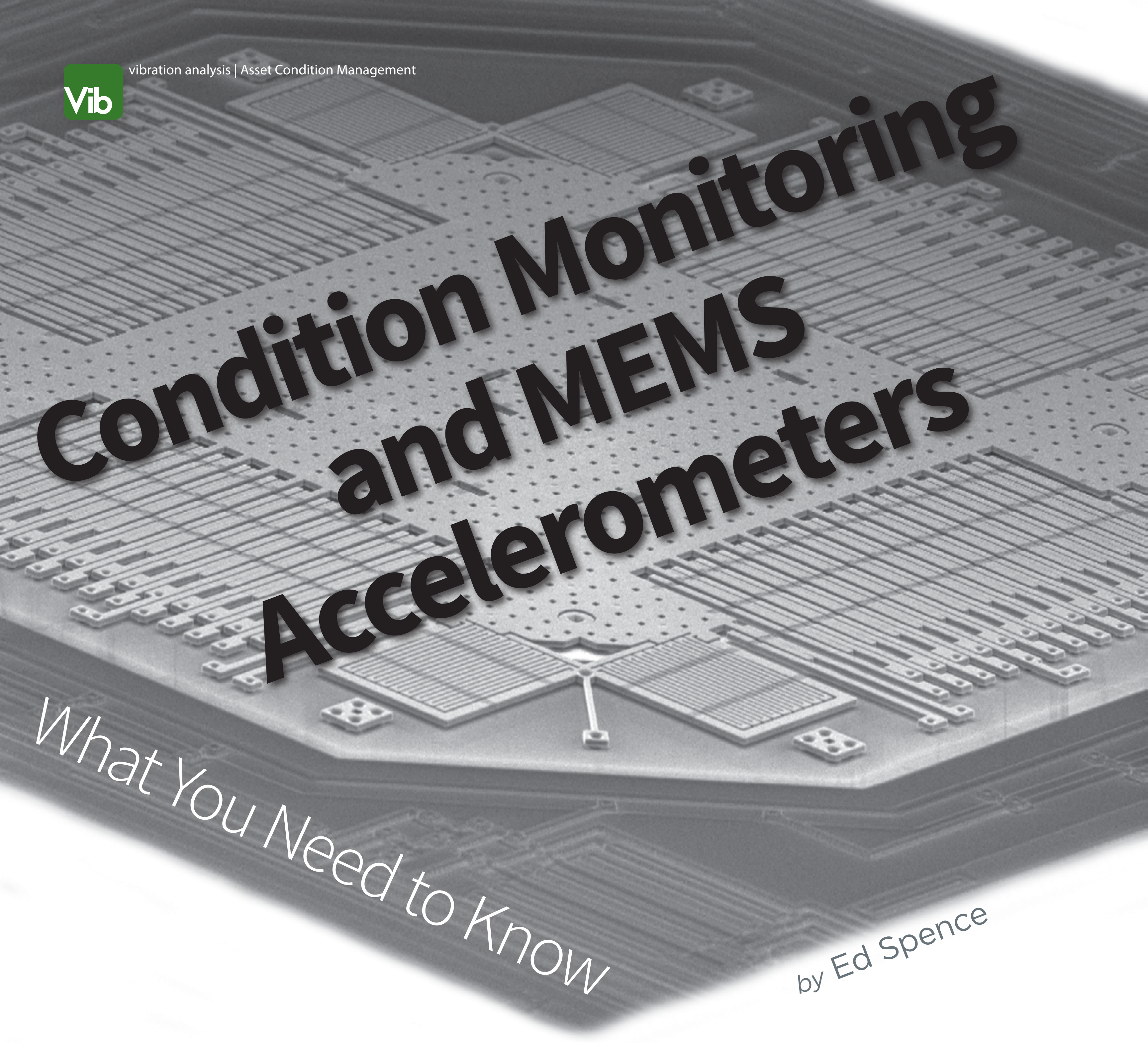


Condition Monitoring and MEMS Accelerometers

What You Need to Know

by Ed Spence

Many highly integrated and easy to deploy condition monitoring products are appearing on the market that employ a micro electromechanical system (MEMS) accelerometer as the core sensor. These economical products help to reduce the overall cost of deployment and ownership, and in the process, expand the universe of facilities and equipment that can benefit from a condition monitoring program.

Solid-state MEMS accelerometers have many attractive attributes when compared to legacy mechanical sensors, but unfortunately, their use for condition monitoring has been restricted to applications that can tolerate the use of lower bandwidth sensors for products, such as low cost, standards based smart sensors. In general, noise performance is not low enough to serve diagnostic applications, which require lower noise over higher frequency ranges and bandwidths beyond 10 kHz. Low noise MEMS accelerometers are available today with noise density levels anywhere from 10 µg/√Hz to 100 µg/√Hz, but are restricted to a few kHz of bandwidth. This hasn't stopped condition monitoring product designers from using a MEMS with noise performance that is just "good enough" in their new product concepts, and for good reason. As a technology based on solid-state electronics and built-in semiconductor fabrication facilities, a MEMS offers several compelling and valuable advantages to the designer of condition monitoring products. Putting aside the performance factor, here are the main reasons why MEMS accelerometers should be of interest to anyone in the field of condition monitoring.

Let's start with the size and weight. For airborne applications, such as in health and usage monitoring systems (HUMS), weight is extremely expensive, with fuel costs of thousands of dollars per pound. With multiple sensors typically deployed on a platform, weight savings can be enjoyed if the weight of each sensor can be reduced. Today, a higher performance triaxial MEMS device in a surface mount package with less than 6x6 mm in footprint can weigh less than a gram. This small size and the highly integrated nature of many MEMS products also enable the designer to shrink the size of the final package, reducing weight. The interface of a typical MEMS device is single supply, making it easier to manage and more easily lending itself to a digital interface that can help save on the cost and weight of cables, too.

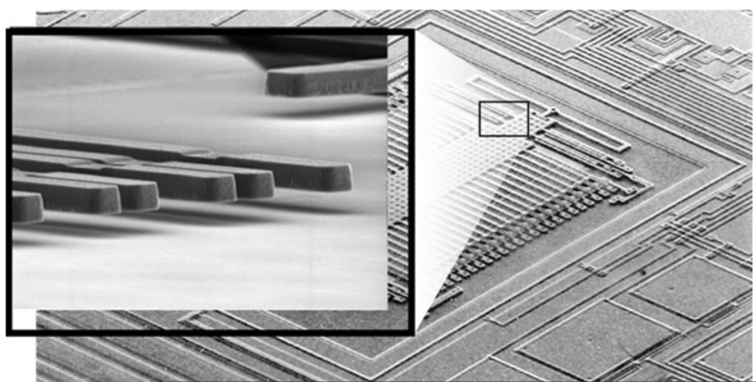


Figure 1: A scanning electron microscope (SEM) image of an inertial MEMS accelerometer. Polysilicon fingers are suspended in a depressurized cavity to enable movement, and electrical capacitance proportional to acceleration is measured by adjacent signal conditioning electronics.

Solid-state electronics also can impact the size of the transducer. A smaller form factor triaxial mounted on a printed circuit board (PCB) and inserted into a hermetic housing suitable for mounting and cabling on a machine can help enable a smaller overall package, offering more mounting and placement flexibility on the platform. In addition, today's MEMS devices can include significant amounts of integrated, single voltage supply signal conditioning electronics, providing analog or digital interfaces with very low power to help enable battery powered wireless products. For example, a high resolution, sigma-delta analog-to-digital converter (ADC) with an effective resolution of 18 bits and an output data rate of 4 ksps consumes less than 15 µa per channel (45 µa for a three channel ADC in a digital output triaxial sensor).

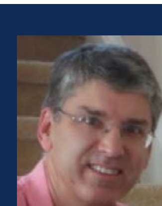
The topology of a MEMS signal conditioning circuit with both analog and digital output variations is common and opens up options for the transducer designer to adapt the sensor to a wider variety of situations, enabling a transition to digital interfaces commonly available in industrial settings. For example, RS-485 transceiver chips are widely available and open market protocols, such as Modbus RTU, are available to load into an adjacent microcontroller. A complete transmitter solution can be designed and laid out with small footprint surface mount chips that can fit within relatively small PCB areas, which can then be inserted into packages that can support environmental robustness certifications requiring hermetic or intrinsically safe characteristics.

A MEMS has demonstrated to be very robust to changes in the environment, as well. Shock specifications of today's generation of devices are stated to 10,000 g, but in reality can tolerate much higher levels with no impact on sensitivity specifications. Sensitivity can be trimmed on automatic test equipment (ATE) and designed and constructed to be stable over time and temperature to 0.01 C for a high resolution sensor. Overall operation, including offset shift specifications, can be guaranteed for wide temperatures ranges, such as -40 C to +125 C. For a monolithic triaxial sensor with all channels on the same substrate, cross axis sensitivity of one percent is commonly specified. Finally, as a device designed to measure the gravity vector, a MEMS accelerometer has a DC response, maintaining the output noise density to near DC, limited only by the 1/f corner of the electronic signal conditioning, which with careful design, can be minimized to 0.01 Hz.

Perhaps one of the biggest advantages of MEMS-based sensors is the capability to scale up manufacturing. MEMS vendors have been shipping high volumes for mobiles, tablets and automotive applications since 1990. This manufacturing capability residing in semiconductor fabrication facilities for both the MEMS sensor and the signal conditioning circuit chip is available to industrial and aviation applications as well, helping to lower the overall cost. Moreover, with more than a billion sensors shipped for automotive applications over the last 25 years, the reliability and quality of MEMS inertial sensors have been demonstrated to be very high. MEMS sensors have enabled complex crash safety systems that can detect crashes from any direction and appropriately activate seat belt tensioners and air bags to protect occupants. Gyros and high stability accelerometers are also key sensors in vehicle safety controls. Today's automotive systems make extensive use of MEMS inertial sensors to enable safer, better handling cars at low cost and excellent reliability.

Currently, there is tremendous interest and investment in MEMS technology for many applications. In addition to the many attractive qualities of a MEMS, MEMS inertial sensors also help alleviate many of the quality problems that plague other materials and architectures. MEMS inertial sensors have been utilized in demanding consumer, aviation and automotive applications for more than 25 years and have been subjected to high shock and demanding environments. Has the time come for the MEMS to further penetrate applications demanding higher performance, such as condition monitoring? It is fully expected that the performance of the MEMS will continue to improve dramatically, providing more options for designers of condition monitoring equipment and enabling a new generation of smart sensors, wireless sensors and low cost vertically integrated systems.

Stay tuned for more information on this subject in the near future…



Ed Spence *is the Marketing Manager for Analog Devices, Inc.'s industrial sensors business unit, responsible for high performance accelerometers. Analog Devices designs and manufactures high performance inertial sensors (accelerometers, gyros), as well as highly integrated solutions, such as inertial measurement units (IMUs). www.analog.com*

Q&A

Terry Wireman

The *Work Execution Management Process Manager's Guide*, produced by Reliabilityweb.com, will be released July 2016. One of its contributors, Terry Wireman, is one of the industry's well-known experts in maintenance reliability. *Uptime* magazine was able to catch up with Terry recently to get some insights and a sneak peek at the new work execution management guide.

Q Why do you feel a work execution management guide is so important?

Work execution management (WEM) may be the most important domain in the Uptime Elements. When you look at the reliability engineering for maintenance (REM) and asset condition management (ACM) domains, they generate significant work that needs to be performed. For example, in the REM domain, RCM, root cause, and failure mode and effects analyses all identify work that needs to be performed on critical assets. However, in many organizations, there is a roadblock in execution. Without the work properly inputted into the WEM process, the analysis, no matter how good it is, will quickly find its way into a file folder or three ring binder. This reduces the effort put into the REM domain to a mere academic exercise.

Similarly, in the ACM domain, critical work is identified through vibration analysis, ultrasound, or thermography. However, if this work is not properly inputted into the WEM process, then the faults identified by the ACM tools are not acted upon soon enough to prevent a failure. As a result, the ACM tools cause you to be reactive on what should've been proactive work.

Q If WEM is so important, where would you begin to focus your initial efforts in this domain?

The best starting point is actually a combination of two of the six elements: preventive maintenance (PM) and defect elimination (DE). The reason being, the goal of a PM program is to reduce reactive work to less than 20 percent of total activities. In many cases, this is achieved through the DE element. In the WEM guide, some of the steps necessary to implement a PM program are highlighted. An example is the need for details on a PM task. Too often, details are lacking, which makes the PM program very subjective. If a PM task has details, it helps prevent the technician from overlooking any defects or making mistakes.

The DE element supports the PM element by focusing on eliminating or not introducing defects into the maintenance process. This involves basic things, such as proper lubrication, torquing methods, and cleaning and inspecting. If just these items are given close attention, it can eliminate the root cause of up to 50 percent of all equipment breakdowns. This shift from reactive to proactive work allows an organization to make progress in other areas.

Which element would be the third one an organization should focus on?

In a linear progression, the third element would be MRO spares management. It's critical to have in place to enable planning and scheduling, and it's the single biggest support function leading to low maintenance productivity. If MRO spares management has a service level of 95 to 97 percent, it can support maintenance planning and scheduling. Without this support level, it is highly unlikely planning and scheduling will be successful.

So, should planning and scheduling be the next WEM element of focus?

It could be, however, another consideration is the computerized maintenance management system (CMMS) element. It's almost like the chicken and egg question: Can I do planning and scheduling without a good CMMS or should I have a good CMMS before I start planning and scheduling?

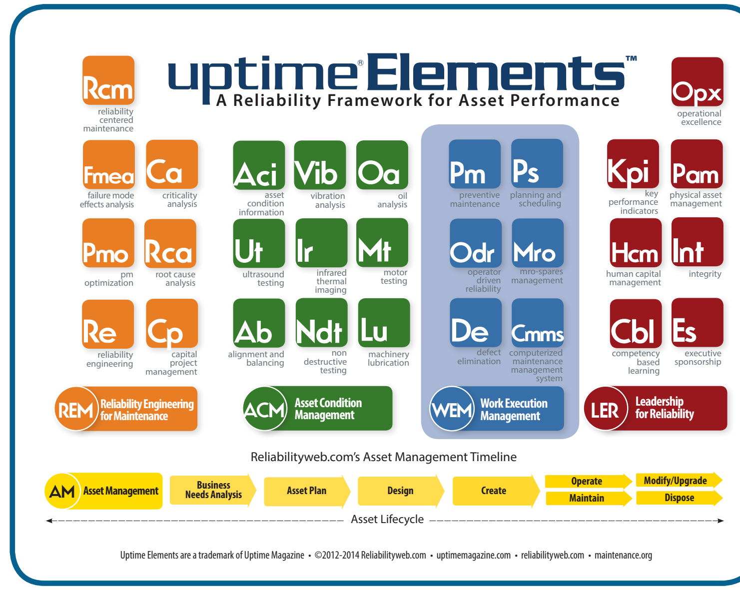
A good CMMS or enterprise asset management (EAM) system should already have its master data loaded before attempting to plan and schedule maintenance activities. At a minimum, the master data should consist of equipment/asset data, MRO spares data, PM data, labor data and other data the system requires for planning and scheduling. If this data is not loaded prior to starting planning and scheduling, it will lead to a high level of frustration for the planners/schedulers and ultimately fail to produce any benefits for the maintenance organization. There are many more good hints and tips for CMMS utilization in the WEM guide.

Regarding planning and scheduling, many organizations fail to staff their supervisors and planners correctly, which leads to a high percentage of the failures. Without proper organizational structure, clearly defined roles and responsibilities, proper staffing and proper reporting, the organization fails to be efficient and effective. Since this is the whole goal of planning and scheduling, the efforts fail to produce any financial results. There are many additional hints and tips on proper staffing levels for maintenance organizations in the WEM guide.

So that leaves one last element, operator driven reliability. How does this element fit in the WEM domain?

Operator driven reliability (ODR) is probably one of the most misunderstood elements in all the domains. Too many people believe ODR is simply giving the operators tools and telling them to do their own maintenance on their own equipment. But in reality, ODR is much more. For example, there are only two reasons to involve operators in the maintenance and reliability of their equipment. The first is to increase equipment capacity. The small simple tasks that take maintenance technicians more time to reach the equipment than to perform them are candidates for ODR. If the operator is trained to perform these basic tasks, then the equipment is not sitting idle waiting for maintenance to arrive.

The second reason is to free up maintenance resources to work on higher level condition monitoring or reliability activities. In a total productive maintenance (TPM) program, operators performs 10 to 40 percent of PM on their equipment, which frees up four to 16 percent of all maintenance resources. An organization would need to scale this to its number of employees, but using these percentages, it would translate to 1/2 to 1-1/2 full-time equivalents for an organization with 10 or fewer maintenance employees. I'm sure any organization today could utilize another full-time equivalent in its asset condition management efforts.



Do you have any final thoughts about the WEM domain or any other Uptime Elements domains?

The single biggest highlight about Uptime Elements is the holistic approach it provides. For example, consider the REM domain. There are many threads that tie it closely to the WEM domain. For example, much of the failure data to be analyzed, whether it's RCM, PMO, or RCA, needs to be provided by the CMMS in the WEM domain. The work generated by an RCM, PMO, or RCA needs to be planned and scheduled through the WEM domain. It is quite likely MRO spare parts will be required and the operators may be involved in performing some of these tasks. Finally, the work performed must be recorded in the CMMS. So, it would be difficult for any company to focus on the REM domain without involving the WEM domain.

Likewise with the ACM domain. Whether through vibration analysis, oil analysis, ultrasound, thermography, or motor testing, work will be identified that must be planned and scheduled on a timely basis to avoid equipment failures. Taking this a step further, alignment and balancing and machinery lubrication are two activities that need to be scheduled either through the PM element or the planning and scheduling element in the WEM domain.

Finally, consider leadership for reliability and the impact WEM has on that domain. When you consider human capital management and competency-based learning, it is clear that without a skilled workforce, it would be impossible to properly execute the work controlled by the WEM domain. In organizations today, many mistakes are being made by maintenance technicians that lead to a lack of reliability and dependability on plant equipment. Without the right people having the right skills, WEM would not be successful. The key performance indicators required for WEM are also monitored by leadership. This allows leadership to take proper actions to keep the WEM domain as efficient and effective as possible.

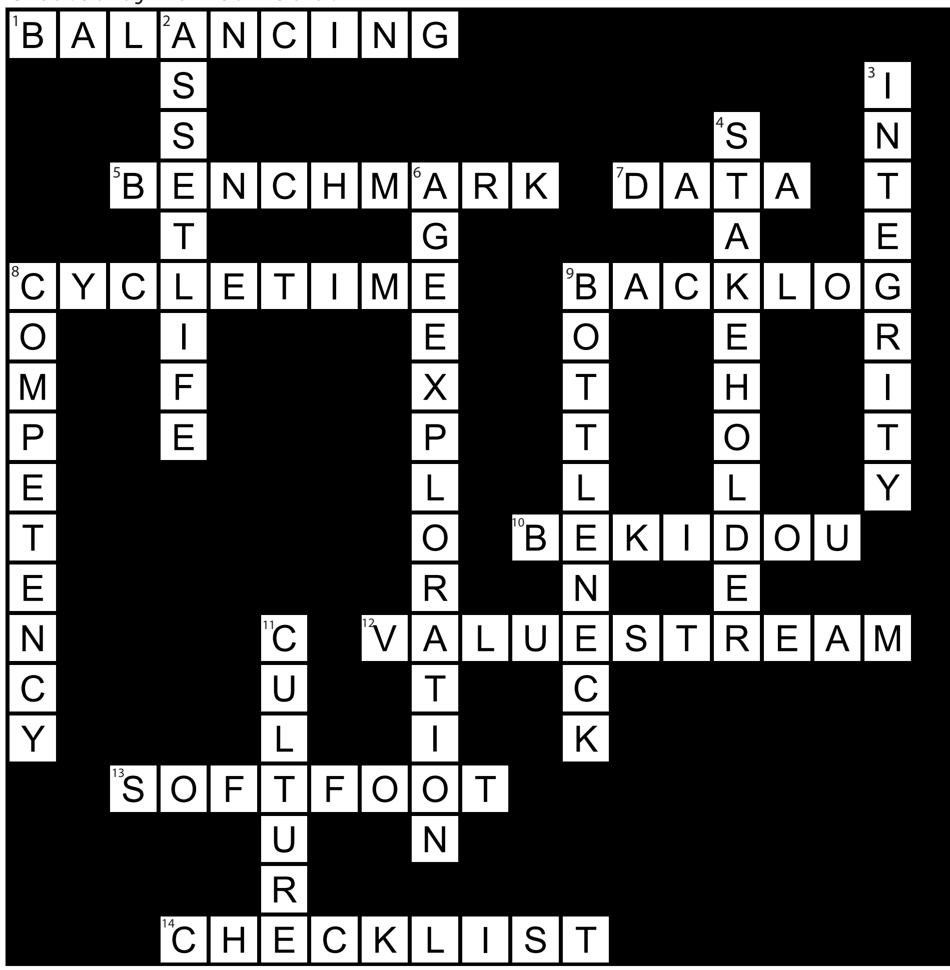
Unless an organization truly takes a holistic approach to the Uptime Elements framework, it is virtually impossible to achieve the benefits necessary to stay competitive in its respective marketplace. I'm looking forward to your readers' reaction to the WEM project guide and hopefully the benefits it can bring them.

Thank you, Terry. We're looking forward to the publication of that guide, as well. Hopefully, our readers will have an opportunity to utilize some of the hints and tips that are found in the guide to improve the efficiency and effectiveness of their work execution management.

uptime® Elements™ ANSWERS

Crossword Puzzle

Created by Ramesh Gulati



ACROSS

1 Adjusting the distribution of mass in a rotating element to reduce vibratory forces generated by imbalance

5 A standard measurement or reference that forms the basis for comparison

7 A discrete piece of information used as a basis for reasoning, discussion, calculations, communication, and further processing for making decisions

8 The elapsed time from the start of an activity / process until it's completed

9 All work waiting to be done

10 A Japanese word for Output Optimization

12 All activities, both value-added and non-value-added, required to bring a product or service from raw material state into the hands of the customer

13 A condition in which one of the feet on a machine does not sit flat on the base

14 A structured, pre-prepared form (list) for gathering and recording data to ensure right and safe operation

DOWN

2 The period from an asset's inception to its end of life

3 A quality of being honest and having strong moral principles

4 A person or organization that can affect, be affected by, or believe to be affected by a decision or activity

6 An iterative process used to optimize preventive maintenance (PM) intervals

8 Knowledge, skills and abilities required to perform a task safely and consistently

9 A point of congestion in a system that occurs when workloads arrive at a given point more quickly than that point can handle them, creating a longer overall cycle time

11 A common set of values, beliefs, attitudes, perceptions and accepted behaviors shared by individuals within an organization

Answers from page 7.

Solution
AWARDS

Awards ceremony was held at
The RELIABILITY Conference
in Las Vegas, Nevada
on April 12th, 2016.

Congratulations to the 2016 Winners!

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