UPTIME MAGAZINE

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oct/nov 16

for maintenance reliability and asset management professionals

Releasing Asset Value Sustainably

An Analysis of ISO55000x

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OCTOBER/NOVEMBER 2016

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

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Elements

Editorial

What Do You Do Once You Reach Your Goal?

Less than 3 years ago, during a keynote presentation at IMC-2013, the 28th International Maintenance Conference, the Association of Asset Management Professionals launched the Certified Reliability Leader (CRL) exam and declared a goal of achieving 1,000 CRL's who will enable the triple bottom line of economic prosperity, environmental sustainability and social responsibility. That is another way to say they would make the world work.

The idea was that the first 1,000 CRLs would create a new future where reliability was no longer wed to maintenance. They would have a major positive impact on their organizations and on the world.

That was a powerful declaration that seemed improbable if not impossible at the time. The goal that was declared in December 2013 was achieved in July 2016!

Congratulations to the 1,000+ professionals who are now CRLs and know about the power of declaration to move the "someday" future to "right now." They are using this to generate reliability in their lives and in their organizations.

They have learned some other things as well:

- You cannot *maintain* your way to reliability.
- You cannot *plan and schedule* your way to reliability
- You cannot *lubricate* your way to reliability.
- You cannot *condition monitor* your way to reliability.
- You cannot "*buy*" reliability.

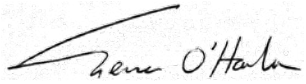
They also know that they are Reliability Leaders, and they work to generate a future that was not going to happen anyway. **They work in a created future – one that is reliable.**

At Reliabilityweb.com, we have delivered training on Uptime Elements to over 10,000 leaders in the past 18 months. The team could not be prouder of the results that have come from Uptime Elements™ Reliability Framework for Asset Performance.

Today we declare a new goal we call CRL2020: 10,000 Certified Reliability Leaders worldwide and at least one CRL in space (think International Space Station or manned mission to Mars).

Join us to make the world work.

Warm regards,



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IN THE NEWS

IMC2016
The 31st International Maintenance Conference

Hosts Two Headline Keynotes

What do car racing and marathons have in common?

Yes, they both focus on racing and performing at one's best but there is something else…leadership and teamwork. IMC-2016 is excited to share two unique and energizing keynotes.

Breon Klopp, Founder and Managing Partner at Sestrana, will present "12 Seconds to Reliability: How Pit Crews Enable Winning Race Teams" on Thursday, December 15th. With millions of dollars at stake each week, man and machine are regularly pushed to the point of failure. Years of preparation culminate in a few short seconds of performance with the success or failure of an entire organization weighing in the balance. The objective is singular: WIN. Learn how your team and organization are closer related to NASCAR than you might have thought. Be sure to check out the Q&A with Breon Klopp on page 60!

Nahila Hernandez is an ultra-marathonista, so she knows the commitment it takes to perform at one's best. Join her December 12th for her presentation on "Leading a Team for High Performance." Nahila will tie together how her own experiences can be connected to and relates to the world of reliability. If there is one thing we know, you will leave inspired and ready to take on the challenges waiting for you!

To learn more and register for IMC-2016, visit:
www.imc-2016.com

International Drone Expo (IDE)

The 3rd annual International Drone Expo & Business Conference (IDE) is the premier professional business destination for the global commercial drone community. The event brings together the most innovative and talented members of the commercial drone community from around the world to participate in the aerial robotics phenomena. Located in southern California, the home of the largest global aerospace community, IDE 2016 is the place to be! Discover the power of drones on December 9-10 at the Los Angeles Convention Center. For additional information and to register, visit:
www.internationaldroneexpo.com

Introducing Uptime Elements Black Belt Program

The Association for Asset Management Professionals recently introduced the Uptime Elements Black Belt Program to the Certified Reliability Leader. This program is designed to acknowledge individuals who move from Reliability Leadership KNOWLEDGE to Reliability Leadership PRACTICE. A separate belt will be awarded for successful completion of projects from each domain within the framework, and the final black belt will be awarded once an individual accrues the five domain belts.

Uptime Elements Black Belt Trainings will be introduced in 2017 – a thorough workshop focused on each of the domains so individuals can dive further into the study and understanding of each one. Trainings will be held at the Reliability Leadership Institute in Fort Myers, Florida. Check **www.maintenance.org** for more details and upcoming dates.

Reliabilityweb.com Highlights

CRL Workshop, Fort Myers, FL

AMP Chapter Meeting, Moffett Field, California

Reliability World Caribbean, Catano, Puerto Rico

CRL Workshop, Amsterdam, Netherlands

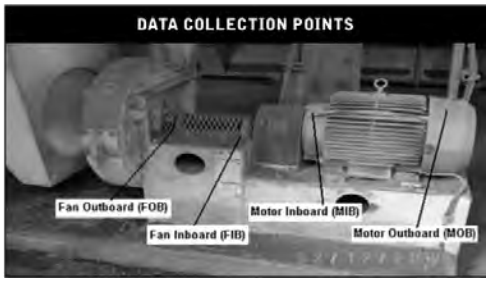
CRL Workshop, Querétaro, Mexico

Reliabilityweb.com Highlights

Maintenance TIPS

Labeling Data Collection Points

To facilitate the initial learning curve, a labeling system was implemented to help technicians collecting data identify bearings that were part of the initial survey. These descriptors were laminated to prolong their life in the unfriendly environment of a typical cement plant. Standard locations for data collection needed to be understood since labels would become difficult or impossible to read over time.



On the job training included understanding that readings collected on the drive motor bearings needed to be collected from the grease fitting on the non-drive end and from the upper portion of the end bell housing on the drive end. On driven equipment bearings, where direct access was possible, the ultrasound readings were to be taken in the horizontal plane directly from the bearing housing. (Note: With ultrasound, it is not necessary to record data from multiple planes on the same bearing). Technicians were trained to take ultrasound readings as close to the bearing as physically possible while respecting personal safety.

This simple label proved important to the integrity of the pilot project to prevent greasing from well-intentioned lubricators.

Tip from *Hear More* by Thomas J. Murphy & Allan A. Rienstra
www.reliabilityweb.com/bookstore/book/hear-more

MRO Inventory Management in Support of EAM

Enterprise Asset Management emphasizes the importance of ensuring the right work is done - by the right people - with the right parts - at the right time. An effective MRO Inventory Management program enables this and ensures optimized maintenance workflow through the proper identification and management of the maintenance spare parts program. Key components that make up an effective program include the identification of an item master list, the process of organizing, maintaining, and controlling inventory using methods such as cycle counting, and the issuing and distribution of the material to maintenance technicians.

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5 Considerations When Selecting a Filter Cart

Filter carts can save you time, money and effort, but only if you choose the right one. Before you make a purchase, make sure you're basing your decision on your company's needs by answering these five questions…

1. What's your target cleanliness?
2. What's your oil type?
3. What flow rate do you need?
4. What will you use it for?
5. Where will you use it?

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10 Things Every Vibration Analyst Needs to Know for Good Data Collection and Analysis

1. Shaft speed of machine being analyzed.
2. Type of bearings involved (sleeve vs. rolling element).
3. Rolling element bearing part numbers and manufacturer(s).
4. Internal configuration of equipment.
5. Machine history.
6. Proper data collection location.
7. Proper sensor to use for data collection.
8. Proper data collection setups to ensure correct data is collected.
9. Is the primary energy sub-synchronous, synchronous, or non-synchronous?
10. If the time waveform is collected in acceleration, then what is the "g" level?

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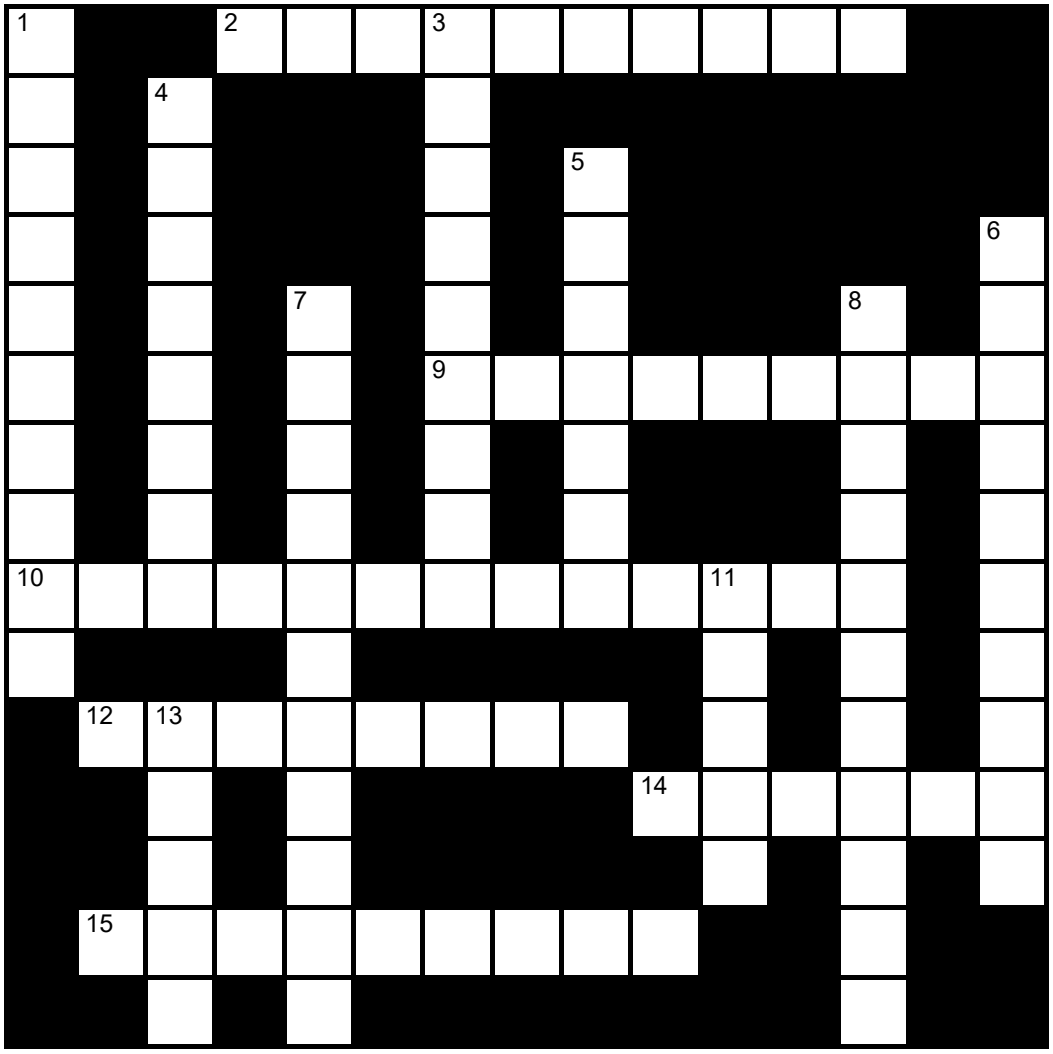
Crossword Puzzle



ACROSS

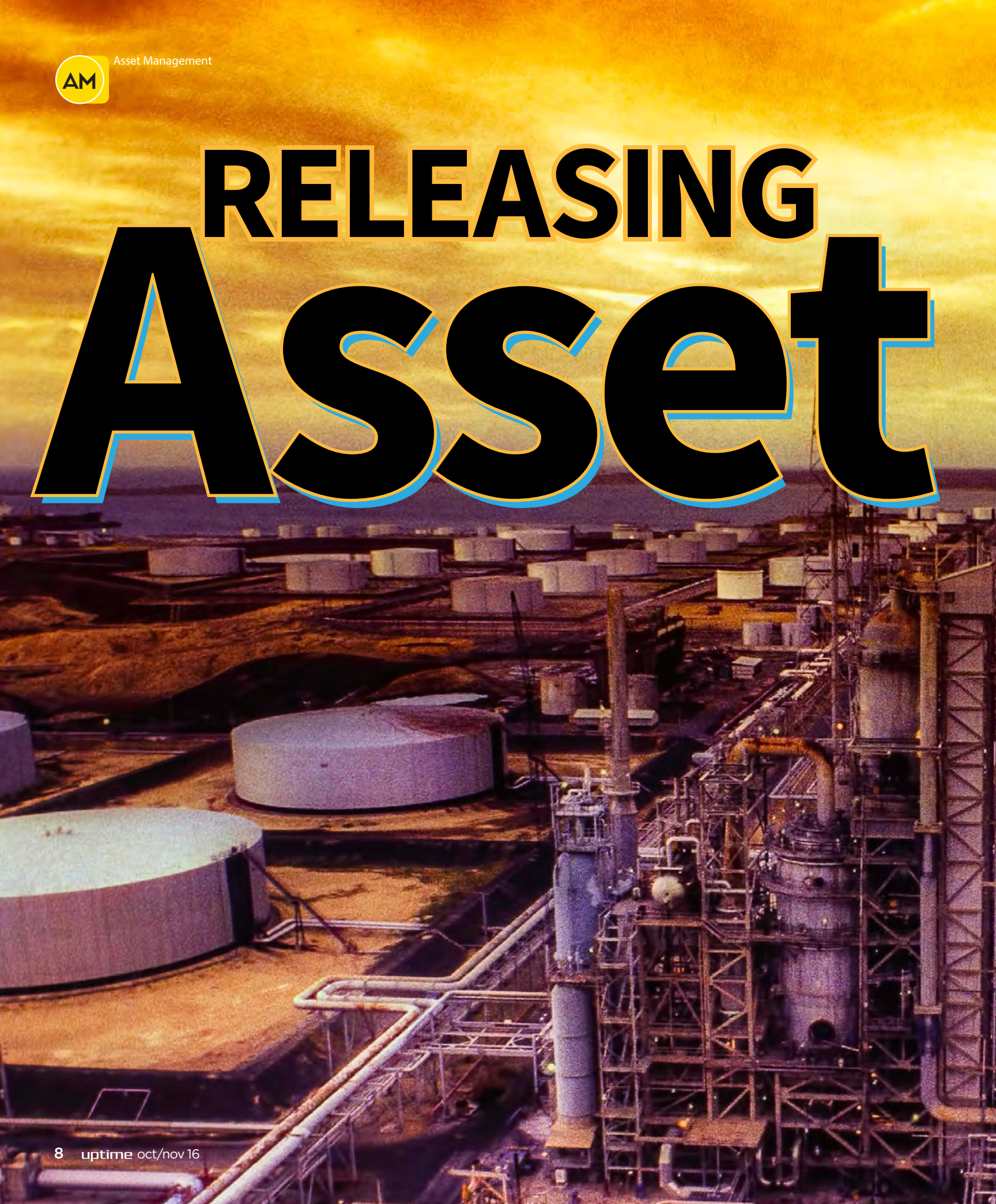
2. An information extraction activity whose goal is to discover facts contained in databases
9. An unexpected interruption to the service of a particular asset
10. An area with limited access and potential respiratory hazard requiring a special permit to enter
12. The specific ability of an item, asset, or person measured in quantity and level of quality over an extended period
14. A condition that causes deviation from design or expected performance and leads to failure
15. A pictorial graphic summary of variation in a set of data that shows patterns that are difficult to detect in a simple table of numbers

DOWN

1. The ability to apply knowledge and skills to achieve intended results
3. A quality or feature regarded as a characteristic or inherent part of someone or something
4. One who facilitates a paradigm change in the understanding and practice of a specific discipline or cause
5. Consequences of failures
6. Fulfillment of a requirement
7. A relative ranking of assets based on the probability of its failure and consequences of the failure
8. Something that follows from an action or condition
11. An item or thing with a potential value that an organization owns and has a use for or creates value
13. A systematic, independent and documented process for obtaining evidence and evaluating it objectively to determine the extent to which a criteria is fulfilled

See page 64 for answers.

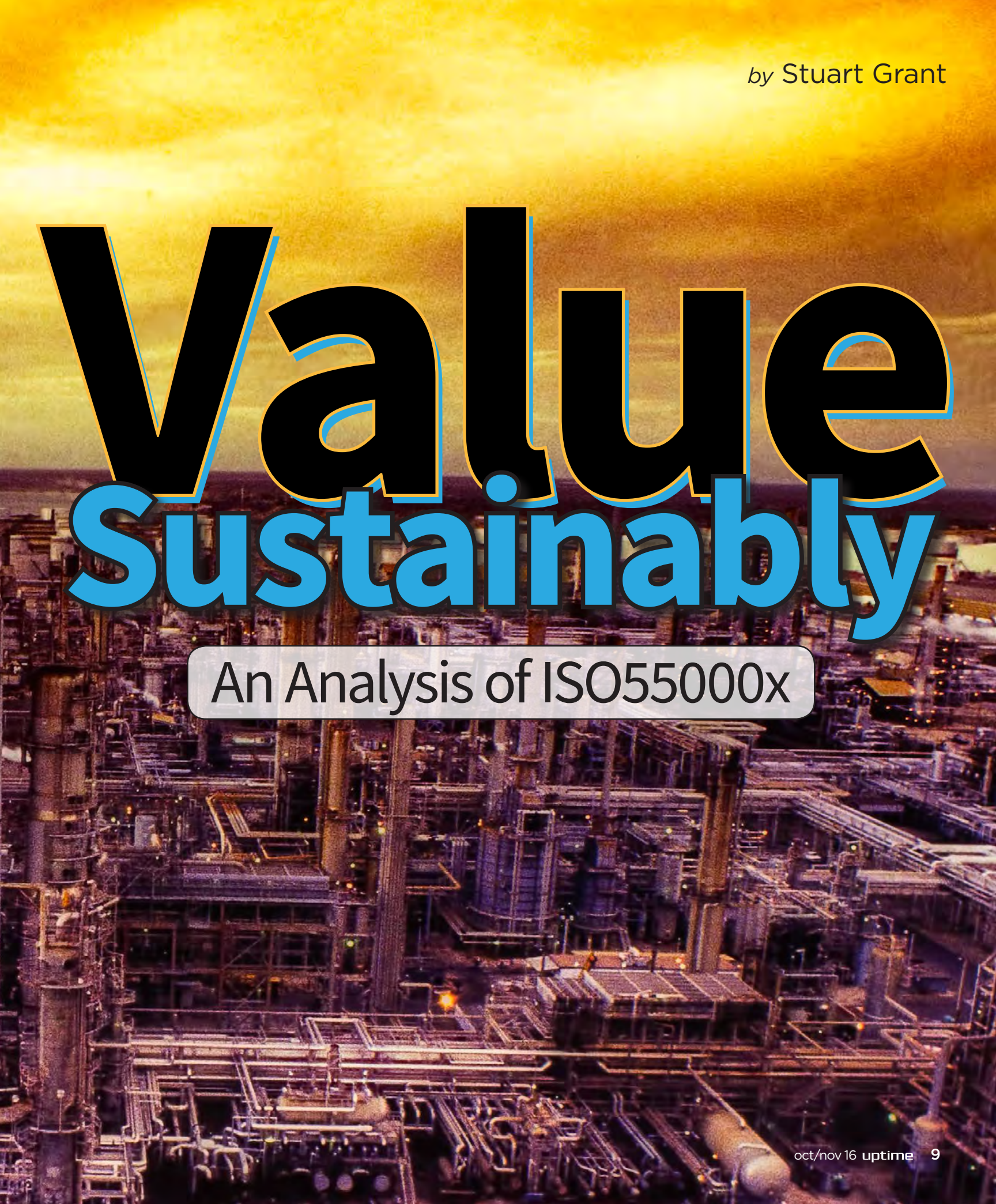
RELEASING Asset



by Stuart Grant

Value Sustainably

An Analysis of ISO55000x



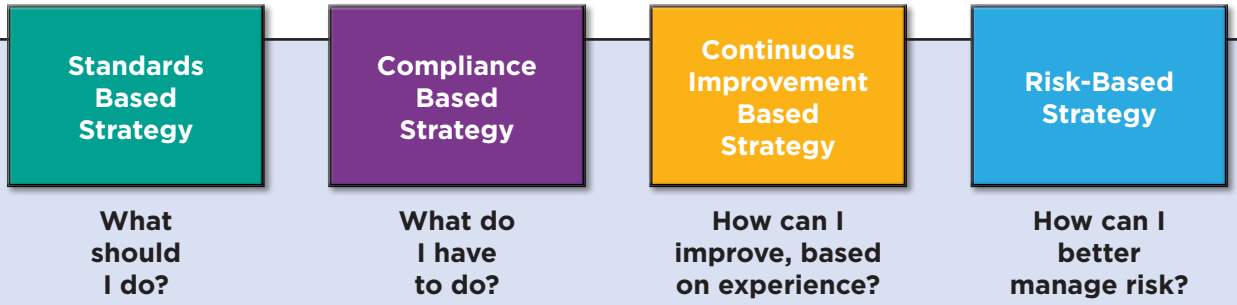


Figure 1: The four key strategies of (safety) asset management (Source: American Institute of Chemical Engineers)

A lot of information, time and energy has been devoted recently to emerging and established practices in asset management. This interest, however, actually has a far longer history. Protocols have been undergoing continuous development and evolution for the past 50 years to keep pace with discoveries, expansion and globalization of industries. Cataclysmic events have often been the driving force for positive change because they expose serious operational and management flaws that are responsible for unmitigated risks and exposing people and the environment to harm. Over time, regulations and standards have matured not only to preempt failure, but also to define improved ways to proactively manage physical assets. Figure 1 captures the four traditional risk-based strategies for asset management.

MOVING FROM REACTIVE TO PROACTIVE ASSET MANAGEMENT

Although safety and risk mitigation is a fundamental part of creating value and boosting profits, it is not the end of the story when it comes to asset management. To realize the true value of an asset across its entire lifecycle, a business must ensure it has a set of key building blocks in place. These consist of forward-looking management structures and processes that adopt a broader perspective than just identifying and addressing threats and vulnerabilities. Their aim should be to achieve the greatest return on productive assets. Put simply, risk management is undeniably important in a time of volatility and uncertainty. But those charged with steering a company through this complex terrain also must be capable of managing the range of valuable assets at their disposal to get the most out of them.

In order to steer organizations toward this goal, a comprehensive set of international standards outlining current best practices in asset management was launched in London, England, in 2014, under the banner of the new ISO55000 series (Figure 2) published by the International Organization for Standardization (ISO). The remainder of this article provides a summary of the key elements and implications of the standards, and then explores how companies can derive hidden value from their assets through effective management practices at both strategic and tactical levels. As will become clear, this should ultimately involve adopting a holistic approach. Later in this article, a DuPont case study will show how a holistic approach developed and applied across its diverse businesses focuses on the four dimensions of sustainability that collectively align with the core strategic intent underpinning ISO55000x.

Figure 2: The ISO55000 series

WHAT IS ISO55000x?

A decade before the ISO55000 series was introduced, PAS55 emerged as an early framework for asset value and risk management. Initiated by the Institute of Asset Management (IAM) in response to asset failure issues arising from the privatization of the British utilities industry, PAS55 was developed by the British Standards Institution (BSI) and quickly adopted internationally. The standard was subsequently updated extensively, following a process that concluded in 2008. But in 2014, a notable change occurred. PAS55 was superseded by both the ISO55000 series that addresses asset value over a lifecycle and the ISO31000 series that addresses risk frameworks. Although successful business models dealing with asset management require robust systems that tackle value and risk simultaneously, the focus of this article is on the value and profitability factors at the heart of ISO55000x. This is also because the series will harmonize with other established standards, like ISO9000x and ISO14000x, resulting in a common approach and articulation of requirements.

WHAT ISO55000x IS NOT

Before exploring the implications of the new standards, it is important to clear up a number of continued misunderstandings about the ISO55000 series. In particular, it is crucial for companies to recognize that ISO55000x is **not**:

1. An engineering standard outlining a technical framework for maintenance reliability.

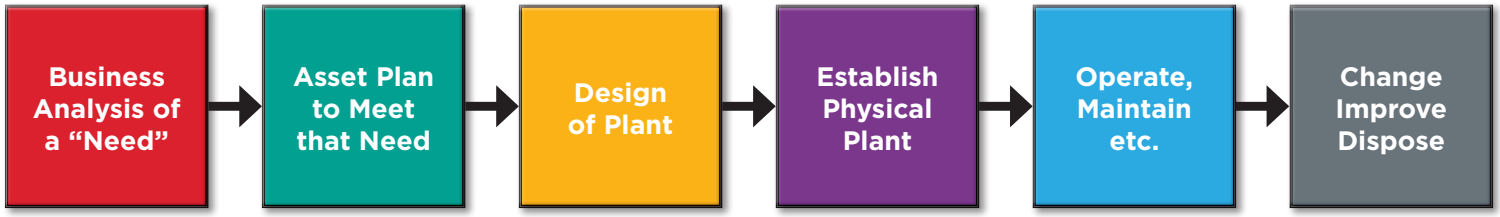


Figure 3: The lifecycle of the physical asset

2. An asset management standard offering a technical framework for new projects.
3. A set of (safety) risk management guidelines.

Rather, the real intention and significance of ISO55000x is to establish a framework standard for managing the *business* side of an asset. In other words, it includes all the necessary business elements that can help managers – and those unfamiliar with technical aspects – derive cash and profit from an asset over its full lifecycle (Figure 3). This is part of the reason why the ISO55000 series operates so harmoniously with DuPont's four-dimensional business framework as outlined later in the case study.

WHY ISO55000x IS INCREASINGLY IMPORTANT

A number of benefits flow from the implementation of a standard like ISO55000x. The series itself can be understood as a kind of assurance system, providing a clear framework for achieving the outcomes for which an asset was originally intended. If properly applied, this includes sustainable improvements in regulatory compliance, financial performance, organizational efficiency, investment and divestment decisions, as well as risk management (when combined with ISO31000x).

Businesses with poor track records in lifecycle financial performance that are traceable to below par asset management governance may struggle to secure coverage from their insurance provider. Similarly, while ISO55000x certification is not a condition of legal compliance, there are strategic reasons for meeting the standard, especially when a business encounters perennial problems with regulators or struggles to attract investment.

A number of serious asset management issues are driving global demands for better standards. These range from aging plants, evolving software systems and data analytics to the emergence of new technologies (e.g., drones, robotics and artificial intelligence), the growing impact of an aging workforce, out-of-date business practices and, more broadly, a frequent lack of understanding how to extract value from assets. Unlike a number of tactical or technical models already on the market, which businesses can and have used to implement well-defined best practices in areas related to maintenance reliability, the ISO55000x does not explain *how* to manage an asset in a tactical sense. Instead, it is framed at a strategic level with a view of unlocking the true value of a business and its assets by defining the *what*, and sometimes the *who*, to meet industry management benchmarks.

THE INTENT OF ISO55000x

Instead of a technical methodology to manage *physical* assets, a more accurate description of ISO55000xseries provided by Terrence O'Hanlon, CEO of Reliabilityweb.com, Publisher of *Uptime* and a contributor to the formulation of the series, is "a coordinated set of activities to realize the value of all assets."[1] This includes intangible and human assets, for instance, the computerized maintenance management system (CMMS) or enterprise asset management (EAM) system, training and leadership vision. Countless organizations can point to teams of capable, qualified, highly motivated and well-intentioned people juggling multiple directives and imperatives. A potential pitfall is for these teams to work in silos, within which many of the important aspects of holistic asset management may seem contradictory. As lines of sight blur and artificial conflicts emerge between risk and productivity, it is difficult to sustain improvement. Coherent standards in asset and risk management seek to bring some strategic clarity to this fog. The intent of ISO55000x, as well as the hierarchy of relationships between its key terms, is illustrated in Figure 4.

DUPONT CASE STUDY – ADOPTING A HOLISTIC VIEW

Introduction: Although ISO55000x does not cover best practices in the area of safety, anticipating and mitigating risk are two key elements in successfully and sustainably managing an asset. Understood in a broader strategic context, the ISO55000 series reinforces the idea that businesses should adopt a holistic view when it comes to asset management.

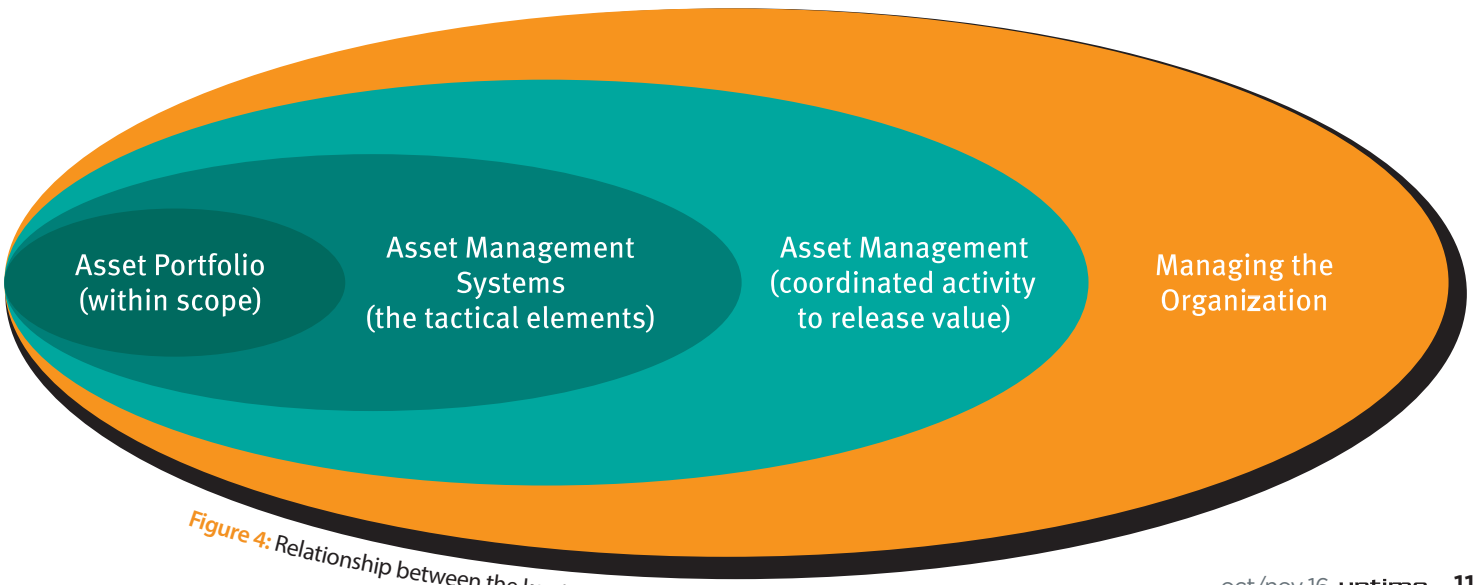


Figure 4: Relationship between the key terms in the ISO55000x standard

Background: As a global science and innovation company with a lengthy track record of continuous improvement in safety and operations, DuPont is able to draw on over 200 years of operational experience across multiple industries. During this time, the company has learned that longer term sustainability requires businesses to achieve an appropriate balance between risk mitigation and profit optimization (Figure 5). This is, of course, easier said than done. It is unrealistic to manage a business and its assets with zero risk. Yet, managing an asset with only the bottom line in mind, for example, by driving uptime at the cost of risk mitigation, is equally unsustainable.

Figure 5: The balance between risk mitigation and profit optimization

Scope: Rather than accept the status quo, DuPont continually reflects on whether it is striking the right balance. In the end, this contributes to an ongoing and positive learning process that ensures potentially unsustainable activities are corrected with appropriate haste. It is also a process that has not only driven improvement in how the company manages its own assets, but also allows the organization to assist its partners to release value sustainably through a similar approach. This approach is based on the four-dimensional business framework alluded to previously and described in a previous *Uptime* article.[2] The four dimensions this framework uses are:

1. Managing processes;
2. Technical model;
3. Capability model;
4. Mindsets and behaviors that drive sustainability.

Goal: For DuPont, the goal was to increase value by optimizing uptime. The four dimensions directly address the overarching goals of asset management, insofar as they zero in on releasing asset value (and sustainably). Referring back to Figure 4, the importance of managing the organization also became clearer. In particular, the imperative to set and implement a strategic asset management plan so key members of the organization understand how asset values can be increased, as well as what barriers may stand in the way.

Actions: Recognizing that mitigating risk is one of the key factors in sustainably managing an asset, but not part of ISO55000x. This is how DuPont applied the four-dimensional model to raise value by increasing profit.

Put simply, the goal was to optimize uptime through improved availability tactics, which take into account where losses occur or where value is destroyed. Sometimes, this is in the margins – that is, due to inefficient practices between departments or processes. At other times, it results directly from a failure to follow best practices in implementation. DuPont has worked with a range of companies and industries in countries that include Russia, Saudi Arabia and South Africa, carrying out indepth assessments of existing frameworks for asset management. While the focus is on maintenance reliability or capital effectiveness, processes rather than departments were investigated. Similarly, DuPont examined the full asset lifecycle, not just the here and now; business processes, not just technical models; and sampled and tested the robustness or validity of what companies do or say they do.

Within the four dimensions, this process explored these areas:

1. **Managing processes** – leadership vision, incentives, rituals, meetings, standardized work processes, key performance indicators (KPIs) and goals. Evidence of "felt leadership," clarity of goals, strategic asset management plans, rewards and recognition, meeting effectiveness, and standard work and line walks by leadership was sought.
2. **Technical model** – the effectiveness of a company's CMMS or EAM, data analytics, learning from incidents, contractor management, reliability processes (e.g., RCA/RCM, CBM, RBI, SIL), work identification, work execution, gatekeeping, turnarounds, and planning and scheduling.

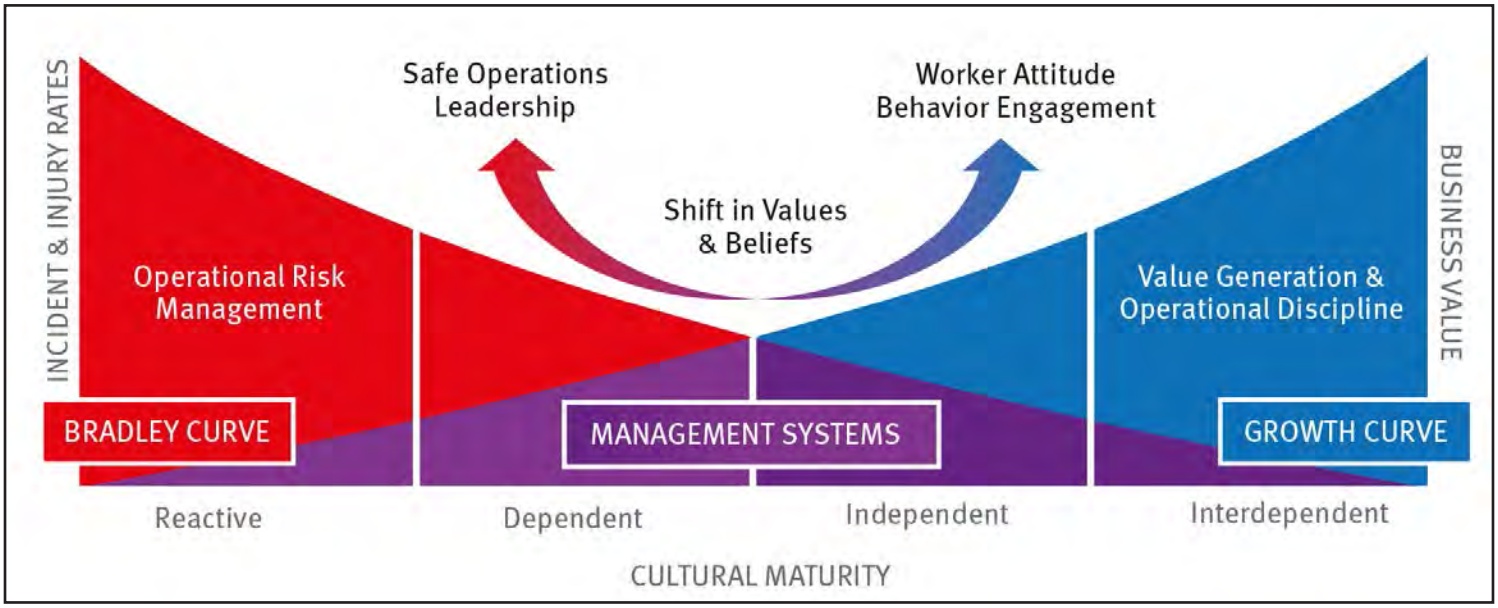


Figure 6: The Bradley Curve cultural quadrants for risk mitigation and business value

3. **Capability model** – training and competence verification, learning, mentoring, hiring, promotion, education, qualifications and a company's broader knowledge management system, if one existed.
4. **Mindsets and behaviors** – silo mentalities, adversarial relationships, the role of operations in maintenance reliability, joint or diverse goals, incentives (again), messages, production versus safety, asset lifecycle, or short-termism.

This final category of mindsets and behaviors is often overlooked in assessment processes. Yet, such qualities and processes speak to the real culture of a workplace.

Results: DuPont has found that undertaking a cultural assessment is mission critical to the longer term application of standards and best practices. In other words, if the right standards are not backed by the right behavior, they will fail. Once existing gaps are understood and verified, work can begin to carefully design and implement solutions that will address and fill them. The solutions are usually quite specific and are delivered by experienced professionals who have often held line management positions at a DuPont facility. It is not an academic exercise to pragmatically implement a solution!

DuPont's experiences have led the organization to an important realization: as an asset is managed better to deliver sustainable value, total risk reduces. A reliable plant is a safe plant. This relationship is captured in Figure 6, which expands upon DuPont's established safety methodology, the Bradley Curve.[3] While proven in practice, the path is not necessarily linear, as slip back can occur quicker than improvement. Nonetheless, this mental model encapsulates the holistic approach that DuPont has pursued and observed in its own journey. The company plans to continue to progress and keep to the right-hand side of the curve. It is understood that when DuPont has to fix its own value or risk problems or help others with theirs, understanding and recognizing the underlying mindsets that drive behavior are fundamental elements. Together with ISO standards and the frameworks for operations excellence they offer, sustainable, longer term improvement in asset management can be achieved.

CONCLUSION

Ultimately, the publication of the ISO55000 series has clarified the broader goal of asset management as a business process focused on releasing value from an asset over its entire lifecycle. It has also clarified that asset management is not about physical assets alone, nor indeed technical models, but includes software, data and a range of human factors.

At the same time, ISO55000x does not specify how to manage an asset tactically, as the series assumes the application of existing best practices at various levels. It is important, however, to connect the dots by linking management processes to business results. This involves understanding the practical issues at hand and then executing relevant tactics pragmatically.

If the tactical level is ignored or overlooked, asset management becomes a paperwork issue, focusing solely on technical models in maintenance reliability, or capital effectiveness that presents only the illusion of true value creation. For instance, new procedures can be put in place, but they are not followed or may prove unworkable. The end result is value remaining locked in.

As the case study shows, DuPont developed a sustainable solution to its own business model and asset management framework that involves engaging with the four dimensions, as well as understanding the cultural patterns that affect risk or value creation. This approach has helped not only its clients, but the company itself, realize hidden value in the organization and connect tactics with wider strategic intent. No technical or engineering model is able to do this on its own. And perhaps the best part is that DuPont's diverse operational experience means the holistic 4-D business assessment process can be applied to any industry.

REFERENCES

1. O'Hanlon, Terrence. "Asset Management/PAS55 – The Sustainable Business Strategy for Operations Excellence." *Maintenance & Engineering, Maintenance & Asset Management Journal*, Vol 15, Issue 2: Mar/April 2015.
2. Grant, Stuart. "Asset Management Culture: The Missing Link?" *Uptime Magazine*, April/May 2015. http://reliabilityweb.com/index.php/articles/asset_management_culture_the_missing_link/
3. DuPont. "The DuPont Bradley Curve Infographic." http://www.dupont.co.uk/products-and-services/consulting-services-process-technologies/articles/bradley-curve-infographic.html

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10 Components of a Successful VIBRATION PROGRAM

by Alan Friedman

Right Processes and Procedures and What Can Be Learned About Reliability on a Silent Meditation Retreat

The *Uptime* series on the 10 components of a successful vibration program continues with this article that focuses on Component #10, the right processes and procedures.

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.

Imagine this: You are starting a new job. You are given a two-hour orientation, followed by about 10 to 20 minutes of hands-on job training conducted by the person you will replace. After that, you are to do your job without speaking to or making eye contact with anyone else. Apart from a few longer term managers, most of the people in the organization are in the same position as you.

Now imagine what it would take to make this organization run like clockwork. This is a lesson in process management and reliability.

In addition to my keen interest in vibration analysis, I also have a passion for intensive meditation retreats lasting from 10 days to several months. At an intensive retreat, the goal is to meditate literally every moment of the day, from before opening one's eyes in the morning until one falls asleep meditating in bed. Practitioners keep their eyes pointed down at the ground and move in slow motion like zombies, meditating even while taking care of daily necessities like eating, brushing teeth, showering and using the toilet. It's like walking around all day trying to balance a bowl of water on your head. Meditators also forgo reading, writing, Internet access, phones, or any activity that takes away from meditation. Speaking or making eye contact with others is strongly discouraged. In other words, the retreats are done entirely in silence and without interacting with others.

But at one retreat, an unexpected lesson about reliability and how to run an organization was gained. On this particular retreat, the meditators were expected to work for about an hour a day doing odd jobs to help keep the center running. Jobs ranged from cutting vegetables, washing dishes and mopping floors to cleaning bathrooms, etc. Although this particular retreat had a start and end date, the center runs continuously all year round, with people constantly coming and going. Therefore, it is necessary for people to acclimate quickly to the environment and learn their jobs without disturbing the people already on retreat. Practitioners need to carry out their job tasks and handle any unexpected complications without disturbing their own practice or that of the other meditators. Although there are some more permanent employees at the center or "managers," their jobs are also well-defined and easily passed on to the next person.

After a two-hour orientation and a ten minute job training, I was able to begin my retreat and do my job sanitizing dishes for two months without ever having to interact with another person or ask a question, even when some unforeseen circumstances arose. Remarkably, during these two months, never did other practitioners struggle or break their silence or meditation to deal with problems related to their jobs. In addition to doing my job, I also had to navigate the center, figure out how to do laundry and get other needs met as they arose without having to directly interact with anyone else.

> "Follow procedures. Improve procedures."

So, how did they do it?

Every job is well-defined and documented. The 10 minutes of training, which was given by the person I was replacing, was able to speak since this individual's retreat had just ended. Everything I needed to know was written on a laminated piece of paper hanging right above the sink in the middle of my work space. Not only did it describe the tasks that needed to be accomplished, it described them in intricate detail. For the job of sanitizing dishes, instructions went like this: Turn on the dishwasher 30 minutes prior to eating your meal, check temperature gauge, rinse, stack, sanitize, tilt rack to speed drying, stack dry dishes on dolly. Sanitize cutting boards every other day, salad spinners on Sundays. A piece of paper and a pen hanging above the sink were used to document that the salad spinners had been washed.

Dirty dish rags were to go in a basket in the kitchen. Another meditator collects the basket and takes it to the laundry. Freshly folded dish rags magically appeared every day on the shelf above the kitchen sink. Clean dishes were placed back on the shelves in the dining hall at the bottom of the stacks so the same dishes were not in constant use. The laminate specified exactly how many spoons and forks were to be placed in each area of the kitchen for the cooks to use. When the counter tops and sink were washed down at the end of a shift, another person entered the kitchen to wash the floors. Everything worked like clockwork.

What really was impressive was what happened one day when an alarm sounded on the dish sanitizing machine and a red light went on. Uh-oh, this was not covered in the training! But I did not freak out, instead referring to the laminate above the sink. Right there on the back it explained what to do if the alarm sounded. It noted: Look for a bottle of disinfectant under the sink and install it in the machine. Sure enough, there was a bottle under the sink and the laminate described exactly how to install it. Within moments, the alarm stopped beeping and the red light turned off. At the end of the shift, as the laminate instructed, I walked to the bulletin board, used the provided paper and pencil and left a note for housekeeping: "More disinfectant is needed for the dish sanitizing machine." Two days later, a new reserve bottle magically appeared beneath the sink.

Not only was the dish sanitizing job described in minute detail with every foreseeable problem or complication thought through and addressed, but everything at the center worked this way. A laminate on the shower door described how to squeegee the shower walls when finished showering (squeegee hanging in shower) and how to use the paper napkins (in a neat pile on the shelf, refreshed daily) to remove any body hair from the tiles. Instructions were given about how to hang the bath mat and spread out the shower curtain so it would dry.

A sign on the door of the laundry room displayed the hours of use. A laminate on the washing machine showed how to set the dials and the correct setting was also marked with permanent markers on the dial itself. A laminate described which detergent to use and how much. The detergent bottle was clearly labeled and the scoop inside was sized appropriately for one load. Instructions were given for cleaning the lint screen from the dryer. A sign-up sheet with attached pen (extra pens nearby), allowed you to reserve a time slot to do laundry so you would not conflict with others.

Two days before I my retreat was to end, a couple of laminates were slipped under the door to my room. They contained detailed instructions for returning the room to the exact state it had been in upon arrival. This included a reminder to reserve a time slot for the washing machine to wash the sheets and towels and instructions for locating a broom, dust pan and mop for cleaning the floor and rags and other cleaning supplies for everything else. It included instructions to flip the mattress over to even out the wear. Each item I had been provided was accounted for and each was to be returned to the same shelf on which it was originally found. After I left, it would be someone else's job to go into the room and inspect it prior to the arrival of the next person.

Follow Procedures, Improve Procedures

This center did not always run like clockwork. The people doing the jobs had to document the procedures and the procedures had to be refined and improved over time. If you are looking for a mantra to chant at work, this would be a good one: "Follow procedures. Improve procedures." This is the way to evolve an organization. Don't just do your job, document your job and improve your job.

The meditation retreat center is an excellent example of what can be accomplished when practicing proactive maintenance reliability and organizational change. A new "employee" could be integrated into the organization and trained with ease, allowing the center to work flawlessly with a constantly changing "workforce." The level of detail applied to the task descriptions, the availability of the right tools for the job and instructions for dealing with varying circumstances have their place in every organization and in every department. This is exactly how you can begin to deal with defect elimination in your plant.

In contrast is a situation that occurred at a cement factory. The consultant had to call the hiring person when the entrance to the site couldn't be found. The consultant was at the wrong site, having driven to the address found on the purchase order sent by the hiring person. Twenty minutes later, the consultant arrived at the correct site, but could not figure out where to park or how to get inside. Was the consultant supposed to be driving on the same driveway as these huge trucks? Was the individual really supposed to drive underneath the giant mixer and park just beside it? Was that little door on the side of the big building really the main entrance? Was there really no security guard or anything on the other side of that door besides a sign-in book? Did the consultant really have to walk into a bunch of offices to get someone's attention to ask where to go? There were no signs anywhere! You get the idea.

When it comes to condition monitoring, many people contact consultants when they are tasked with taking on a condition monitoring program after the "expert" who had been running the program leaves. More often than not, the expert hasn't documented anything and the new person has to start the program over from scratch. Condition monitoring is based on trending data collected in the same way under the same conditions. If test procedures are not well-documented and followed, then existing alarms and baselines become meaningless.

Not only are test procedures frequently not documented, there also aren't clear procedures for reporting or follow up and review. It is not clear who gets the reports, when they get them, or what they are supposed to do with them. No one verifies if the diagnosis are correct or follows up with root cause failure analysis to prevent the same problem from happening again in the future. Processes and procedures are the string that binds the 10 components of a successful condition monitoring program together and each component can be defined and refined as a set of processes and procedures.

It's been widely reported that up to 70 percent of defects and machine failures are caused by humans.

It's been widely reported that up to 70 percent of defects and machine failures are caused by humans. This can be attributed, in part, to a lack of processes and procedures, or to personnel not following procedure.

As the tasks at the meditation center show, there is something to be said about taking pride in one's job, whatever that job may be. People feel like they are part of something and that they are doing their job in order to benefit others. In other words, they are working on behalf of a community and their fellow workers – even if they never look them in the eye or speak to them – and take pride in being part of an organization that functions so effectively. Basically, people can be happy doing any job if they care about it and if they care about the people they work with and for. Perhaps "right attitude" should be added as the 11th component of a successful program?

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

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An Asset Manager's Guide to

VISION

BUILDING A MEANINGFUL COMPANY VISION

by James Mourafetis

What does it mean to have a vision for your company? Why should you have one and how do you create it? As you'll see in this article, developing a vision requires buy-in from department level managers and is crucial for a company's success.

Why Create a Vision?

Businesses that rely on heavy assets depend on an effective enterprise asset management (EAM) program to address three common challenges: increasing asset utilization rates, increasing operational performance and minimizing costs. For an EAM program to be effective, a company needs a vision that is executable, easy to manage and sustainable. This vision also needs to define quantifiable measures, time frames and responsibilities, all of which produces buy-in of process owners.

Who Creates a Vision?

The key to aligning your company's goals, mission and values is to convert these concepts into a department level strategy. Organizations often try to deploy top-level goals and measures to meet a corporate level objective, but they don't enable department level key managers to determine their own vision and strategies. The result is a lack of commitment by key stakeholders, who now simply work through a corporate exercise to meet commitments they don't necessarily embrace.

Rather, these six steps should be followed in creating a vision that emphasizes buy-in from department level managers.

1 Form the real team

Begin by forming a cross-functional asset management steering committee with key department level stakeholders. For complex organizations, develop a functional area interface map between key processes and departments.

Here is a real-life example:

In a Class 1 railroad, a locomotive work group (LWG) was formed as the asset steering committee for locomotives, which is a key asset in freight rail. Since many of the functional interactions occur between network operations and the mechanical department, the LWG included key stakeholders from network operations (the department that schedules and utilizes locomotives) and the mechanical department, which maintains the locomotives.

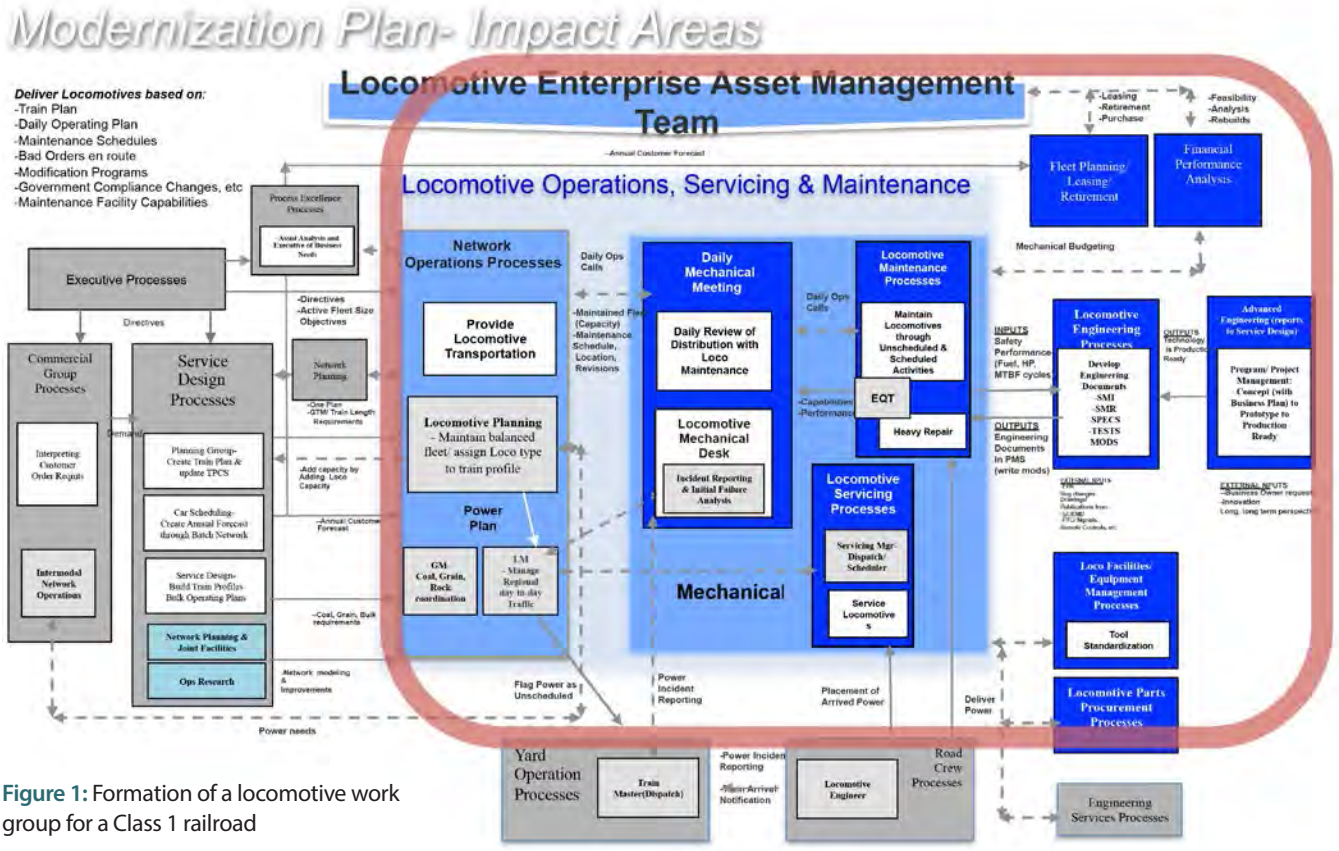

Figure 1: Formation of a locomotive work group for a Class 1 railroad

2 Set key goals, drivers and attributes

To set the vision for the asset steering team, conduct interviews with managers cascading from the asset steering team. There are two interview goals: identify how the asset steering team will develop its EAM strategy and deployment, and formulate the asset team's key operating goals, drivers and attributes. In the example of the Class 1 locomotive asset steering team, interviews generated key locomotive goals, drivers and attributes.

It's crucial to understand the key goals, drivers and attributes as a system in order to understand that decisions based on one driver will impact another. The asset steering team can then use a balanced, aligned approach to authorize capital expenditure (CAPEX) for projects. This might change how the organization aligns resources to support the asset steering team's goals.

Goals	Asset Drivers	Attributes Describing Drivers
· Right locomotive at right place and time · Minimize disruptions due to fleet condition gaps · Minimize locomotive maintenance and train-to-train dwell	Locomotive distribution	Fleet resizing, agile pairing, capacity-driven scheduling, footprint aligned with demand
	Fleet Availability	Readily available parts and tools, maximized labor productivity, perfect quality, optimal workflow
	Fleet Condition	On-road problem resolution, real time health status, confidence in ETR's, compliance
	Execution	**Optimal energy efficiency, achieve planned results, enable employees to learn and grow**

Figure 2: Key goals, asset drivers and driver attributes for Class 1 railroad

3 Set benchmarks: outside-in

Based on its top-level goals, drivers and attributes, the asset steering team can now assess what other world-class, heavy asset organizations are doing using outside-in benchmarking. This enables you to compare industry best in class practices and how your organization is resourced and performs against best practices.

Your team can now identify external best practices that align with the key attributes of your asset team's drivers and determine gaps. It's important to highlight great things departments are already doing. The asset steering team can use benchmarks from other heavy asset industries, as well as their own, to set realistic targets.

This is important because managers form beliefs of what is good based on how they rate their department's performance with their industry peers. Over time, this forms an insular perspective of what's good, which prohibits managers from learning best practices outside the industry. The example in Figure 3 highlights the comparison of outside-in best practices with internal initiatives and gaps.

Attributes	*Opportunities*	*Good Practice*
Capacity driven Scheduling	▪ Manual shop capacity assessment ▪ Difficult to quantify shop capacity in real time ▪ Shop count drives scheduling which discourages FIFO workflow	▪ Optimization tools for Q scheduling
Footprint Aligned with Demand	▪ Variation in maintenance repair and Q capabilities generates light moves ▪ Limited coverage of future growth corridors due to existing footprint ▪ Compliance of certain commodities prevent fastest route (ie; chemicals)	▪ Network modeling initiatives
Agile Pairing	▪ Static locomotive plan for train profile ▪ Manual power assignment, heavily dependent on LM' s capabilities and knowledge ▪ Local optimization due to limited visibility of overall network impact	▪ Distribution guiding principles
Fleet Rightsizing	▪ Multiple locomotive classes constricts power assignment & distribution ▪ Productivity factors and sensitivity matrices are used to convert GTM to fleet size requirements. Need for improved fleet life cycle planning tools ▪ Limited locomotive level cost visibility	▪ Fleet strategy in place for key classes – AC, 4000 DC, 3000 DC,4 Axel

Attributes	*Cross- Industry Best Practices*	*Internal Initiatives*
Capacity-driven Scheduling	▪ Shop capacity models with real time data on shop workload, service time, free capacity and expected repair times	▪ SAS forecasting implementation in service design ▪ For Q: Locomotive shop balancer and route

Footprint Aligned with Demand	▪ Optimized shop location using network models and failure history
	▪ Create 'super shops' and improve flexibility
		▪ Network modeling –
		  ▪ Shop & Service Center Locations
		  ▪ Infrastructure
		  ▪ Corridor Congestion
		  ▪ Fuel Truck Simulation Model

Agile Pairing	▪ Dynamic locomotive assignment based on real time load information ▪ Decision support systems - software that advices LMs on best assignment in real time	▪ Hump yard simulator (need similar for shops) ▪ Locomotive plan optimizer, simulation optimizer ▪ SAS forecasting implementation in service design

Fleet Rightsizing	▪ Reduce fleet complexity
	▪ Explore secondary markets for aging fleet disposal
	▪ Lifecycle cost approach to drive use-repair-dispose strategy
		▪ Loco PIT-
		  ▪ Purchase 50 new GE Units
		  ▪ Utilization 4.1 to 4.15 GTM/HpHr
		  ▪ Retirements

Figure 3: Current state and best practices for locomotive distribution

4 Establish an inside view of functional performance

Look at functional areas to gauge your organization's internal best practices. This is where your skills at getting functional managers on board are critical.

In large organizations, where key supporting functions, such as maintenance, have few internal operating and financial measures, operating measures are often only at the reporting level outside the functional area. They also often lag indicators, such as how many assets are inspected, repaired, or on hand; how long assets are dwelling; and what percentage of fleet level measures is out of service or available. Financial operating expense measures are typically rolled up to the line item level without detailing work scopes within the operation.

These high-level, lagging measures don't provide the resolution to change the impact of the operating and financial measures. They don't show progression of work, drill downs of reliability issues, labor and material costs, or cost of maintenance lines, such as overhauls, engine change outs, etc. In many organizations, these top-level measures are perceived as a deceptive means to hide what's really going on in the facility or operation.

It's best to bring in outside consulting resources for two reasons: credibility from third-party observation and analysis of operational and financial performance, unbiased by the politics of the organization, and preventing internal rifts.

"For an EAM program to be effective, a company needs a vision that is executable, easy to manage and sustainable"

5 Facilitate a series of vision sessions

You're now ready to facilitate the development of a vision to gain a shared understanding of what is good from both industry best practices and an outside-in perspective on what other world-class heavy asset companies are doing. The question to answer is: How will the future be different from today? This phase enables the asset steering team to formulate a long-term vision and develop the building blocks to achieve it.

A real-life example would be a prescriptive analytics firm working in the mining industry. When an outside consulting firm helped the Class 1 railroad develop its long-term vision, fleet condition was a key driver for the locomotive working group. A more reliable fleet of locomotives meant the fleet could be more predictably utilized and provide improved asset efficiency. Through vision sessions, locomotive working group members learned about an outside-in approach to prescriptive analytics to improve reliability, so they procured the prescriptive analytics firm to reduce catastrophic locomotive engine failures. Locomotive reliability for this Class 1 railroad is now best in class in the industry.

Hold three to four vision sessions so asset steering team members can digest all the input. Use outside help to facilitate these sessions to avoid political mines from internal employees facilitating sessions. Figure 4 is an example of the vision for the Class 1 railroad's locomotive working group.

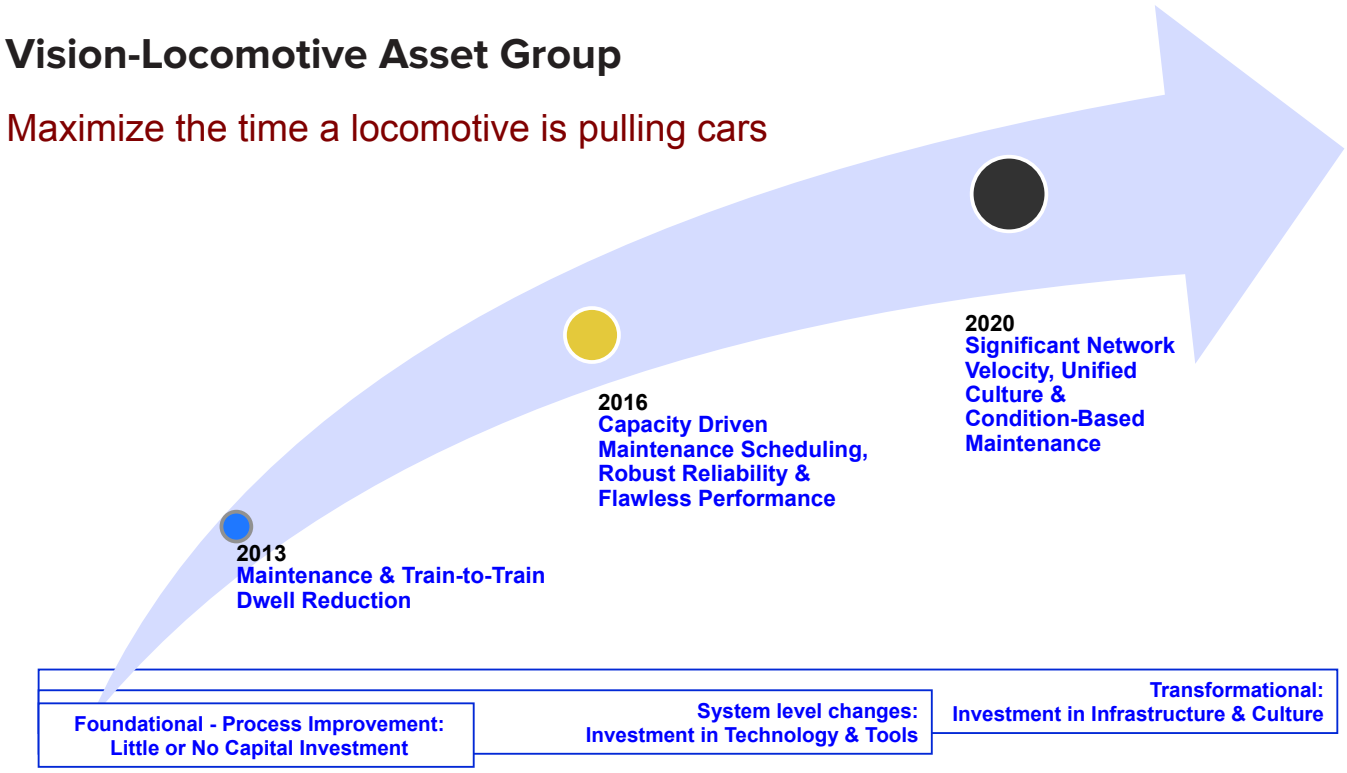

Figure 4: Development of a vision for a Class 1 railroad

6 Implement the vision

The goal of the vision sessions is to collaboratively develop a working draft asset vision comprised of short-, mid- and long-term initiatives that are developed, vetted and agreed to by the asset management steering committee. The vision needs to be in a simple enough format so all levels of the asset management team's cascading organization, including down to the mechanic, understand where the team is heading.

What's Next?

As you see, a vision can help a company be more effective in its programs and operations by creating a department level strategy. In order for the vision to produce business success, department level managers must be on board. Following the six steps outlined in this article will help you get your team aligned with your company's goals, mission and values.

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Connected Maintenance Solutions Enable New Business Models

by Isaac Brown

There is tremendous hype around the burgeoning Internet of Things (IoT), but the IoT is not a singular entity as the value proposition, timeline and technological needs vary widely across its three major domains – industrial, consumer and healthcare. The hype across all three of these IoT domains is palatable, with talk of industry 4.0, smart homes and digital healthcare increasing on a daily basis. This makes finding the right IoT markets and the best bets an enormous challenge.

For those seeking near term returns, the Industrial Internet of Things (IIoT) is an attractive candidate, as hype is beginning to give way to value. Manufacturers, utilities providers, farmers, oil producers and other industrial stakeholders are witnessing returns from investments in sensing, connectivity, analytics, systems integration and process transformation. Nearly every industrial organization stands to benefit in one way or another from these developments, leaving those that act too late at a significant competitive disadvantage.

> **"Among the many value propositions of the IIoT, asset optimization is one of the most promising."**

Fueling the hype of the IIoT is its ability to deliver value in many different value propositions, from increasing supply chain visibility to improving worker safety. Among the many value propositions of the IIoT, asset optimization is one of the most promising. For many years, organizations have remotely monitored individual internal assets to understand their performance. The Cloud has made it possible to monitor a fleet of globally separate assets and analyze their data in conjunction with each other, something that is becoming a common practice for forward-thinking organizations.

While many organizations have analyzed their own internal operations over the Internet for years, the ability for industrial original equipment manufacturers (OEMs) to draw data from their product fleets in the field is completely revolutionary. To illustrate, a major airline may have hundreds of aircraft in operation at any given time. If GE Aviation and its partner companies can collect data feeds from its jet engines once they are in use by the airline, it can develop a far deeper level of insight into engine performance than any other single airline could accomplish on its own. This new practice of monitoring and analyzing equipment *after* it has been deployed in the field by customers is a key aspect of the IIoT revolution.

Connected machines come with new business models. For example, Caterpillar plans to roll out a suite of Web- and mobile-based predictive diagnostics and fleet optimization services over the course of 2016, aiming to draw data feeds from 3,000,000 Caterpillar engines and machines worldwide. Kaeser Compressors, a German manufacturer of air compressors, has a few experimental pay-per-use customers. With this model, it gives customers compressors for no up-front costs, monitors the equipment remotely, guarantees a service-level agreement, maintains the compressors when necessary and charges customers for the quantity of air they compress. This model is very appealing to both OEMs and their customers, but proper pricing structures must be put into place. In addition, customers must be comfortable with having their equipment monitored over the Internet by their providers.

However, challenges exist beyond a strong value proposition and business model. According to a recent Lux Research survey of more than 120 operational leaders, organizations like Kaeser Compressors may see more cultural pushback than organizations like Caterpillar. As shown in Figure 1, heavy industry tends to be comfortable with remote monitoring, with 61 percent of respondents reporting they were comfortable with OEMs monitoring their machines over the Internet, compared to 50 percent for energy organizations and only 47 percent for manufacturers.

Figure 1 further shows that regional preferences turned out to be an important factor as well, with 61 percent of North American respondents accepting of remote monitoring over the Internet, compared to only 38 per-

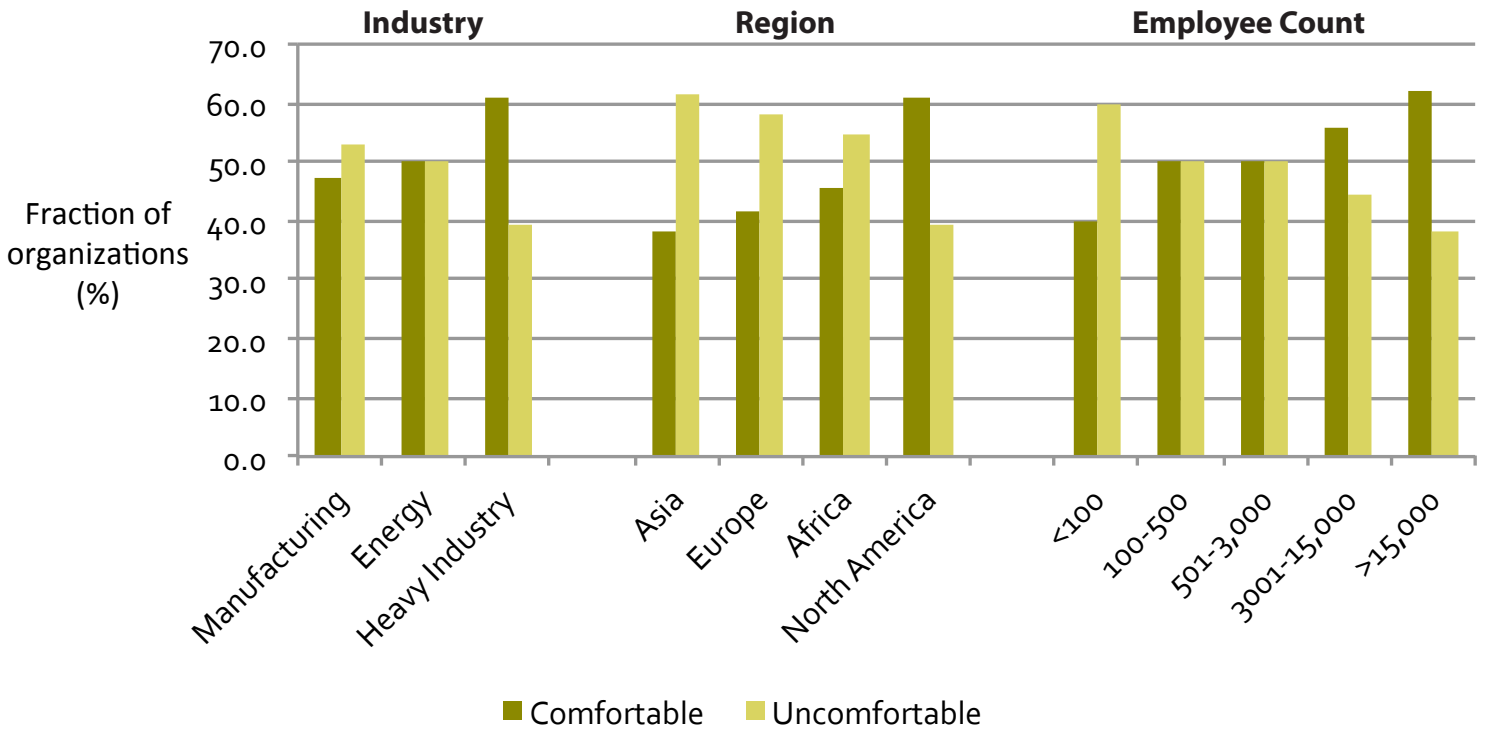

Figure 1: A breakdown of responses to the question: "Would your organization be willing to allow your equipment providers to monitor your equipment remotely (over the Internet) in order to provide predictive maintenance services?"

“Would your organization be willing to allow your equipment providers to monitor your equipment remotely (over the Internet) in order to provide predictive maintenance services?”

cent of Asians. The organization's size proved to be another strong factor, with only 40 percent of organizations with less than 100 people responding being comfortable with monitoring over the Internet; this number rose steadily with increasing employee count, to 62 percent for organizations with over 15,000 employees.

As OEMs develop their connected product strategies, it will be essential for them to understand the value proposition, business model and customer culture. Examining the extremes, connected products and solutions targeting large heavy industry organizations in North America must have very different forms than connected products targeting small manufacturing firms in Asia.

In the end, users should be able to deploy products and solutions in whichever format makes them most comfortable. These major formats will be products that connect over the Internet, products that connect to local intranets and products that do not connect to any network at all. Without a doubt, any IIoT solution deployment will experience some hiccups along the way as vendors iron out these cultural kinks.

Isaac Brown *leads the Industrial Internet of Things Intelligence practice at Lux Research in Boston, Massachusetts. He helps Global 1000 clients implement IIoT strategies, identify emerging opportunities, and explore strategic partnerships. Isaac graduated with a BA in Physics from Northwestern University, with a concentration in astrophysics. www.luxresearchinc.com*

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MAINTAINING BELT DRIVES FOR BEST RELIABILITY

by Randy Riddell

Belt drives are often considered the fuse of the power transmission drive path, which can be an advantage for belt drives. In that line of thinking, not much thought is given to the impact on overall equipment reliability with respect to the belt drives connecting driver and machine.

Belt drive design, belt installation and belt maintenance affect more than just the belts, but the driver and machine as well. Machine components, such as shafts, bearings and seals, are some of the elements that will suffer from poor belt reliability.

Chronic belt failures and short life can increase valuable maintenance manpower, which is already under constant pressure in today's environment. Unhealthy belt drives also typically increase equipment vibration, which can negatively impact a component's life, as well as processes. Poorly operating belt drives are also energy wasters, as low power transmission efficiencies come along with poor reliability. Lastly, unreliable belt drives carry with them a potential safety risk. Constantly working on belt drives with multiple pinch points puts maintenance technicians in the line of fire for potential accidents.

A belt drive must be designed correctly to have a chance at a full life in a 24/7 industrial application. Many belt drive reliability issues have been traced back to an initial design problem. There are many belt drive power transmission suppliers that offer online software to aid in belt drive selection, although some are just designer's choice, such as what type of belt to use. However, there are several design factors that must be accurate because even good maintenance won't correct them. For example, having enough belts to transmit the connected horsepower (hp). This article concentrates on belt drive maintenance, so it's assumed the belt drive design has no deficiencies.

Storage and Handling

Since equipment reliability begins with material storage and handling, drive belts should be stored and handled in a way where they are ready to deliver good power transmission. Belts should not be stored in tight radii smaller than minimum recommended sheave diameters. Many manufacturers have a number of coils and loops for a certain belt cross section and belt length. Also, do not coil in reverse bend directions.

Optimum belt storage conditions are less than 85°F and 70 percent relative humidity. Belts stored around machine areas where excess heat exists will have a much shorter life. Belts also should not be stored in direct sunlight or near chemicals that can break down the rubber compounds. Most belt labels should have a manufacture date. While they usually will still run after being in storage for six years, full life may be reduced after long storage times.

Best Practices

When installing belts on used drive sheaves, the sheave wear should be checked. The small sheave (typically the motor sheave) especially should be checked as this is the one most likely to have the most wear. Sheave templates, such as the one shown in Figure 1, can help determine if wear is over 1/32" and needs to be replaced.

Figure 1: Checking sheave wear with a template

Table 1: Recommended Deflection Force Per Belt for Super HC® V-Belts, Super HC PowerBand® Belts, Super HC Molded Notch V-Belts or Super HC Molded Notch PowerBands Belts

V-Belt Cross Section	Small Sheave Diameter Range (in.)	Small Sheave RPM Range	Speed Ratio Range	Recommended Deflection Force (lbs.)	
				Minimum	Maximum
3V	2.65-2.80 3.00-3.15 3.35-3.65 4.12-5.00 5.30-6.90	1200-3600 1200-3600 1200-3600 900-3600 900-3600	2.00 to 4.00	3.0 3.3 3.7 4.4 4.8	4.3 4.8 5.4 6.4 7.1
3VX	2.20 2.35-2.50 2.65-2.80 3.00-3.15 3.35-3.65 4.12-5.00 5.30-6.90	1200-3600 1200-3600 1200-3600 1200-3600 1200-3600 900-3600 900-3600	2.00 to 4.00	2.8 3.2 3.5 3.8 4.1 4.8 5.8	4.1 4.7 5.1 5.5 6.0 7.1 8.6
5VX	4.40-4.65 4.90-5.50 5.90-6.70 7.10-8.00 8.50-10.90 11.80-16.00	1200-3600 1200-3600 1200-3600 600-1800 600-1800 400-1200	2.00 to 4.00	9.0 10.0 11.0 13.0 14.0 15.0	13.0 15.0 17.0 19.0 20.0 23.0
5V	7.10-8.00 8.50-10.90 11.80-16.00	600-1800 600-1800 400-1200	2.00 to 4.00	11.0 13.0 14.0	16.0 18.0 21.0
8V	12.50-17.00 18.00-24.00	600-1200 400-900	2.00 to 4.00	28.0 32.0	41.0 48.0

Setting Belt Tension

Since V-belts transmit power by friction, the most important step in belt drive reliability is setting belt tension. The best belt tension is just enough to drive the load and not slip. Knowing the type of operating conditions (e.g., shock loading or steady loading) is a key factor in determining the correct belt tension. V-belts work off friction between the belt sidewall to the sheave, so belt tension is what develops that friction force to drive the load.

Several methods can be used to obtain a belt's tension targets. Belt manufacturers have tables that give target belt tension information (e.g., force, frequency) depending on the belt's maximum cross section size, speed and minimum sheave diameter. Since the tension given is based on the belt's cross section, most applications may be over tensioned for the drive power to be transmitted. A more precision method for getting tension information is to calculate the tension based on the actual drive's horsepower to be transmitted. This can be done manually or by using a sizing program.

This tension targets the actual drive power to be transmitted instead of horsepower capacity of the belts on the drive. The impact to bearing reaction loads and bearing life can be significant. Double the bearing load and the bearing life is reduced by a factor of 10. For example, in a standard table shown in Table 1, a 250 hp belt drive on a fan using 8/8V3000 belts calls for up to 41 lbs per strand of belt tension. At this tension, the belt pull force is nearly 6,000 lbs. From engineered belt tension calculations for a 250 hp drive, the target belt tension is 18 to 22 lbs. The result is a belt pull force of 2,000 lbs. In this example, bearing life is reduced by 97 percent by using the maximum value in the belt tension table instead of the specific engineered belt drive tension from the connected drive's horsepower.

There are several methods to set belt tension. The more common ones are the belt deflection force method, sonic tension measurement and the powerband multiplier method. The belt deflection force method, shown in Figure 2, uses a simple spring tension tool that shows the deflection distance and deflection force. The single-barrel type tools are typically good for belts up to 33 lbs deflection force. For powerbands, a double-barrel tester may be used, which is good for up to 66 lbs deflection force.

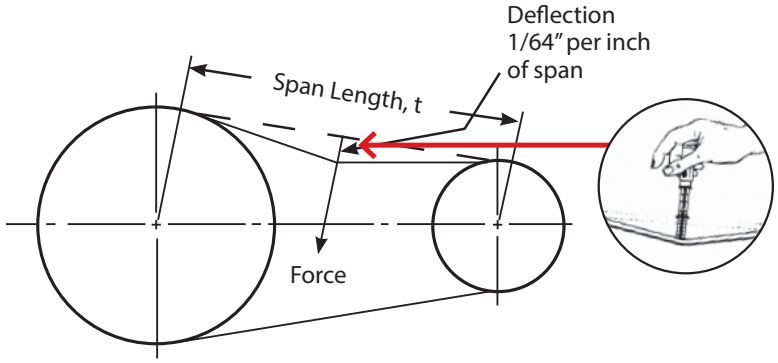


Figure 2: Belt deflection force tension method (Source: Gates Preventive Maintenance Manual, pg. 7)

Guarding may not always play a hand in reliability, but it can have negative effects in certain conditions. Besides protecting employees from injury, guarding is a noise suppressor and keeps contaminants out of the belt drive. In general, guarding should be vented to allow cooling because elevated belt temperature will cause decreased performance and belt life.

While belt and sheave alignment is not as critical as a direct drive, it will have negative effects on belt drive reliability. The maximum allowed misalignment for V-belts is approximately .5 degrees (~.100"/ft of center distance). Synchronous belts require better alignment, with a maximum allowed .25 degrees (.062"/ft of center distance). Synchronous belts usually squeal with significant misalignment as the belt rubs the side flange on a sprocket. There are several acceptable methods for aligning belt drives, such as a straight edge, string, or a laser tool.

All three methods have a potential for error. The straight edge and string need to have two points of contact on one sheave. Some lasers with sights on the outside of the sheave may need to account for sheave flange thickness differences, while lasers with sights on sheave grooves may have to account for sheave wear.

Another best practice is to install sheaves with the least amount of overhang as possible. This reduces the resultant bearing reaction loads, hence improving bearing life.

When installing belts, be sure to loosen the adjustable base so the belts are not rolled on. Not only is rolling belts on a safety issue, it can cause damage to the belts and result in high shaft and bearing loads. If individual belts are used, do not mix new and old belts. This ensures belt length and stretch differences do not affect power transmission. It is also not advisable to mix belts from different manufacturers because length tolerances can vary.

The other thing to remember about powerbands is that the tension is given per strand, so the target belt tension must be multiplied by the number of strands in the powerband for the powerband's target belt tension. For wide, large, cross section powerbands, the belt deflection force method is generally not a feasible method due to very high belt deflection forces. When this happens, the powerband multiplier method may be used. The untensioned belt length (circumference) is measured with a Pi tape and multiplied by a multiplier to obtain a target circumference, hence stretch and belt tension.

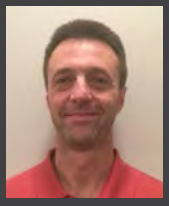
The newest method for setting belt tension is the sonic tension method. The belts are hit or strung to vibration naturally. A sonic measurement tool is

used to measure the frequency, typically in hertz. The belt tension is adjusted and the process is repeated until the actual belt's natural frequency matches the target belt frequency. The only limitations for this method are very low frequencies, typically less than 10 Hz, and noisy areas, which may pose a challenge in measuring belt frequencies.

One last, somewhat obvious reminder, but not always followed, is to never tighten belts on the run. The first concern is personal safety, as hold down bolts must be loosened. Equipment that is running is under load, so any temporary looseness will likely cause belts to slip. The other big issue is there is no way to measure belt tension on the run, so it becomes reliability roulette.

Conclusion

While performing maintenance on a belt drive may appear routine, to achieve best reliability requires precision practices and attention to detail. The journey to improved belt drive reliability begins with knowing and executing the basics.



Randy Riddell, *CMRP, CLS is the Reliability Manager for SCA located in Barton Mill, Alabama. He has over 25 years of industrial experience with a career focus on equipment reliability. He has a BSME from Mississippi State University.*
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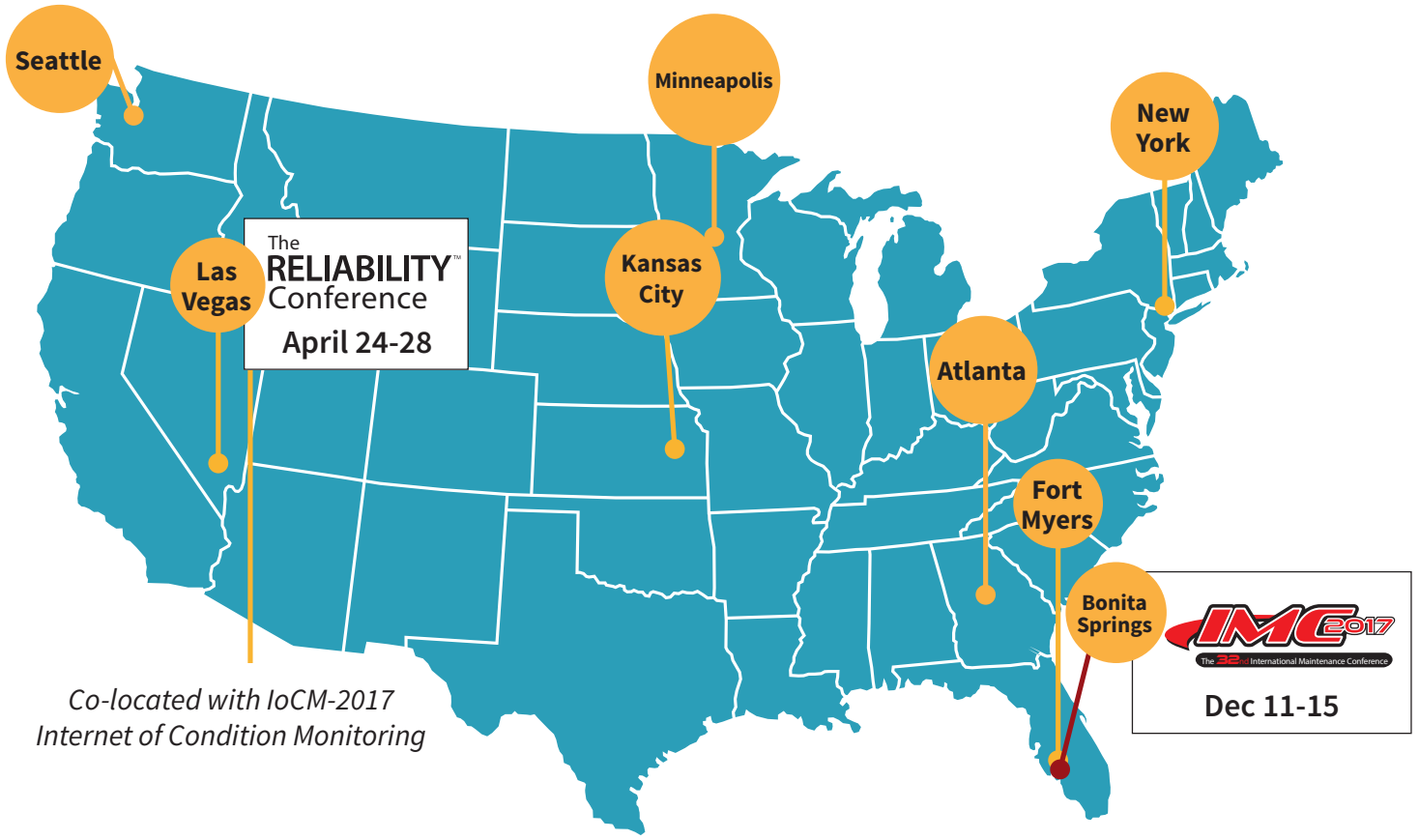
Continental U.S. Dates and Locations



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Asset Condition Management
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August 9-10
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New York, New York

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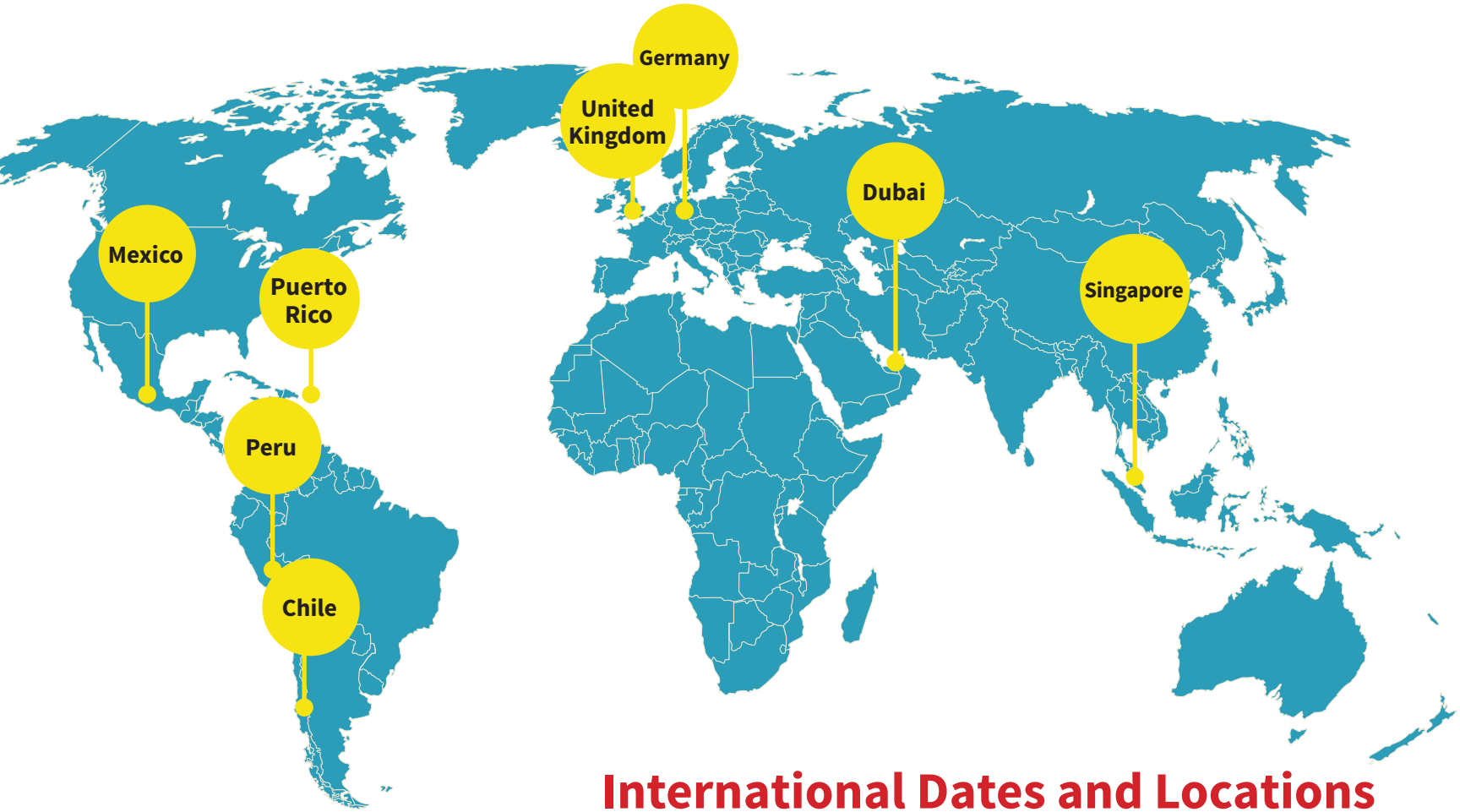

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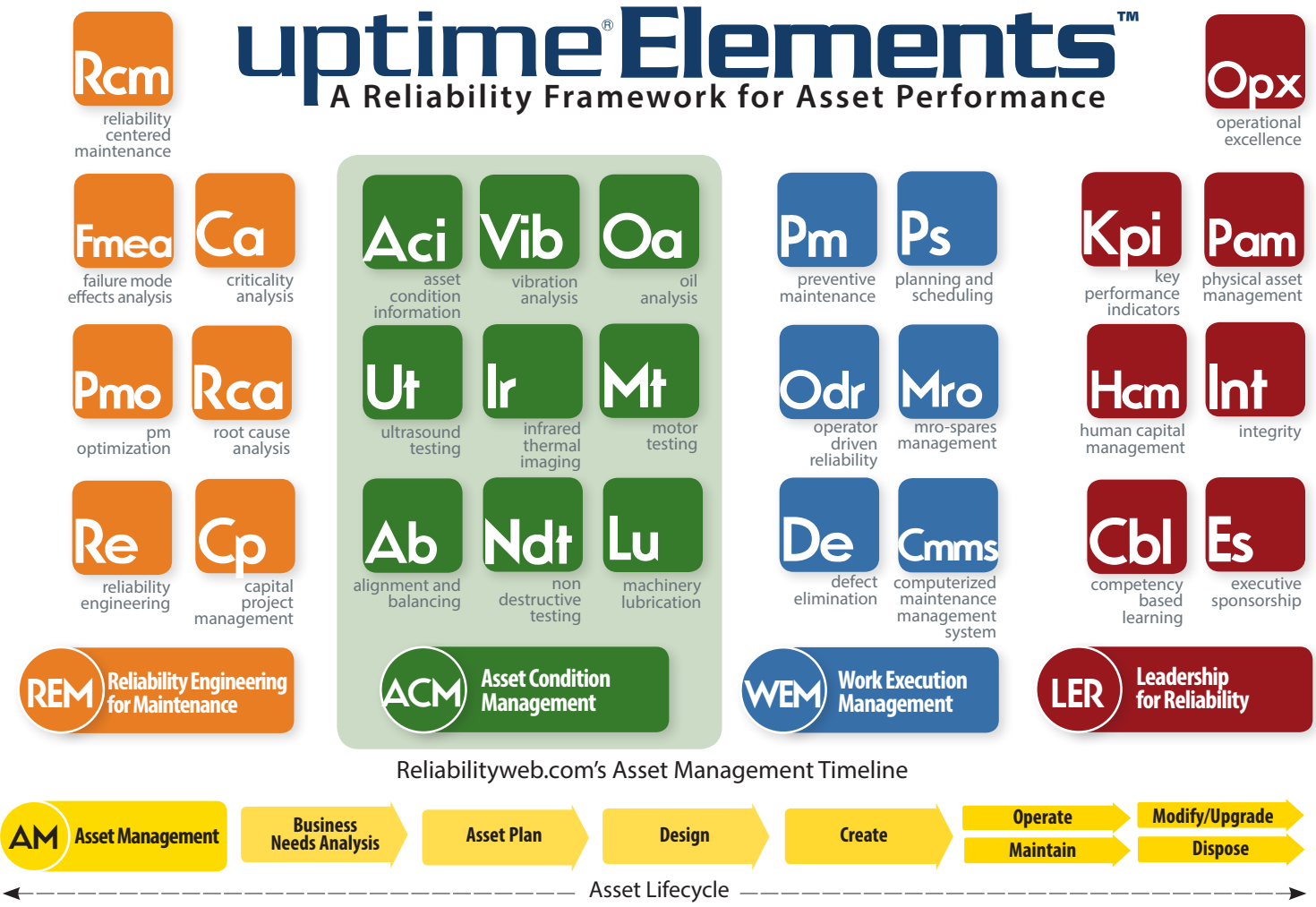
Condition-Based Monitoring and Acoustic Lubrication:

Bearings May Need Lubrication Prior to When "Scheduled"

by Jim Hall



Reliabilityweb.com's Asset Management Timeline

Figure 1: Uptime Elements™ Framework

Although many are utilizing ultrasound in their condition-based monitoring (CBM) program, many are still lukewarm about implementing the acoustic lubrication application as part of a CBM program. But here's why that application should be utilized.

The Uptime Elements™ framework includes five domains:

- Reliability Engineering for Maintenance (REM);
- Asset Condition Management (ACM);
- Work Execution Management (WEM);
- Leadership for Reliability (LER)
- Asset Management (AM).

Within the ACM domain, there is an element known as asset condition information (Aci). It comprises all the data, observations and conditions of an asset. This information is more than just current state; it is the cumulative condition of an asset over its lifecycle.

This approach enables day-to-day decision support and is a prognostic of future conditions. Therefore, data collected through CBM is a key component in Aci. This allows for the detection of early onset failure and is normally aligned to known failure modes. This would include vibration analysis, oil analysis, ultrasonic testing, nondestructive testing and any other methodology of analyzing the condition of an asset with regards to its deviation from its normal operating condition. The use of CBM to ascertain the onset of failures is only as valuable as the information collected.[1]

Acoustic lubrication is a program that can be implemented as part of a scheduled or unscheduled lubrication program. When implemented as part of a CBM program to assist with the identification of early signs of failures, the benefits can mean huge savings by reducing loss of production, loss of equipment (asset) and loss of man-hours from unscheduled maintenance.

CBM is a strategy that monitors for certain key performance indicators (KPIs) that may indicate signs of a lack of performance. These KPIs drive reliability while guiding your choices for improving maintenance. Unlike time directed (TD) tasks maintenance, which are maintenance tasks performed at predefined intervals, CBM maintenance is performed when the KPIs are indicating lack of performance or signs of a future failure.

> "The use of CBM to ascertain the onset of failures is only as valuable as the information collected."

Types of Condition-Based Maintenance

The types of technologies used for CBM include instruments and processes, among them:

- Vibration Analysis – vibration sensors, permanent or handheld;
- Infrared (IR) – IR cameras to detect high temperatures of utilized motors;
- Nondestructive Testing (NDT) – ultrasound used to detect cracks in welds, corrosion of pipes, or the thickness of metals;
- Ultrasound – used to detect leaks of gases or a vacuum;
- Oil Analysis – measure particles/sampling;
- Electrical – motor current analysis;
- Operational Performance – sensors throughout a system to measure performance.

When looking at this list of instruments and processes, the technology of ultrasound comes to the forefront. Ultrasound is defined by most technicians as leak detection of compressed air or gases. Or, depending on their background, ultrasound may mean ultrasonic NDT of welds or pipes for corrosion, or for thickness readings.

An effort must be made by industry to educate technicians and engineers in the differences of these two technologies. If your knowledge of ultrasound is limited to finding air leaks and NDT, then you truly lack a strong foundational understanding of the uses of ultrasound for maintenance inspections.

Ultrasound is used to detect leaks of compressed air or gases (positive or negative pressure); monitor motor bearings, acoustic lubrication and gear boxes; diagnose steam traps; and inspect electrical apparatus, such as transformers, electrical switchgear, substations, and distribution for the presence of arcing, tracking, or corona discharge (e.g., low, medium, or high voltages). Ultrasound detects high frequency signals above the human hearing range. That means in a noisy plant environment, ultrasound can detect electrical anomalies, compressed air or vacuum leaks, monitor the motor bearings, hear a gearbox failing, or detect that double spherical bearing being eaten up due to a badly misaligned short shaft connected to an agitator on the other side of the room.

Ultrasound is high frequency sound above 20,000 hertz or 20 kHz, a short wave that typically measures 1/8 inch to 5/8 inches long and is directional.

Ultrasound training from an experienced trainer/technician is most valuable when it is utilized in multiple applications or simply to complement other technologies, such as vibration and infrared.

CBM and Acoustic Lubrication

You can actually find CBM and acoustic lubrication mentioned in the same sentence by ultrasound manufacturers on the Internet.

- Is the practice of acoustic lubrication and CBM too **new** of an application?
- Are there too many skeptics regarding the practice of acoustic lubrication and CBM?
- Are there too many technicians unsure of the actual procedure to implement acoustic lubrication as a CBM program?

The response to the first question is probably, no, but yes to the others. Some skeptics do remain regarding acoustic lubrication, but they outweigh the frequent feedback from users on how the program is working well for them.

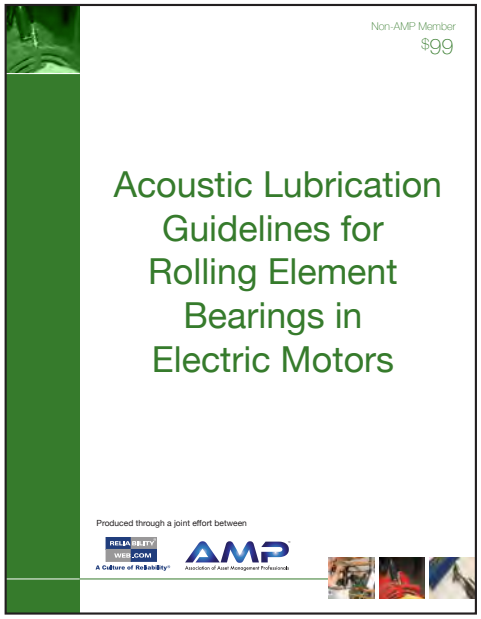


Figure 2: Many are reading the Acoustic Lubrication Guidelines for Rolling Element Bearings in Electric Motors

With hundreds of copies of the *Acoustic Lubrication Guidelines for Rolling Element Bearings in Electric Motors*[2] having been downloaded, one may reflect on the amount of downtime, lack of production loss and how a large percentage of motor maintenance is being reduced through the practice of acoustic lubrication. Someone is doing something right.

However, a large segment of ultrasound users have not implemented the acoustic lubrication practice correctly. When inflection points[3] are not adhered to, lubrication continues with possible adverse effects from over lubrication, such as premature bearings failure due to high temperatures, blown grease seals due to excessive internal pressure and possibly grease getting into the armature of the motor. Figure 3 shows a motor that ran inefficiently for several months due to grease working its way into the stator body and rotor assembly. Eventually, grease was distributed into the windings.

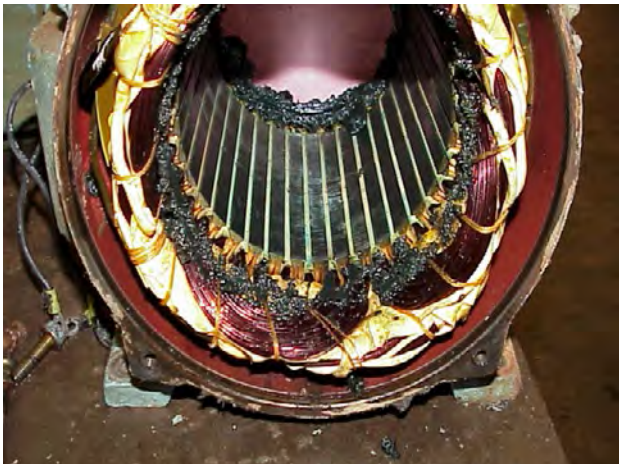


Figure 3: Over lubricated motor caused the motor to operate inefficiently due to grease insulating the windings

Acoustic lubrication is the use of a high frequency receiver or translator to detect sound that may relate to the condition of a motor bearing prior to lubricating the motor bearing.

Technicians should be trained to focus on the decibel because the rise in decibels means something is going wrong. Often times, technicians are told to focus on the sound of the bearing. However, what the practitioner hears through his/her own hearing may differ greatly from one person to another. The other problem with listening is that today's digital ultrasound instruments are not as revealing as yesterday's analog instruments. The highs and the lows are missing. For example, an analog instrument with frequency tuning allows the user to focus on certain sounds or conditions to detect brinelling[4], balls out-of-round or ball defects, inner and outer race defects and under or over lubricated bearings. It is, however, a digital age, so data logging and waveform analysis are part of it, especially waveform analysis. A down converted ultrasonic (above 20,000 hertz) recording, which takes the high frequency signal and converts it to low frequency so it can be used for ultrasound signal analysis or converted to a decibel, can reveal numerous conditions or faults.

Today, there are instruments that adapt to your grease gun and allow the end user to simply use the ultrasound instrument and magnetic or contact transducer to monitor a motor bearing during the lubrication procedure. This is very ef-

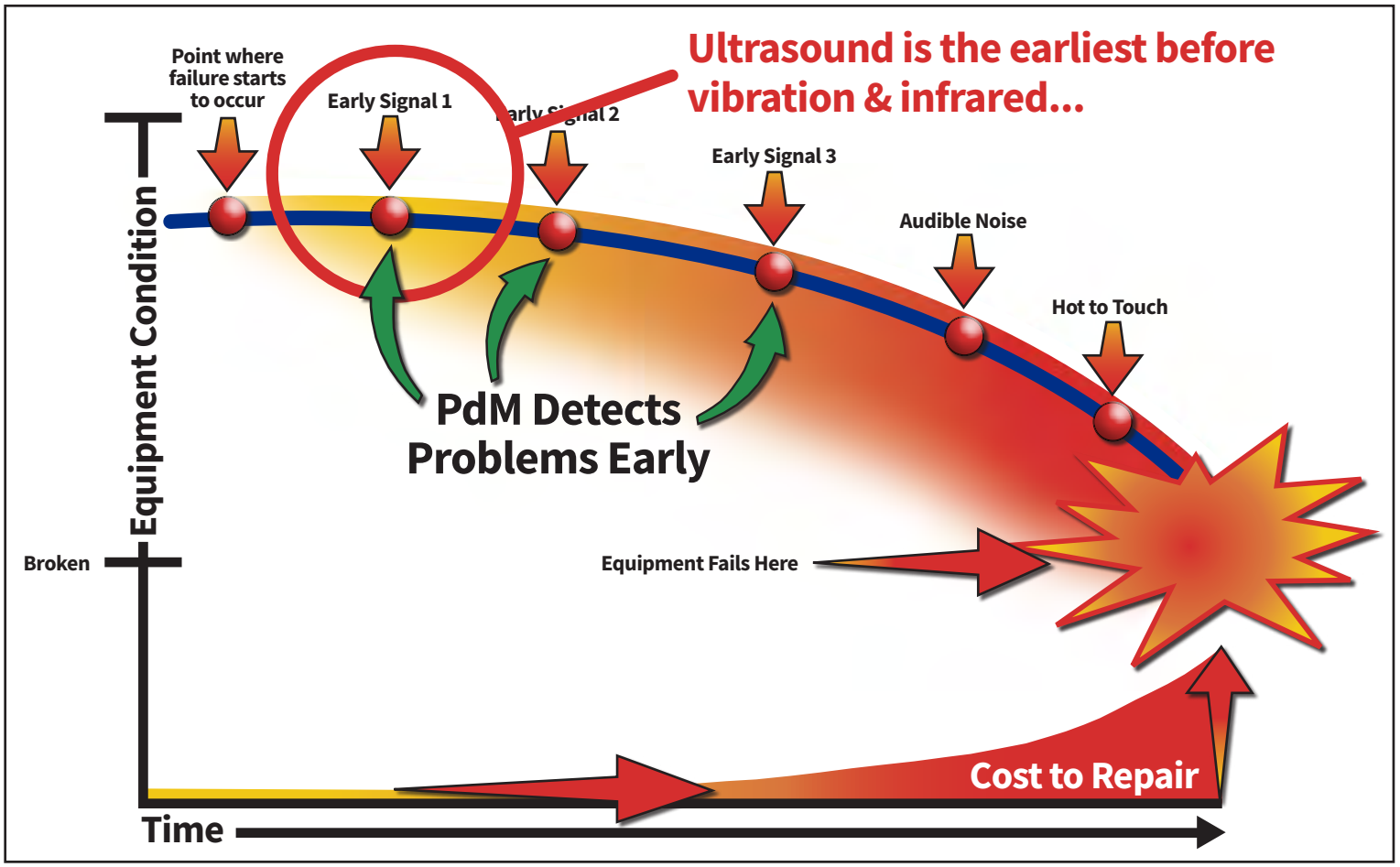


Figure 4: Ultrasound is the first detectable signal on the P-F curve

fective in preventing over greasing of the motor bearings.

Acoustic lubrication is a viable means for CBM. Why? Simply put, ultrasound is the first means of detecting a fault before vibration or infrared. Also, the learning curve to use and implement an ultrasound program is short.

A good understanding of ultrasound and the many applications this technology offers is recommended prior to implementing an acoustic lubrication program, such as the equivalent to an ultrasound Level I training course.

NOTE: Prior to starting an acoustic lubrication program, you should follow your local plant's recommendations and the original equipment manufacturer's suggestions for removing the purge port, plugs, or bottom grease relief valves, when applicable. You should also know the type of bearing to be lubricated.

Granted, there are many different ways and different configurations used to apply acoustic lubrication. One way includes the use of an ultrasound instrument "fixed" upon a grease gun for a one person, two-handed operation. Second, is simply taking an ultrasound instrument in one hand and a grease gun in another, which may or may not require a second person.

Here is an example of the procedure:

Once you have the instrument and grease gun ready, place the zurk or hook onto the lubrication point. Many technicians prefer a button and hook with a short connection to the ultrasound transducer because the tightness of the connection provides a more consistent and repeatable decibel.

NOTE: Within the acoustic lubrication practice, technicians are instructed to implement greasing if the dB level is 10 or more decibels above baseline.

As you start the procedure, you may notice the baseline was 35 decibels for this motor bearing, but your reading today is 48 decibels (13 dBs above baseline). Using a grease gun with a handle, you choose to use the preferred half stroke method versus the full stroke method of the grease gun for this application. After a half stroke, you pause three to four seconds; no reduction or increase in dBs is evident. After a second half stroke, you pause another three to four seconds and again, no dB drop or increase is seen. Then, after the third half stroke, you notice the dB drop is two dBs. Another half stroke, pause and another two dB drop is seen. You are now getting a smidgen of grease on the bearing. Another half stroke, pause, a three to four dB drop is seen. Another half stroke, pause, the dB rises. This is the inflection point. Pause 10 seconds. If the dB level doesn't return to the reading prior to inflection, you then log the reading and stop lubricating.

However, what if during the acoustic lubrication, inflection occurred (an increase of one to two dBs) after one half stroke of the grease gun? You should pause 10 seconds and if the dB reading does not return to where it was prior to inflection, you should stop the lubrication procedure. Do not continue greasing. Possibly, someone before you had lubricated the bearing. But, you say, "This

> "Simply put, ultrasound is the first means of detecting a fault before vibration or infrared"

> "One engineer documented savings of **37 percent less** motor maintenance after implementing acoustic lubrication into the CBM program."

Figure 5: A type of grease caddy *(Photo courtesy of UE Systems, Inc.)*

bearing is still 13 to 14 dBs above baseline? What do I do?" Well, you make a call to a vibration technician to analyze the motor.

Can you see where the goal of your CBM program to spot future motor/bearing failures can be achieved by adding acoustic lubrication? One engineer documented savings of 37 percent less motor maintenance after implementing acoustic lubrication into the CBM program. Isn't it time for your organization to realize savings, as well?

References

1. Referenced from the Uptime Elements Passport – Asset Condition Information (ACI) booklet
2. Download Acoustic Lubrication Guidelines for Rolling Element Bearings in Electric Motors: http://ultra-soundtech.com/tui/wp-content/uploads/2016/07/acousticlubrication.pdf
3. Inflection Point when used in acoustic lubrication is a point at which the decibel changes upward and not downward.
4. Brinelling is a process of wear in which similar marks are pressed into the surface of a moving part, such as bearings.

***Jim Hall** is the Executive Director at The Ultrasound Institute (TUI). Jim has been in the ultrasonic market for over 25 years and has trained many Fortune 500 Companies in the use of airborne ultrasound, including electrical power & generation, pulp & paper and automotive & aviation. Jim has been a contributing editor for UPTIME Magazine (ultrasound segment) since the magazine's inception.*
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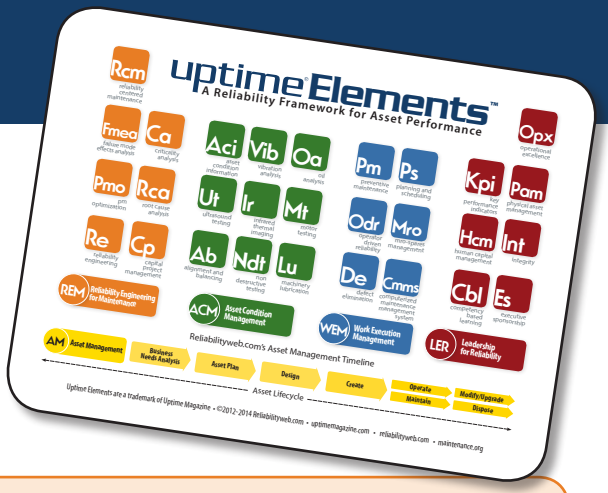

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- Blue Sky Reliability Consulting LLC — blueskyreliability.com
- nexus global — nexusglobal.com
- People and Processes — peopleandprocesses.com

ACM Asset Condition Management

- Lubrication Engineers, Inc. — lelubricants.com
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How to Develop an Industrial Internet of Things Solution

by Tomasz Puk

Phase 2: Research and Development

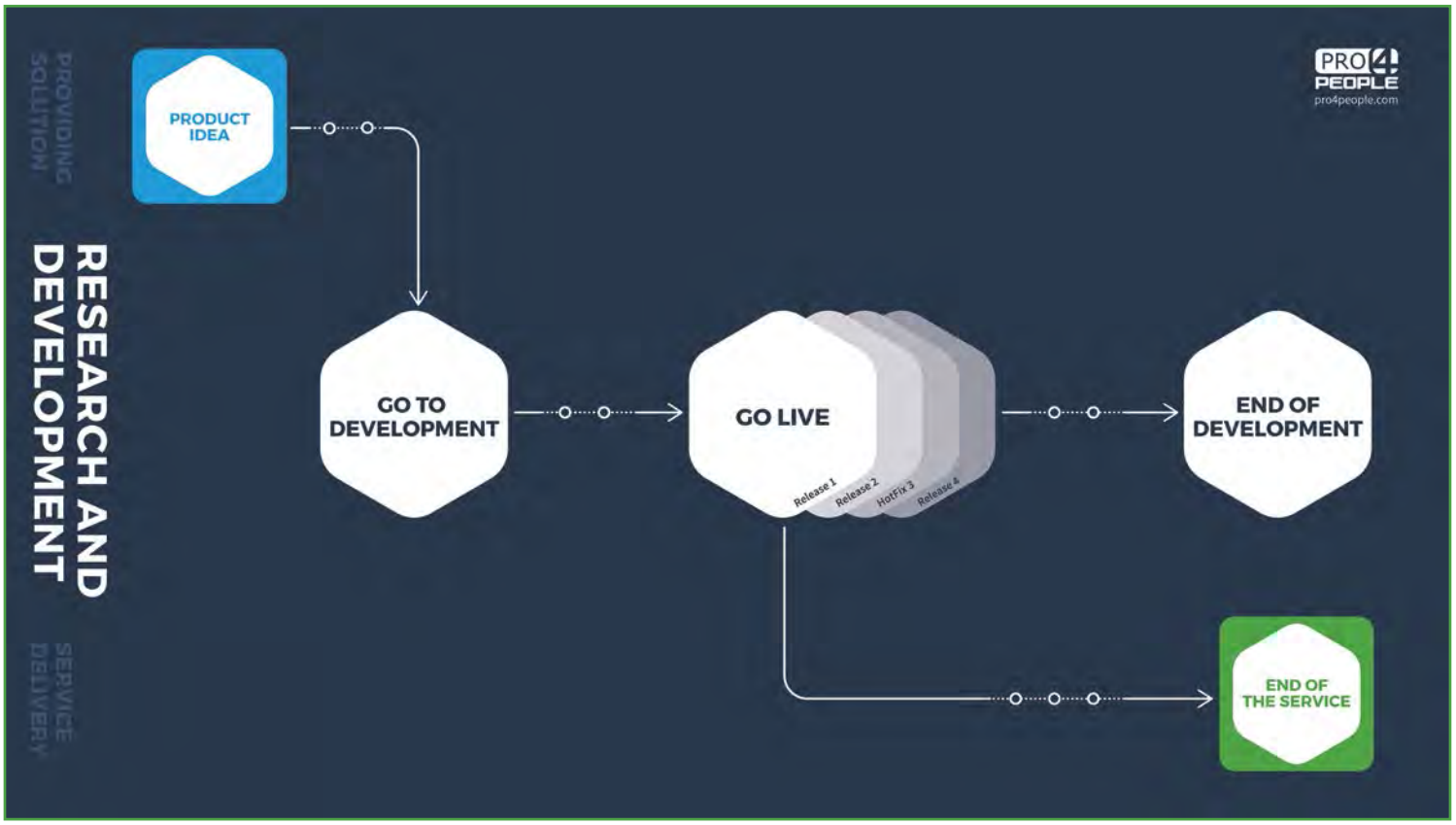

Figure 1: Main milestones of an IIoT solution lifecycle

This article, the third in the series (Feb/March 2016 and Aug/Sept 2016) about developing an Industrial Internet of Things (IIoT) solution, takes a closer look at the second phase: research and development (R&D). R&D starts with the go to development milestone, then continues to the first go live and subsequent releases until the final stop when the decision to finish the development is taken.

INTRODUCING RESEARCH AND DEVELOPMENT

At this point of the IIoT solution lifecycle, you should have all the outcomes of the *providing a solution* phase. You understand the business model and the value proposition of your product, defined the program/project structure, specified high-level solution architecture and chose technologies for product development. You have your business team in place and selected the technology partners/internal departments that will be engaged in the development.

As the outcome of the R&D phase, expect frequent releases (every 2 weeks) of an IIoT solution so your product team can contact your customers and early evangelists and engage them in the product's evaluation. The feedback will be then used to align the value proposition of your solution with actual market needs.

On the engineering side, expect frequent solution releases, specifications, designs, tests executions and engineering inputs to the future solution development road maps. Remember, an IIoT solution is more like a marathon, not a short distance run, so it is better to get ready for it from the very start.

PROGRAM STRUCTURE

The Figure 2 (see page 42) diagram shows how to structure your organization's solution in the R&D phase. A typical organizational structure consists of a business team; back end/front end project team(s); hardware project team; mobile project team; and service delivery team.

> "Remember, an IIoT solution is more like a marathon, not a short distance run, so it is better to get ready for it from the very start."

The Business Team

The business team is responsible for providing solution road maps that transform a defined value proposition into features and functions to be implemented by the engineering teams. Within the business team, there should be a product manager who is accountable for gathering all the requests/feedback from the program's stakeholders, filtering them with the current solution concept definition and presenting them as an input to the R&D team.

The business team takes R&D's intermediate version of a working solution and demonstrates it to customers. The feedback is used to fine-tune the solution's business model, as well as its further development plan. The business team is also responsible for defining and executing a sales and marketing strategy.

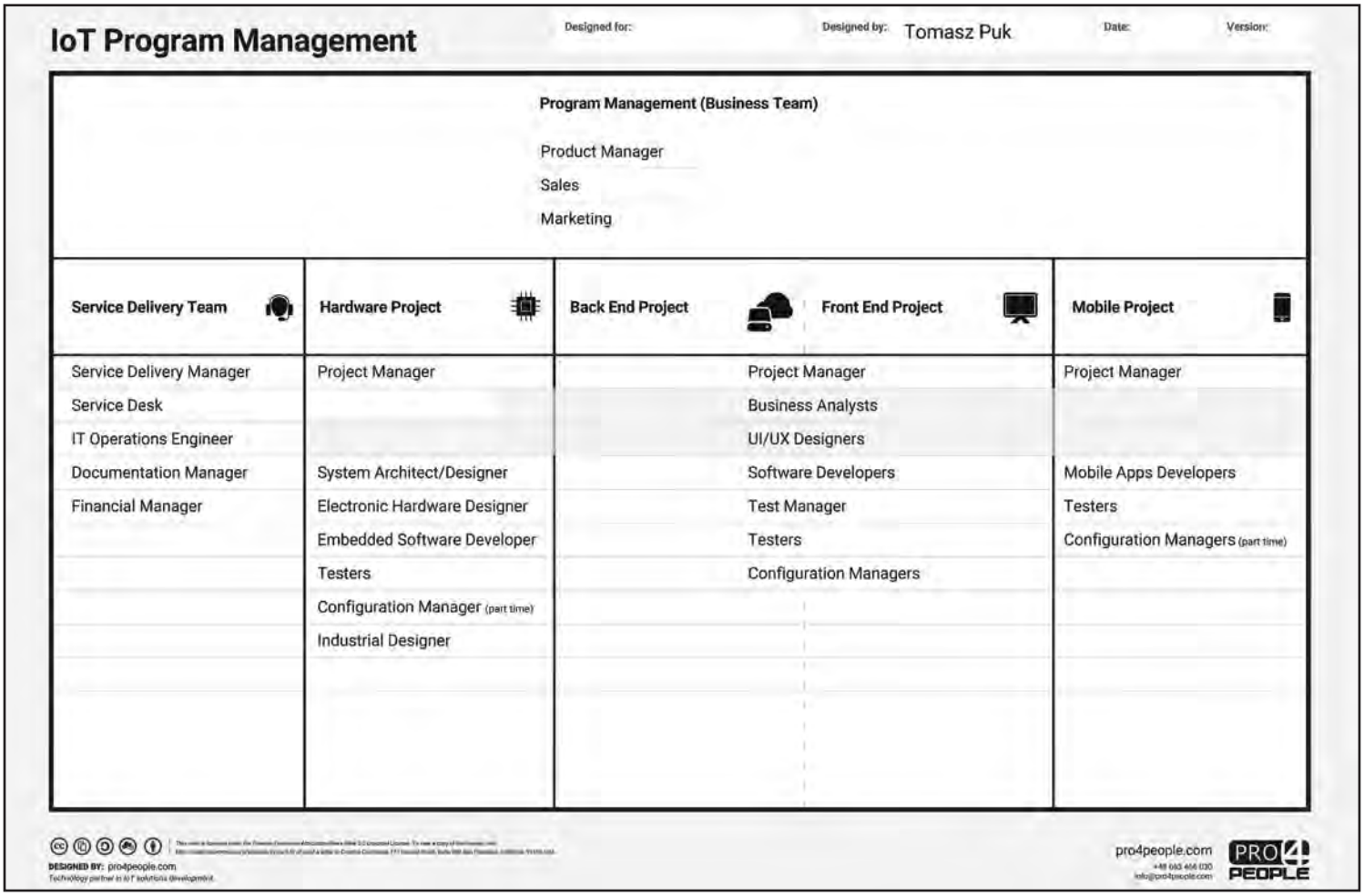

Figure 2: Sample IIoT program structure

The Back End/Front End Project Team

Figure 2 presents a single team for both back end and front end projects. The back end component represents a service, usually hosted on the Cloud, responsible for processing service logic and data storage. The front end component represents a web application that is used to access the service by end users.

The back end team develops a service logic to handle communication with edge devices and then turns the data into information. This is the very backbone of your solution. The front end team develops a web browser or native Mac/PC application that provides access and presents your processed information. This type of application is often used by business customers who highly value mobile applications, but still like working on convenient desktop/laptop platforms.

Within this project team, these roles should be covered:

- **Project Manager** – responsible for communications between the client, other program stakeholders and project execution.
- **Business Analysts** – gather the solution concept from the product manager and turns it into specifications used later by the other teams. Individuals in this role should have a full understanding of the solution from the functional perspective of all IIoT program elements.
- **UI/UX Designers** – design a user interface and are responsible for the user's experience of the overall IIoT solution.
- **Software Developers** – responsible for writing the code and providing designs.
  - **Solution Architect** – in charge of the overall solution architecture and communicating it to all program stakeholders.
  - **Tech Lead** – supervises the project from the technology perspective and resolves any technology questions.
- **Test Manager** – defines testing strategies and tests levels crucial for the final approval of product releases.
- **Testers** – test design and execution activities for software packages and any activities within project execution.
- **Configuration Managers** – in charge of managing IT infrastructure and the solution's environments.

Due to the R&D characteristics of an IIoT solution, the business analyst, UI/UX designers and solution architect roles should be shared among all project teams making up the final IIoT program. The business analyst specifies a **common** consistent vision of the solution shared among all projects; the UI/UX designers turn the vision into a **common** user experience along all IIoT elements; and the solution architect creates **common** solution architecture that all projects must follow.

Hardware Project Team

The hardware team designs, implements and prepares edge devices for manufacturing. The structure of a sample hardware team is:

- **Project Manager** – secures communications between the program and the hardware team and coordinates hardware development activities.

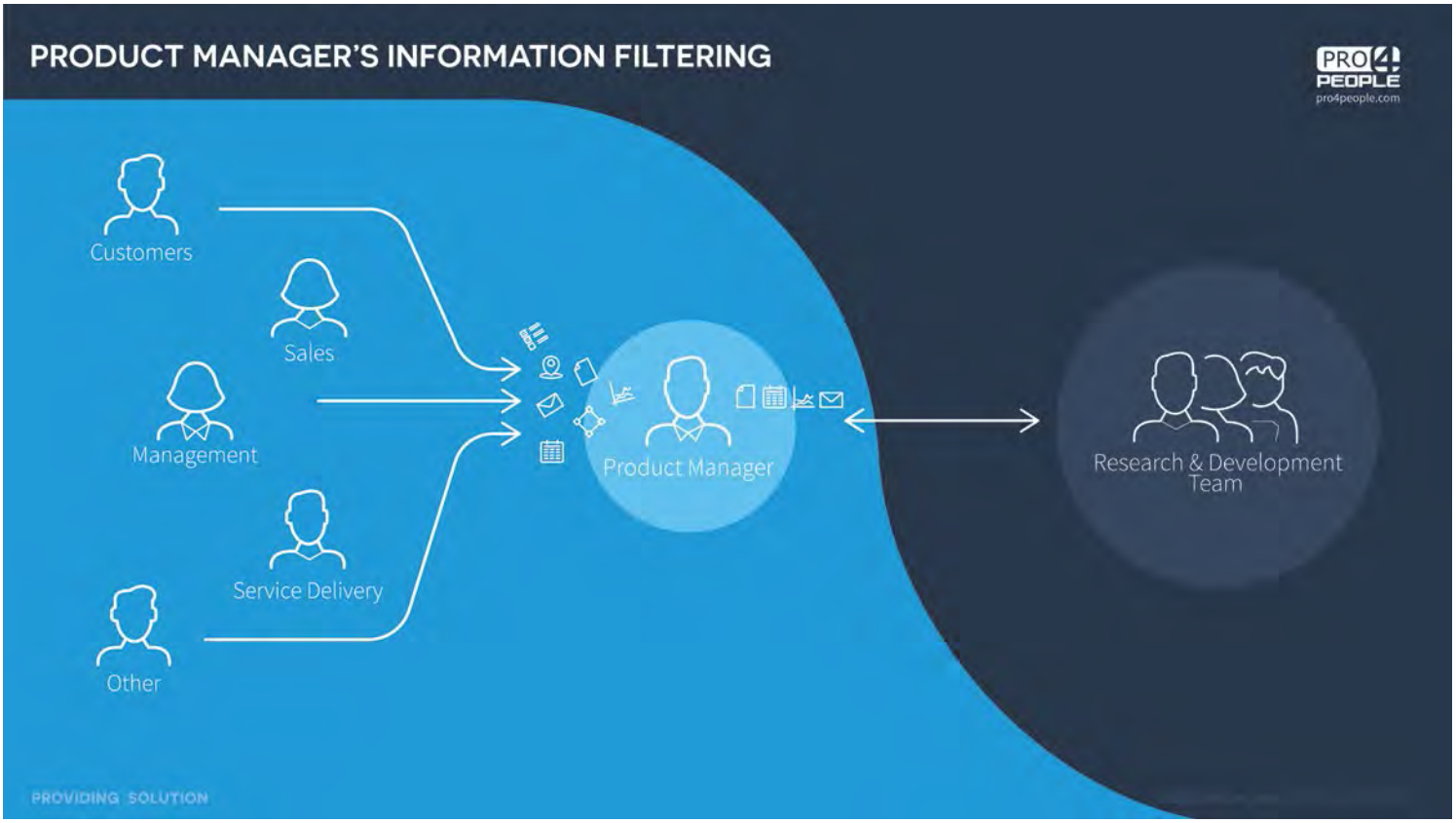

Figure 3: Business team input into R&D phase

Figure 4: Research and development execution overview

You should have not only competent teams but a structured approach to Research & Development processes with a strong focus on collaboration as well.

- **System Architect/Designer** – in charge of design decisions, decomposition into hardware/software components and final system architecture. The individual in this role should have an in-depth knowledge of both hardware and software components of the embedded devices.
- **Electronic Hardware Designer** – handles digital and analog circuit designs, printed circuit board (PCB) designs and components selection.
- **Embedded Software Developer** – develops the embedded software and the corresponding automatic tests.
- **Testers** – perform test strategy development for the hardware project and test designs and execution.
- **Configuration Manager** – responsible for managing environments, bill of materials (BOM) for the edge device, the release of the edge device and its identification along its lifecycle.
- **Industrial Designer** – designs the physical aspect of the product that will be aligned with its intended use, attractiveness and feasibility to manufacture at a reasonable cost.

The primary outcome of a hardware project is a physical device to be manufactured. Thus, the hardware team collaborates closely with other project teams, as well as the external organizations responsible for manufacturing and assembling the edge device.

Mobile Project Team

The mobile project team designs and develops mobile applications for the IIoT solution. On the one hand, mobile applications may be used to communicate with the edge devices, such as during the initial configuration. On the other hand, they let end users utilize the solution in the immediate proximity of monitored objects and play an important role in end user communication. Mobile apps communicate with the back end component to retrieve and present data through the mobile application.

Members of the mobile project team have similar roles as the back end/front end team: project manager; business analysts; UI/UX designers; mobile apps developers; testers; and configuration managers. Organizations developing a mobile application for both iOS and Android platforms can reuse some common designs and specifications, but both applications have to be developed independently.

AGILE / MATURITY / COMPETENCIES PARADIGMS

The next area to discuss is the development paradigms. The first one is Agile/Lean approach. Embrace the fact that you are not going to fully understand your product before the Research & Development phase. Assuming that you have done a good job in the Providing a Solution phase, you have proven that your business model is going to work. Now, with the Research & Development, you should use frequent IIoT solution releases (every 2 weeks) to present your product to users and turn their feedback and information into the development roadmap and the updated solution's value proposition. This approach to development is described more broadly in *The Four Steps to the Epiphany*[1] book and is reflected in such development methodologies like Agile or Scrum.

With the level of complexity required to develop an IIoT solution, the agile methodologies are not sufficient to manage it alone. Five different project teams working jointly on a quite complex business/engineering program needs a structured approach to R&D processes with a strong focus on collaboration to execute efficiently. On the management side, methodologies, such as project management body of knowledge[2] and information technology infrastructure library (ITIL)[3] provide that structure.

In addition, other tools should be incorporated to enhance communications and program execution, such as:

- Confluence – wiki like team collaboration platform, with the ready-to-apply collaboration templates
- JIRA – issue and project tracking system
- ins2outs.com[4] – a quality and know-how collaboration platform where all the roles and processes have been documented; also can be used to structure service delivery processes;
- Amazon Web Services (AWS) – as the primary vendor of IaaS services

Developing an IIoT project requires a mix of managerial, technology and business skills. Therefore, you should look for employees or business partners that have already taken part in the development of such solutions. You should be looking for managerial competencies proven with project or program management certification. Technology competencies should be based on people who have worked on complex projects and have experience in technologies that are fit for use in IIoT solutions. Equally important is expertise in one of the Cloud platforms, as your IIoT solution will more than likely use one of them. In terms of business skills competencies, look for partners who can help you address challenges in the IIoT product lifecycle. If this is your first IIoT project, remember the flows in the business model and value proposition are the hardest to fix in the project execution, so strong business skills will be of great value.

TIME TO MARKET

With some IIoT projects, the R&D phase may close within 12 months, starting from the go-to-development milestone to the go-live version release. That time includes recruitment, all program components development and releasing the solution to the IT infrastructure. That proves that the IIoT's first version development can be accomplished in a relatively short time. However, it would be a mistake to think that the IIoT R&D phase is over then. Usually, it continues incrementally, focusing on product development beyond the minimum viable product (go live) release.

DEVELOPMENT PROCESS FLOW

So, how should you structure a "typical" IIoT program development process flow? Figure 4 represents an example of one such.

Divide your program into three-month planning increments. For each of those phases, prepare a program road map that is agreed upon among the product manager, project managers and business analysts. At the end of each three month period, schedule a joint release from all program components.

Then, business analysts start their work preparing specifications for both back end/front end and mobile projects. The hardware project manager, together with the system architect/designer, prepares the same plan for the edge device development. The high-level plan for the next three months is agreed upon, as well as the approach for integrating all program components and their acceptance criteria specified.

Next, divide project execution into two-week sprints. Business analysts start working on more detailed specifications in the form of user interface mock-ups, user stories, requirements, or any other designs for the upcoming sprint. Each project team takes those specifications as input to plan the next two-week development period.

Within a sprint, UI/UX designers turn UI mock-ups into final UI/UX designs. Developers implement the functionalities of the solution based on the specifications, UI/UX designs and in accordance with the documented solution architecture. Testers independently verify the outcomes of that

work and also extend test specifications with the new test conditions. Testers use the specifications from business analysts as the basic criteria for verifying the implemented work. The configuration manager creates/updates the environment installation manuals and version deployment manuals that later will be handed over to the service delivery team.

At the end of each sprint, release the new projects' functionality and deploy the solution to one of the presentation environments, such as a Cloud-based web service, so it's available to all program stakeholders.

At the outcome of each sprint, the business team has a new live solution version ready to try out and can evaluate it with customers and other IIoT solution stakeholders. Use the feedback from such meetings to adjust the product development's direction to current market needs.

Next, prepare the final solution release. The release tests plan is executed in order to prove that the release meets specified acceptance criteria. The release package is then delivered to the service delivery team for planning the deployment/transition on the production environment. Then, a new cycle for the next three months starts with the same activities.

RESEARCH AND DEVELOPMENT CONCLUSION

The approach to the R&D phase poses all the challenges of developing an IIoT program with all the software, hardware and organization components. Still, with a proper team in place and the use of the agile/maturity/competencies paradigm, the development of such a system should not be a challenge to a competent and experienced team. Just remember, your first go-live IIoT solution release can be as close as only 12 months from now.

The next article in the series will focus on Phase 3: Service Delivery. Be sure to read it in the next issue of *Uptime*.

References

1. Blank, Steve. *The Fours Steps to the Epiphany*, Second Edition. Palo Alto: K&S Ranch Publishing, 2013.
2. Project Management Institute. *Project Management Body of Knowledge (PMBoK) Guide*. 2013. http://www.pmi.org/pmbok-guide-standards/foundational/pmbok
3. AXELOS. *ITIL Best Practice Solutions*. https://www.axelos.com/best-practice-solutions/itil
4. Quality and Know-how Collaboration Platform. ins2outs.com

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MEMS ACCELEROMETER PERFORMANCE COMES OF AGE

by Ed Spence

In the June/July 2016 *Uptime* article, "Condition Monitoring and MEMS Accelerometers: What You Need to Know," several attributes of micro-electromechanical system (MEMS) accelerometers were presented that make the technology compelling for condition monitoring applications. This article reviews data demonstrating the state of MEMS technology development and performance levels by comparing it to a commercially available piezoelectric (PZT) condition monitoring accelerometer.

Investment in MEMS process technology, coupled with design innovations, have greatly improved MEMS performance, enough to make MEMS a viable option for a wider range of condition monitoring applications. Accelerometers with resonant frequencies up to 50 kHz and noise density levels down to 25µg/√Hz are now possible with specialized MEMS structures and process technology. Careful design of signal conditioning electronics fully exploits the low Brownian motion noise of these new accelerometers.

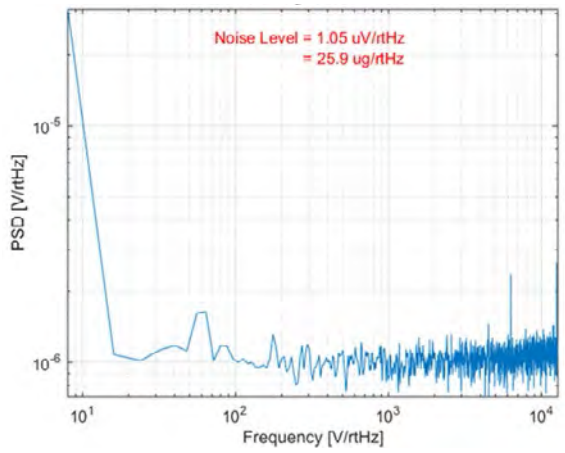

Figure 1: The noise spectral density plot for a new, high frequency accelerometer

Performance and Comparison Data

In order to assess whether the newest MEMS accelerometer would be suitable in a condition monitoring application, measurements were taken side by side with a commercially available PZT-type condition monitoring accelerometer. To ensure both sensors had similar mass and were subject to the same stimulus, the MEMS sensor was adhered to the case of the PZT sensor. The single supply analog output of the MEMS accelerometer was inputted directly into the analog input channel of the same data logger as the PZT sensor. A data acquisition instrument (DAQ) was used as the acquisition system for these experiments.

Motor Misalignment Simulation

A real-world scenario, such as the one described in *Vibration-based Condition Monitoring,*[1] was recreated on a vibration tester in an effort to compare devices using a known stimulus. This example outlined the vibration levels for a gas turbine running at 5100 rpm (85 Hz) and a synchronous generator at 3000 rpm (50 Hz) running misaligned. The scenario describes the frequencies and amplitudes that the vibration system was programmed to produce using the random vibration test mode. Table 1 lists the amplitude measurements at the frequencies of interest for both devices.

Table 1 – Motor Misalignment Simulation Set Point

Tone #	Frequency Hz	Level(s) g pk
1	50.00	0.400
2	85.00	0.400
3	100.00	0.250
4	170.00	0.250

Figure 2 shows resulting frequency spectrum measured for the MEMS accelerometer with 21 kHz resonant frequency and the PZT sensor with 25 kHz resonance. The root mean square (RMS) output of the MEMS accelerometer in the band from 1 Hz to 1 kHz is higher than the PZT accelerometer by approximately 30 mg, or 1.7 percent.

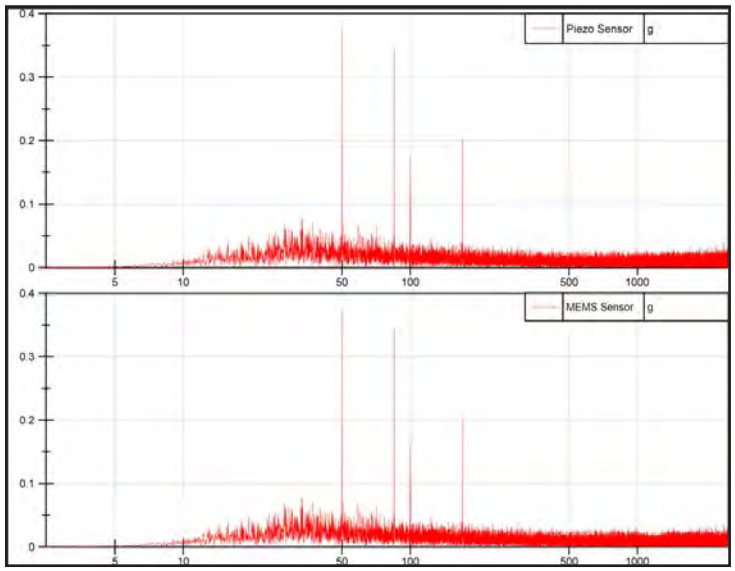

Figure 2: Noise density spectrum for PZT accelerometer (top) and MEMS accelerometer (bottom); results are nearly identical up to 10 kHz, with a key difference in the low frequency response of the MEMS accelerometer

Unlike the PZT device, the MEMS device has a direct current (DC) response, which is of interest for very low frequency machines, such as wind turbines (also enables a faster recovery from saturation). Since the frequency response of the vibration stimulus system rolled off at very low frequencies, the response for both devices were tested by "tapping" the test jig and capturing the resulting responses. The recorded time domain measurement was then transformed to the frequency domain. The results are shown in Figure 3. Note that the MEMS accelerometer was able to record a response down to DC.

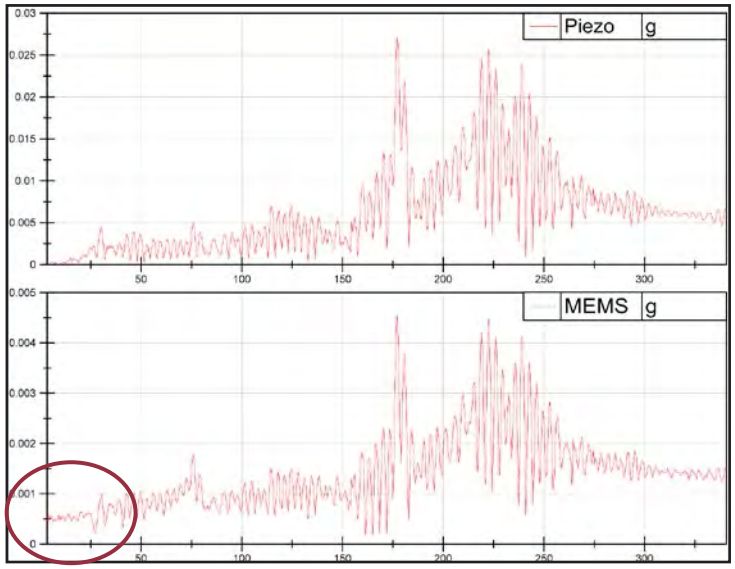

Figure 3: A comparison of the response of both accelerometers when tapped

Conclusion

The MEMS performance with the analog output driving the DAQ directly achieves good results comparable to the PZT sensor. This suggests that MEMS accelerometers are good candidates for re-architected output channels of new condition monitoring products, in particular enabling entirely new concepts based on semiconductor components that run on a single +5V power supply, such as wireless smart sensors.

> "Investment in MEMS process technology, coupled with design innovations, have greatly improved MEMS performance"

On the surface, the first generation accelerometer appeared attractive for this application due to the high frequency resonance (22 kHz) and high full scale ranges (FSR) of ±70 g, ±250 g and ±500g. Unfortunately, the noise level is 4 mg/√Hz, unacceptably high for most condition monitoring applications. For the second generation device used in the comparison, noise is reduced two orders of magnitude from the first generation, while power is reduced to 40 percent. Table 2 summarizes the performance comparison of both MEMS accelerometers, highlighting the improvements in performance.

Table 2 – Key Specifications Comparison of 1st and 2nd MEMS Accelerometer Generations for Condition Monitoring

	1st Generation Accelerometer	2nd Generation Accelerometer
FSR	±70 g to ±500g	±50 g to ±100 g
F0	22kHz	21kHz
Supply Current	2.5mA	1.0mA
Self Test	Yes	Yes
Temp Range	-40C to +125C	-40C to +125C
Package	5 x 5 mm 8 pin LCC	5 x 5 mm 32 pin LFCSP
Noise Density	4mg / √Hz	<30 µg / √Hz

The convergence of electronic signal conditioning expertise and the development of high resolution MEMS accelerometers have enabled performance capable of serving condition monitoring applications. High frequency MEMS accelerometers with low levels of physical noise, coupled with high performance, low noise, highly stable signal processing design techniques, address the fundamental limitations that have previously kept MEMS from offering performance comparable to contemporary PZT-based condition monitoring sensors.

Reference

1. Randall, Robert B. *Vibration-based Condition Monitoring*. Hoboken: John Wiley & Sons, 2011.

Acknowledgements

Special thanks to Juan Chong of Analog Devices for providing the data for this article.

Ed Spence *is the Marketing Manager responsible for high performance accelerometers for the Industrial Sensors Business Unit at Analog Devices, Inc. Analog Devices designs and manufactures high performance inertial sensors (e.g., accelerometers, gyros), as well as highly integrated solutions, such as inertial measurement units (IMUs). www.analog.com*

The Soft Stuff Really Is the HARD Stuff

by Ron Moore

You have probably heard the phrase, "the soft stuff is the hard stuff," meaning that the tools and techniques are actually easier to do than the "softer" issues, like leadership, alignment, teamwork and managing cultural change. Consider, for example, the finding of a Harvard Business Review study of some 200 management tools, such as total quality management (TQM), enterprise resource planning (ERP), etc., used in 160 companies over a five-year period.

> *"Most of the management tools and techniques we studied had no direct causal relationship to superior business performance."*

Supporting this conclusion are various reports that indicate the more popular tools and techniques do not have a very high success rate. For example, Bob Williamson, an industry expert in total productive maintenance (TPM), estimates that some 60 percent of TPM programs fail after three years of effort and 98 percent of 5S programs in the U.S. over the past 15 years have failed.

Furthermore, Jeffrey Liker, an industry expert in lean manufacturing, estimates that less than one percent of U.S. companies are effectively applying lean principles. Reliability expert Tom Dabbs states that some 70 percent of

manufacturers have tried to apply some form of lean manufacturing, but of those, only two percent were satisfied with the results and nearly two-thirds saw no improvement.

Also, Neil Bloom, an industry expert in reliability-centered maintenance (RCM), estimates that over 90 percent of all RCM programs initiated are never successfully implemented. *Uptime* Publisher Terrence O'Hanlon says his surveys indicate that more than 60 percent of manufacturing organizations have doubts regarding their root cause analysis efforts as they relate to management buy-in, implementation of recommendations, triggers for doing the analysis, program structure and communication of results.

Most of these tools have been around for decades, are well understood and have adequate resources for developing and implementing them, either through external consultants or internal experts. So, what's the problem?

THE SOFT STUFF

Observations over the years have shown that the very few companies that have had the greatest success in improving reliability and operational excellence have been those that effectively addressed issues around leadership, or more accurately, sponsorship, as well as alignment of the organization, teamwork, including cross-functional teams as needed, and certainly not least, managing cultural change.

In most all other companies, any number of technically-oriented programs (e.g., tools and techniques) start, have some initial success and then fade away. This usually occurs for various reasons – the "champion" leaves; the manager driving the program moves on; new senior corporate management comes in with new ideas about how things should be; the union leadership refuses to go along; only three or four percent of the workforce participates in solving specific problems, leaving the other 96 percent to wonder, "What are those guys doing? That doesn't help me;" or other less common issues.

So, what's missing? It's usually issues related to leadership/sponsorship, alignment of the organization, teamwork within and across organizational boundaries and managing cultural change. And, it begins with leadership creating the environment for assuring alignment, teamwork and cultural change. The soft stuff really is the hard stuff.

LEADERSHIP

What is leadership? I have read several books on the concept of leadership. My personal definition of leadership is:

> *"The ability to inspire ordinary people to consistently perform at an extraordinary level."*

Ordinary people is not meant in any pejorative sense, but rather putting really good systems in place that allow people to thrive, along with the company.

Winston Ledet provides a simpler and direct explanation of this principle in his model for leadership. He defines a leader as anyone who has followers. Leadership floats to the person best qualified to eliminate the source of any defect, that is, the nature of the work determines who is in the lead position. In his model, rank is not equal to expertise, so the lead position can come from the top or bottom depending on the situation and is found in a relationship of leaders.

In general, Ledet says there are three types of leaders:

1. Executive leaders provide vision and resources;
2. Operational leaders provide time for workers to improve;
3. Network leaders, most often found on the shop floor, provide the ideas for improvement.

With this approach, you also get better alignment, since executive leaders provide the vision and resources, and operational leaders the time, but the shop floor is actually providing most of the ideas for improvement. They're engaged and have a sense of purpose and ownership. It's a well-known fact that if you want to understand problems with the work, ask the workers and get them involved in making things better. This also addresses the issue of teamwork and cultural change.

Moreover, it extends the concept of leadership to sponsorship. Too many leaders make pronouncements about some major initiative, appoint someone to "lead" it, and then walk away, expecting it to happen. This is not leadership, or sponsorship, but rather it is merely permission, and generally does not work. Ledet's model explains more fully the concept of sponsorship and active engagement in driving any initiative until it is embedded in the organization.

With this in mind, here are more specifics on how to better align an organization, get better teamwork and manage cultural change.

ALIGNMENT

According to a survey by Harris Interactive, Inc.:

- 37 percent of employees had a clear understanding of what the organization was trying to achieve;
- 20 percent were enthusiastic about organizational goals;
- 20 percent of employees saw a clear connection between their tasks and organizational goals;
- 15 percent of employees felt the organization enabled them to achieve their goals;
- 15 percent of workers felt they were in a high trust environment;
- 10 percent felt their organization held people accountable;
- 13 percent felt there was a highly trusted, highly cooperative working relationship with other groups or departments.

Consider the consequences of this survey if you were a coach and your team's athletes felt this way. The consequences would be similar in any company.

According to organizational development expert Edgar Schein, the process of organizing creates naturally competing groups – shifts, plants, divisions, etc. More importantly, ***as task interdependence increases, teamwork and collaboration become increasingly critical for organizational effectiveness*** (e.g., production and maintenance, between shifts, between marketing and manufacturing). Overcoming this tendency to compete requires the creation of superordinate goals that take priority over group interests. As such, leaders must constantly remind people to focus on the higher level goals and to think at a systems level. In other words, don't optimize at the suboptimal level in your little silo. Instead, ask, "What effect will this have on the system?" And finally, performance measures must include shared measures between "competing" groups and partnership agreements that assure collaboration.

TEAMWORK

When task interdependence is high, such as between production and maintenance, cross-functional teams are often essential. In that context, effective teamwork requires that:

- Teams have a clear purpose and direction aligning business interests and individual interests.
- Boundaries for the team assignments are given, but there is self-determination within those boundaries, with an understanding that a common business purpose must produce results.
- Openness and cooperation are stated expectations.

Figure 1: Managing cultural change

- Verification of skills to operate within the boundaries or applicable training is necessary.
- Discipline and measurement of effectiveness as to its impact on the business are implemented.
- Continuing feedback and support, along with some flexibility to address changing needs (e.g., boundaries, training, measures, etc.), are provided.

Applying these principles will provide for better outcomes and facilitate greater cooperation, particularly across functional boundaries.

MANAGING CULTURAL CHANGE

First, it's important to understand that managing cultural change is an ongoing effort, not something you do once and it's done. It requires continuous effort. An effective model for managing cultural change is provided in Figure 1.

The heart of this model is engaging all employees in the change process. Many claim that, "People don't want to change." Actually, they do, but only:

- ***IF*** given compelling reasons for change;
- ***IF*** there's something in it for them, for example, a more secure future, better pay or rewards, less stress and hassle, or less personal risk or fewer injuries;
- ***IF*** they participate in creating the changes, giving them a sense of ownership, purpose and control. To support this, you must set up routine, periodic, structured improvement time, such as small action teams; train and apply the appropriate tools for their needs; remove the obstacles from their success; routinely solicit and act on their ideas for improvement; and show gratitude and appreciation for their contribution.

All three ***IFs*** must be met to align employees' personal interests with the company's interests. As Margaret Wheatley, management consultant and organizational behavior expert, said: "People own what they create." You must help your employees create by giving them a sense of purpose, control and ownership!

CONCLUSION

For the greatest success in reliability and operational excellence, executive sponsorship is essential. Remember, simple permission is not sponsorship or leadership! Active engagement by the leadership is essential. You must also have a good production and maintenance partnership, among others, which includes clear goals and expectations that are reasonably achievable. To support this partnership, there must be *shared* key performance indicators (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 routine, structured improvement time.

This way of thinking will help you better manage the soft stuff. It's the hard stuff!

Ron Moore *is the Managing Partner for The RM Group, Inc., in Knoxville, TN. He is the author of "Making Common Sense Common Practice- Models for Operational Excellence," 4th edition; "What Tool? When? – A Management Guide for Selecting the Right Improvement Tools," 2nd edition; and "Where Do We Start Our Improvement Program?," all from Reliabilityweb.com, and "Our Transplant Journey: A Caregiver's Story" and "Business Fables & Foibles," both from Amazon.com, as well as over 60 journal articles.*

A Two-Plane Balancing Solution for the Lag Phase Measuring System

by José A. Méndez-Adriani

A balance program developed for the lead phase measuring system was used for searching the effective two-plane balancing solution for the lag phase system of measurement for an overhung rigid rotor.[1] This article presents the mathematical expression of the solution and its validation from the results of a test for two-plane balance by comparing calculated values using experimental data.

Overview

For a balancer designed for one-plane balancing that utilizes a lag phase measuring system, the phase angle is computed as if the vibration event occurs first, followed by the tachometer event, with the rotating scale convention. It was demonstrated that it is equivalent to utilizing the usual lead phase measuring system, which computes the phase angle as if the tachometer event occurs first, followed by the vibration event with the fixed scale convention, but in the same coordinate system associated to the rotating scale convention where the phase angles are measured in a sense opposite to the rotation. Additionally, it was demonstrated for an overhung rotor that the interference ratio between the correction planes is reduced when employing the effective method of influence coefficients.

For two-plane balancing, it was demonstrated that it is possible to utilize the standard solution to find the effective static couple solution by

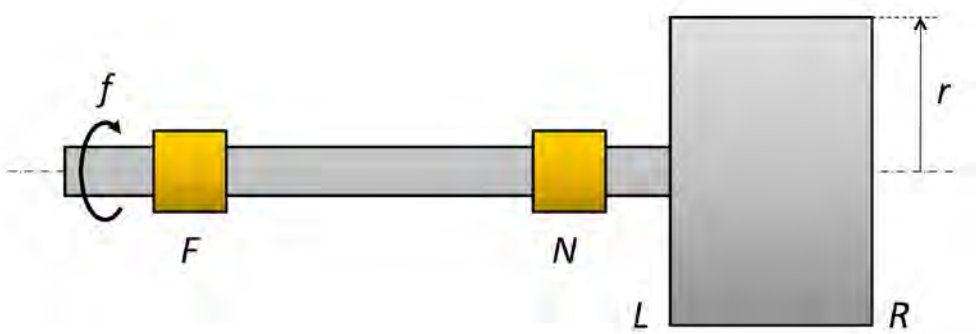

Figure 1: Overhung rigid rotor

employing a pair of trial weights during the third run and assuming that the left correction weight is interpreted as the quasi-static correction weight located in the left balancing plane and, in addition to the right correction weight, it must be added an equal and opposite correction weight in the left plane. The two correction weights in the left balancing plane may be combined in only one weight.

The invariance of the vector factors in the standard solution with the relative position of a frontal observer of an overhung rotor with respect to the bearings is easily deduced.

Solution

The logic extension of these results leads to the statement of the standard solution for the two-plane balancing and, in particular, to the proper statement of the effective static couple solution for the two-plane field balancing of an overhung rigid rotor with an instrument that utilizes the lag phase measuring system.

Figure 1 shows a drawing of an overhung rigid rotor, as a shaft supported on the near bearing *N* close to the rotor and on the far bearing *F* far from the rotor. It is rotating in a clockwise direction as seen from the right side with an operating speed *f*, with a disk of radius *r* to attach trial and correction weights in the left balancing plane *L* and in the right balancing plane *R*.

Figure 2 illustrates the image produced by a stroboscope synchronized by a sensor, as a velocity pickup or an accelerometer, when the maximum signal of the sensor occurs due to horizontal vibration of the near end *N*.

In the coordinate system (*x*,*y*) associated to the convention of the rotating scale and for the lead phase system of measurement, the vibration displacement of the near bearing is represented by the vector $\vec{N} = Ne^{i(\omega t + a_N)}$, where N is the magnitude, *e* is the natural number, $i = \sqrt{-1}$ is the imaginary unit, $\omega = 2\pi f$ is the angular speed, *t* is the time, and a_N is the phase angle, which is indicated by the fixed reference mark on the rotating angular scale or measured by means of the photocell with the reflective tape. When the angle $\omega t = -a_N$, then $\vec{N} = N e^{i0}$, which attains its maximum value. Note that when $t = 0$, then $\vec{N} = N e^{i a_N}$.

Also, the conjugate vibration displacement of the near bearing is represented in the same coordinate system by the vector $\overline{\vec{N}} = Ne^{-i(\omega t + a_N)}$, where the phase angle $2\pi - a_N = -a_N$ is indicated by the rotating reference mark on the fixed angular scale, or for the lag phase system and the rotating scale convention, measured by means of the photocell with the reflective tape. Note that if $t = 0$, then $\overline{\vec{N}} = N e^{-i a_N}$. A similar analysis can be done for the horizontal vibration of the far end *F*.

To imagine the rotary motion with the aid of Figure 2 will help to understand the lead and lag phase measuring systems and the rotating and fixed scale conventions for phase measurement, as well as the vector representation of the vibration displacement of the near bearing and its conjugate by means of the respective general expression as a function of time.

Therefore, from the standard solution for the lead phase system with the rotating scale convention and the standard solution for the lead phase system with the fixed scale convention is stated the standard solution for the lead phase system with the fixed scale convention, but for the coordinate system associated to the rotating scale convention, given by the correction weights in the left and right balancing planes, respectively, as:

$$-\vec{W}_L^* = \overline{\overline{V}}_L \vec{W}_{TL}$$

$$-\vec{W}_R^* = \overline{\overline{V}}_R \vec{W}_{TR}$$

Where the conjugate vector factors in the corresponding left and right balancing planes are:

$$\overline{\overline{V}}_L = \left[\frac{\left(\overline{\vec{b}}\,\overline{\vec{B}}\right)\overline{\overline{F}} - \overline{\overline{B}}\,\overline{\overline{N}}}{\overline{\overline{A}}\,\overline{\overline{B}} - \left(\overline{\vec{a}}\,\overline{\overline{A}}\right)\left(\overline{\vec{b}}\,\overline{\overline{B}}\right)} \right]$$

$$\overline{\overline{V}}_R = \left[\frac{\left(\overline{\vec{a}}\,\overline{\overline{A}}\right)\overline{\overline{N}} - \overline{\overline{A}}\,\overline{\overline{F}}}{\overline{\overline{A}}\,\overline{\overline{B}} - \left(\overline{\vec{a}}\,\overline{\overline{A}}\right)\left(\overline{\vec{b}}\,\overline{\overline{B}}\right)} \right]$$

Initially, for the first run:

$\overline{\vec{N}}$: Original conjugate vibration vector at bearing *N*

$\overline{\vec{F}}$: Original conjugate vibration vector at bearing *F*

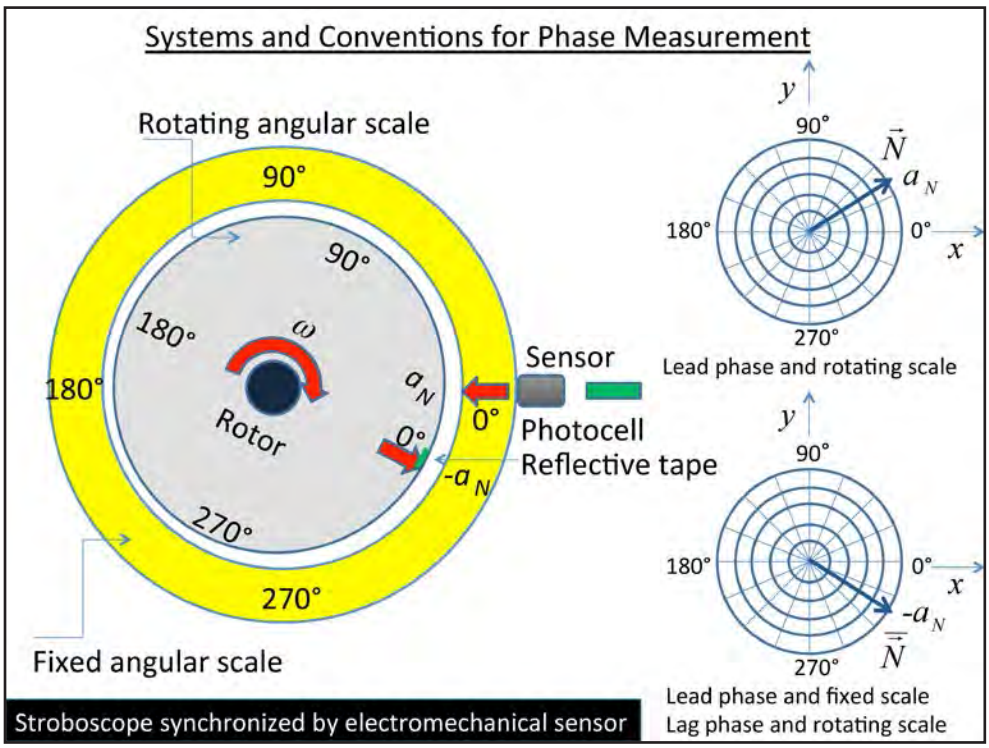

Figure 2: Phase systems and conventions

Figure 3: Experimental setup

When a left trial weight $\vec{W}_{TL}$ is added for the second run:

$\bar{\bar{N}}_2$: New conjugate vibration vector at bearing *N* due to the left trial weight

$\bar{\bar{F}}_2$: New conjugate vibration vector at bearing *F* due to the left trial weight

When a right trial weight $\vec{W}_{TR}$ is added for the third run:

$\bar{\bar{N}}_3$: New conjugate vibration vector at bearing *N* due to the right trial weight

$\bar{\bar{F}}_3$: New conjugate vibration vector at bearing *F* due to the right trial weight

And the remaining terms in the equations are defined as:

$\bar{\bar{A}} = \bar{\bar{N}}_2 - \bar{\bar{N}}$: Conjugate effect vector at bearing *N* due to the left trial weight

$\bar{\bar{a}}\bar{\bar{A}} = \bar{\bar{F}}_2 - \bar{\bar{F}}$: Conjugate effect vector at bearing *F* due to the left trial weight

$\bar{\bar{b}}\bar{\bar{B}} = \bar{\bar{N}}_3 - \bar{\bar{N}}$: Conjugate effect vector at bearing *N* due to the right trial weight

$\bar{\bar{B}} = \bar{\bar{F}}_3 - \bar{\bar{F}}$: Conjugate effect vector at bearing *F* due to the right trial weight

If a pair of trial weights, $-\vec{W}_{TR}$ and $\vec{W}_{TR}$, are added to form a couple for the third run, the cross effect is minimum and the effective two-plane static couple solution is stated by the following expressions, which give the quasi-static correction weight in the left balancing plane and the couple correction weights in the left and right balancing planes, respectively, as:

$$-\vec{W}_E = \bar{\bar{\bar{V}}}_L \vec{W}_{TL}$$

$$\vec{W}_R \;\&\; -\vec{W}_R = \bar{\bar{\bar{V}}}_R \vec{W}_{TR}$$

The two correction weights in the left plane can be combined into a single weight:

$$-\vec{W}_L = -\vec{W}_E + \vec{W}_R$$

The technique for dual plane balancing of an overhung rotor has been well established. For the correct application of the effective two-plane field balancing procedure, it is very important to check the orientation of the overhung or cantilevered rigid rotor and to understand which bearing or measurement point relates to which correction plane for each balance program.

> **"It is very important to check the orientation of the overhung or cantilevered rigid rotor"**

Table 1 – Recorded Experimental Data

Common Method

$\dot{\bar{N}} = (0.391 \text{ in/s pk}, 334.2°)$

$\dot{\bar{F}} = (0.352 \text{ in/s pk}, 332.4°)$

$\vec{W}_{TL} = (2.8 \text{ g}, 0°)$

$\dot{\bar{N}}_2 = (0.728 \text{ in/s pk}, 358.4°)$

$\dot{\bar{F}}_2 = (0.562 \text{ in/s pk}, 354.7°)$

Effective Method

$-\vec{W}_{TR} = \vec{W}_{TL}$ & $\vec{W}_{TR} = (2.8 \text{ g}, 180°)$

$\dot{\bar{N}}_3 = (0.337 \text{ in/s pk}, 320.0°)$

$\dot{\bar{F}}_3 = (0.256 \text{ in/s pk}, 320.4°)$

Solution

$-\vec{W}_E = (2.09 \text{ g}, 249°)$

$\vec{W}_R = (4.11 \text{ g}, 7°)$

$-\vec{W}_R = (4.11 \text{ g}, 187°)$

Correction

$-\vec{W}_E = (1.7 \text{ g}, 252°)$

$\vec{W}_R = (4.0 \text{ g}, 0°)$

$-\vec{W}_R = (4.0 \text{ g}, 180°)$

Remaining Vibration

$\dot{\bar{N}}_{Rem} = (0.024 \text{ in/s pk}, 2.2°)$

$\dot{\bar{F}}_{Rem} = (0.016 \text{ in/s pk}, 62.1°)$

Trim Balance

$-\vec{W}_E = (0.34 \text{ g}, 199°)$

$\vec{W}_R = (0.69 \text{ g}, 204°)$

$-\vec{W}_R = (0.69 \text{ g}, 24°)$

> "The effective solution determined by the applicable equations was checked by means of the online software developed for the lead phase measuring system"

Once the conjugate effect vectors have been determined, the rotor can be trim balanced from the conjugate remaining vibration vectors, $\dot{\bar{N}}_{Rem}$ & $\dot{\bar{F}}_{Rem}$, in the corresponding near and far bearings until reaching the required vibration tolerance for on-site or field balancing.

Validation

Figure 3 shows a photograph of the prototype with the balancing equipment. For the test with the prototype of the overhung rigid rotor, the analyzer was used only as a measuring instrument, along with a two-plane balance program installed in a minicomputer.

The trial weights for the prototype of the overhung rigid rotor are magnets of fixed weight and volume located at specific angles. This model does not allow for the use of balancing wax or, as a substitute, dental orthodontic wax, as a temporary trial weight.

It was determined previously that the high vibration level with a stable phase at the operating speed was caused by unbalance.

Table 1 shows the recorded experimental data using the prototype of the cantilevered rotor at an operating speed of $f = 1617.54$ CPM, where the vibration vectors and the trial and correction weights are represented in polar coordinates.

For example, in the same coordinate system, for the conjugate vibration displacement of the near end $\dot{\bar{N}} = Ne^{-i(\omega t + a_N)}$, the derivative with respect to time t produces a change in the magnitude N by the factor $\omega = 2\pi f$, which is the angular speed and a rotation of $\pi/2 = 90°$ from the angle a_N to give the corresponding conjugate vibration velocity:

$$\dot{\bar{N}} = \frac{d\dot{\bar{N}}}{dt} = -i\omega\dot{\bar{N}} = \omega e^{-i\frac{\pi}{2}}\dot{\bar{N}}$$

Analogous expressions are obtained for all the other terms in the right members of the applicable equations, which implies by simplification that the results will be the same independently of the vibration units.

From the observed greatest value of the remaining vibration in the near bearing and in accordance with the International Organization for Standardization's ISO 2372 for a machine's power of 1/20 HP, the vibration severity is rated "Good."

The effective solution determined by the applicable equations was checked by means of the online software developed for the lead phase measuring system with the rotating scale convention, which uses complex algebra and is normally applied to centerhung rotors. For the overhung rotor, the drive end is the far bearing *F*, but corresponding to the left correction plane *L*.

Since the program and the calculator use complex arithmetic to perform the mathematical computations, identical values were obtained for the trim balance, which validates the effective two-plane balancing solution for the lag phase system.

The residual unbalance weights would be equal, but 180 degrees opposite to the calculated trim correction weights determined from the final vibration levels after balancing is complete, as was accomplished in this case.

Conclusion

A useful solution for dual plane balance has been established, which could expand the capacity of an instrument designed for single plane balance that uses the lag phase system of measurement.

Reference

1. Sánchez-Quintero, Ramón A. and Méndez-Adriani, José A., "Design and Construction of a Prototype for the Demonstration of the Field Dynamic Balancing of Cantilever Rigid Rotors." *Journal of the Faculty of Engineering of the Central University of Venezuela*, Vol. 28, No. 2, 2013, pp. 37-52. (In Spanish). https://www.researchgate.net/publication/292823776_Design_and_construction_of_a_prototype_for_the_demonstration_of_the_field_dynamic_balancing_of_cantilever_rigid_rotors (In English)

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The Most Definitive Test of a

Several tests can be performed on a hydraulic pump to indicate its condition. The temperature of the pump case, the flow of the case drain and the current draw of the drive motor are common checks that can be done regularly and over a period of time to track the wear of a hydraulic pump.

As a pump wears, its internal tolerances get greater, so the bypassing increases; and the more it bypasses, the hotter the pump case will be. However, pump wear is not the only factor that can determine pump case temperature. The same goes for case drain flow. In a variable displacement pump, oil that bypasses across the tight internal tolerances returns to the tank to keep the case pressure from building high enough to rupture the shaft seal. As the pump wears, case flow increases. Thus, measuring the case flow on a regular basis is another good way to track the condition of the pump.

Again, however, pump wear is only one of the possible reasons that case flow can be high. As a pump wears, the current draw to its electric drive motor will decrease. But what is the "normal" temperature of your pump case? Or the "normal" case flow or current draw? There are general guidelines, of course, and manufacturer documentation can give you a general idea of acceptable parameters, but what is normal for your machine may be different for another.

While these checks should be made on a regular basis and recorded so they can be used as a reference later, most industrial plants do not keep such records. Even when the proper records are kept, in many cases, all you have is a measured likelihood of the condition of the pump. You can compare results of the tests over a period of time, but you still aren't absolutely certain until you replace the pump and see if the symptoms disappear. Changing a pump during a time of lost production is time consuming and costly. But, there is one check that can be made to definitively determine if a pump is good or bad and it can be made in less than one minute if the system is set up for it. Unfortunately, most systems are not.

> "there is one check that can be made to definitively determine if a pump is good or bad"

Even a bad pump will deliver all or nearly all of its flow as long as the flow is met with little or no resistance, but only a good pump can deliver its rated flow under normal system pressure. This is most easily determined by measuring the flow through the system relief valve. For just a few hundred dollars, a flow meter can be permanently installed in the system to measure the flow through the relief valve whenever you want to know the condition of the pump. This may seem frivolous when the system is working properly. After all, the flow meter could very well sit there in the system and not be read for years. Chances are good that as long as the system is producing satisfactorily, no one will ever check the meter. But, when the system is down and you are faced with hours of expensive downtime as you try to determine what is wrong, suddenly you wish that you had a better way to diagnose a problem.

For most industrial facilities, the very first time a pump is not unnecessarily changed as a direct result of having a flow meter in place to test it, enough money is saved to install flow meters in every system in the plant. Many of these pumps are quite expensive. They can run between $4,000 and $40,000, or more. Frankly, spending five figures on a pump and not spending a few hundred more to be able to test and monitor it easily is a little like trying to save a few hundred dollars on a new car by trying to find one without a speedometer or a temperature gauge.

by Jack Weeks

Hydraulic Pump

"Regardless of the type of pump, be sure the relief valve is turned to a very low pressure *before* starting the machine!"

Depending on the configuration of the system, the flow meter can be mounted either in the pressure line of the pump upstream of the relief valve or in the relief valve tank line. Obviously, a flow meter in the relief valve tank line is the less expensive option because the meter that is used can be rated for a lower pressure. Unfortunately, many systems do not have an exposed relief valve tank line. In this case, a high pressure flow meter must be installed in the pressure line somewhere between the pump and the relief valve so when the system power supply is isolated from the rest of the machine, flow through the relief valve can be measured on the meter.

If you are using a fixed displacement pump system, close the isolation hand valve to block the flow from the system so the only flow path to the tank is through the relief valve. Power up the system and measure the flow with the relief valve adjusted to a very low pressure. Even if the pump is bad, it should deliver all or very nearly all of its rated flow. Now, begin raising the pressure adjustment while watching the flow meter. If you can increase the setting all the way to normal system pressure with no significant reduction in flow, there is no question that the pump is good. Your problem is elsewhere. If, however, the flow drops on the flow meter as you increase the pressure setting on the relief valve, the pump is bad and must be replaced.

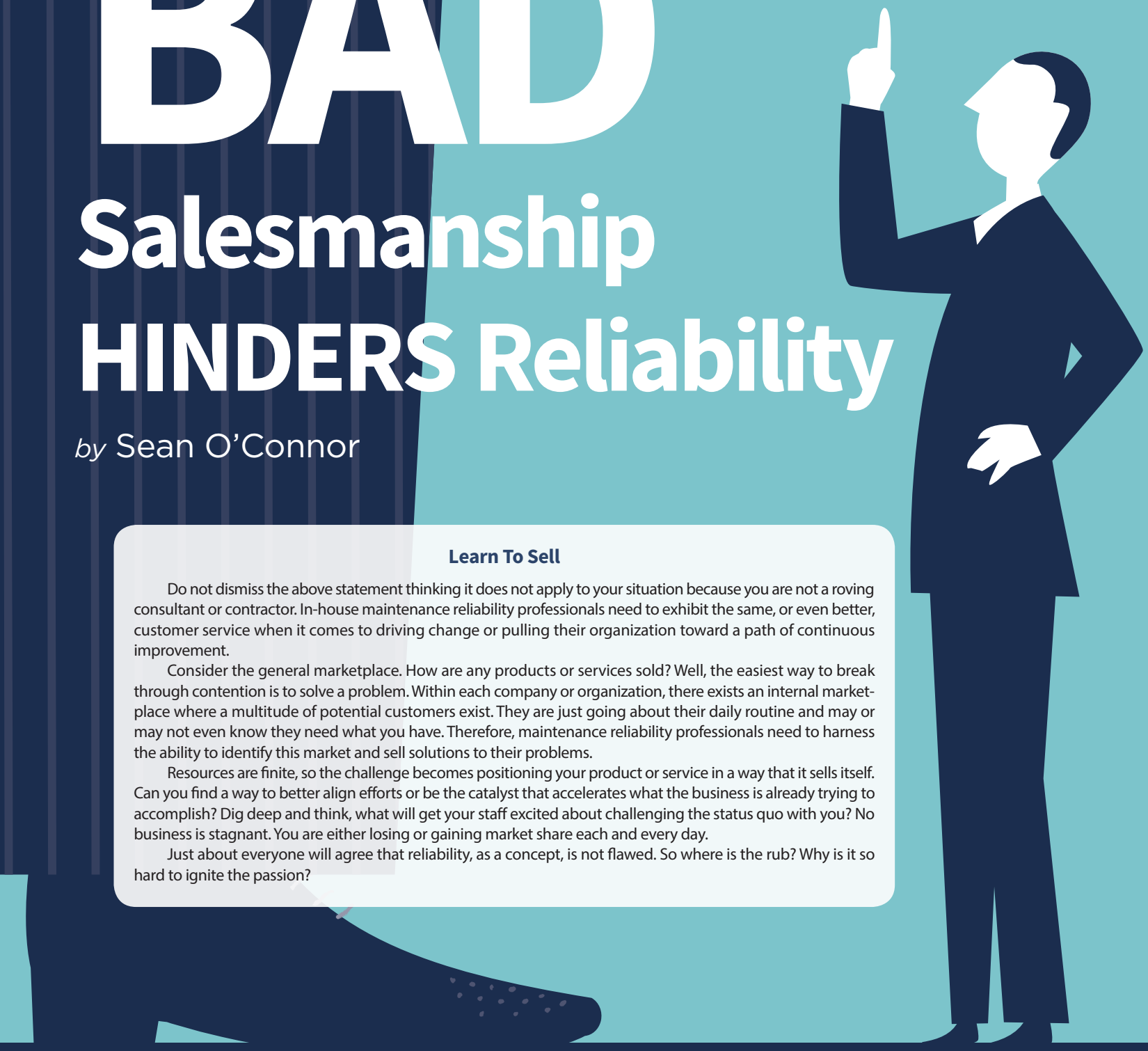
In a pressure compensating pump system, turn the compensator adjustment fully clockwise before starting the system. This will make the pressure compensating pump behave as a fixed displacement pump so it will deliver its maximum volume of flow at all times and not de-stroke while you are conducting this test. *Regardless of the type of pump, be sure the relief valve is turned to a very low pressure before starting the machine!* Then, make the test the same as you would with a fixed displacement pump. With the relief valve adjusted very low, measure the flow. Raise the pressure setting on the relief valve while watching the flow meter. If the flow remains steady all the way up to normal system pressure, you can be absolutely certain the pump is good.

Based on a review of hundreds of industrial plants across the United States, Canada and other countries, a few of them have flow meters mounted in the case drains of their pumps, but almost none of them have the meters installed so this check can be made. Rarely is there even a flow meter in stock that could be temporarily installed. These meters can be extremely valuable troubleshooting tools. Make use of them!

Jack Weeks, *Hydraulic Instructor & Consultant, entered GPM's organization in January 1997 as a CAD draftsman and hydraulic instructor. He has trained thousands of electricians and mechanics in Hydraulic Troubleshooting methods. His computerized animations have made GPM's presentations and training CDs the recognized leader in the industry. He received his education from the Georgia Institute of Technology School of Electrical Engineering and the Department of State Foreign Service Institute. Jack taught radio wave propagation for the U.S. Air Force and telecommunications equipment operation and repair for the Central Intelligence Agency at American embassies overseas.*

BAD Salesmanship HINDERS Reliability

by Sean O'Connor



Learn To Sell

Do not dismiss the above statement thinking it does not apply to your situation because you are not a roving consultant or contractor. In-house maintenance reliability professionals need to exhibit the same, or even better, customer service when it comes to driving change or pulling their organization toward a path of continuous improvement.

Consider the general marketplace. How are any products or services sold? Well, the easiest way to break through contention is to solve a problem. Within each company or organization, there exists an internal marketplace where a multitude of potential customers exist. They are just going about their daily routine and may or may not even know they need what you have. Therefore, maintenance reliability professionals need to harness the ability to identify this market and sell solutions to their problems.

Resources are finite, so the challenge becomes positioning your product or service in a way that it sells itself. Can you find a way to better align efforts or be the catalyst that accelerates what the business is already trying to accomplish? Dig deep and think, what will get your staff excited about challenging the status quo with you? No business is stagnant. You are either losing or gaining market share each and every day.

Just about everyone will agree that reliability, as a concept, is not flawed. So where is the rub? Why is it so hard to ignite the passion?

"NO YOU DO NOT! Think again."

Don't Make Reliability a Cussword

Having a great product that everyone wants is not going to automatically move units out the door. Price point is a crucial factor surrounding any product. What you want to avoid here is sticker shock. Introducing an initiative that is incredibly dynamic with stratified layers may make perfect sense in your head. And if you could clone yourself, it might even work. Yet in the real world, you have to be effective or you will soon be out of a job. Don't make your people, your customers, hate reliability.

The currency you are working with is time and understanding. For this, simplicity and consistency are blue light specials.

Simplicity. Make it too hard to understand and you will quickly intimidate your way into a perpetual reactive environment. Think law of diminishing returns. You might know the absolute best way to accomplish a task. What happens, then, if this task is so complex and dynamic that nobody in the organization even attempts to tackle it the second you turn your back?

Consistency. This is not a simple life hack or something that is one and done. This is a campaign that will evolve into culture. Its simplicity will enable it to be sustainable, but only if you are consistent. Don't reinvent the wheel with each and every minor endeavor. Copy, paste and continuously improve.

People will find the path of least resistance. So, make that path one in which you prefer them to travel. Make it easy to do the right thing. Make it hard to do the wrong thing.

This is where you venture into the dichotomy of leadership. Navy SEALs Jocko Willink and Leif Babin outline it beautifully in their book, *Extreme Ownership*. It's a must read for anyone who desires to be a better leader.

Being Too Technical Is Technically Wrong

If you are reading this magazine, there is a good chance your technical prowess is sufficient. Does that mean you should stop learning? Absolutely not. What it may signal, however, is that you have potentially reached critical mass on how effective you can be within your current organization. Engage in a little self-reflection and understand who you have trouble making inroads with. Consider this question and its options:

Who will have a higher probability of success?

The mediocre reliability engineer within a company that has made a commitment to improve;

OR

The world's best reliability engineer within a company that is set in its outdated ways.

Most people would put their money on the first person. So, now the question is: How do you get yourself within that company that has made a commitment to improve? Just like the famous line in the classic movie, *Field of Dreams*, "*If you build it, he will come.*" The simple statement, however, does imply the task will be an easy one.

You must make a commitment within yourself to lead up and down the organizational chart. You listen to problems to gain an understanding of the issues at hand. Questions, good leading questions, are asked that get people talking. The learning process begins. Fill in the blanks as you progress. What makes this person, this department, this company resonate?

Never actually turned a wrench or operated the line before? Go down to the floor and assume the role of the student, not the teacher. You will be amazed at the wealth of knowledge just waiting to be heard.

Feel lost on why your budget seems nonexistent and to you SOX compliance means they both just have to match? Again, you will be amazed at what a cup of coffee and a genuine desire to understand can do to your perspective.

People love to talk about themselves and their job. Along with that comes their stresses and complaints. This is your chance to listen and solve. People feel good knowing that what they do is important. It is, so leverage that to the hilt!

Leaders Eat Last

Perhaps you are on a timeline to show results on how well the maintenance department is running. Maybe you have a finite amount of time to come up with a proposal to increase throughput on your most profitable line. That means you have an agenda, right?

NO YOU DO NOT! Think again.

As a maintenance reliability professional looking to sell your skill set, you must align to the agenda of others.

Instead of making your electricians sit through infrared (IR) thermography training just because they have been selected to do the annual inspection, try this: Give them the same training, but show them how this new tool can help make them more effective in their day-to-day tasks. Show them how the infrared imager just gave them superhuman sight. Holy cow, now your electricians can see hot spots! How can this new skill be used as a troubleshooting tool to accelerate their existing workload? Plus, IR is a really cool technology that you can use to improve your predictive maintenance (PdM) program. Did you just find a very willing, and now able, IR technician?

You can look to garner buy-in for a technology or concept before instituting a full-blown program with requirements, added responsibilities and what might be perceived as a downright burden. This is new and you are still within the proof of concept phase.

Once your employees' agenda has been fulfilled incorporating your solutions, your agenda, in turn, will be served. This all relates back to customer service and identifying the needs within the marketplace.

Let Them Fail

Yes, let them tumble, trip and fall. Barring safety or environmental implications, let your staff make some bad decisions. Build in controls so those mistakes are quickly realized by the person directly making them and give them the latitude to work out a proper solution. This instant feedback allows an organic learning environment to be cultivated. This is where buy-in is solidified and ah-ha moments are born. Congratulations, you have just sold reliability. Cha-Ching!

Manipulative or overly prescriptive directives may cause short-term increases in your stock price, but these are not realized gains. Chasing artificial appreciation is not the way to build a portfolio that can weather the storm during an economic downturn. Be the dividend investor who is in it for the long haul.

Your customers, both up and down the chain, are people and people want to be treated like…PEOPLE! Get to know their hobbies, their likes and dislikes. Relate to them and find out what they are good at. Invest in them when an opportunity for development presents itself. These dynamic problem solvers are the most important assets you will ever manage.

Sure, it is great to hit a home run every once in a while, but, ideally, you move from base to base with singles and doubles. That can be a tough pill to swallow, especially for impatient fans wanting (and for some teams, expecting) the home runs!

Sean O'Connor's *current role is a PdM SME to a Fortune 500 global BioPharma company. Prior to this, he was providing predictive maintenance and reliability engineering services in the oil & gas and food & beverage industries as a CAT II Vibration Analyst and Level III Certified Thermographer.*

Q&A

Uptime Magazine had the opportunity to sit down with the 31st International Maintenance Conference (IMC-2016) Keynoter, Breon Klopp. Breon is the Founder and Managing Partner at Sestrana, a company that develops and facilitates high-impact experiential learning and training events to engage and motivate organizations on methods for improvement. From a perspective that is entertaining and realistic, Breon inspires participants through a racecar pit stop challenge that focuses on performance, processes, and teamwork.

Q In your career, what led you to motorsports racing and pit stops?

A I am fortunate to always have been involved in athletics in some form. I played some college football in Wisconsin followed by the opportunity to work with a collegiate football program in North Carolina. I was working in corporate fitness facility operations in the Charlotte region and two of our employees were moonlighting with motorsports race teams as fitness instructors prior to teams having dedicated coaches. During a casual conversation, it was mentioned how difficult it was for teams to find employees for the pit crew roles due to the unique skills involved, lack of a system to develop pit crew members, and very little time dedicated to recruiting and on-boarding. The conversation continued over several months until we committed to opening the first of its kind facility dedicated to the recruitment, training, and placement of people who desired employment within the industry and teams in need of qualified employees.

At the time, pit stops were improving but most of the process knowledge was "because that's the way I was taught" type tribal knowledge. Using what amounted to the "5 Why's" approach, we met with representatives of many teams and found common methods and processes and used those standards to develop an eight-week curriculum that provided the basic skills for each pit crew position. Individuals with the desire to pursue a dream of being a crew member could now go through a structured program and receive on-going coaching for another 3-12 months until their skills progressed to a level accepted at the professional team level. At that time the trained crew members could become a "for hire" freelance crew member through our business or seek full-time opportunities with a specific race team.

Q How did you link pit stops and their activities to continuous improvement?

A Racing is a young man's game. During the success of the school I sold the business to a former Daytona 500 Champion crew chief and a race team owner. I am now owner of my second business (Sestrana) focused specifically on teaching non-racing industries how to do the right things, at the right time, with the right people every time. I made a small shift from

coaching race teams to coaching business teams and most of the concepts are identical.

About a year after we launched the school, tour groups began visiting our facility to see where and how these crew members trained. Among the tours were business managers and owners that began inquiring if we offered team building activities. At one time my father was a TQM instructor and I was exposed to TQM during my business operations experience. So when businesses talked about team building I immediately translated that into how do we make businesses better using the methods that we use training pit crew members.

There was, and still is, growing pressure for race team pit crews to improve their performance as a competitive advantage over other teams. In the late 1980's, pit stop times were in the mid-20 seconds. By 2000 those time improved to about 18 seconds. When we opened the training program, pit stops were about 16 seconds and the industry was convinced that was the bottom and would not be able to get any faster. Today teams are performing sub 11 second pit stops.

Much of this improvement is applying Lean concepts and driving out waste. In racing and pit crews, we don't general use these industry terms but rather do what we need to in order to "just get better" every week.

How did you find the personnel for key positions at your school, such as coaches?

A Finding able instructors and coaches was probably the most difficult and least anticipated challenge we had. Kids grow into sports like football, basketball, and baseball. People do not grow up exposed to changing tires as an athletic event. Initially I went from a business manager and development role to having to learn everything I could about coaching pit stops. I had great mentors from the best teams willing to help me learn and teach classes because they knew their teams would eventually benefit from the talent we developed.

Long term we had to recruit, train, and develop our own staff from a variety of resources. Some students did not have the physical skills to be professional pit crew athletes but were great communicators and instructors so we tapped them for additional training in a coaching capacity. Some instructors came from coaching roles outside the racing industry like myself, but had a natural instinct for process and efficacy of movement.

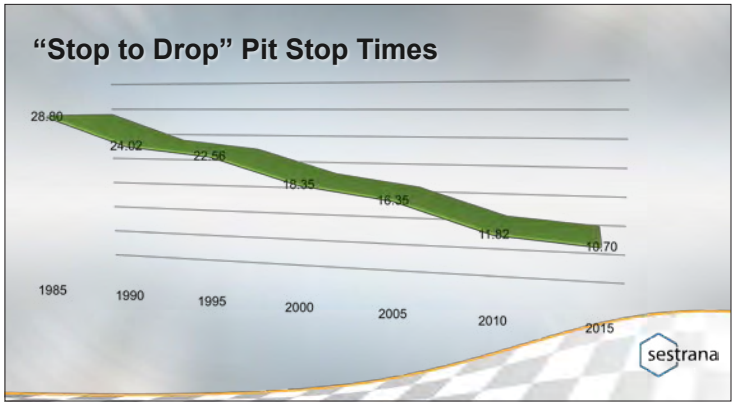
We did a great job of developing athletes and coaches alike. The greatest compliment to our program was not only seeing crew members over the wall doing pit stops but also behind the wall coaching the best teams on pit road. At one time 11 former students or coaches of our program were coaching pit crews at the highest level in our sport.

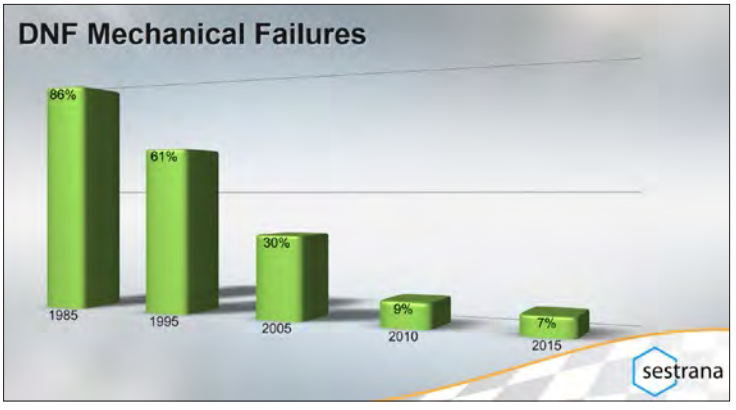
You see, as we were successful, teams began internalizing our system into their own. Teams wanted control and have ownership to customize the process of recruiting, training and on-boarding specific to their team. This arose mostly from competitiveness of teams and wanting to maintain secrecy of their equipment and methods.

You will be presenting the keynote at the 31st International Maintenance Conference (IMC-2016). How do you think reliability will link to racing and pit stops?

A To me, almost every aspect of any industry is reflected in the relatively simple process of a 12 second pit stop. In manufacturing and maintenance, every company in has assets it needs to operate at peak levels of performance in order to remain competitive and therefore relative in the industry.

One statistic I cite that is eye-opening is the percentage of teams that start a race but do not finish (DNFs) due to mechanical failure. In 1985 the DNF rate was 86%. In 2015 the rate dropped to just under 7%. Why? Teams realize that if you can't complete every lap and don't finish the race, they have no chance to win. Mechanical failures during a race mean the equipment was not built, was not installed, was not maintained, or was not operated in a manner conducive to completing the race. In essence, the team failed and lost the race before the race even began. It's not about the fastest car. I call this the "Race to the Green Flag." The majority of a race is won before you even get to the track. I firmly believe every business should operate on that basic principal. Not always the case. How can a business be successful if its operations are not reliable?





At Sestrana, some of your sample applications include role alignment. How important are defined roles to pit stops?

A Every task is dictated by role or position on the pit crew. There are a significant number of tasks that need to be completed exactly right during a 12-second pit stop. Without role delineation and task responsibility, a pit stop would be chaos. Crew members are now highly skilled, well-trained athletes with roles so specific they are recruited to a specific job based on their height, their speed, their flexibility, their strength, and even by their hand dominance. Left-handed tire changers are rare due to the equipment and processes of a pit stop.

And while each team member understands how their roles influence one another, each of the six positions is so unique they are nearly impossible to exchange within a team. Conversely, the pit stop process has become so standardized that each team could potentially interchange members of different crews, position for same position, without much disruption.

But just as a certification or qualification requirement in industry makes an applicant eligible for further consideration for employment, having the physical characteristics of a role is just the beginning to becoming a successful pit crew member.

A relatively new role in motor sports is the coach and coaching staff. Only since the mid 1990's did teams begin having a coach or coordinator. Prior to that if a crew member didn't perform, they were simply replaced by another individual reflecting the emphasis on outcome rather than preparation and planning. When coaches began influencing the team, they became responsible for each individual and the team as a whole. When a pit crew didn't perform, often a coach was replaced before a crew member.

Coaches are now primarily responsible for eliminating every opportunity for failure in the pit stop process during the week prior to a race. During a race the coach's main goal is to keep the team focused and being physically and mentally prepared. It is very challenging to go from sitting for 20 minutes while the cars are on the race track to being at peak level of performance for 12 seconds with little to no warning.

A second area of similarity is skills training. How does that fit in with pit stops?

A I believe no one knows their job better than the person utilizing their skills to perform the tasks required. When you watch a Sunday race on television, those crew members have been honing their skills for 3-4 years before they've earned that level of opportunity.

Initial training includes cross-training each person for every role on the team. This accomplishes two objectives; 1) if some major failure occurs during a pit stop such as an injury, someone else on the team has enough skill to complete the tasks with an expected drop-off in performance, and 2) most importantly, they gain understanding of how their job performance affects everyone else on the team making them more open to modifications to their performance that benefits the entire team.

After cross-training, crew members work to be proficient in one job role. No task, no movement, no skill is taken for granted or minimized. For example, most people understand the tire changer's role to be to remove and install lug nuts on the wheel. However, the greatest opportunity for waste reduction and improved performance is actually when they run from one side of the car to the other. So that specific skill of getting up and moving to the other side of the car and sitting down is practiced just as much as hitting lug nuts.

While on-the-job training is provided by the team, individuals are held accountable to improving their own performance by whatever means necessary. That includes for their future beyond being an over-the-wall crew member. The physical nature and constant drive for something new and better means a crew member's career is short. So continuous education in additional skills like fabricating, welding, painting, and related vocations is necessary if someone wants to remain employed in the sport after their pit crew career ends.

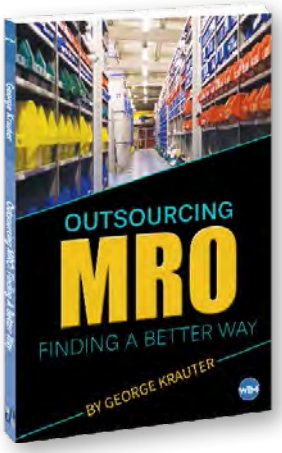
A third area is metrics. Why are they important to pit stops?

A Metrics are everything in racing and pit crew but not always in the way most people immediately think. An 11 second pit stop is awesome…unless you left a lug nut loose or missed an adjustment or didn't get the car full of fuel. So time is relative to the task to which it is applied. I like to say that time is the sum of the system. If you focus just on time there is likely to be a failure somewhere in the system.

For example, when I first entered the sport and watched other teams practice, the pit crew would finish a stop and say "Okay, 16 seconds. Let's do it again but faster." They had no idea what to change other than push harder and faster which ultimately led to failures and a floor on how low pit stop times could get.

Now we utilize video and software to analyze the movement and tasks that comprise tenths of seconds during a pit stop. Coaches breakdown a 12 second pit stop into more than 40 separate metrics to understand what is happening to improve performance. The most beneficial outcome of analyzing video and metrics is not the historical perspective of "what happened" but rather the ability to see forward to opportunities to do more in the same amount of time and provide a competitive advantage for the organization and put the team in the best position to win.

Thank you for your time. Based on the topics we covered in this interview, our readers are going to be very interested in attending your keynote address at the conference.



OUTSOURCING MRO FINDING A BETTER WAY

Written by George Krauter • Reviewed by Dr. Neha Mittal

Outsourcing MRO: Finding a Better Way by George Krauter is very interesting and engrossing, and a great learning tool. The book contains valuable information for both practicing professionals and students pursuing a degree in supply chain management. It provides concepts, explanations with examples and case studies to expand the reader's comprehension.

The world of maintenance, repair and operations (MRO) is fragmented and not many people understand its complexity. Through this book, the author describes the value and importance of MRO and the effect it can have on a company's overall performance.

The book begins with a brief history and provides an effective definition to understand the term. It provides instances where businesses incur significant loss due to improper accounting of their inventory and/or because of the duplication of tools and materials in their storeroom.

The author presents an interesting perspective in the book. He makes a point about having a "world- class" storeroom rather than a "perfect" room, which is thought-provoking. Through a case example of a milk company, he demonstrates how a costly loss in production could have been avoided if storerooms are properly managed. The author makes a case for businesses to consider the option of collaborating and contracting with third-party, on-site MRO management companies to effectively run their operations and reduce costs. The case example demonstrates how instead of a "perfect" room, a "world-class" storeroom can be more effective and beneficial to the company.

The author also explains different ways of outsourcing MRO and building an integrated supply in the company. He explains the implementation process and assesses the benefits of an integrated program. At the end, the author provides a valuable case study using a fictitious company to show how establishing a relationship with an MRO expert can help the company restore its reliability, reduce its cost of ownership, recover time and free itself from burdens of MRO inventory management.

In summary, the author has attempted to provide a strategic approach for managing MRO in this book. Using neat tables and well-defined bullets, he clearly presents his ideas and makes them easy to understand. The narratives and case examples are laid out in a clear and concise manner. The different insights, perspectives and solutions provided by the author are precise and to the point.

Although the task of inventory management varies from business to business, the concepts presented in this book can be applied universally and help businesses in any domain. The multiple ways to outsource MRO that the author describes, including sourcing through aggregators, vendor managed inventory, procure to pay and end to end comprehensive outsourcing, make the book versatile and worthy for every business.

The book reflects the author's passion for the subject, which makes the topic exciting and keeps the reader's attention. The rich experiences that the author has gathered in over 50 years of his work are well narrated in the book.

For managers dealing with MRO inventory management, this book is a *must* read.

The views expressed in this book review are solely of the author's and bears no affiliation with the department, school, or Temple University.

***George Krauter** was the Founder, President and CEO of Industrial Systems Associates before his retirement. He currently serves as Vice President for SYNOVOS Mr. Krauter is recognized as the originator of the industrial supply chain concept that became known as integrated supply. Mr. Krauter is recognized as an authority on methods to optimize costs and achieve reliable, maintenance-connected MRO storerooms.*

***Dr. Neha Mittal** is an Assistant Professor in the Dept. of Marketing and Supply Chain Management at the Fox School of Business, Temple University. Her research focuses on network modeling and optimization, data analysis, supply chain management, project management, and transportation policy.*

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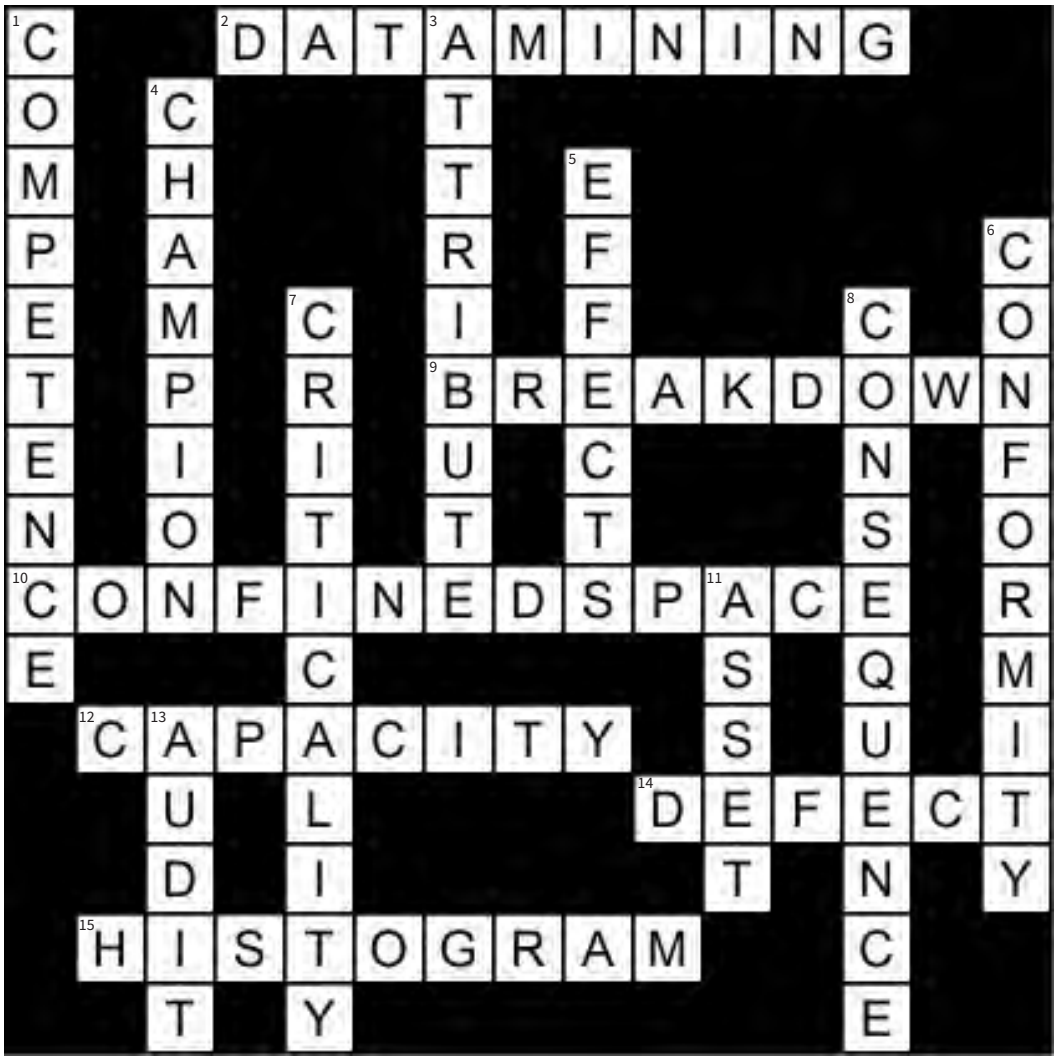
ANSWERS

Created by Ramesh Gulati

Crossword Puzzle



ACROSS

2. An information extraction activity whose goal is to discover facts contained in databases
9. An unexpected interruption to the service of a particular asset
10. An area with limited access and potential respiratory hazard requiring a special permit to enter
12. The specific ability of an item, asset, or person measured in quantity and level of quality over an extended period
14. A condition that causes deviation from design or expected performance and leads to failure
15. A pictorial graphic summary of variation in a set of data that shows patterns that are difficult to detect in a simple table of numbers

DOWN

1. The ability to apply knowledge and skills to achieve intended results
3. A quality or feature regarded as a characteristic or inherent part of someone or something
4. One who facilitates a paradigm change in the understanding and practice of a specific discipline or cause
5. Consequences of failures
6. Fulfillment of a requirement
7. A relative ranking of assets based on the probability of its failure and consequences of the failure
8. Something that follows from an action or condition
11. An item or thing with a potential value that an organization owns and has a use for or creates value
13. A systematic, independent and documented process for obtaining evidence and evaluating it objectively to determine the extent to which a criteria is fulfilled

Answers from page 7.

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