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june/july 17

for reliability leaders and asset managers

CREATING AN EFFECTIVE **ASSET MANAGEMENT** DELIVERY MODEL

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Featured Uptime® Cartoon

Tom Fishburne, Marketoonist

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

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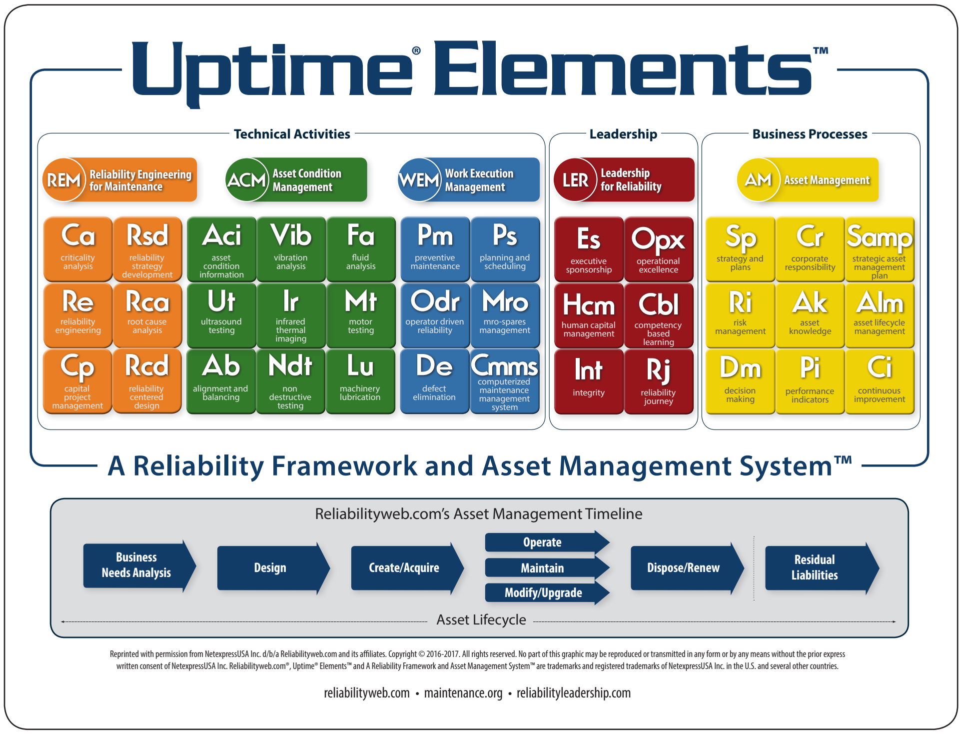

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WHAT IS YOUR POLICY ON POLICIES?

- **If I asked, could you explain your organization's vacation and holiday policy?**
- **If you travel a lot like I do, could you explain your airline's change fee policy?**
- **If you shop at Wal-Mart, do you know their return policy?**
- **If you attend conferences, could you explain the privacy policy? (You should because except for Reliabilityweb.com conferences, you may be shocked at the lack of privacy.)**
- **What about your organization's asset management policy? Have you read it? Do you understand it? Does it even exist? NO?!? *(using my best shocked and amazed expression)***

Wait, let me see if I have this right. You mean your company has a fully detailed policy on vacation and holidays, but they do not have a policy for the millions, tens of millions, hundreds of millions of dollars of assets they depend on for value creation?

In the *Uptime® Elements™ Asset Management* passport, it advises us to think of asset management as a philosophy, a set of guiding principles for a way of doing things better. As one might expect, ensuring consistency in the application of the asset management philosophy requires a management system for asset management (i.e., an asset management system) to be put into place.

A management system is effectively a collection of policies, processes, procedures and guidance that helps to manage retained risks associated with carrying out activities. It also supports continual improvement through the plan-do-check-act (PDCA) cycle. The requirements for an asset management system are set out in **ISO55001:2014** Asset management – Management systems – Requirements.

The asset management policy is the first building block of an organization's asset management system. Its purpose is to establish the intentions and direction of the organization regarding asset management. The asset management policy **IS** the declaration and the stand.

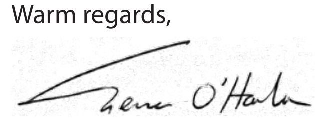
- The asset management policy clearly states the aim of the organization.
- The asset management policy lays out the overall approach to asset management.
- The asset management policy states the high-level objectives for asset management.
- The asset management policy clearly makes the "rules of the game" for decision making.
- The asset management policy anchors consistency for Asset Management Strategy, Asset Management Objectives and Individual Asset Management Plans.

I have been coaching and mentoring some inspired asset managers and reliability leaders to take a stand for reliability and asset management. We have collaborated to create an asset management policy as the first step. If you are ready to take a stand and create an asset management policy, please email me and we will get started!

There are some great articles in this issue of *Uptime®* magazine that are designed to provide you with opportunities to discover ways to advance asset management and reliability in your organization. The entire Reliabilityweb.com team practices asset management at a high level, and I am proud to be included with them.

Thank you for being a reader.

Warm regards,



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LER

RELIABILITY

IN THE NEWS

The RELIABILITY Conference™ Hits Record Attendance
and Gathers Some of the Best in the Industry!

The RELIABILITY Conference (TRC-2017) was held April 24-28th in Las Vegas, Nevada. Over 600 individuals gathered to hear presentations from subject matter experts (SME), practitioners and industry leaders, as well as visit the TRC Expo Hall featuring the latest technologies and products in the market today. Fun was had by all with numerous networking events, including live Vegas entertainment and Who Wants to Be a Reliability Millionaire?

The Rat Pack at TRC (left to right: Jack Nicholas, Jr., Terrence O'Hanlon, Ramesh Gulati and Anthony 'Mac' Smith)

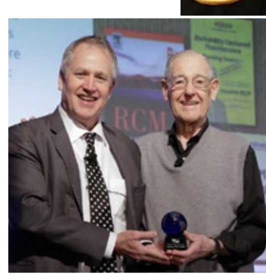
RLI membership face-to-face meeting held at TRC-2017

Lifetime Achievement Award: Anthony 'Mac' Smith

RCM pioneer, Anthony 'Mac' Smith, coauthor of *RCM - Gateway to World Class Maintenance,* received the distinguished Lifetime Achievement Award for his dedication and service given to this industry over the last 40 years.

"No man is an island. I had many smart and professionally dedicated people along the way who I feel are very much a part of this. I will never forget the wonderful experiences with all of them."

~ Mac Smith



Mac Smith accepts the Lifetime Achievement Award from Reliabilityweb.com's CEO Terrence O'Hanlon

Reliability Leadership Institute Annual Meeting

TRC-2017 hosted one of four RLI face-to-face meetings. With over 25 members attending, the discussion covered topics including asset management versus managing assets and the Internet of Condition Monitoring (IoCM).
Next meeting: July 26-27, St. Paul, Minnesota

For more information on RLI membership, visit: www.reliabilityweb.com/rli

RELIABILITYWEB.COM HIGHLIGHTS

CRL Workshop, Greenville, North Carolina

CRL Workshop, Singapore

ISO/TC251 Meeting, Brisbane, Australia

CRL Workshop, Fort Myers, Florida

CRL Workshop, Cork, Ireland

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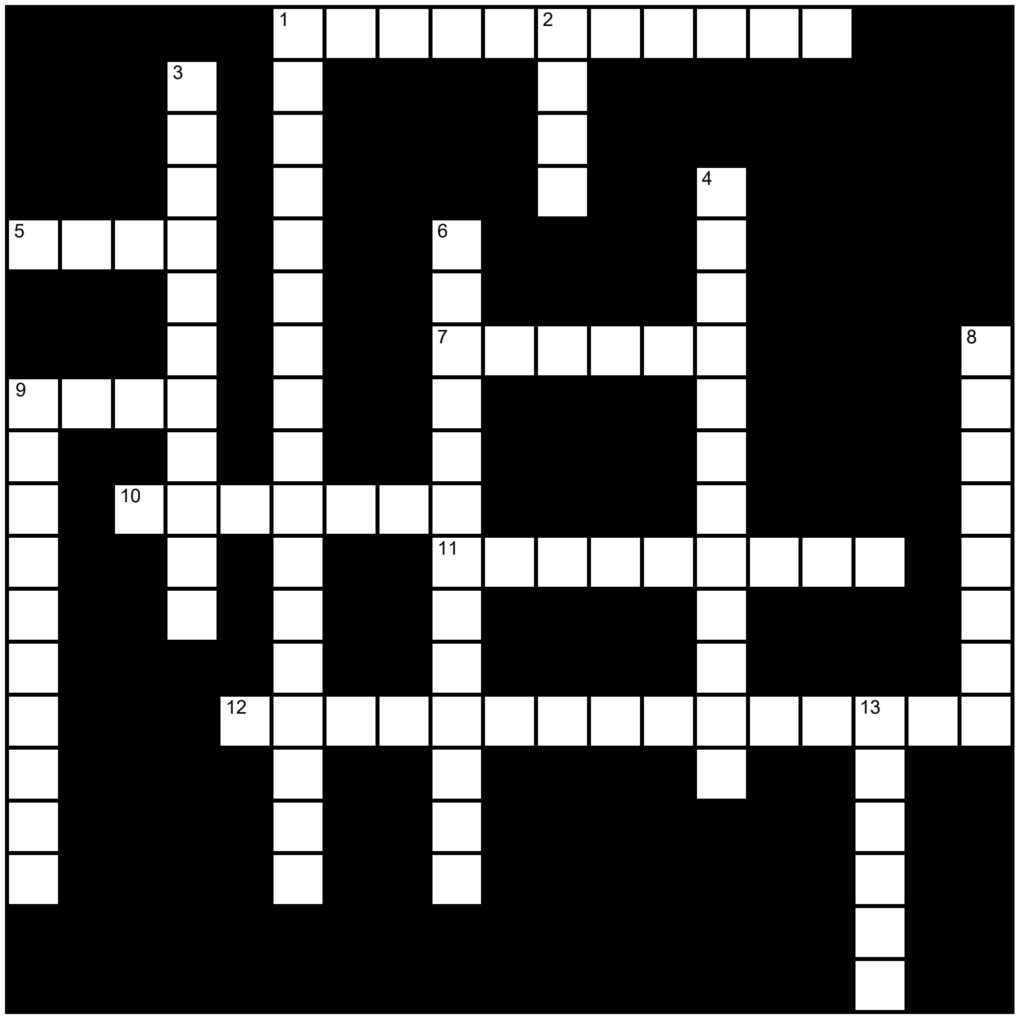
Crossword Puzzle

Created by Ramesh Gulati



ACROSS

1. A measure of the relationship between two data sets of variables
5. Attrition or rubbing away of the surface of a material as a result of a mechanical action
7. A standard measure to assess performance in a specific area
9. The Japanese lean word for waste or non-value added work
10. An organization's purpose
11. A concept of consistency of actions, values, measures, principles, expectations and outcomes
12. A principle that states that the critical few items, e.g., asset failures, parts, etc., should receive attention before the insignificant many

Answers for this month's crossword puzzle will be published in the August/September issue.

DOWN

1. A new, positive name of maintenance
2. A practice of waste identification and elimination
3. A practice performed to reduce friction and heat
4. A process of identifying, learning, and adapting outstanding practices and processes from any organization to help an organization improve its performance
6. Exchanging information between individuals through a common system of symbols, signs, or behavior
8. A Japanese term for a mistake proofing device to prevent a defect
9. A method that eliminates or reduces the consequences, likelihood, or effects of a hazard or failure mode
13. Intentions and direction of an organization as formally expressed by its top management

CREATING AN EFFECTIVE **ASSET MANAGEMENT** DELIVERY MODEL

THIS ARTICLE PROVIDES INSIGHT AND A PROVEN BLUEPRINT FOR IMPLEMENTING AN EFFECTIVE ASSET MANAGEMENT SOLUTION.

Grahame Fogel, Jacques Stander and Dean Griffin

Asset intensive organizations face numerous challenges, one of which is the need to create an accountable methodology and delivery model for risk managed performance that reinforces organizational objectives.

This is made even more challenging when organizations choose to focus on short-term operational performance. Overcoming this hurdle requires big picture thinking combined with an intimate knowledge of the asset management (AM) enablers. Furthermore, to align effort to outcomes, one must have a strong understanding of how an organization defines and measures value.

This article provides insight and a proven blueprint for implementing an effective asset management solution. Ultimately, it provides managers and decision makers with an execution model for structuring a performance driven asset management solution.

The first step toward this clarification is understanding the known knowns of asset management, from which the implementation blueprint will be built.

Asset management activities that have the **strongest influence** on organizational value often have the **lowest maturity** within the same organizations

Strong Influence

- Strategy Management
- Asset Care Plans
- Work Planning and Control
- Operator Asset Care
- Focused Improvement

Weak Influence

- Information Management
- Technical Information
- Organization and Development
- Contractor Management
- Financial Management
- Risk Management
- Environment, Health & Safety
- Materials Management
- Support Facilities and Tools
- Lifecycle Management
- Project and Shutdown Management
- Performance Measurement

Asset performance is driven through the simultaneous execution and mastering of key performance enablers.

Figure 2: The influence of asset management activities on value creation

Understanding the Known Knowns

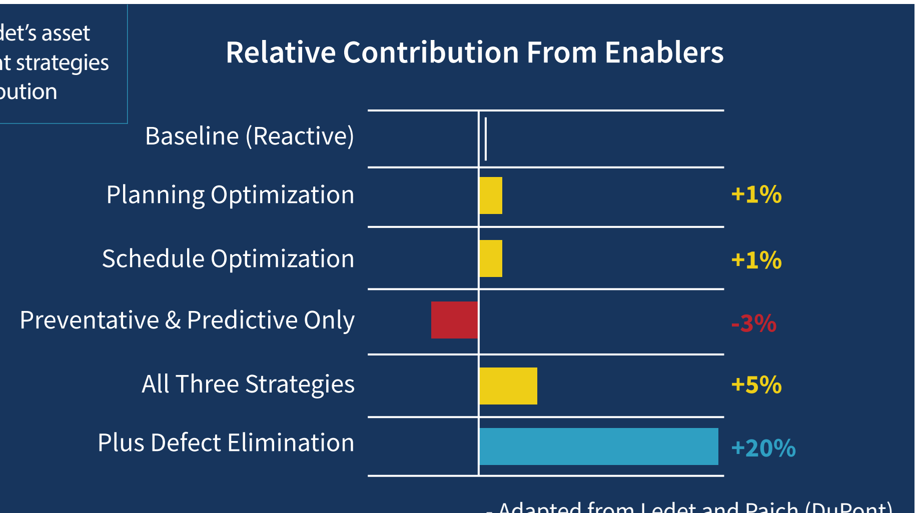
To understand the known knowns or what you know, you first need to understand your historical journey as a professional discipline.

The discourse over the last 20 years has surrounded two themes. First is the profusion of embarrassing claims in the marketplace, normally from vested interests, about what creates asset performance. Second is from those involved at the forefront of implementing solutions, where there is a real challenge to create long-term sustainability in programs that result in ongoing performance.

One must look hard for documented, peer reviewed evidence of what creates asset performance. The abundant claims that exist are at best anecdotal and not substantiated with hard evidence. Through multiple decades of experience, it has been noted that most improvements are temporary, vulnerable to any of the dynamics that occur in the corporate world.

Over the years, literature and other sources of information, such as conference proceedings and organizations' individual experiences, have been carefully tracked to gain insight and real evidence to help in understanding what creates asset performance.

Figure 1: Ledet's asset management strategies value contribution



Foundational to this understanding is the 1994 pioneering work by Winston P. Ledet at DuPont. Ledet undertook a detailed modeling exercise on how and why maintenance initiatives had failed to meet expectations within DuPont. In summary, he concluded that point solutions (i.e., individual solutions applied in isolation) were only partially successful and that, in some cases, asset productivity decreased if applied inappropriately. The key learning gained from this foundational study was that there were key enablers to an asset management system and their integrated effects created an alignment that drove performance. The key enablers Ledet listed are shown in Figure 1. Further, the study assumes some underlying information management system that supports the above, but interestingly, that it is not considered a performance driver.

The second key issue is the role of the computerized maintenance management system (CMMS) or enterprise resource planning (ERP) system in driving performance. With large budgets and vested interests, market players in this area have made exaggerated claims with regard to the ability of these systems to drive asset performance. This is supported by benchmark data; surveyed data from over 50 industrial sites finds no perceivable correlation between continued investment in CMMS/ERP systems and asset performance.

While having a well-structured information system is foundational to the modern industrial enterprise, its role and usefulness must be put into context as to where it enables value to be derived. Yet, vendors are quick to sell upgrades and increase licensing fees, adding to the overall cost of the management system which, in turn, simply cannibalizes scarce budget and manpower resources. This calls for a clear reevaluation as to where scarce resources should be invested if one wishes to drive asset performance.

In a 2013 major study of benchmark and assessment data by Fogel and Terblanche, 17 key performance areas from over 50 asset intensive organizations were analyzed in detail to understand the relationship between increased maturity (i.e., investment) in the enabler and whether and how much this increased asset performance (see Figure 2). Results show strong correlations between strategy management (i.e., the execution of asset management strategy), the development of asset care plans, the management of work through planning, scheduling and work close out, the involvement of operators in first-line maintenance, and structured strategic focused improvement. There was little to no correlation with the remaining 12 enablers.

Fogel and Terblanche further examined the ongoing investment in information systems, which indicated a weak correlation to improved performance. This means the claims of further investment in information systems must be very carefully reviewed with what the organization is trying to achieve.

Further reinforcement of an integrated approach comes from comprehensive comparative studies performed by the Aberdeen Group and published in 2012. They, too, present no single solution silver bullet, but a multivariate contribution to enterprise asset management, with the key driver being cross functional collaboration within an organization.

The Value Paradigm: What Constitutes Organizational Value?

There has been an increasing and more focused discussion in recent years surrounding what constitutes organizational value. Within the professional community, the thinking has been refined from a purely, yet important, financial dimension to a broader understanding of stakeholders and their value expectations. This is built on the belief that organizations exist to satisfy their stakeholders. The value discussion has been sharpened by the excellent work done within the technical committees that developed the ISO55000 and 31000 international standards. These standards should be used as normative references when evaluating the value *from* assets and value *of* assets.

In a presentation by Fogel and Kemp at the 2016 Institute of Asset Management (IAM) annual conference, an asset management value model (see Figure 4) was developed in a single representation. In this model, value is some variable that changes with time as the organization meets differing trading circumstances and challenges. The model indicates this dynamic tension, which is under continual review to adjust it strategically to a differing business environment. Fogel and Kemp advocate that leadership teams need to clarify exactly what the value goals are in terms of creating a performance outcome. Implementation teams can then align priorities and activities to these value definitions. The organization then requires a nimble strategy to adjust to changing priorities.

Over the last decade, the thinking with regard to creating an implementation structure for creating an effective asset management delivery model has been refined and sharpened.

The goal is to create a delivery model that is easy to explain, clearly understood and aligns with both international standards and accessible bodies of knowledge. Moreover, the model needs to be adaptive to both different industries and maturities within organizations. Furthermore, it needs to be flexible enough to respond to changing value requirements. Overall, the goal is to make it pragmatic and useful to asset management professionals to communicate a simple solution vision for delivering sustainable value. It should also go beyond the general guidelines in ISO55000 to a pragmatic implementation framework, both from an assessment perspective and to allow a clear implementation road map to be modeled.

The end result is an effective asset management delivery model or the delivery model.

Introducing the Effective Asset Management Delivery Model

The delivery model can be best encapsulated as the key enablers, which work together to ensure effective asset management. Figure 5 shows the diagrammatic representation of this delivery model.

The model incorporates the knowledge created in the historical journey. It is backed up by benchmark data and aligned to both international standards and existing bodies of knowledge. Real-life performance data that substantiates the relevance of such an approach also is presented.

In summary, the model is made up of a top-down (i.e., strategic) and bottom-up (i.e., foundational) approach that is aligned to the delivery of value. The blocks represent a set of interconnected and interrelated value drivers referred to as enablers. In most cases, the enablers or a subset of enablers are in place and it is their interconnectivity and integrated presence that creates the model. This interconnectivity, as illustrated in Figure 6, builds on what was uncovered by Ledet at DuPont.

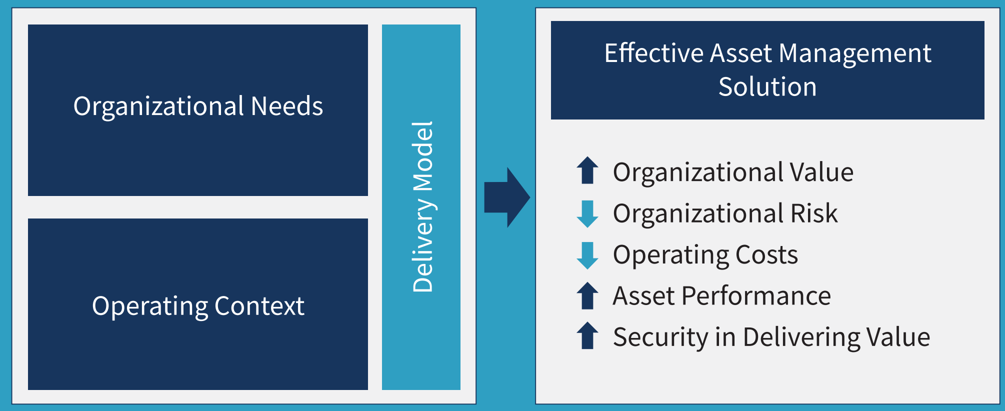


Figure 3: Describing effective asset management

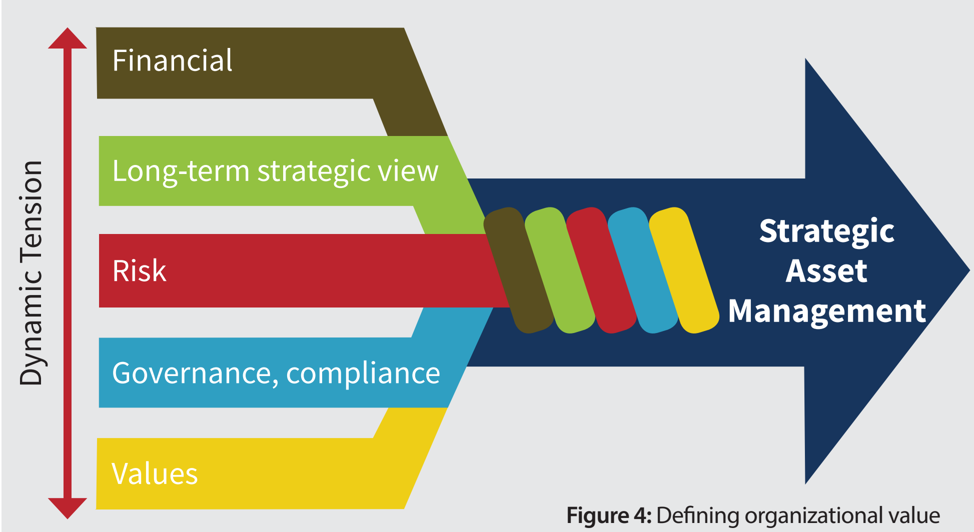


Figure 4: Defining organizational value

AM

Table 1 – Summary of Asset Management Enablers

ENABLER	DEFINITION	EFFECT
Asset Data Configuration	The initial and continued process of ensuring data is of the correct quality and configuration to enable asset management activities	Data, which is credible, provides the basis for evidence-based decision-making Data and data configuration in alignment with overall strategic informational needs
Understanding Risk & Opportunity	The identification, assessment and prioritization of risks followed by the coordinated and economical application of resources to minimize, monitor and control the probability and impact of the risk; It is also the tool to maximize the realization of opportunities	Risk directed application of effort and resources
Establishing a Reliability Basis	A set of activities, processes, skills, use of technology and methodologies to ensure systems meet the reliability expectations to achieve business objectives	Incorporates the development of maintenance reliability tactics, which effectively create the ability to have systems available within acceptable cost and risk parameters when needed; May include such activities as reliability-centered maintenance (RCM), condition monitoring, reliability analytics, etc.
Condition Management	Management of the condition of critical or important systems so they are positioned high up on the P-F curve, minimizing the risk of unannounced failure	The ability to timely deal with failure mechanisms in critical and important systems so they are risk and cost managed
Integrated Planning	Planning processes and activities that integrate across multiple functions within an organization to maximize value	Provides a coordinated ability to create organizational focus across organizational boundaries
Managed Focused Improvement	The process of applying systematic problem-solving methods to improve system performance	Risk and performance based effort directed toward value creation
Managing Financials	Efficient and effective management of money (i.e., funds) to accomplish the objectives of the organization	Includes core activities, such as budgeting, capital planning and financial performance management
Risk Driven Decision-Making	Maximizing opportunity while managing unwanted outcomes	Realizing new value within the organization while reducing value loss from unwanted risk events
Whole Lifecycle Decision-Making	Decisions made that impact total cost of ownership of an asset or system over its life	Balances short, medium and longer term decision-making to ensure sensible and aligned cost of ownership
Value Realization	Monitoring, managing and reporting on the total value realized	Provides the necessary indication of the return on effort
Organizational Readiness	The organization's preparedness and shared resolve to implement a strategic change; A measure of a shared belief and collective capability to implement such a change	Measures the organization's ability to transform toward its strategic goals
Competency Development	Development of skills, behaviors and attitudes that workers need to perform their roles effectively	Ensures the skills and motivation to achieve objectives
Translating the Strategic Plan	The ability to communicate the organization's goals and the actions needed to achieve those goals; Within ISO55000 configuration, this is divided into policy, strategic asset management plan (SAMP) and AM execution plan	The ability to coordinate the set of implementation actions that deliver stakeholders' expectations of value

The various enablers of the delivery model are briefly described in Table 1.

The delivery model provides organizations with structure, enabling a methodical approach linked directly to asset performance. Structuring an asset management system this way provides both form and flexibility, ensuring that nothing is missed when creating an asset management solution. The model is not prescriptive on how those enablers are achieved, or at what maturity level the enabler should be positioned.

The model is also aligned to other contextual inputs, such as the International Organization of Standardization's ISO55000, ISO31000, ISO8000 and ISO9000, industry bodies of knowledge (e.g., IAM's asset management anatomy) and accepted regulations (e.g., IFRS's accounting standard). This is illustrated in Figure 7.

An important aspect that goes hand in hand with implementing an asset management solution is being able to measures its value.

Measuring the Asset Management Value Contribution

The professional community has been searching for a meaningful measure of asset management value contribution. While measuring leading metrics, such as the ratio of planned to unplanned work or the traditional reliability metrics, such as mean time between failures (MTBF) and mean time to repair (MTTR), are important in monitoring asset performance, they do not reflect a satisfactory measure of tangible business value.

Over the years, American business magnate and investment guru Warren Buffet has provided a strong argument that return on invested capital (ROIC) provides the most illuminating understanding of whether a management team is adding or eroding value to an organization. The ROIC metric is directly aligned to the asset management value contribution and should be used as a measure of

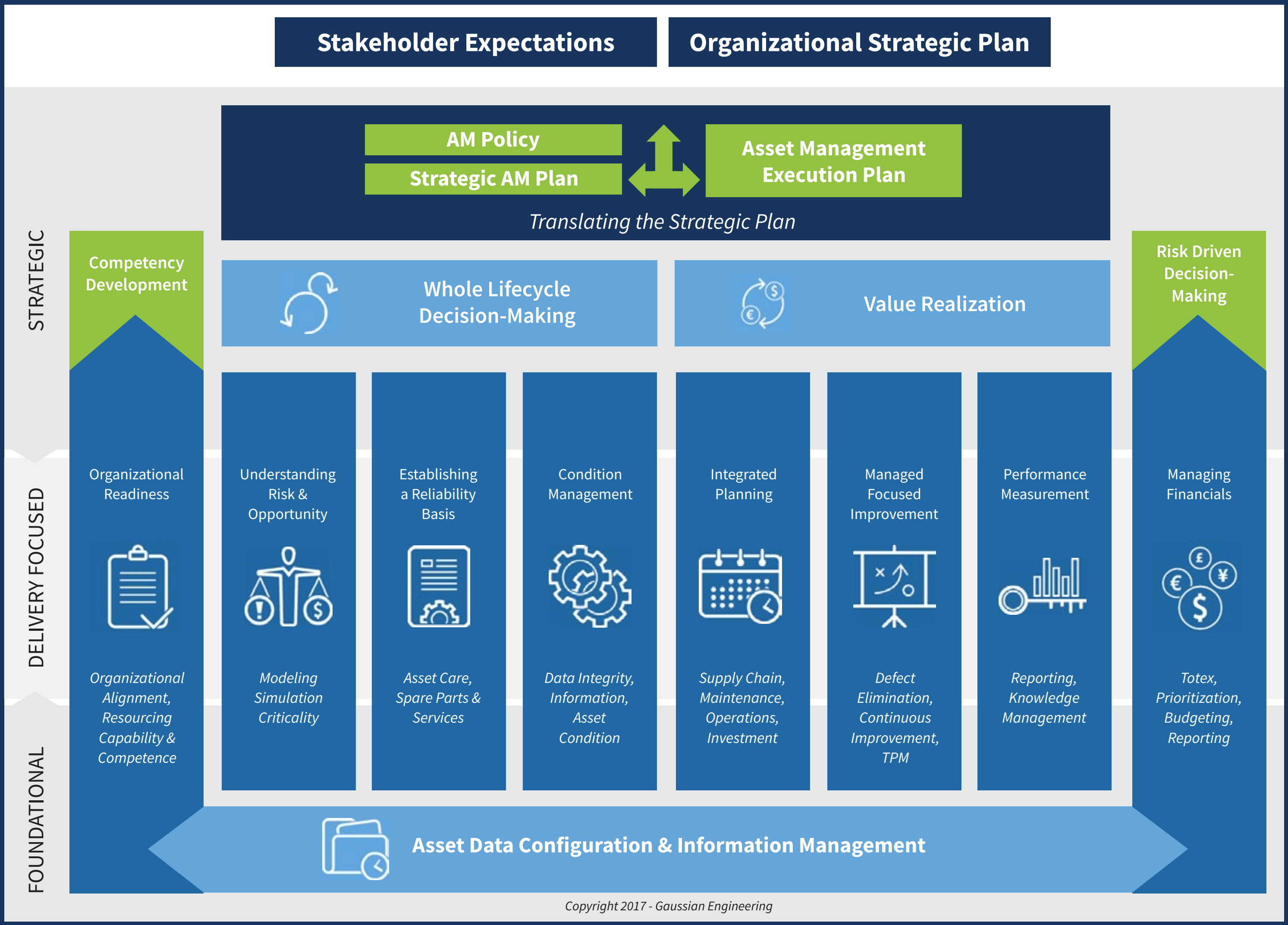


Figure 5: The Effective Asset Management Delivery Model

asset value contribution. Recently, ROIC has been used to benchmark several programs and organizations around the world, providing a significant body of experience in understanding how asset contribution affects ROIC, which will be the subject of a future *Uptime* article.

Furthermore, many management teams and senior executives have their compensation packages linked to ROIC and when talking about ROIC as the golden asset management metric, it serves as a pathway to discussions about a much more strategic approach to asset management.

By measuring and comparing ROIC on a period to period basis, a management team has the clearest measure of whether it is adding or eroding value to the organization. ROIC cascades directly down to the asset management delivery model and how the specific enablers are contributing to the business.

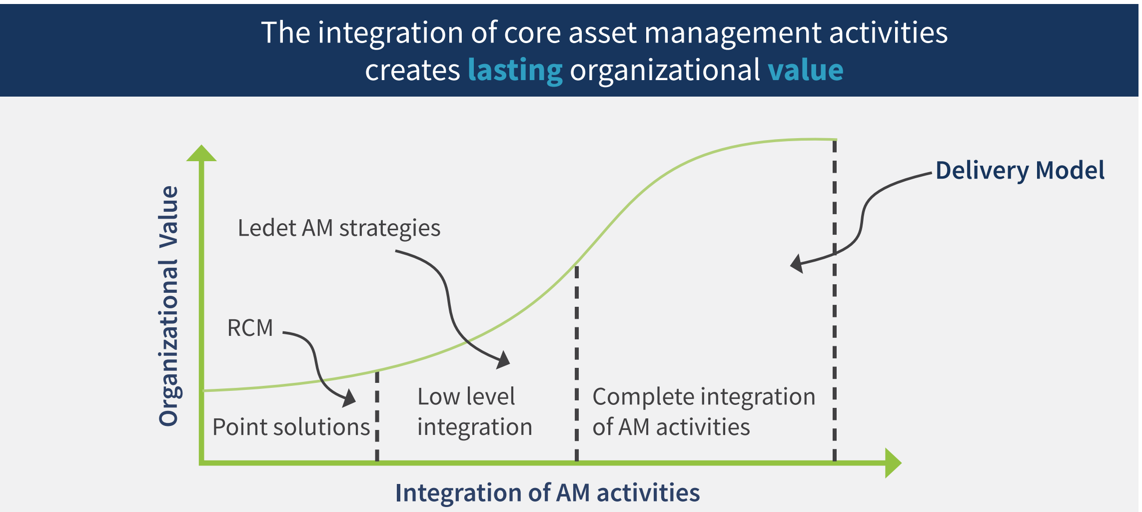


Figure 6: Benefits of integrating asset management activities

Results of Using an Integrated Solution

The results from one organization that has been on a multiple year journey demonstrate year on year sustainable gains in performance. Figures 9 and 10 show improvements within the organization over a four-year journey. This organization had a strong commitment from leadership that drove the implementation of the delivery model. In addition, the sustainability basis was due to the ongoing integrated approach. The benefits are obvious, with a strong decline in the replacement asset value and a steady increase in production. These benefits were echoed by the shift from reactive maintenance tactics to more predictive and preventative tactics.

Aligned to numerous international standards and best practices, the Delivery Model **executes seamlessly** within various industries

International standards

- ISO 55000
- ISO 31000
- ISO 8000
- ISO 9000
- ISO 14000

Bodies of knowledge

- IAM - Anatomy of Asset Management
- Reliabilityweb.com® – Uptime® Elements™
- Communities of practice
- OEM recommendations
- GFMAN – 39 subjects of asset management

Local & international regulations

- Local operating regulations and limitations
- International regulations and limitations

AM best practices

- Specialist consultants
- Industry standards

Figure 7: External influences of the delivery model

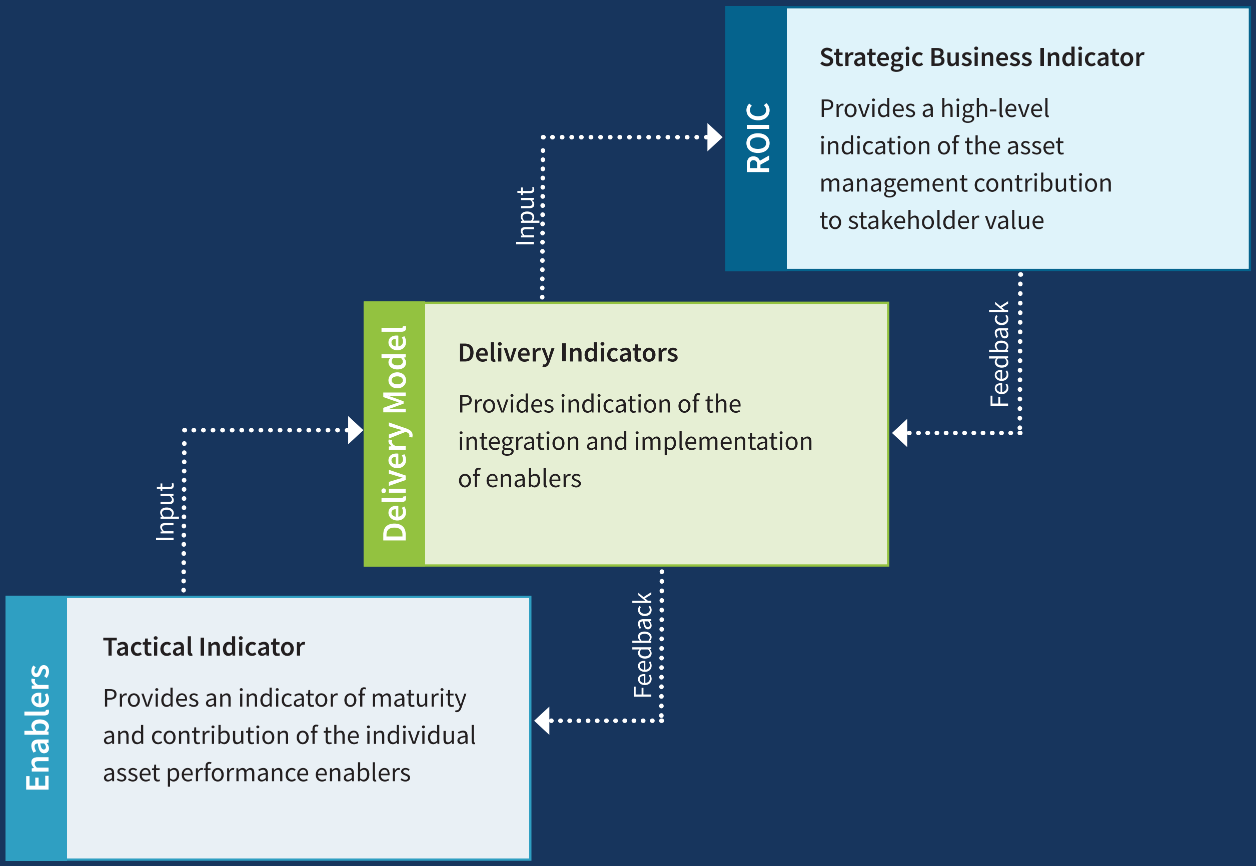


Figure 8: Measuring value

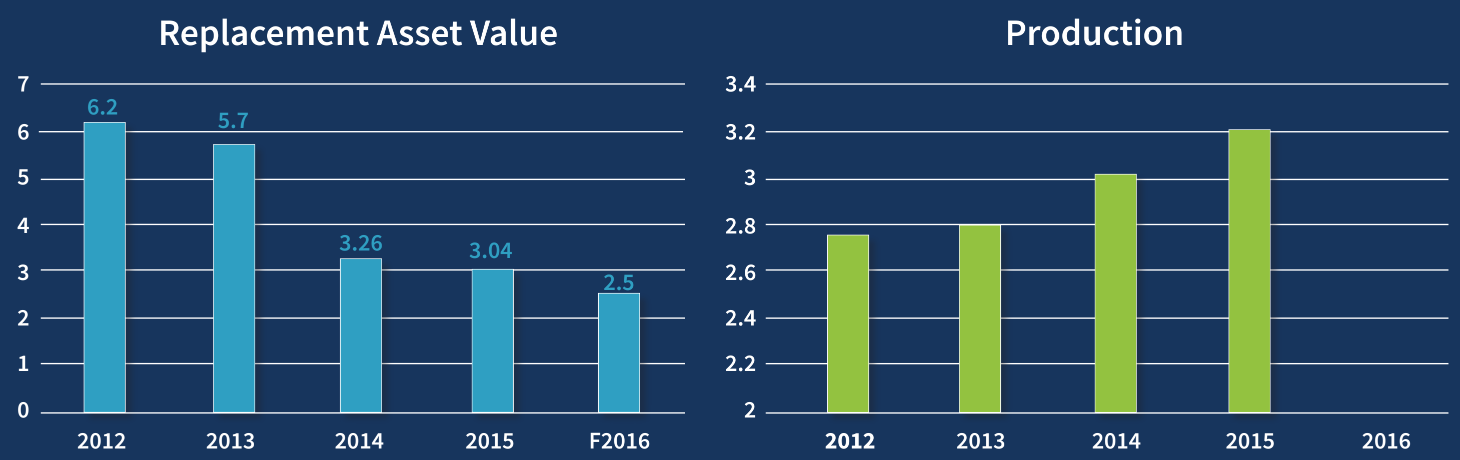


Figure 9: Results of using the delivery model part 1

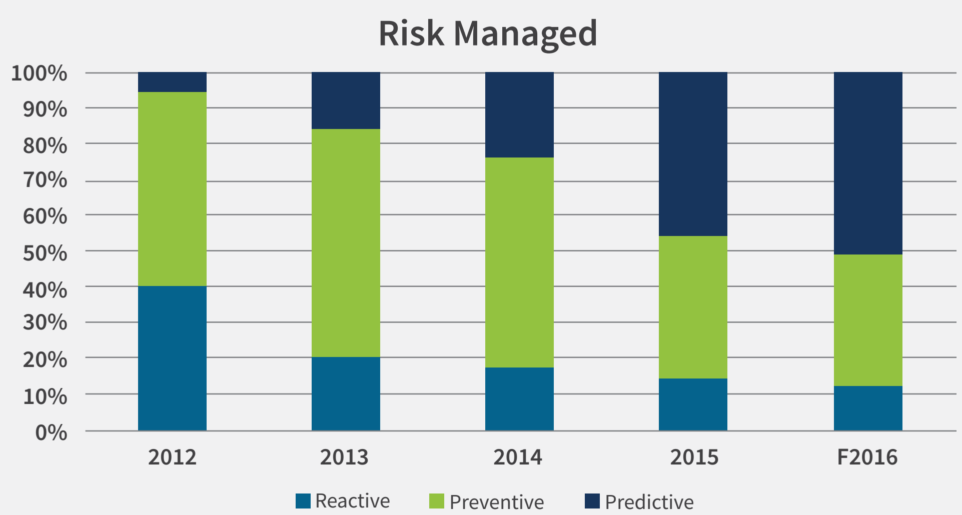


Figure 10: Results of implementing the delivery model part 2

As the organization matures on its asset management journey, it is now focusing more on defining the linkages between effort and capital investment linked to business value to drive further gains.

While the effective asset management delivery model is method agnostic, it offers a structured approach to implementing an asset management solution. This ensures that asset managers around the world can be certain in their efforts.

Conclusion

The effective asset management delivery model is the culmination of years of experience, research and analysis. It has been created for managers and practitioners to help in delivering an effective asset management solution within their organization. It incorporates inputs from the latest international standards and bodies of knowledge to ensure a complete and dependable model. Throughout its creation, there were core considerations, such as the need to be method agnostic, as well as driving value. The concept of value for an organization has been a hot topic in recent years. The delivery model considers the outcomes of these discussions and achieves stakeholder value over and above pure asset performance.

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Vib
vibration analysis

THE NEW GENERATION OF ONLINE VIBRATION ANALYSIS

Dan Ambre

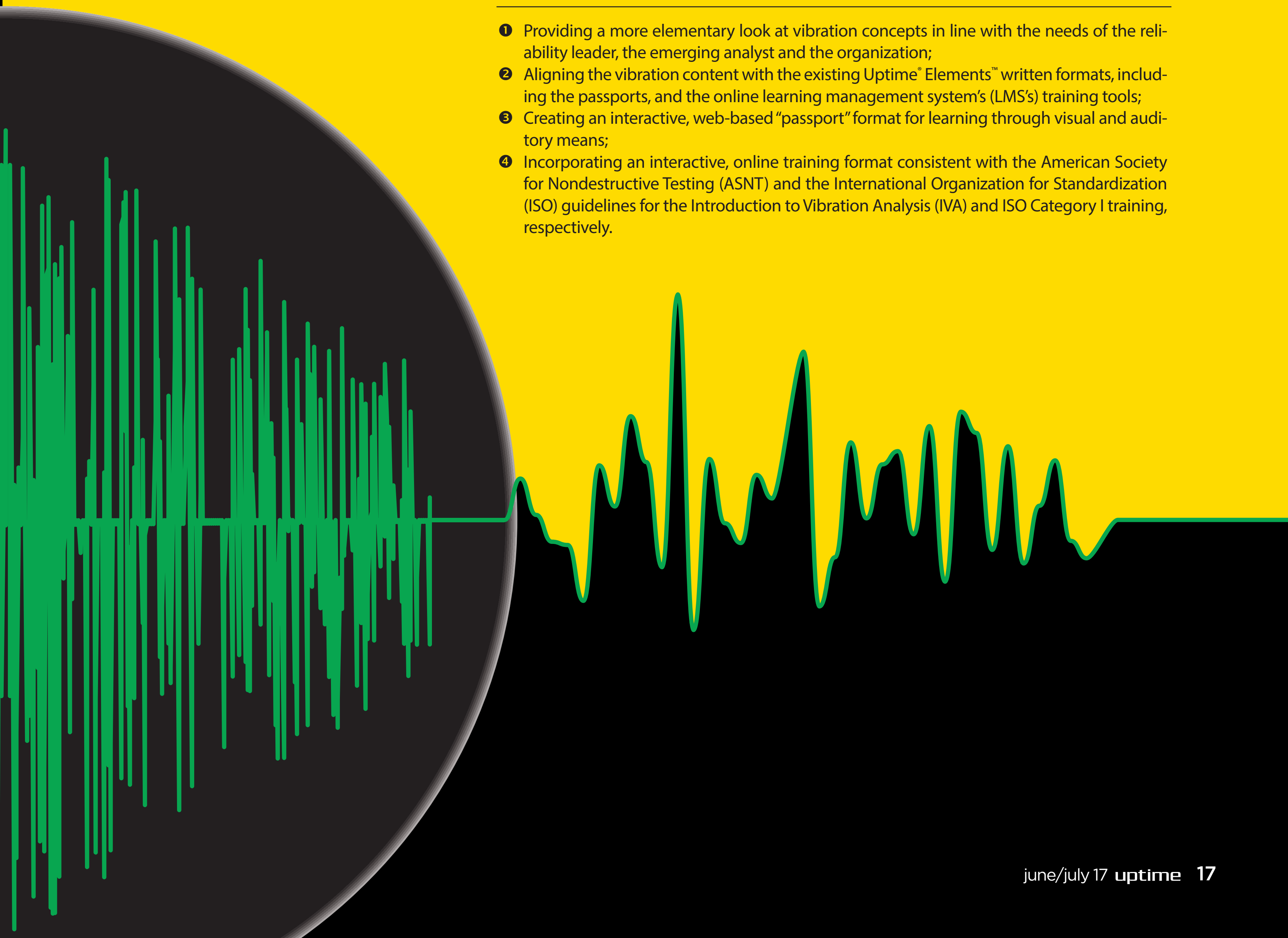
The Vibration Fault Periodic Table concept was created and introduced to the public in an article published in the June/July 2012 *Uptime®* magazine. The original concept was designed to classify vibration faults in the form of a periodic table of the elements. That is to say, the faults were grouped according to frequency content and dominant direction or response. This format was found to be very useful in gaining a better understanding of the nature of each individual vibration fault, as well as providing the analyst with a quick assessment tool for determining the likely root cause for a particular problem in the field.

The original Full Spectrum Diagnostics home page was designed to feature the Interactive Online Training & Perpetual Guide via the Vibration Fault Periodic Table concept. This training concept is a completely online, interactive HTML format presentation designed for the individual student. The training format is a self-guided tour of 35+ machinery vibration problems. The user can move back and forth through the hyperlink icon platform and drill down to 13 submenus embedded in each fault topic. The 900+ pages of web content includes hundreds of real-life spectrum, time history and animation examples. The content can be used as a refresher of concepts or a diagnostic aid while analyzing data.

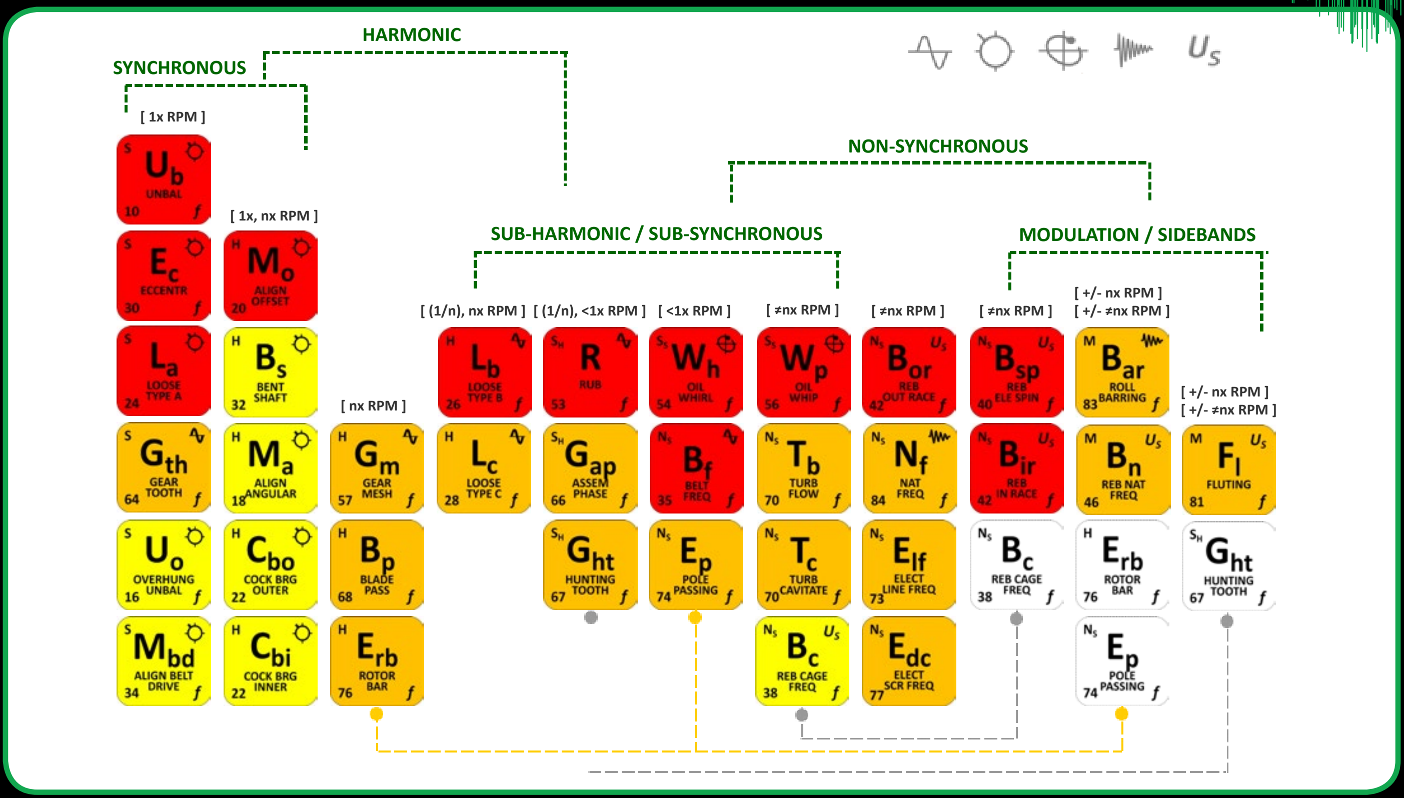
The next generation of the Vibration Fault Periodic Table was reconceived with the help of Reliabilityweb.com to focus on the needs of the emerging vibration analyst with little experience in this field. It was felt that this was the next logical step for the reliability leader. The new focus takes a smaller bite out of the vibration world and provides reliability leaders with enough information to better utilize the implementation of vibration analysis and ultrasound techniques in their organization.

The new focus is defined as:

1. Providing a more elementary look at vibration concepts in line with the needs of the reliability leader, the emerging analyst and the organization;
2. Aligning the vibration content with the existing Uptime® Elements™ written formats, including the passports, and the online learning management system's (LMS's) training tools;
3. Creating an interactive, web-based "passport" format for learning through visual and auditory means;
4. Incorporating an interactive, online training format consistent with the American Society for Nondestructive Testing (ASNT) and the International Organization for Standardization (ISO) guidelines for the Introduction to Vibration Analysis (IVA) and ISO Category I training, respectively.



The VIBRATION FAULT PERIODIC TABLE



ELEMENTS INTERACTIVE TRAINING

The materials for this new focus on basic concepts in vibration analysis include attributes consistent with requirements for the new analyst.

Each fault is described as a **phenomenon** in everyday terms.

The individual fault is further described via the internal **forces and dominant direction** responsible for the anomaly.

The **amplitude** of the fault is defined in a way to introduce the analyst to amplitude units, as well as commonly used severity guidelines.

The **dominant frequency** of the fault is determined from the groupings on the Vibration Fault Periodic Table. The frequency groupings (i.e., columns) are defined as Synchronous, Harmonic, Sub-Synchronous, Non-Synchronous and Modulation type faults. These groupings are presented on the table to allow the analyst to quickly eliminate problems not associated with what is shown on the latest vibration survey (i.e., spectrum).

Many common vibration problems are associated with the **motion or phase** of the rotating machinery. The online Uptime Elements training applies numerous computer animations of machinery faults to integrate the so-called book learning with visual learning. When the fault motion is viewed in an animation, the concepts now start to come alive, even for users with zero experience!

Amplitude and frequency concepts are now grounded when the **time waveform** is introduced for an individual fault. Normally, the time waveform is a starting point for understanding the amplitude, frequency and phase concepts. Rest assured, when it is introduced in these materials, you already have seen it and have a more comfortable feel for the underlying concepts.

The final concepts are **analysis, correction and verification**. The most common analysis or diagnostic formats have been described already. Amplitude of the fault, the frequency of the fault and the direction of the fault are the foundations for diagnosing the underlying rotating machinery problem(s). At this point, your toolbox also includes spectrum (i.e., frequency) analysis, phase analysis and time waveform analysis. Some extensions of these tools include ultrasound (i.e., frequency) analysis and orbit analysis from time waveform concepts. The correction and verification processes involve removing the fault and re-baselining the machine to verify your analysis.

The learning process is structured in a way that will set the foundation for what may lie ahead. If your goal is to only be exposed to vibration analysis and better understand the terminology and basic concepts, the Uptime Elements Passports and online materials are definitely for you! If your future path designates you as the "vibration lead" in your organization, the Uptime Elements Passports and online materials will set the foundation for the Introduction to Vibration Analysis online training. This training can be accessed live or online, depending on the user's preferences. The online materials can be viewed in a linear, start to finish progression or in any way that suits the individual's learning preferences.

The next generation Reliabilityweb.com training format is a self-guided tour of 35+ machinery vibration problems. The user can move back and forth through the hyperlink icon platform and drill down to nine submenus embedded in each fault topic. The 500+ pages of web content include hundreds of real-life spectrum, time history and animation examples. The content can be used as a refresher of concepts or a diagnostic aid while analyzing machinery measurement data.

Coming soon - summer of 2017!

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Hcm human capital management

The Latest Buzz

Word on the street

Latest Craze

Trending Topic

Heinz P. Bloch

DISCOVERING VALUABLE TRENDS in Machinery Reliability

Much can be said about trends that relate to equipment reliability in one way or another. Like everything else, they come and go randomly. Just like carbonated water, trends that are reduced to the flavor of the month can fizzle out and disappear rapidly. Trends probably always existed in all fields of endeavor and have been observed for years in the field of machinery reliability improvement. This article focuses on some recent ones that are on relatively solid ground and should be of interest to you.

The basis of certain trends is of interest. Misleading trends often originate in nostalgia for the past (i.e., "the good old days"). These trends can be quite costly because inaccurately remembering the past often causes people to repeat errors and get locked in a never-ending cycle of repeat repairs. Not learning from past mistakes can steer a profession or even an entire industry in a multitude of unforeseen directions, with dead ends among them. By its very nature, nostalgia for a past that is not remembered correctly overlooks or suppresses facts, thereby assigning undue importance to unsupported opinions. Whenever managers act with nothing but unsupported opinions to guide them, the laws of unintended consequences leave many job functions without a realistic coping mechanism.

Numbers Versus Quality of People Trend: Stable Quality, Just Not Enough of Them

Observers have expressed amazement when they see how some engineers and managers spend precious resources compiling meaningless statistics and benchmarks. As but one example reaching back a few decades, reliability engineers attempted to quantify manpower requirements in terms of manpower per horsepower (hp). As the thinking went, a good refinery should employ one machinery expert per "X" hp of installed compression equipment, or that it's best to have a backlog of "Y" working days in the facility's repair shop. Today, reliability engineers now know there is little gain in making comparisons based on these metrics alone. While certain benchmark studies are still incorporating these and similar statistics, there is little or no correlation with best of class (BoC) performance. It's decidedly not the number of people, but rather the quality of people that matters.

Today, the reliability engineering profession includes staffers who are resourceful thinkers and others with a bureaucratic streak, to say the very least. Figure 1, which depicts an oil ring partially immersed in a pool of lubricant, is a recent example of shallow thinking. The intended function is to fling a certain amount of oil into one or more nearby bearings. However, oil ring performance is immersion sensitive. Here's where a bureaucratic streak can cause problems. In late 2016, an overseas reliability engineer had found a discrepancy between a number given in a book and an article written later. The book recommended an oil ring immersion depth of 5/16th of an inch, while the article mentioned oil rings should be immersed to a depth of 8 mm. For the record, 5/16th of an inch times 25.4 mm/inch equals 7.9 mm.

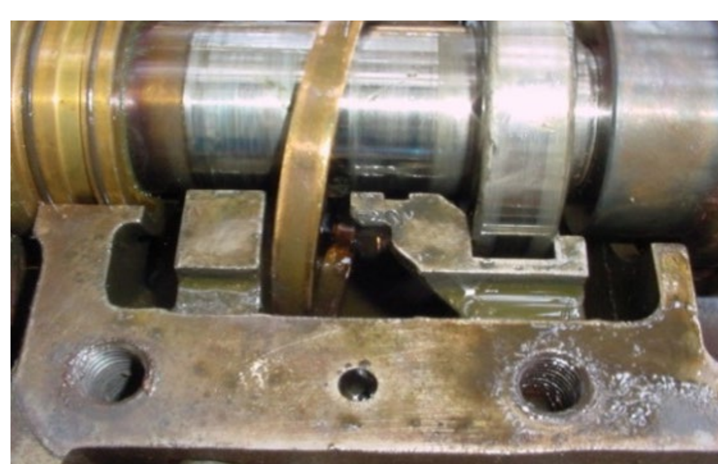

Figure 1: Typical oil ring

The problem is this engineer was serious, an indication of the lack of common sense often seen today. If this 8 mm versus 7.9 mm individual reported to a concerned manager, this person would be asked to become more familiar with how oil rings function and what makes them malfunction. Hopefully, the manager would question whether the employee is using his and the employer's time wisely. Notice that what is being described is an unhealthy trend that people are becoming less inquisitive and more inclined to offer opinions instead of facts. You should anticipate problems when there is no management function in place that questions or readjusts shallow thinkers. Shallow thinkers are grown, not born. Training, tutoring and mentoring are management supported activities that foster professional growth. Take, for example, a 21-year-old who in 1955 was taught how to dismantle a Willys Jeep engine, regrind the eight valve seats, perform appropriate measurements, replace worn parts and reassemble the engine. As awareness of the actual and related collateral value of such hands-on work continues to decline, the machinery reliability industry will be the eventual loser. Putting it more bluntly, the application of common sense is also declining and that, quite obviously, is a worrisome trend.

Does Company Size Matter? Trend: Erroneous Assumptions on What Matters

Managers who are impressed by the sheer size of a supplier or the low bid price of products is an unhealthy backward trend. In the absence of detailed specifications, supply chain managers favor low bid price over everything else and participate in a trend that rarely makes sense. Nevertheless, big name providers and the buyers' quest for low as bid cost are receiving more emphasis today than three decades ago. This issue merits being examined next.

To answer questions on size and merit, ponder the example of a company many have dealt with decades ago, Bently Nevada Corporation. Don Bently was born in 1924 and lived until 2012; he started Bently Nevada in his garage in 1961. He designed and manufactured vibration monitoring sensors and whatever instrumentation is needed for data acquisition and data analysis. Bently Nevada was minuscule in size compared to GE, to whom Don Bently sold his company in 2002. Bently was an innovator and innovators create demand. That's quite different from waiting for demand to develop or assuming that only out of an abundance of demand the mythical innovators will arise. Fluid machinery users who early on accepted and supported Bently Nevada reaped great benefits. Innovators create demand from the reliability-focused. In contrast, providers that emphasize low product price over high quality are favored by the more risk-prone buyers.

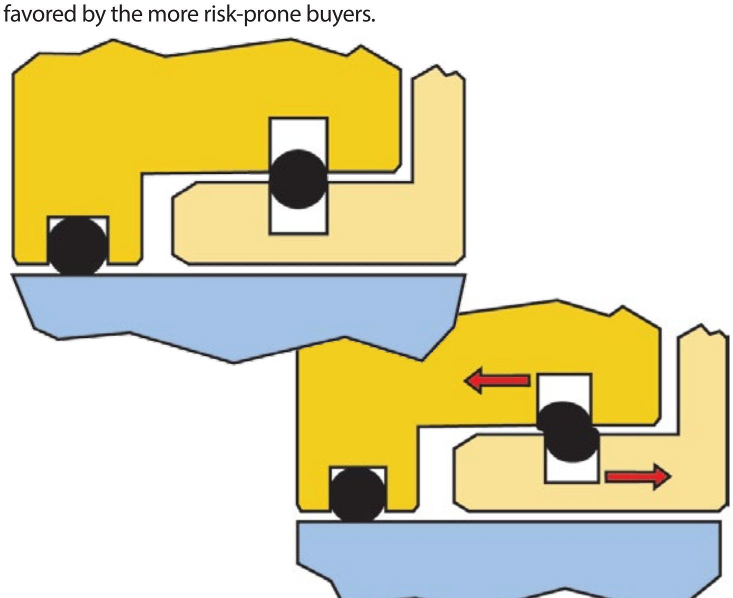

Figure 2: Bearing protector geometry where a dynamic O-ring could inadvertently make radial contact with sharp edges, i.e., a pinched O-ring *(courtesy of ASSEAL, Inc.)*

It's something to keep firmly in mind as you consider linking up with a potential supplier or provider company. You might think of it as you visualize how the bearing protector seals in Figures 2 and 3 work. The configuration shown in Figure 2 allows its dynamic O-ring to contact the sharp edges of an O-ring groove, whereas the one shown in Figure 3 has its active O-ring move axially, without the risk of damaging the O-ring's surface. Because Figure 2 is less expensive, it outsells the superior technology depicted in Figure 3. Reliable products tend to cost more than products marketed with cost as the primary objective. Almost always, reliable products reward you with surprisingly attractive payback.

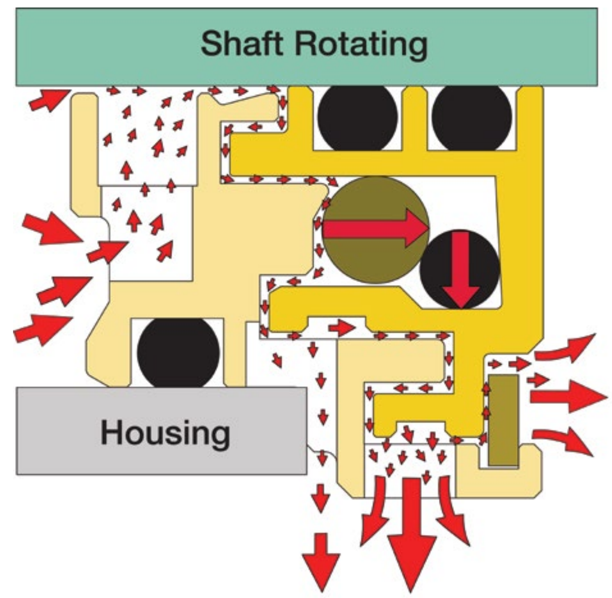

Figure 3: There is zero risk of sharp edges being contacted by either of the two O-rings in this advanced bearing protector seal *(courtesy of ASSEAL, Inc.)*

Why Waiting for Demand Stifles Innovation

The preceding paragraph gives an indication of the tie-in between today's emphasis on price and the relatively stagnant demand for innovative solutions. Waiting for demand stifles forward momentum and it is interesting how user indifference may have made users complicit in slowing down some recent reliability enhancing developments.

Looking back on decades of elusive failures traceable to the many inadequacies of oil rings, users could have helped themselves by diligently logging in relevant data. All they had to do was measure and record two important dimensions on a new oil ring and measure and record them again during a repair event, perhaps after one or two years of operation. Measuring the difference between the diameters before versus after dimensions gives users the out of concentricity; differences in width measurements are indicative of wear.

Although not eagerly broadcasting product deficiencies, fluid machinery manufacturers will (privately) agree that oil rings are not the best available technology components. Vendors and manufacturers have explained a lack of incentive to develop better lubricant application methods until there is a very high user demand. Meanwhile, observations continue on how complacent and complicit users spend time and money on oil rings that will almost certainly malfunction whenever (a) the shaft system is not perfectly horizontal; (b) the oil viscosity is not staying within narrow limits; (c) the depth of immersion fluctuates; and (d) the ring bore is no longer round, but has become slightly oval.[1] For oil ring bore dimensions to remain true to within 0.002 inches, an oil ring has to be stress relief annealed before finish machining.[1] Cheap oil rings are not being produced in harmony with necessary thermal stabilization steps. Without heat stabilization, most oil rings will not be true running and concentric. Therefore, they will slip, oscillate, abrade and contaminate the oil. With an abrasive product inevitably causing bearings to fail prematurely, let's construct an example and assume the bearings will survive for three years.

There is a good probability that a majority of non-BoC users think three years is a reasonable bearing life. Suppose, though, that better informed BoC users routinely achieve a bearing life of six years. If the six year expectation, or 2:1 ratio is correct, the average user spends twice as much for bearing replacements and maintenance than the informed user. As of 2017, the trend toward becoming more informed seems to have leveled off and the slope for acquiring maintenance knowledge is probably horizontal. And that's the disappointing part; it didn't have to be that way. A solid training program would bring these facts to the attention of plant engineers and maintenance technicians. How nice it would have been if only the U.S. emulated other industrialized nations that have implemented strong and consistent apprenticeship programs long ago. However, if history is our guide, an overwhelming urge to capture short-term rewards will again get in the way of progress. And that's the sad outlook.

Upward Trend for How Well BoCs Work With Innovative Technology Providers

Fortunately, there is a favorable trend in how BoC companies interact with innovators. But first, note that for many years, the top five or 10 percent most profitable fluid machinery users have been arbitrarily labeled best of class. This subjective good versus bad judgment is based on published surveys and many informal conversations with BoC reliability professionals and their competitors at meetings, seminars and conferences. In addition, impressive or disappointing practices are observed during consulting visits to plants where incidents happened or at other plants where incident avoidance is deemed of much greater importance. In some plant visits, issues and deficiencies are obvious to the experienced observer. Against this background, many reliability engineers report noticing an upward trend in how BoCs and innovative vendors and service providers cooperate and make decisions that benefit both parties. Remember, again, that innovators create demand among the true reliability professionals. And if you make it a habit to link up with only the lowest cost provider, it sends innovators a signal to bypass your plant and focus instead on building a relationship with one of your more responsive competitors a few miles down the highway.

Here is just one more example concerning the mechanical seal shown in Figure 4.[2] An innovative manufacturer developed this mechanical seal around 2007-2008. Note that it features a bidirectional, tapered pumping impeller. The manufacturer certainly can point out numerous installations or services where this invention has saved considerable money. The pumping impeller effectively pumps the flush liquid through a small heat exchanger. Do you know which of your hundreds of process pumps would qualify for and benefit from this enhanced fluid moving arrangement? Have you asked your seal supplier? Have you asked the innovator? Could you learn from your present supplier? Would it be helpful for you to communicate with and perhaps even learn from an experienced innovator? Would doing so be one of your roles?

Strengthening the Role of the Reliability Professional

There are very significant differences in the work assigned to a reliability person at location "A" versus location "B." In 1966, a BoC role statement for machinery engineers contained 20 or 25 items. It was not considered a proprietary document when published several decades back. The role statement clearly shows that subject matter experts (SMEs) at BoCs are proactive instead of reactive. Value-adding SMEs will have decided before arriving at their employer's parking lot in the morning what it is they will be working on during that day. As the SMEs drive home in the afternoon, they will ask themselves if they have, in fact, done what they had hoped to accomplish on that day. The quality of their work product is the primary yardstick by which they do this self-assessment; the value of one's work product will last when all else has been forgotten.

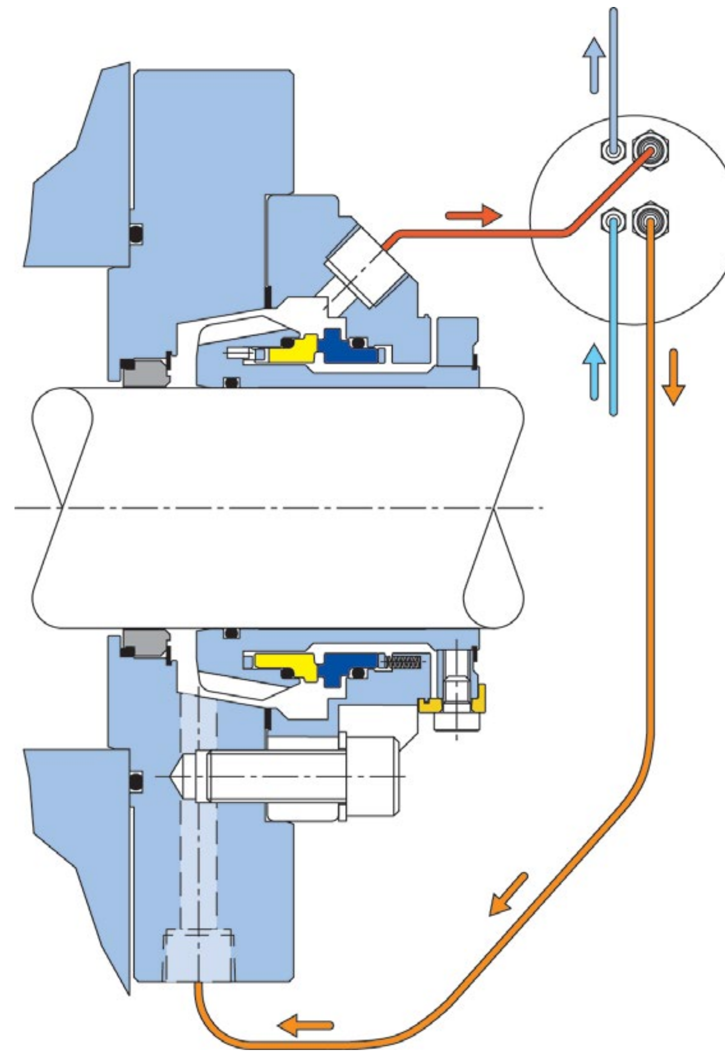

Figure 4: Mechanical seal cartridge with innovative bidirectional tapered pumping impeller *(courtesy of ASSEAL, Inc.)*

There is much more on the subject of improving existing machinery. A true "uptime extender" pays attention to every maintenance intervention. She or he views maintenance events as worthy of attention; failures present an opportunity to implement an upgrade, if previously cost justified. Reliability professionals make this feasibility and cost justification determination long before a maintenance event happens. Determining feasibility and cost are the two most important roles of reliability professionals. With that in mind, BoCs make a clear distinction between a maintenance engineer and a reliability engineer. Maintenance engineers put their effort into maintaining a machine in the as designed condition. They get activated the moment the machine is available for maintenance or is taken out for repairs. Many may argue about definitions and their occasionally unpleasant connotations, but maintenance, broadly speaking, is a reactive activity.[2]

The reliability engineer's workday is almost entirely proactive. These professionals use all their available time to seek, obtain and develop answers to three very important questions:

1. Is an upgrade possible?
2. If yes, is an upgrade cost-effective?
3. Which innovative technology provider should be selected to implement the combined repair and upgrade?

Needless to say, reliability professionals work with innovators; they make these innovators one of their primary technology resources. An innovator assists the reliability professional in determining and explaining payback. Together, reliability professionals and their upgrade provider review and document prior experiences. Both participate in finding or defining the field experiences at other client sites and, if possible, prepare a presentation to the reliability professional's management. This shared activity is actually part of a structured machinery quality assessment (MQA) process. The cost of an MQA should be in the user's or purchaser's budget since MQA largely contributes to decades of future machinery reliability. Although that message was first broadcast in the late 1960s, MQA appears to be on the decline today; the trend is sloped in the wrong direction.

Unfavorable Trend Observed Regarding MQA

It is apparent that a rigorous MQA is on the decline. Again, consider an interesting example pointing to the time when MQA activities received the attention they deserved. In late 1965, a senior machinery engineer involved in an MQA was on what was then called a loan and training assignment from a company affiliate in the United Kingdom. He was the lead machinery engineer tasked with selecting electric power generator drives for one of the employer's greenfield refineries in Southeast Asia. The customary bid process had narrowed the choice between slow speed, two-stroke marine diesels from Vendor A and higher speed, four-stroke diesel engines offered by Vendor B. But, maintenance costs and the crafts' competence at the destination site had to be considered during the MQA, so the situation needed to be examined or assessed for the developing country where these diesels were to be installed.

> The value of one's work product will last when all else has been forgotten.

To properly do this, the senior reliability engineer embarked on a two-week trip to West Africa, where such four-stroke diesels were operating and local conditions and crafts training most closely matched the conditions anticipated in Southeast Asia. The employer spent $60,000 (at that time close to two years' salary) for the senior engineer's overseas travel and associated outlays. It was later estimated that choosing the four-stroke diesels over the well reputed, two-stroke machines had saved the refinery $60,000 during its first four months of operation.

What to Do About the Declining MQA Trend

Because a declining trend was noted in how often companies engage in properly structured MQA activities, here are some noteworthy facts. Each of the four bulleted items suggests effort and reward.

- Becoming best of class is not a chance event; it's achieved through work and forethought, recognized as consistency and persistence.
- Every fluid machinery user company in the hydrocarbon processing industry described as best of class is using structured MQA efforts to assure and ascertain long-term reliable performance of critical machinery.
- Reasonable efforts to find and act on facts instead of hunches and opinions will meet with substantial rewards down the road.
- Seeking out and closely associating with innovators will pay surprising dividends.

Now, think about the world you live in and the exact role that evolved from the preceding MQA example. The late 1970s through the early 1990s saw an encouraging trend among best of class companies to reconfirm the roles of reliability professionals and to remind them of the expectations. Various elements that surely contributed to reliability professionals' achieving their anticipated roles to the fullest were listed and revisited during periodic performance appraisals. As an example, a plant manager asked one of his reliability engineers about two reciprocating compressors that were scheduled for turnaround work a few months later. The reliability engineer was fully informed and answered with the plot designation of the two machines in hydrogen service at that plant. He knew the name of the manufacturer and the years the machines were made (1962) and put into operation (1963). When the plant manager asked about the difference between machines built in 1962 and the machines a successor company would supply if purchased today, the reliability engineer explained that today's compressor frames are provided with internal bracing that allows approximately 12 percent higher frame loads and that the 1962 versions had piston rods with a nickel base hard surfacing alloy with chromium boride, whereas today these rods are supplied with a tungsten carbide coating. The reliability engineer also explained that the site was still using a certain style of compressor valve "A" and today's compressor valves would invariably be style "B."

This reliability engineer was an informed value adder. Working in cooperation with an innovative company, he proactively ascertained that upgrading to valve style "B" would be cost-justified, but no great gains would be derived from making changes to the present piston rod coating. He also began investigating whether operating cost savings would justify upgrading to electronically guided, infinitely variable cylinder clearance arrangements and, if so, would have his findings ready in time for order placement and delivery before starting the future turnaround. Needless to say, the reliability professionals at this particular plant worked with a compressor manufacturer whose engineering efforts and technology were leading edge.

Today, the trend among the few best of class user companies is to still do all of the aforementioned, and then some. The solid advantages of working with a supplier or provider with expertise in design, manufacturing and virtually all related phases of service are recognized by BoC companies. As noted previously, smart users enlist others as their technology resources. These users confirm that everybody benefits when there is close collaboration with midsize provider companies that make conversion, modernization and selective upgrading one of their core competencies.

So, pay attention to leading providers whose integration of engineering and service allows them to gain recognition on a very wide geographic basis. These worldwide technology leaders excel in safety and environmental performance, employee satisfaction and, perhaps, many other important attributes that ultimately reflect the value they can bring to a client's enterprise. Such provider companies have a global presence and can be found in widely differing fields. They can be found in technology fields, such as mechanical seals, high performance couplings, centrifugal pumps, dynamic compressors, twin screw rotary compressors and positive displacement reciprocating and diaphragm compressors, to name but a few.

Working with these knowledgeable suppliers and providers gives modern, results-oriented users a competitive advantage. These collaborative efforts greatly accelerate the user's or purchaser's upward move on the profitability and reliability improvement scale. Collaboration and cooperation are training tools not matched by anything else. Be sure to recognize the imputed value of this training; it must be given weight in the user's selection process.

Summary and Recap

- Only shallow thinkers are impressed by low prices. Low price and high quality rarely coexist. The discerning reliability professional disapproves of purchasing inferior quality products and shows how risking safety, blindly emphasizing and accepting low cost.

- There are fewer useless trends, such as benchmarking on the basis of shop backlog or blindly aiming for a finite number of engineers per 10,000 hp of installed compression or fluid flow machinery.
- Fast-moving favorable trends are seen in best of class user companies. These companies have found ways to work ever more closely with technology leaders that constantly develop innovation. Early access to innovations in reliability, energy efficiency, maintenance cost reduction, or maintenance elimination is increasingly given more emphasis.
- Through the use of role statements, best of class (BoC) users are strengthening and better explaining the definitive steps they want their reliability professionals to take. At these BoCs, reliability professionals are increasingly working with innovative technology providers. Their work product is valued by mid-level managers and the plant's reliability professional is given easier access to upper management.
- Plant managers at BoCs insist on hearing facts and well-researched solutions. These managers strongly discourage wasting time on listening to problems and opinions. The trend toward offering facts and solutions is favorable.
- There are highly favorable trends in the development of closer working relationships between midsize service providers and equipment users or purchasers. The value of collaborative training in a service sector is better understood and is emphasized to a greater degree. The trend is highly favorable.

After decades of active involvement in reliability engineering, some have come to realize that blindly joining in on a popular trend is worthless if the trendsetters were uninformed or have acted out of nostalgia from an inaccurately remembered past. Chances are you would not knowingly follow trendsetters who are responding to a wrong premise or are greatly misreading the future. A well-informed person will not be swayed by trends, but will reason on facts. Considering only the facts allows an individual to make informed decisions and he or she will do so in the assured expectation of future rewards.

Having read this article, consider how you can play a key role in the advancement of mutually rewarding manufacturer–purchaser relationships. Remember, there will never ever be a substitute for common sense, for being a person with motivation and, yes, a person who has developed a deep and lasting appreciation for the laws of science and basic physics. These laws are immutable; there are no substitutes for them. Like it or not, learning, applying and retaining the underlying principles of these laws are lifelong processes.

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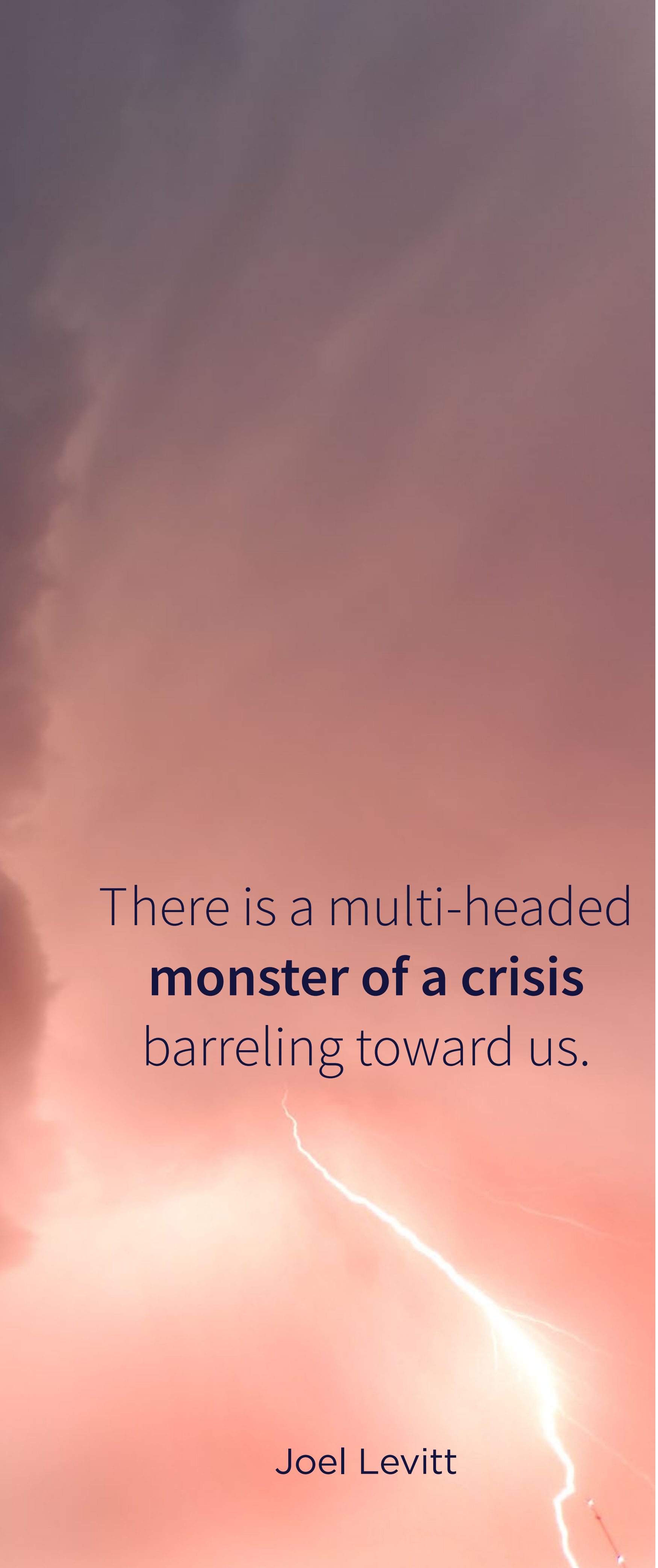
Mro mro-spares management

A Perfect Storm for an MRO Stockroom CRISIS



There is a multi-headed **monster of a crisis** barreling toward us.

Joel Levitt

This crisis in the sourcing, stocking and justifying of maintenance, repairs and operations (MRO) spares has been developing since the 1990s and will likely get worse before it gets better. The core of the crisis and the reasons for it are distinct. These distinct contributors form the perfect storm of trouble for any maintenance department, especially ones that have implemented lean principles. The solution is surprisingly in the domain of asset management.

Organizations are increasingly having trouble gaining access to spares for critical assets (note that you do not have to own the spare, just have access to it when you need it). The core of this crisis is the fundamental misunderstanding of the role of spares inventory in general and of critical spares in particular, and tremendous changes in the parts supply chain.

> "Organizations are increasingly having trouble gaining access to spares for critical assets."

Before Addressing Spares, Let's Define AIM

The AIM of an organization is defined as the publicly published mission, vision and values. The AIM is the ultimate truth for any organization; it is the reason for the organization's being.

Metrics

Metrics, also known as performance indicators (Pi, Uptime® Elements™), are numbers and ratios that tell the story of what is going on in the organization. Ideally, metrics are used to manage action within the organization. Choosing the right metric is important because the wrong one will drive the wrong actions. There are many *right* actions on a functional or departmental level that are *wrong* when looked at from the perspective of the organization's AIM.

For example, if you are trying to encourage customer engagement, you might measure complaints. You might interpret increased complaints as proof of increased engagement. After all, complaints do measure engagement, so what is the problem?

While greater complaints = greater engagement might be true, greater complaints might be considered deleterious to the AIM (i.e., mission, vision, values) of the organization. The problem is the metrics might drive the wrong behavior.

Let's say your organization's AIM states that it is a "low-cost, high quality producer with great customer relationships committed to people, planet and profit." While people now know your reason for being, the greater complaints = greater engagement tends to contradict that AIM.

Getting back to storerooms, what do metrics that are contradictions to the AIM look like? Where is the misunderstanding of the role of the spares inventory?

Let's say you carry a $3,000,000 inventory and you are ordered to dispose of any inventory items held for more than two years to free up space, reduce cost of ownership and free up funds. There is $275,000 of spares in this category.

Disposal of the $275,000 will free up space, reduce the cost of ownership (marginally) and might even free up some funds (5 to 10 cents on the dollar anyone?).

The other side of the argument is the impact on the AIM in being a "low-cost, high quality producer." If a disposed part is needed for a maintenance incident, then the cost of the metric to dispose of the inventory might be 50 or 100 times greater than any savings or money generated from the disposal.

Another metric might be turns, which is annual purchases divided by inventory value. Higher turns mean the inventory is sitting on the shelf for a shorter time. It is said to be turning faster. This is particularly important in retail because the more turns for the same inventory, the greater the profit. Since you don't make money until the item turns, it is a direct drag if it isn't sold.

> "The MRO spares inventory should be considered as a portfolio of insurance policies. Each policy has a premium and a benefit."

There are categories of maintenance stock that can be evaluated by turns. In fact, all items used more than once a month can be subjected to turns calculations. Considerable savings can be gained from an analysis of these categories.

Unfortunately, as many as 50 to 75 percent of the SKUs turn less often than once a month. Many items might turn only once a year or less often.

Optimizing slow moving items to improve turns creates a situation where you'll save a few dollars until you need an item, but then you might induce production losses costing millions.

This situation is driven by actions that make sense to a function or department, but do not make sense to the organization's reason for being or its AIM.

The misunderstanding is that many departments consider MRO spares inventory as an inventory asset. Inventory assets should be minimized because they soak up working capital and provide no direct value to the value stream producing the product. Logically, from this point of view, reducing this non-value-added inventory is the right thing to do.

More Accurate Point of View

The MRO spares inventory should be considered as a portfolio of insurance policies. Each policy (i.e., critical spare part) has a premium (i.e., cost of ownership) and a benefit (i.e., reducing duration of downtime).

Typically, no one would look at their insurance policies and decide to discontinue coverage if they didn't use a policy for two years. What people should do is decide if they still have the particular risks and if coverage is worth the premium they pay. This is one way of managing risk.

The Second Half of the Problem: Changes in Getting Parts

When did the supply chain for parts change? Surprisingly, one of the best new tools drives most of the changes to the supply chain. These changes were enabled by advances in computer and data analytics used to optimize value chains.

There are four factors that caused the change. All of these new realities contribute to the present day supply crisis:

1. Optimization of the finished good inventory by the original equipment manufacturers (OEM) of the spares;
2. Changes and optimization to the stocking policy by the end user;
3. Disintermediation due to the Internet and other changes to distributors;
4. Nature of spares themselves.

Factors one and two are driven by the same desire. Optimizing company assets requires you to look at stocking rules and what is stocked. If you are a retailer, the OEM parts stock is a retail inventory and if something does not sell for a year or more, it does not belong on the shelf. Good business practices dictate getting rid of parts that do not sell or are not used.

Everyone along the MRO supply chain, from the OEM and the distributor to the dealer and user, has been saving money by optimizing their inventory using computer analytics.

The dwindling resources available for the MRO inventory by users of the parts has already been noted. The arithmetic, metrics, rules and techniques of inventory optimization is the same for an OEM, distributer, or end user. The difference is that the retail and wholesale ends of the supply chain profit from inventory optimization (even if it does upset their customers).

Since the end user is buying insurance against downtime, optimization can have contradictory effects. All the financial benefits of years of optimization can be and will be offset by a single breakdown in a critical asset or process. It is that simple. All the savings of not buying home insurance for 10 or even 20 years are wiped out by a single event or by multiple, smaller events.

Note that none of this information supports having triple coverage for a loss (i.e., too many parts) or having coverage for a car you already got rid of (i.e., parts for critical assets you retired). Finally, this in no way supports policies that are not reviewed to see if they are still good and useful (i.e., damaged, broken, corroded parts). These are all legitimate surpluses to be disposed of.

Distributors and Dealers

In years past, distributors sometimes served as the intermediate inventory and, if it was profitable enough, kept sufficient parts for their customers even if the OEM did not. Two changes happened.

One change is described by the fancy word, disintermediation. Because of the Internet, it is easier for customers to locate and buy direct from the OEM. With advances in order entry software and low-cost logistics, like parts banks, it is economical and profitable for OEMs to sell direct to customers.

One fact of life for OEMs is that most of their profit comes from their parts and service business and little comes from the actual sale of the machine or component. The parts business is serious business for OEMs. Disintermediation puts more parts profit into the OEM's pocket in a very competitive world.

That leaves distributors and dealers in some industries with lower volume and lower profit. In part, their lower profits drove the need to optimize their own inventories. Now, with their business threatened, they cannot justify stocking some of the more exotic parts.

Are You Already a Hero?

You are if you:

- ☑ Already are cutting the inventory level before you even get started.
- ☑ View inflation in prices of parts over the last decade or two and can see that parts prices have inflated faster than wholesale prices, consumer prices, or most other inflation metrics.
- ☑ Bravely hold the line on maintenance inventory, equivalent to a five to 10 percent decrease in inventory. You recognize that although it might not sound like a lot, it does accumulate over time, so a $1,000,000 inventory today would be equal to a $2,000,000 just 10 or so years ago.

Parts Are Parts, Aren't They?

For a myriad of reasons, such as accelerating technology, a need for increased efficiency, higher quality tolerances and the fickle nature of specifiers and buyers, the lifecycle of equipment is shorter. Shorter lifecycles mean the opportunity to profit from the part is shorter.

With more variations and shorter lifecycles, it is becoming more expensive and difficult for an OEM to stock everything for all their equipment series, especially the older ones.

Your firm is also part of the problem if, when buying new equipment, you don't review the parts you already stock and try to buy equipment that uses at least the same lines. Much of the problem locally is that designers are attracted to the newest, best and greatest. This attitude requires more SKUs and makes metrics, such as inventory value, balloon and turns crash.

> "How low does the probability catastrophe have to go to justify the savings?"

Asset Management to the Rescue

According to the new ISO standard 55000, asset management is defined as managing the value from the asset and managing the risks associated with producing that value.

What is the value? The value is whatever your organization's AIM says it is. The AIM begets the assert management strategy. The strategy begets the plan. Your challenge is to build a decision process that weighs the risk and the value, and answers the question for the whole company and not solely for a single silo.

So the question, "How low does the probability catastrophe have to go to justify the savings?" is a business question that must be addressed! A management-wide approach to managing risk is a primary function of asset management. It is not for the finance silo or the operations silo to address. It is for management to address through strategies developed by working from the AIM.

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Cr
corporate responsibility

BEST GREEN RELIABILITY PROGRAM

Brian J. Pertuit

LOOP LLC operates the only crude oil deepwater port complex in the United States, consisting of an off-loading facility in the Gulf of Mexico and pipeline, storage and domestic terminaling facilities in southeastern Louisiana. The deepwater port complex is a vital energy hub, with pipeline connections to approximately 50 percent of the nation's refining capacity. The Clovelly Hub facility can store over 70 million barrels of crude in belowground caverns and aboveground tanks. LOOP's unique pumping systems can transport crude at rates in excess of 100,000 barrels per hour on multiple, interconnected pipelines.

In 2011, LOOP initiated a vision of becoming market driven and operationally excellent. Related strategies and tactical objectives were developed and implemented early on, and are now being enhanced for its future successes in the evolving petroleum market. As LOOP's strategic planning process evolved, the company identified a specific strategy to provide dependable and secure execution of services that add value to its customers and owners. The uptime or availability of assets, along with its environmental stewardship and energy consumption reduction, are all considered critical components of LOOP's business

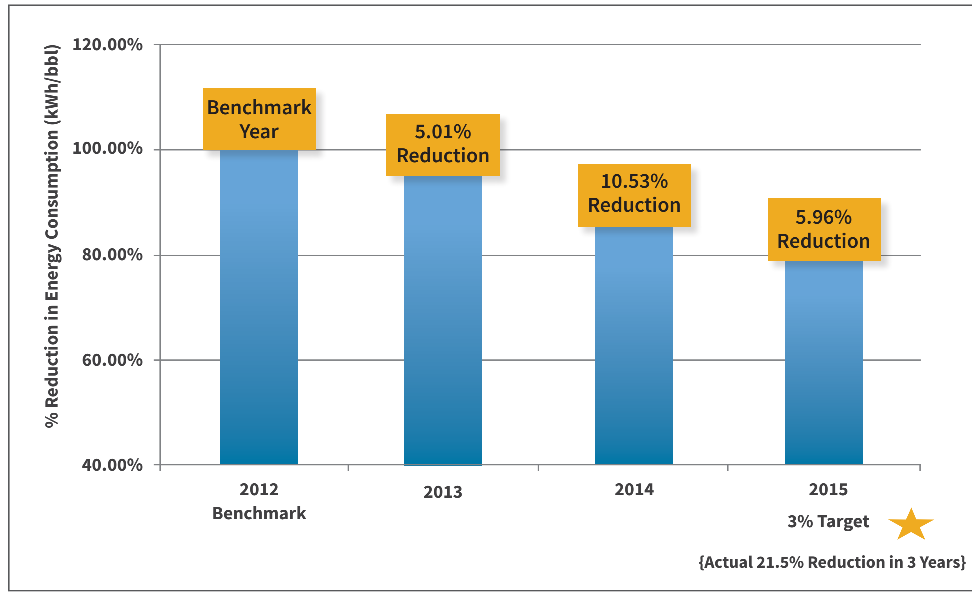

Figure 1: Energy consumption reduction per barrel of crude oil transported

Figure 2: LOOP marine terminal living quarters and helipad replacement project, 2015

performance. These initiatives, therefore, align with the company's vision for a successful future. Its proactive systems and programs have changed LOOP's culture, as evident by the statistics, but also in normal coffee break talks in the breakrooms and actions throughout its facilities. LOOP continues to plan its work and work its plans, making it habitual to seek opportunities for continuous improvement in all aspects of the business, always and everywhere throughout its facilities and even in the company's third-party service shops.

The results have been rewarding, as the company achieved a record 99.75 percent uptime on its main oil line (MOL) assets in 2013. LOOP remains over 99 percent and has now exceeded 98 percent uptime for over eight years. In 2014, LOOP won the Uptime® Awards for Best Work Execution Management Program and is honored to have recently received the 2016 Uptime Awards for Best Green Reliability Program as well.

In 2015, LOOP handled 875,646,384 barrels of crude (that's 36.8 billion gallons) at its Clovelly Hub in Cut Off, Louisiana; 445,309,410 barrels in and 430,336,974 barrels out. Though LOOP recorded 12 reportable releases that year – the company reports every drop of potentially hazardous fluid that enters the water – the total volume released was only five ounces or less than one cup. That ratio of throughput to release volume is a new record for LOOP, but its target goal is always zero for both safety and environmental incidents, so there is more work to be done.

The company also established a five-year goal in 2013 to reduce its energy consumption per barrel of crude oil transported by 15 percent when compared to its 2012 baseline numbers. This was accomplished in less than two years and LOOP continues to decrease energy consumption through 2017, as the company is now consuming over 26 percent less energy per barrel than it did when compared to 2012 usage. By the end of 2015, energy consumption had decreased over 21.5 percent when compared to the benchmark year in an inverse relationship to its increased throughput and equipment uptime, as shown in Figure 1.

LOOP converts diesel consumed for its offshore platform, support vessels and onshore facilities, as well as helicopter fuel, to a common unit of energy: a kilowatt-hour (kWh). This energy consumption is then added to its electricity usage at its onshore facilities, which is also tracked in kWhs. The company then calculates how many kWhs it takes to move a barrel of crude oil at LOOP (kWh/barrel). Engineering, reliability, operations and maintenance have worked hand in hand to pioneer new ways to optimize the company's marine terminal (MT) MOL pumps so they operate at their best efficiency point most of the time. Operational changes to oil movements and scheduling, as well as optimization of the company's boat and helicopter usage, have significantly reduced LOOP's energy consumption per barrel. The company continuously strives to become even leaner as it realizes this is good for both the business and the environment. LOOP understands and appreciates Terrence O'Hanlon's, CEO of Reliabilityweb.com® and the creator of the Uptime Awards, theory of the triple bottom line of people, planet and profit, and supports and encourages those related initiatives within its work groups.

LOOP made a commitment after its first Uptime Award in 2014 not to camp out at success or rest on its laurels. Among the many investments in growth and continuous improvement efforts, the company has enhanced a warehousing program and is now enhancing its condition-based monitoring program for field assets. Another investment recently completed successfully *on budget, ahead of schedule and without incident* was the replacement of the marine terminal living quarters on the control platform in the Gulf of Mexico. The old living quarters were in service for over 35 years. The effort included two critical lifts exceeding 700 tons (*out with the old*) and 800 tons (*in with the new*), as shown in Figure 2. This

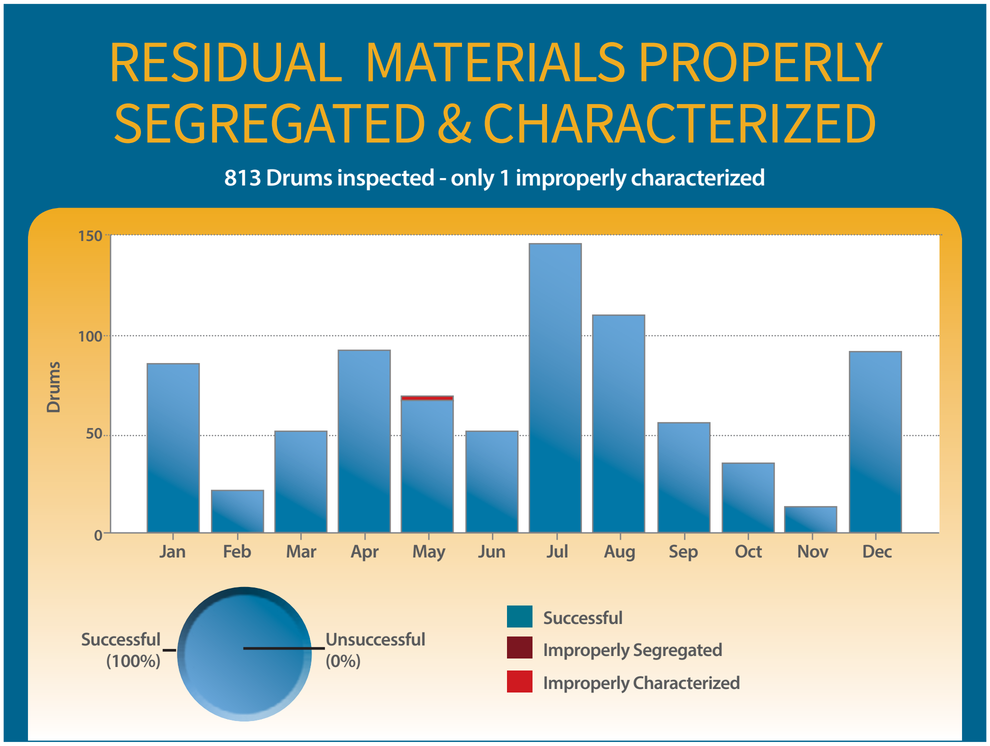

Figure 3: Improved waste management is another green initiative at LOOP's operating facilities

quarters building not only provides office space and housing for personnel, it is also the point from which LOOP's critical vessel traffic control system is operated and maintained. A larger helipad was also installed above the quarters. As part of the replacement project, higher efficiency HVAC systems were installed, as well as LED lighting, which consumes about 40 percent of the amount of electricity that incandescent lighting uses. The building itself was also sealed tight and designed for positive pressure, thus preventing moisture intrusion and energy losses due to air leaks. With this project, LOOP reinvested both in the company and the safety of its personnel.

In 2015, LOOP also introduced a green initiative to reduce the quantity of mislabeled waste drums throughout all operating facilities. This effort helps reduce ineffective landfill selection and management practices by segregating and labeling oily rags and other hazardous waste correctly, as well as normal waste and recyclables. Company efforts were very successful; out of 813 drums inspected, only one was improperly labeled (Figure 3). Therefore, LOOP achieved a 99.88 percent success rate for proper labeling and characterizing of waste drums in 2015. The one drum found in error was corrected prior to being transported for off-site disposal, so the company was actually 100 percent successful with this initiative overall.

This proves, just as in asset health management, with well-placed efforts and effective leadership operators can successfully manage what is measured. As always, data quality is important when it comes to metrics and key performance indicators (KPIs), as well as relevance. The company learned to measure the things that should be managed and where a cultural evolution has already taken place to eliminate data tracking that is no longer pertinent. This leaning out of its metrics and KPIs allows the company more time to focus on current, relevant objectives and tactics that are being embedded into its positive, proactive processes.

In 2017, LOOP is implementing the recommendations set forth in the American Petroleum Institute's RP1173 for a more structured and integrated pipeline safety management system. This includes a Deming cycle style of plan-do-check-act (or adjust) component for all its processes and programs, starting with risk assessments and mitigation evaluations at all operating facilities. Although this was a recommendation and not a regulatory compliance requirement, the company opted to get ahead of the game by improving where it can as early as it can in the process. There are similarities between API RP1173 and ISO55000, so LOOP's efforts are yielding a win-win for the company and its assets.

All LOOP employees, its owners and strategic contract partners are very proud of its stellar team performance and successes. As stated in 2014 and again with its 2016 award:

With an embedded, proactive culture, a clear focus on "getting it right" and a passion for "continuous improvement," LOOP continues its journey toward operational excellence.

Figure 4: LOOP leadership team (all members not present due to other commitments)

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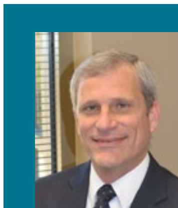

Special Recognition

***Chris A. Labat,** CMRP, is the Vice President of Engineering & Technology at LOOP LLC, where he once served as the Reliability Superintendent. He supported the proactive and green initiatives referenced in this article and served as general manager during the period of MOL pump efficiency rerates. Chris has over 30 years of experience in the oil and gas industry. He obtained a Bachelor of Science degree in Mechanical Engineering from Louisiana State University in 1987.*

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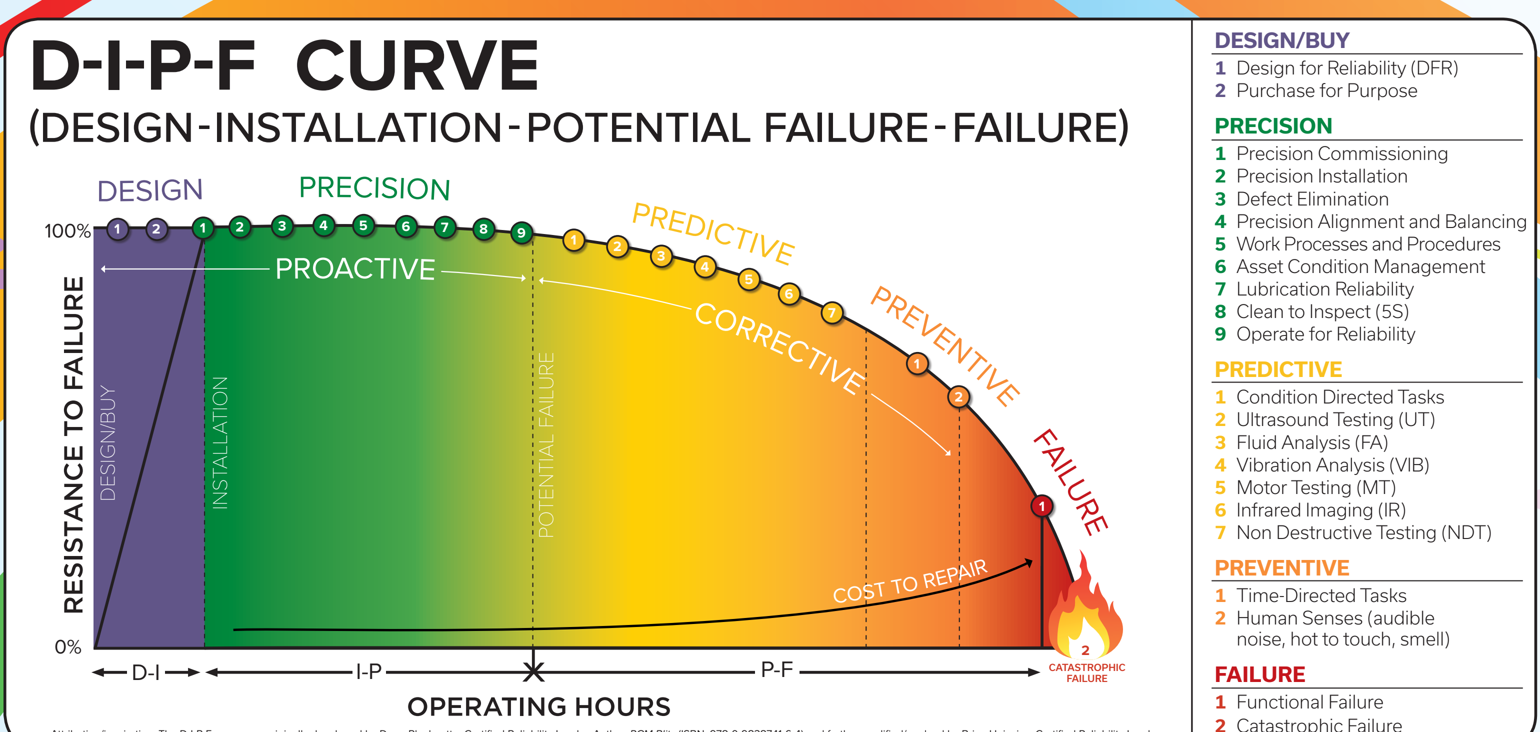


Figure 1: I-P and P-F reliability curve

When looking at the P-F reliability curve, there are two main categories of maintenance reliability action where resources may be focused: the P-F region and the I-P region.

The P-F region (see Figure 1) is the portion that typically receives most of the attention. Since the equipment defect or failure has already begun, this region is about detecting and predicting equipment failure modes so repairs can be made in a planned manner.

Basically, you are managing potential failures (P) as they progress toward functional failures (F). Nothing about your activity beyond P will prevent the failures from happening. Even though you may intervene to prolong a condition, the failure is inevitable.

There is certainly a lot of value in the activities in the P-F region. The only way to prevent equipment failure is to do something prior to P. Activity in the P-F region is like checking your blood cholesterol on a regular basis and deciding the right time to take action. Just checking and tracking it does nothing to prevent it. For your equipment, activities in the P-F region include asset condition management efforts, such as vibration analysis, fluid analysis (i.e., wear particle analysis and contamination), infrared thermal imaging, ultrasound testing, operator basic care rounds and a few other reliability elements. In general, the technology and execution of these activities are understood and performed successfully by trained personnel.

The I-P region, as shown in Figure 1, is the time frame from when the equipment was installed to the point in which failure begins. In many evolving reliability cultures, there may be more time spent on the P-F region than the I-P region. But, as organizations mature, emphasis grows in the I-P region.

The I-P region is the only part of the reliability curve where failures actually can be prevented. If any facility is to uncover the hidden plant and improve asset reliability, then a significant amount of resources must concentrate on the I-P region.

> "The I-P region is the only part of the reliability curve where failures actually can be prevented."

The short-term financial return is executing strategies in the P-F region, however, the big return area is working in the I-P region. The cost of reliability increases the farther down the P-F curve in which it is implemented. Efforts on the I-P end to prevent failures are relatively cheap compared to those in the P-F area to predict or manage failures.

The key question in the I-P region is: What can be done to prevent or delay failure? The remainder of this article focuses on the I-P section and what can be done to extend the I-P interval or prevent failure altogether.

There are numerous reliability elements that work to prevent failures. One of them is root cause failure analysis (RCFA). RCFA is both a reactive and proactive action that occurs in the I-P region, but begins in the P-F region. Good RCFA is directly linked to failures by focusing on actual failure modes. With accurate analysis and completion of action items, failures can be prevented for the future, making this a proactive element. Failures not only may

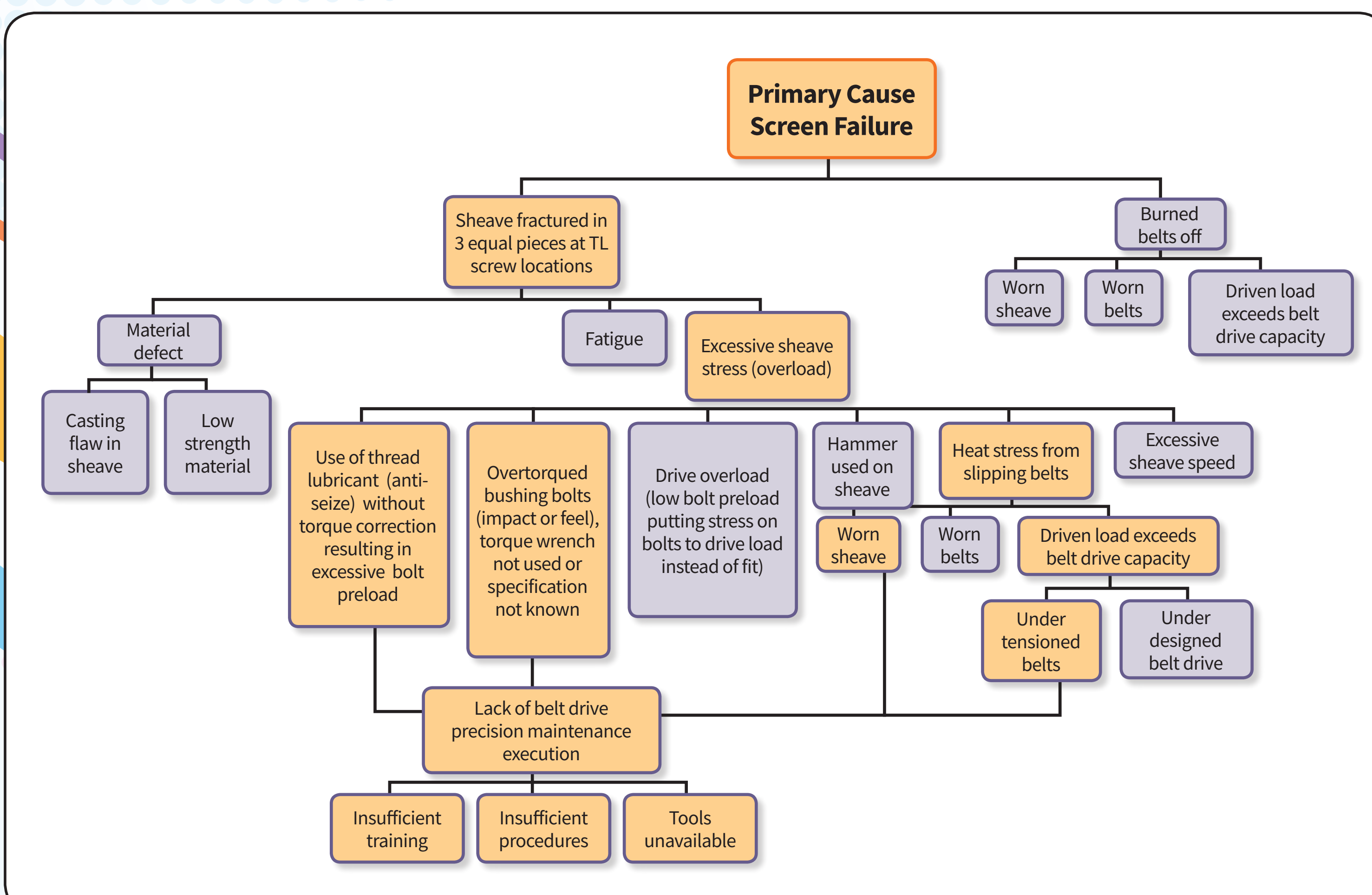
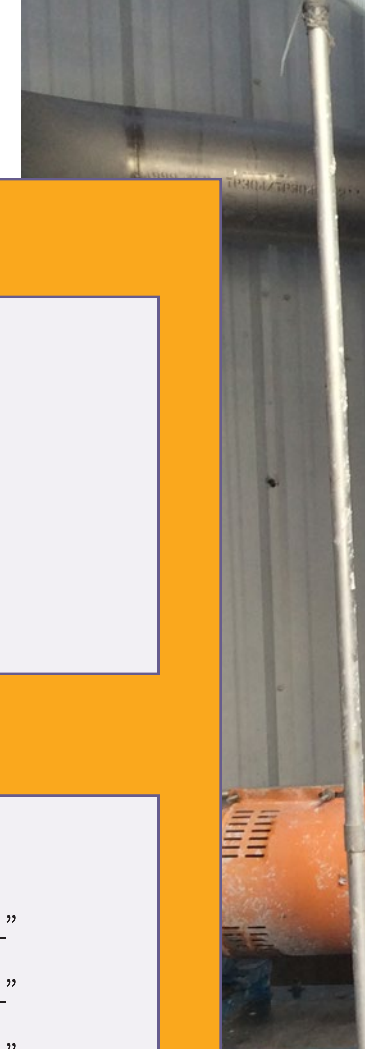
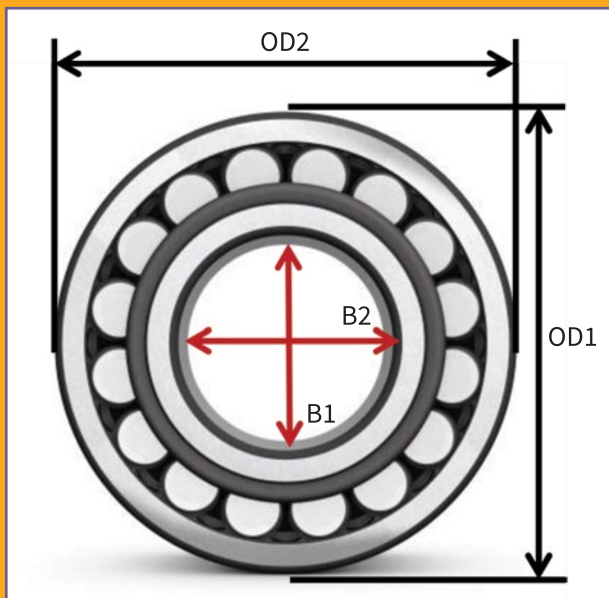


Figure 2: RCFA logic tree





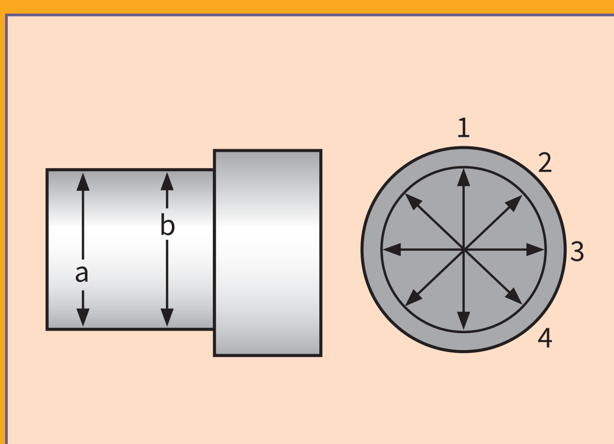
Bearing Measurements:

B1 ______________” OD1 ______________”

B2 ______________” OD2 ______________”

Ave. B ___________________________”

Ave. OD ___________________________”



Shaft Measurements:

A1S ______________” B1S ______________”

A2S ______________” B2S ______________”

A3S ______________” B3S ______________”

A4S ______________” B4S ______________”

Ave. Shaft Diameter ___________________”

Bearing Shaft Fit ______________________”

Figure 3: Precision practices for bearing fits

be prevented on a specific piece of equipment, but the knowledge gained may be applied to all similar equipment.

A similar process is failure mode and effects analysis (FMEA). The major difference between FMEA and RCFA is that FMEA is purely proactive, while the latter is reactive initially. FMEA takes a broad look at all possible failure modes, while RCFA looks only at the actual, experienced failure modes. Due to limited resources in many organizations, RCFA is a favorite choice by default. RCFA is very efficient since it places priority only on the items that cause failures. Good RCFA will likely have some action items in many of the other areas discussed in this article. Figure 2 shows a typical logic tree from a failure.

Precision installation is another key area for proactive efforts to improve reliability and prevent failure. Precision installation requires a lot of detail to follow specific component or equipment setup instructions. If components have correct fits, clearances, pressures, alignments, no pipe strain and proper balance quality, the result is longer life. These details only can be established up front at purchase or installation. If you don’t do these things, short I-P intervals will result, or worse, infant mortality soon after start-up.

It’s important to note that infant mortality is defined differently for different equipment, components and failure modes. A bearing that fails in three years may be, in many cases, infant mortality, but a contact lip seal that last three years is considered good life. To be successful in this, good procedures and worksheets need to be in place, as well as properly trained maintenance craftspeople. Only having one of these in place will not yield the desired results. Figure 3 is an example of a bearing fit worksheet to record fits during installation.

An often undervalued preventative failure action is proper spare parts management. This includes having the correct material specifications in a computerized maintenance management system (CMMS) bill of material (BOM) so it can easily be identified and ordered in the future. While a seasoned planner can overcome some BOM errors or gaps, it requires extra work, which is inefficient. This should all be set up prior to machine start-up. The maintenance planner can maintain an already established BOM in the CMMS, but will not have the time after start-up to build an entire system.

Proper storage and handling of spare materials is also important. It has been shown in many areas where failure modes have already begun before installation due to poor storage and handling practices. Is the storeroom set up for good reliability? Does the parts storage area have proper storage conditions (e.g., temperature, humidity, low vibration) and proper storage positions (e.g., vertical or horizontal)?

Figure 4: Design errors showing not enough straight run piping on pump suction

Another major area that prevents equipment failure is equipment and system design. This can be one of the biggest reasons for unreliability. So, what specific failure modes can be designed out? Proper lubrication systems will ensure the wear failure mode is eliminated or at least reduced to a level that provides very long life. Proper lubrication includes component selection, sizing, seals, contamination control (i.e., proper filtration) and corrosion protection. Design for maintenance is key for ensuring condition monitoring of lubrication systems is done. This includes an oil sight glass, oil sample ports and filtration.

Design also includes proper sizing of components and equipment so they operate without overload or underload conditions. Two examples are a bearing that does not have above minimum loading and a cylindrical bearing used in a thrust application. A process design must fit equipment and components so loading is optimum. Some examples: an oversized process pump that runs near deadhead condition or a bearing that is running under a minimum load. A system design with insufficient net positive suction head (NPSH) for the pump also can cause cavitation related failures. Design also includes fatigue resistance of components, such as proper sizing, metallurgy, strength, surface finish and elimination of stress concentrations. These design conditions result in a chronic reliability issue that only can be solved by redesign. Figure 4 is an example of a process design error.

> While the activities that prevent failures and extend the I-P interval often don't get the attention they deserve, these efforts likely produce the best return on investment for companies.

Lubrication excellence means having the right lubricant type and quantity in the right location on the equipment to prevent wear and premature failures. This includes having already established lube routes and a lube database with a trained maintenance workforce to execute it.

Fluid analysis can be an I-P activity or a P-F activity. When fluid analysis reveals the lubricant is degrading, it is proactive (I-P) as it allows for action to occur before equipment failure results. Examples of this include tests for viscosity, water, particle counts, additives, etc. When the fluid analysis reveals wear metals, then lube degradation has already occurred on some level and equipment wear has already begun to show up, as shown in the example in Figure 5.

System reliability also comes into play in project management and installation. Having the resources and systems already established enables the operating and maintenance teams to begin proper execution at start-up. This is likely one of the biggest failures in project implementation and roadblocks to reliability. Area maintenance teams do just what their name implies – maintenance. They are not organized to be system builders with all the tasks on their plate every day to keep a facility operating 24/7. If an organization ex-

Manufacturer: SHELL **Oil Type:** OMALA S2 G 320 **Grade:** 320.0

Lab Number / Sample Date		Units	630844 06/30/16	620868 03/29/16	609965 12/28/15	594526 08/14/15	586571 06/05/15	527060 01/14/14	496324 05/20/13
WEAR ELEMENTS									
Iron	Fe	ppm	90	2020	881	1170	1040	787	3950
Chromium	Cr	ppm	1	20	12	10	10	12	50
Molybdenum	Mo	ppm	0	0	4	0	0	0	10
Aluminum	Al				0	0	0	0	0
Copper	Cu				4	10	0		
Lead	Pb				0	0	0		
Tin	Sn				0	0	0		
Silver	Ag				0	0	0		
Nickel	Ni				13	10	10		
Vanadium	V				0	0	0		
Titanium	Ti	ppm	0	0	0	0	0		
Manganese	Mn	ppm	0	10	6	10	10	10	40
Cadmium	Cd	ppm	0	0	0	0	0	0	0
CONTAMINANT ELEMENTS									
Silicon	Si	ppm	6	20	7	0	10	7	20
Sodium	Na	ppm	0	0	2	0	30	2	0
Boron	B	ppm	16	0	3	0	0	30	10
ADDITIVE ELEMENTS									
Magnesium	Mg	ppm	0	0	3	0	0	1	0
Calcium	Ca	ppm	0	20	21	0	0	25	90
Barium	Ba	ppm	0	0	0	0	0	0	0
Phosphorus	P	ppm	376	270	251	220	230	438	250
Zinc	Zn				14	0	0	17	70
NON-METALLIC CONTENT									
Water					1.5	13.5	Nil	Nil	Nil
Solids					1.5	2.0	0.5	<0.1	<0.1
LUBE DATA									
Viscosity @ 40'C					300.3	352.7	310.0	241.5	299.8
Total Acid Number		mg KOH/g	0.86	38	0.45	0.45	0.60	0.76	1.34
PARTICLE COUNT									
4		/ml	72741	99999			99999	99999	99999
6		/ml	1787	99999			99999	5637	15722
14		/ml	68	15530			8620	99	78
20		/ml	19	174			60	17	13
30		/ml	3	30			4	4	2
40		/ml	2	14			2	1	0
ISO Code 4/6/14 um			23/18/13	24/24/21			24/24/20	24/20/14	24/21/13

Original gearbox lube was not protecting gearbox; failure occurred in 2015; gearbox lube changed to ISO460 and iron wear element dropped

Wear element showed failure coming for years, but results not being reviewed

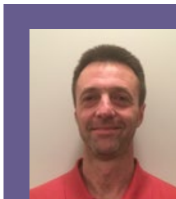
Particle count high, so later added kidney loop filtration

Figure 5: Fluid analysis failure prevention and management on gearbox

pects a lean maintenance team to build all the reliability systems, then be prepared for frustrated employees and an unreliable operation.

While the activities that prevent failures and extend the I-P interval often don't get the attention they deserve, these efforts likely produce the best return on investment for companies. Chronic failures that result from design issues are often times very difficult to resolve as they become baked into the physical infrastructure of operating plants. They require extra effort and skills from your maintenance reliability staff to resolve.

The question you need to answer is: Where are the opportunities for your plant to improve reliability on the front end of the I-P region of the reliability curve?



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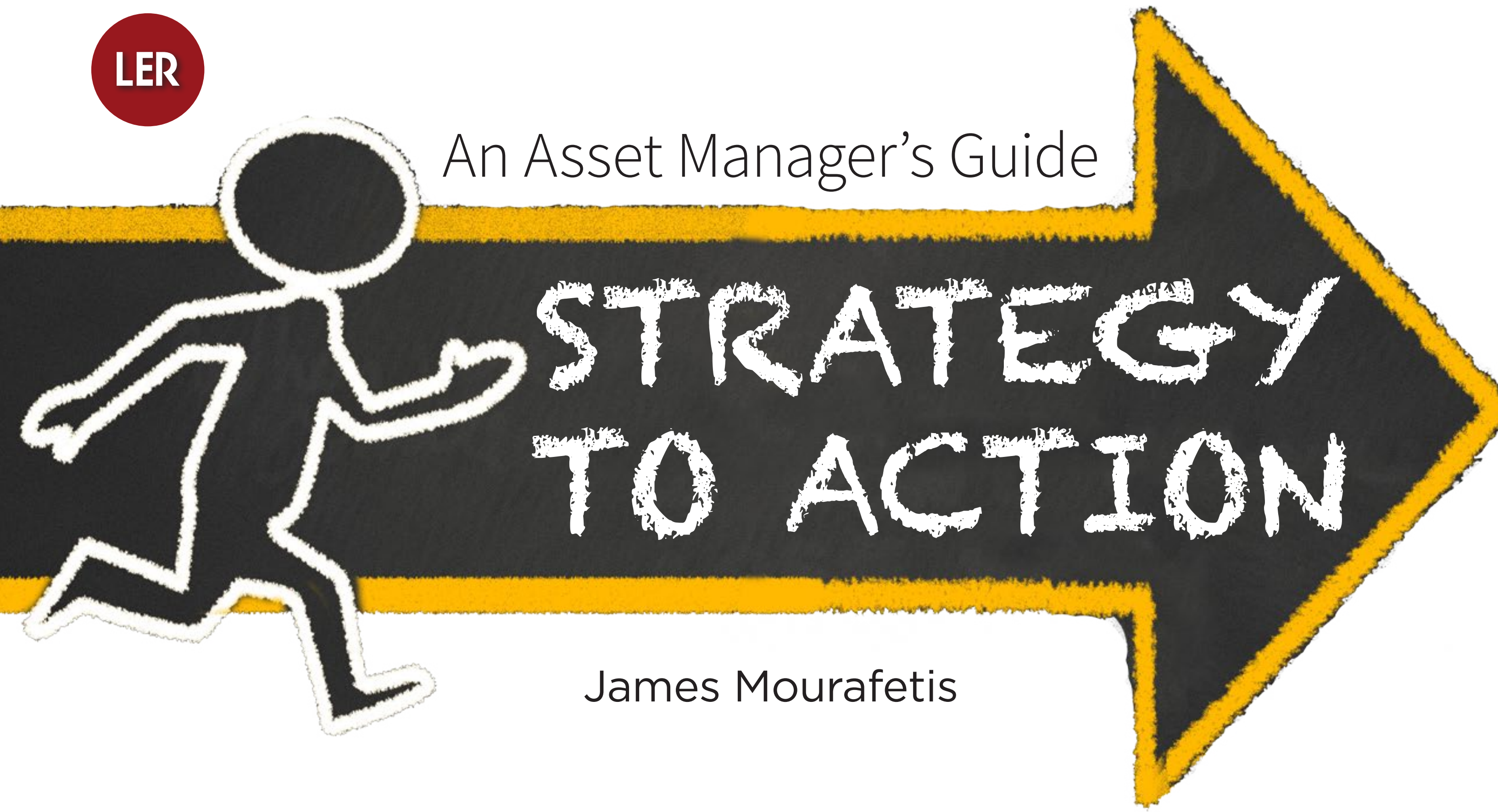


An Asset Manager's Guide

STRATEGY TO ACTION

James Mourafetis

The Feb/March 2017 *Uptime* article, "An Asset Manager's Guide to Harvest Management Commitment," explained how to sell your company's vision to the executive level team of your organization. If you were not successful in getting to this point, don't feel bad; not even a handful of asset managers across the globe have achieved successful enterprise asset management (EAM) transformation. However, if you were successful at harvesting management commitment, it is now time to take the next step and take it quickly: turning strategy into action!

The important thing to remember is to have a vision of what your successful EAM will look like. Do not underestimate the power of gaining management commitment.

Here are the four crucial steps, including important reports, necessary to move forward with EAM.

1. Determine poor performing operational areas within each EAM work stream in order to establish a pilot within each work stream

Every company has known weak performing functions, whether it is in the process of sales, operations and planning, engineering change orders, operations, or after delivery services. In order to implement change and strengthen the weak functions, it is important for asset managers to go to the right parties in the right order for their buy-in – a process that is extremely delicate.

It is crucial to start with the department level managers and gain their commitment to allow for a fact-based assessment of the known weaknesses. Not only does this show respect for the department managers, it also provides them the opportunity to take the initiative and start the EAM process with the team.

Next, present the department level managers' assessment of weaknesses to the executive level asset steering committee for approval. This ensures the department managers do not lead you down a wrong path. Since asset managers might not always know the functional problems very well, an inaccurate assessment could steer you into a dead-end operation where there is not enough activity to determine a baseline for improvement.

Finally, approach the respective vice president. Don't reverse the hierarchical steps, otherwise you end up asking the vice president before the department managers weigh in, creating an awkward situation.

2. Invite an objective third party to baseline performance through fact-based observed and analyzed assessments

Generally speaking, there are two main truths about an organization's failure to self-attempt continuous improvement. One, an organization's structure is designed to perform repetitive daily functions. Good industrial process design, which includes all processes in the organization, is often not implemented at the outset of these daily functions. This means good industrial process design is not part of the repetitive functional process. Therefore, poorly run processes are repeated day in and day out, and they are even viciously guarded to ensure the repetition does not change, even for the sake of improvement. This creates a culture where senior and middle managers safeguard original organizational design practices and block good industrial process design. The result is an organization that cannot and will not change.

Two, even when an organization has good intentions to break these cultural chains by establishing an internal continuous improvement (CI) team, this internal team is limited by its own fear of change unless there is outside intervention. By promoting persons from within to the CI team, the existing culture is reinforced. This leads to the CI team using math and science to reinforce its own poor practices. It's understandable. Why would the CI team make or recommend changes if its visionary members know they may one day be reassigned to those whom they want to change?

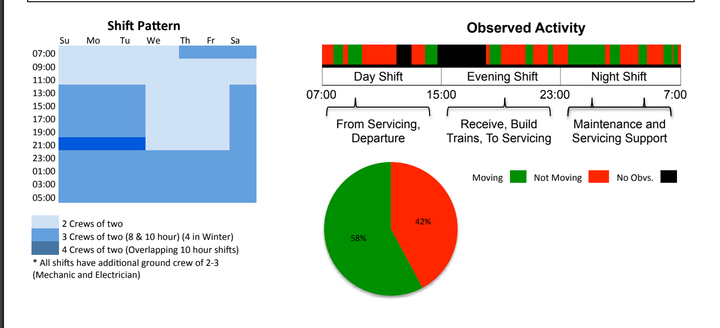
Internal assessments always will be seen as biased within and between departments. That is why it is absolutely necessary to hire third-party consultants who are boots on the ground operators and can develop fact-based assessments without bias to speak the truth through observation, analysis and facts. Remember, in many organizations, department managers will be defensive and want to discredit findings. Therefore, it is important to select the right consulting firm that has the emotional maturity to baseline fact-based performance.

3. Have the third party report the assessment and pilot program to the executive level asset steering committee

The knowledge that the department and their respective vice president will have their souls exposed to the executive management team is frightening to that department. Luckily, consulting firms experienced in this area know how to manage this process effectively, professionally and with great sensitivity. These consultants provide fact-based reports that baseline the current performance of the assessed scope and make realistic recommendations, complete with projected base and best-case financial and operational improvements. The assessment reports need to reflect the magnitude and impact of the overarching asset measures and assess each measure in terms of operating expense (Opex) and capital expenditure (Capex).

Figures 1 through 6 provide sample elements of such fact-based assessment reports in the operation of trains.

Yard moves are supported by 2, 3, or 4 crews of two. Based on observations and discussions with locomotive attendants, the move types vary across shifts, with night shift supporting more activity due to maintenance and servicing needs.

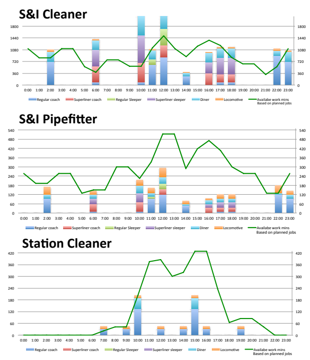


Workload in winter is roughly twice as heavy due to increased need for maintenance and service support, additional time spent with switches due to ice and snow, and complications arising from components freezing in low temperatures.

Current staffing is not matched to workload after factoring for work content, unplanned work, arrival variation and planned worker absence

Service & Inspection (S&I):
- Cleaner utilization is 66%
- Big drop is during 10 p.m. – 6 a.m. shift, which has light workload from trains with regular coach cars.
- Workload exceeds current staffing during 10 a.m. – 1 p.m. slot. This causes delays.
- Carman, pipefitter, laborer, machinist and electrician utilization are in 20-40% range even after factoring for unscheduled repairs.

Station
- Cleaner utilization is 22%. Big drop is due to redundant staffing that overlaps with work scope of outlier locations.
- Carman, pipefitter and laborer utilization are in 15-20% range. These losses are driven by need to provide coverage at Station.

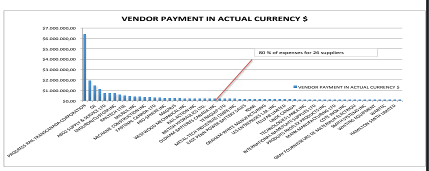


Proposed Action:
Redesign staffing matrix for S&I and Station

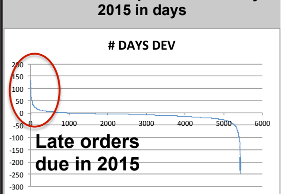
Performance improvement of suppliers can reduce late orders from 9% to 3%.

Structure of supplier base enables you to focus on the 26 major ones developing a direct relationship for cost and quality improvements. This has not been regularly done in the past (exception: rails). Nine percent of all P/Os due in 2015 have been delayed more than one week.

- Expenses are concentrated in 26 major vendors > 80.000 Can $.
- There are no scorecards or performance KPI for smaller suppliers in place.
- Delivery performance is monitored, but ongoing issues are reducing material availability.



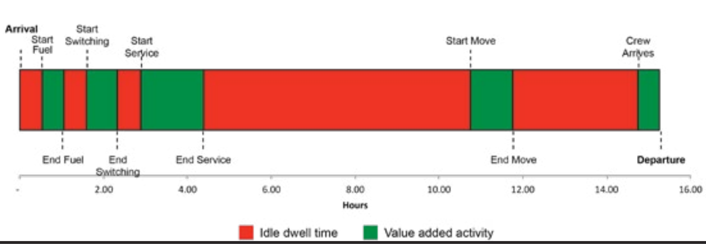
Purchase order performance May 2015 in days



Purchase order performance May 2015

	Actual	Late > 7 days	%
Project Orders - P:	643	48	7,5%
Consumable & New Condition Order - S & D:	987	118	12,0%
Repairable Order - M &R:	350	64	18,3%
Warranty Order - WM:	48	19	39,6%
TOTAL:	**2028**	**249**	**12,3%**

Looking at train dwell cycle shows that for most of its time in the yard, it is idle. Value added activity comprises only 4.26 hours (28%) of the 15.26 hours average dwell. Additional servicing or maintenance activities could be undertaken during the remaining 11 hours.



In the future, Site 2 will have a total of 20 full time employees (FTE) dedicated to contract work. Based on Site 1 work pipeline and profitability, you can select one of these workload scenarios.

BASELINE		Expected time standard after improvement (hrs)	SCENARIO 1		SCENARIO 2		SCENARIO 3	
Baseline Contract Production			Wheels and Engine Focus		Wheels and TM Focus		Wheels, Engine and TM Focus	
Contract Work Type	Current Annual Prod.		Annual Prod.	Arr – Dep Time	Annual Prod.	Arr – Dep Time	Annual Prod.	Arr – Dep Time
Wheel Sets	183	4	800	1 week	800	1 week	800	1 week
Engine Overhaul	1	400	25	3 weeks	2	-	10	6 weeks
Traction Motor Repair	4	40	8		250	1 week	150	1 week
Traction Motor Replace	6	24	16		250	1 week	150	1 week
Outside Maintenance	2	30	2		2		2	
Revenue	$320,000		$7,212,000		$4,918,000		$5,489,000	
Annual Profit	$47,500		$1,095,000		$696,000		$803,000	

1. Cost basis – estimated material cost from work scope; labor cost based on standard hours, $74 per labor hour, future efficiency
2. Revenue basis – 20% material markup; 15% labor markup

DIMENSION	MEASURE	CURRENT	BEST CASE	REALISTIC FUTURE STATE
SAFETY	Lost time injuries per 200,000 labor hours	5.38	1	1.5
	# lost time injuries	26	3	7
RELIABILITY	Post E 90 day failure rate - loco	2.72	1.5	2.31
	Post E 90 day failure rate - car	3.26		2.71
	# delays per month (Mechanical only)	39		35
PRODUCTION/ AVAILABILITY	Availability - Loco	79.1%	90%	85%
	Availability - Car	79.3%	90%	85%
COST	Wrench turn time	45%	80%	60%
	Cars/ locos waiting for material	4-6	0	2-3
	Inventory - relates to overstock (as it impacts availability to operations)		$2.6M reduction	$1.3M reduction
ENGAGEMENT	# ideas from craft per month	< 0.1	2	1
	Center of Excellence (CoE) maturity matrix score	Level 0-1	Level 5	Level 4
	Supervisor Leadership Behavior compliance	39%	95%	90%

Figures 1-6: Snippets of fact-based assessments in train operations

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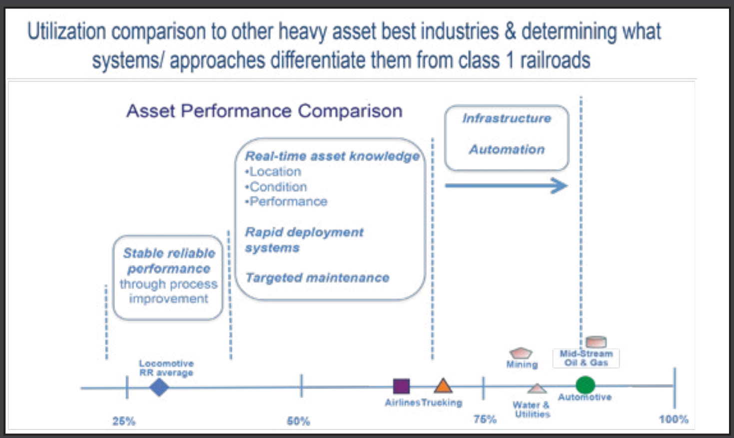
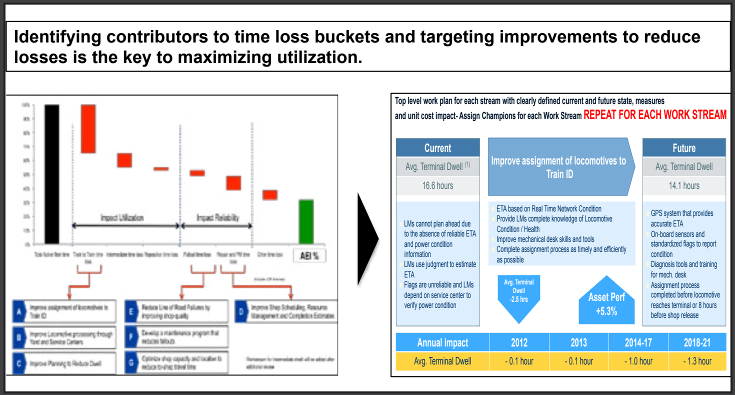
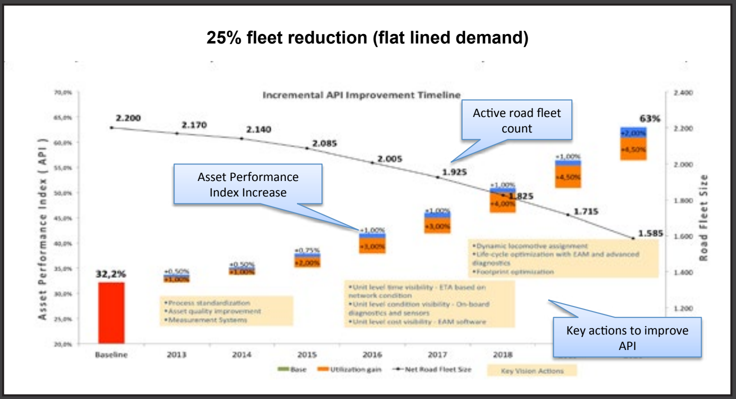
4. Develop work streams to achieve the overarching asset measure

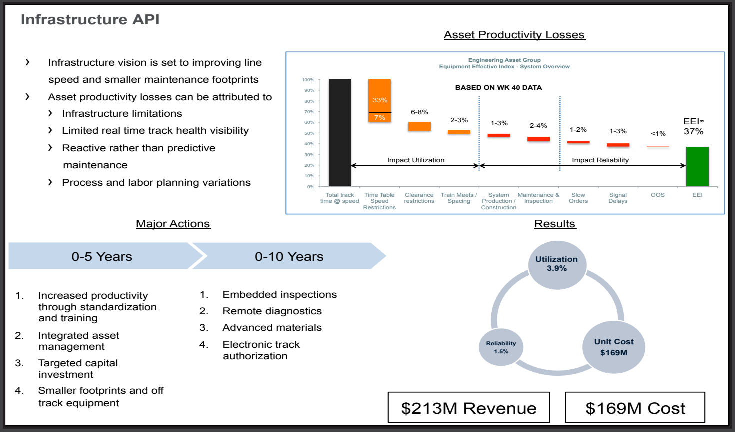
Once the fact-based assessment and recommendations are presented with impact and the asset manager has the executive asset management steering committee's attention, it is time to sell the next phase: the development of work streams linking to the overall asset performance measure. In the next report to the executive steering committee, the functional business owners, typically the vice presidents, present their work streams linked to the overall financial and operational benefits. For large, heavy asset companies where sales are typically more than $10 billion, this may be up to a $700 million long-term benefit, which is a very exciting proposition to the CEO and board.

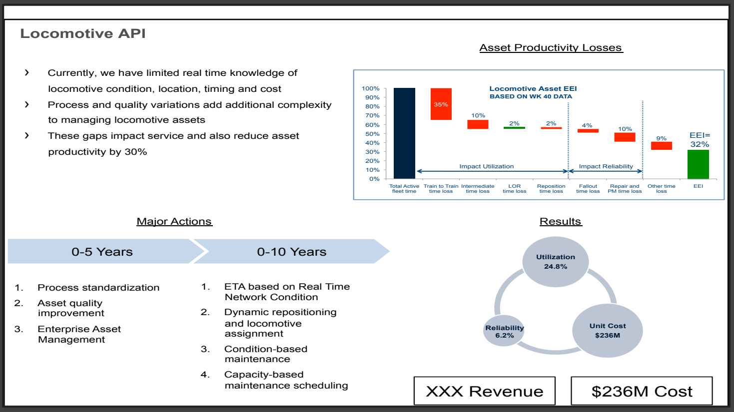
Figures 7 through 12 showcase examples of how work streams link to overall company benefits.

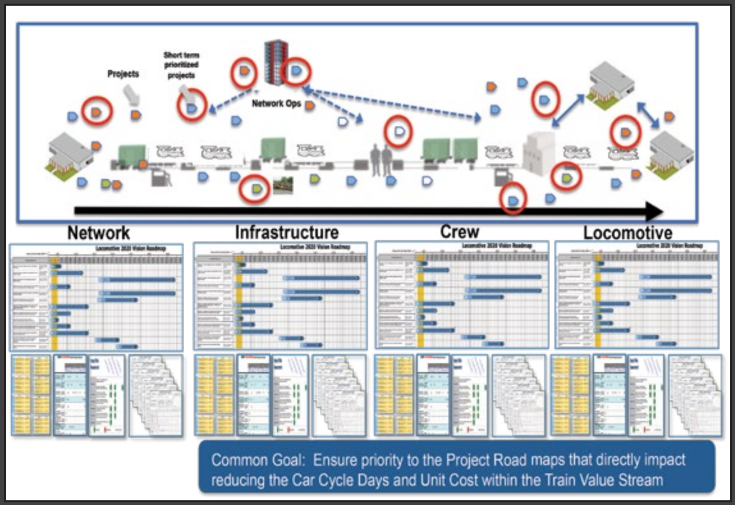












Figures 7-12: Sample report snippets exemplifying work streams linked to overall company benefit

> The functional business owners present their work streams linked to the overall financial and operational benefits.

Next Steps

Once an asset manager has accomplished the above steps, he or she has achieved the first major milestone of putting strategy into action. Most asset managers do not make it this far, mainly because they are not successful in articulating the linkage between better availability and utilization of assets for improving operating performance, future Capex offset and contribution margin capacity through improved use of the key assets. This is when an asset manager has the attention of senior management; it is now time to develop and deploy enterprise asset management.

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ACM

ASSET CONDITION MONITORING

TECHNICIAN CERTIFICATION

Jack R. Nicholas, Jr.

Editor's Note: This article was adapted from the 94-page Asset Condition Monitoring Project Manager's Guide published in January 2017. The guide is coauthored by Terrence O'Hanlon and Dave Reiber of Reliabilityweb.com and Jack Nicholas, an independent sole proprietor.[1] The guide is sponsored by Des-Case (Precision Lubrication), Pruftechnik (Alignment), SDT (Ultrasound) and SKF (Motor Condition Monitoring), whose representatives appended insightful statements on the impact of their technologies on asset condition monitoring. The guide supplements comprehensive material in Jack Nicholas' new book, *Asset Condition Monitoring Management*, published by Reliabilityweb.com in December 2016.[2]

Most commercial and industrial organizations do not have sufficient in-house resources to train and examine candidates for various levels of certification in asset condition monitoring (ACM) technologies. They depend on ACM training and certification organizations (ACMTCOs) to provide these services and document successful completion of requirements. As of mid-2017, there are no known requirements for formal certification established by North American regulatory agencies for predictive condition monitoring technologies, such as vibration and passive ultrasound analysis, infrared thermography, motor testing, lubricant and wear particle analysis, visual testing/inspection, or any other asset condition monitoring (ACM) technology. Because there are no known regulatory requirements for formal certification, many large companies, like General Motors, have established standards for certification and levels of acceptance from vendors. They have created standards for training personnel and the amount of time needed at each level before individuals can qualify to move on to the next. Also, when accepting rebuilt equipment, like motors and pumps, they require the vendor to reach a high-level of alignment and low vibration signatures before returning the equipment to them. There are some regulations for nondestructive testing training and certification for skills in radiography, magnetic particle testing, active ultrasonic examination, leak testing and some other technologies, especially in the nuclear industries and for inspectors of assets, such as pressure vessels, boilers and pipelines.

The amount of training and established levels of certification for ACM technicians are more a function of perceived need for various purposes by an organization's management. For example, training and certification are supported as incentives for technicians to add to their skills, serve the organization more effectively and, where offered, be better compensated. By establishing personal goals for successful ACM training and certification achievements, organizations can provide a career path and a "what's in it for me" element for their technicians that helps to retain them for as long as possible in those positions.

In general, the time required for an ACM technician to achieve full competency depends on the timing of the training, the number of assets monitored, opportunities to practice the use of the technology and many other factors. It is not uncommon for ACM team members to become certified, or at least competent, in two or three technologies, in addition to being certified in visual testing/inspection. An ACM program where technicians cross-train in two or more predictive sciences usually offers more complete problem-solving skills. The times needed to become competent and/or certified in multiple technologies typically overlap. After achieving Level I and starting Level II, candidates may also start to achieve competency in a second technology. The length of time for ACM technicians to achieve real proficiency or competency depends on the scientific complexity of the principles of the technology, frequency of monitoring, when and where in the process the training takes place, availability of on-the-job mentors, such as ACM contractors already monitoring on-site assets, and prior education and aptitude of the technician for mastering related bodies of knowledge as demonstrated by passing practical and written examinations.

As a practical matter, the level to which ACM technicians should be certified depends on what is offered in the marketplace and the needs of the organization where they are employed. Examples of ACM certification goals for the most commonly applied technologies are shown in Table 1. Based on experience with many ACM initiatives and an informal survey of ACM hardware and software vendors and some ACM technicians at the 2016 Society for Maintenance & Reliability conference, the months required to achieve competency in a given ACM technology at Levels I and II are provided in the second column of Table 1.

There are at least 20 more condition monitoring technologies that could be included in Table 1, but most of them have not had certification requirements addressed formally by standards organizations or commercial ACMTCOs.

With regard to the visual testing/inspection certification in Table 1, this certification should be pursued by practitioners of all other ACM technologies because of its universal application. At present, this is not common for most organizations. Those that have required this certification have found that the skills are also applicable to many other operations and maintenance personnel and returns the investment many times over its cost.

References

1. The information on the General Motors approach to certification was provided by coauthor Dave Reiber, who retired from that organization in 2016. The coauthors are grateful for the insight provided by Ken Culverson, principal consultant at NK Precision LLC, on qualification and assessment criteria included in ISO18436 - Condition monitoring and diagnostics of machines -- Requirements for qualification and assessment of personnel.
2. The Asset Condition Monitoring Project Manager's Guide is available for free download at: https://reliabilityweb.com/acm-project-managers-guide. The book, Asset Condition Monitoring Management, is available for purchase from the MRO-Zone bookstore via: https://www.amazon.com/Asset-Condition-Monitoring-Management-Nicholas/dp/1941872522 or http://reliabilityweb.com/bookstore/book/asset-condition-monitoring-management.

Table 1 – Example of Certification Goals for ACM Team Technicians

Technology	Certification Level & Months to Full Competency	Requirements of ACM Training and Certification Organizations (ACMTCOs)	Comments
Vibration Analysis	Level I 9 to 12 months	Attend ACMTCO vibration analysis Level I training courses and pass written, oral and/or practical exams based on content. Document required hours of field experience before or after each course before mastering a relevant certification exam.	Some ACMTCOs require completion of a 20+ item checklist of vibration analysis related learning task items prior to admission to the basic Level I training course. SNT-TC-1A specifies training and field experience hours needed for Levels I and II.
Vibration Analysis	Level II additional 9 months to 1 year	Attend ACMTCO vibration analysis Level II training course. Document required hours of field experience and pass written, oral and/or practical exams based on content.	ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (ANSI/ASNT CP-105-2016) outlines course requirements for Levels I and II. An alternative is to follow the Vibration Institute's Categories 1 through 4 requirements which are based on ISO18436 Part 2 Vibration condition monitoring and diagnostics.
Infrared Thermography	Level I 6 to 9 months	Attend ACMTCO Level I infrared thermography course and pass written, oral and/or practical exams based on content. Document required hours of field experience after course completion.[1]	SNT-TC-1A specifies training and field experience hours needed for Levels I and II certification. ISO18436 Part 7 (ISO18436-7) provides qualification and assessment requirements for thermography.
Infrared Thermography	Level II additional 9 months to 1 year	Attend ACMTCO Level II infrared thermography course and pass written, oral and/or practical exams based on content.	ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (ANSI/ASNT CP-105-2016) outlines course requirements for Levels I and II.

“ As of mid-2017, there are no known requirements for formal certification established by North American regulatory agencies for predictive condition monitoring technologies.

Table 1 – Example of Certification Goals for ACM Team Technicians (Continued)

Technology	Certification Level & Months to Full Competency	Requirements of ACM Training and Certification Organizations (ACMTCOs)	Comments
Ultrasonic Analysis	Level I 4 to 6 months	Attend ACMTCO Level I training course and pass written or oral and practical exams. Document required hours of field experience after course completion.	Vendors of hardware and software suites and ACMTCOs offer courses, recommendations for field experience and hands-on practical exams and/or mentoring.
Ultrasonic Analysis	Level II additional 4 to 6 months	Attend ACMTCO Level II training course and pass written exam.	Training courses based on ISO18436-8 (Ultrasound) meet the ISO Technical Committee 108 (ISO/TC 108) Subcommittee 5 consensus.
Motor Circuit Off-Line Testing	Level I 4 to 6 months	Attend ACMTCO de-energized motor circuit testing course and pass written exams on theory and equipment, and one-on-one practical exam on equipment.	There are no recommended equivalent training and field experience requirements from professional organizations/societies. Vendors of hardware and software suites offer courses, recommendations for field experience and hands-on practical exams.
Motor Circuit On-Line Testing	Level I 4 to 6 months	Attend ACMTCO energized motor circuit testing course and pass written exams on theory and equipment, and one-on-one practical exam on equipment.	There are no recommended equivalent training and field experience requirements from professional organizations/societies. Vendors of hardware and software suites and ACMTCOs offer courses, recommendations for field experience and hands-on practical exams.
Visual Testing/ Inspection	Level I	Complete ACMTCO visual inspection Level I training course and written and practical examinations.	SNT-TC-1A specifies training and field experience hours needed for Levels I and II.
Visual Testing/ Inspection	Level II additional 2 to 3 months	Complete Level II training course and written and practical examinations.	ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (ANSI/ASNT CP-105-2016) outlines course requirements for Levels I and II. Courses are typically taken back-to-back and competency achieved at Level II thereafter on the job.
Machinery Lubrication Technician and/ or Analyst	Level I 9 to 12 months	Complete ACMTCO Level I machinery lubrication technician or machinery lubrication analyst training course and exam(s) of the International Council for Machinery Lubrication.	Requires two years of education (post-secondary) or on-the-job training in one or more of the fields of machine lubrication, engineering, mechanical maintenance and/or maintenance trades.
Machinery Lubrication Technician and/ or Analyst	Level II additional 6 to 9 months	Complete ACMTCO Level II machinery lubrication technician or machinery lubrication analyst training course and exam(s) of the International Council for Machinery Lubrication.	Requires three years of education (post-secondary) or on-the-job training in one or more of the fields of machine lubrication, engineering, mechanical maintenance and/or maintenance trades, which are based on Parts 4 and 5 of ISO18436.

[1] Documentation of field experience requires a handwritten or digital log of dates, hours, plant and number of finds. This also applies to on-the-job experience documentation for other technologies.

> "Training and certification are supported as incentives for technicians to add to their skills, serve the organization more effectively and, where offered, be better compensated.

__Jack R. Nicholas,__ Jr., P.E., CMRP, CRL, IAMC, is author or coauthor of 12 books and was lead or sole writer of many magazine articles and conference papers. He is a frequent conference presenter, workshop leader and keynote speaker on asset condition and performance monitoring, asset management and business leadership. Jack graduated from the U.S. Naval Academy, The American University of Washington, D.C., and Navy destroyer engineer, nuclear propulsion and officer submarine schools. He served in the U.S. Navy for 35 years and has been consulting and advising clients since then for over 28 years.

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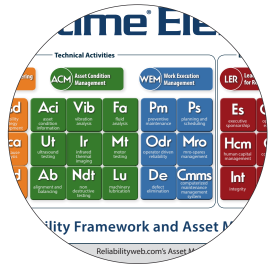

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How to Make the Most of

Traditionally, reliability engineers have been the leaders in introducing new maintenance processes and technologies. As the primary owners of asset reliability, whether or not it came from the introduction of condition-based maintenance or instrumentation, they have been at the core of the transformation.

With the start of predictive maintenance, many other branches of the organization will become part of the process; at a minimum, there will be strong IT involvement and involvement of the chief operating officer (COO) or vice president of operations. Furthermore, companies might have an Internet of Things (IoT) strategy unit, a digital unit, or an analytics center, all of which will be interested in the rollout of predictive maintenance.

Despite these forces and the excitement at all levels of the organization, reliability engineers should strive to remain at the center of this transformation. This article presents some practical ways on how they can get involved.

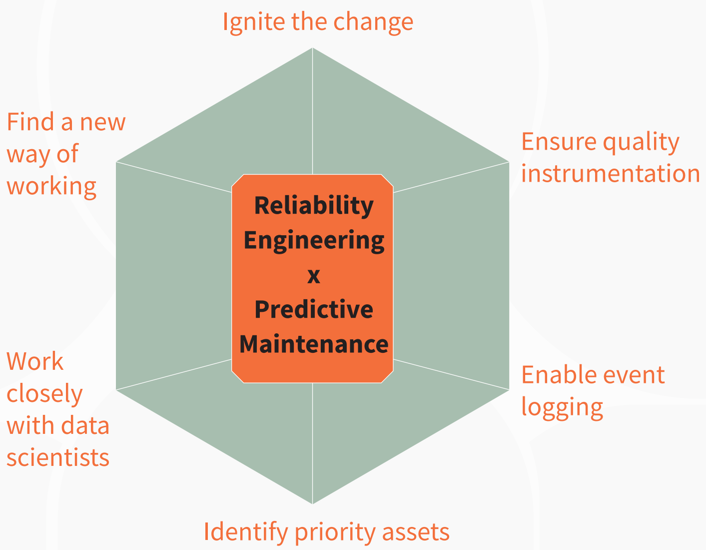

Figure 1: How to make the most of predictive maintenance from the reliability engineering perspective

Ignite the Change

The McKinsey Global Institute estimates that predictive maintenance solutions will have a potential impact of nearly $630 billion per year in 2025 in manufacturing alone. This level of reduction in equipment downtime and equipment capital investment should be very attractive to reliability engineers who can recommend exploring predictive maintenance and recruit other parts of the organization to provide the necessary level of support.

First, it is important to communicate the potential return on investment (ROI) to the organization. Reliability engineers have significant opportunities either in uptime and/or equipment capital investment that can be addressed using data and predictive maintenance.

Second, it is important to understand that this ROI can be phased in through small rollouts and experiments. By trying small pilots on critical equipment, the potential impact can be proven cheaply and only then transitioned into a broader program.

Third, the IT and analytics organization can be reassured that their capabilities might need to grow in this process and there are many external consultants who can help. Some major consultancies provide end-to-end analytics services that cover predictive maintenance and many other operations usage cases. It is a great starting point for industrial companies to increase their digital competency.

Ensure Quality Instrumentation

It should not come as a surprise that data is the cornerstone. For predictive maintenance to work, critical equipment needs to be comprehensively instrumented with sensors. These sensors, in turn, should be connected to a central and structured data collection facility (i.e., the historian).

Here is a good test for determining whether the right sensors have been used: Can the reliability engineer use a complete extract of data being collected automatically to build an informed picture of asset health? If so, there is hope in transferring this knowledge into the predictive maintenance algorithm and applying it at a much larger scale across the complete set of sensors.

If there are critical sensor readings that are only collected manually or available in a fragmented fashion across multiple systems, using them for predictive maintenance will be challenging, but still possible.

PREDICTIVE MAINTENANCE

Peteris Erins

Enable Event Logging

By figuring out how to introduce more automation in data collection, valuable data sources can be established from which predictive maintenance systems can directly benefit. Counterintuitively, knowing 100 instances of past failures can be more important than having terabytes of sensor readings.

If data is sitting around in spreadsheets or e-mail, it would be useful to start capturing it in your maintenance system. Downtimes, failures and repairs should be logged, tagged and described. Missing out on critical events or not labeling them correctly reduces the value potential of predictive maintenance.

Identify Priority Assets

Predictive maintenance needs to be rolled out in a controlled and asset-by-asset fashion. Thus, selecting where to start and how to prioritize is important. Reliability engineers should provide input when assessing which data is relevant, which asset classes behave in a predictable way, as well as where opportunities for downtime or investment reduction are the greatest.

Work Closely with Data Scientists

It is likely that data scientists will be involved in constructing predictive models based on past data. They will be looking to join up, clean and structure data sets and then reveal and exploit hidden correlations.

It is tempting to see this process as a black box, whereby a standard set of techniques will reveal additional insight and replace human reasoning. However, it is the opposite – reliability engineering expertise needs to be captured at every step and the algorithm is an enhancement that will be used by the reliability engineer to uncover more maintenance opportunities.

The data scientists will need to understand the accuracy of the sensor, the behavior before sensor failure, the behavior before machine failure and the type of sensor. Everything they do will be based on information learned in this process. For example, in the case of a vibrational failure, Fourier transforms likely will be applied to recover the right signals, whereas a simple degradation failure can be noticed via moving averages.

Find a New Way of Working

Finally, you can expect predictive maintenance to change the way the maintenance organization works. The morning report printout will be replaced and preventive maintenance schedules will give way to predictive maintenance predictions. A larger part of inspections will be conducted remotely and legacy maintenance systems will be complemented by new, more modern tools.

The reliability engineer needs to take on an active role and fit tools that are built around predictive maintenance to new, more effective ways of working that are grounded in reality. The best way to do this is for neither party to invent solutions – they need to work together and evolve a solution that is both feasible from a technical perspective and valuable from an engineering perspective.

Conclusion

Predictive maintenance works best when reliability engineers are in the driver's seat of the transformation. Their expertise is irreplaceable and needs to be leveraged in guiding data collection, use cases identification, predictive model creation and user experience development. Only then will predictive maintenance achieve its full potential.

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ultrasound testing

PM AND SCHEDULED OR CONDITION-BASED ACOUSTIC LUBRICATION

Jim Hall

When implementing an acoustic lubrication program…you need to establish a baseline to account for increases in readings and decibels.

Acoustic lubrication has taken off with afterburners lit (old aviation phrase). During the 2017 RELIABILITY Conference ™ hosted by Reliabilityweb.com®, several representatives from various organizations remarked at how well their acoustic lubrication program had made such a difference. As an example, the cost savings by way of reduced man-hours using time-based lubrication and the amount of grease not purchased are two reasons.

Over the last several years, others have commented on the implementation of time-based versus condition-based acoustic lubrication. Implementing a condition-based acoustic lubrication program instead of a time-based one for some motors makes good sense. For example, one company implementing a condition-based acoustic lubrication program sends its technicians out to take ultrasonic trending data. If the reading is 8-10 dBs over the previous baseline, grease may be warranted. Now, technicians are taking ultrasound trending data and, in some cases, also performing the acoustic lubrication procedure.

Whether it be 30-, 60-, or 90-day inspection intervals, the company's technicians may encounter readings that suggest a bearing needs lubrication. In some cases, after acoustic lubrication is performed and the decibel has not returned to previous or near previous baselines, the next step, depending on criticality of the asset, may be to request vibration data on the motor. Many times, this proved to be an early warning of a failure occurring, possibly a category 1, 2, 3, or 4 failure.

With an ultrasound program within its condition-based maintenance program, the company performs 37 percent less motor maintenance since implementing acoustic lubrication.

During The RELIABILITY Conference, several attendees were asked about their acoustic lubrication program. The question posed was: "How are your PMs worded when told to grease a motor?" One participant responded that it "only tells us to grease motor bearings" and gives no particular amount. For technicians, this might mean two, three, or more pumps of grease for each PM without knowing, in many cases, whether they are over or under lubricating

Figure 1: Use ultrasound as a preventative maintenance tool to trend, record and use as a condition-based lubrication tool *(Photo courtesy of The Ultrasound Institute)*

Figure 2: An ultrasonic lubrication delivery system being used *(Photo courtesy of UE Systems)*

I first practiced the procedure of acoustic lubrication in 1993 in downtown Atlanta, GA. It was while listening to the bearing with an analog ultrasound instrument that I first heard what sounded like a "dry" bearing. It sounded exactly like what a bearing assembly with no grease, held up to your ear and spun would sound like…dry.

An analog ultrasound instrument is pure noise, unlike many of today's digitized instruments. But, if you're going to data-log, record sound, etc., then you need a digital instrument.

With seven years' experience in the use of my analog instrument, I felt very comfortable being able to diagnose bearing issues. A bearing with the correct amount of grease or lubricant that was properly installed and aligned properly may sound very fluidic or like a rushing sound. A bearing under-lubricated will sound the same, but with a higher degree of noise due to friction. When using an ultrasonic translator or receiver, high and low frequency components are present. But, the ultrasound instrument detects the high frequency components (above 20,000 hertz or 20 kHz) which would be friction and "not vibratory displacements of rolling elements," such as those that the vibration meter would recognize. As friction increases so does the amplitude or decibels.

I know that some of you are simply using both infrared and vibration as your sole predictive technologies. When using an infrared imager to check motor bearings, "caution" is warranted and must be taken in your diagnoses. High temperature readings may be the result of an incorrectly aligned shaft, improperly installed bearing and either/or, over- or under-lubrication. This is an example where ultrasound may complement your infrared technology. If you have an indication of high temperature, simply use the acoustic lubrication method and apply a half-stroke of the grease gun. If the decibels increase immediately and after 10-15 seconds do not return to the level prior to the half-stroke, this is an indication of a bearing that has enough grease and there must be some other reason for the high temperature.

What is the decibel reading? How does this relate to previous readings?

because they aren't using ultrasound as a condition-based technology, and a PM is normally performed with motors offline.

With this logic, it's easy to understand how a motor bearing can be over greased, especially if the motor is not in full-time (i.e., 24/7) operational status.

Another attendee responded that his PMs may tell them two to three pumps of grease. So, no matter what, technicians would always put two to three pumps of grease and, in some cases, they would report seeing grease coming from the seal of a bearing or from the motor casing.

But, what if the grease never shows itself externally? Perhaps the excess grease has made its way to the armature, coating the windings of the motor. This can insulate the wires and not allow heat to dissipate, leading to a shorter motor life or possibly shorting out the motor.

When implementing an acoustic lubrication program, as with vibration or any ultrasonic trending program, you need to establish a baseline to account for increases in readings and decibels.

With an estimated 95 percent of all ultrasound instruments purchased today being digital, the emphasis should be placed on the rise in decibels and not what you can discern from listening with the instrument.

With ultrasound, standard trending data is accomplished by taking either a magnetic base sensor or a sensor with a rod screwed onto the end of the ultrasonic sensor that acts as a waveguide directing the sound to the sensor. You make contact, and after five seconds, store the reading into your data logger (you just saved five minutes or more of man-hours not taking multiple vibration points) and you then continue on to the next motor bearing.

With some instruments, you can record the bearing's sound and replay it through spectral analysis, possibly rendering useful data that could help diagnose the bearing's condition.

Now, imagine implementing an acoustic lubrication program. Besides man-hour savings from lubricating fewer motors and cost savings from purchasing less lubricants, you are using technicians to take data readings and not utilizing the vibration technicians as much for non-critical motors. As such, you are freeing up the vibration technicians to analyze and concentrate on critical assets instead. And let's not forget the other savings, such as motor maintenance, motor failures and man-hours due to downtime.

There are now instruments specifically made for the acoustic lubrication procedure. However, you should keep it simple. You can get so caught up in technology that the people you are trying to convince to use the technology simply don't want another high-tech instrument that requires too much thinking. It's lubrication, it's greasing a doggone bearing for crying out loud. On the other hand, depending where your lubrication program is, these specialty products may be advantageous to your particular reliability program.

Perhaps rewriting your PM may be an alternative solution preventing motor failure due to over or under lubrication. Or, perhaps rewriting your PM to actually tell the technicians to remove a lock and start the motor to temperature so that you can perform acoustic lubrication. Why put grease into a motor if it does not require it? In "The Fundamentals: How to Write an Effective PM Procedure" (a recommended read), author Ray Atkins provides some key elements for writing a preventive maintenance procedure.

1. **Assessment** – Start with a motor that already requires greasing or lubrication. Assess whether acoustic lubrication is practical. Perhaps this motor is fully operational 24/7. Surround yourself with experts that have a vested interest in a successful PM writing.
2. **Documentation and Analysis** – Utilizing maintenance and production personnel, review formal documentation of prior reliability issues, if available, research certain anecdotal evidence, or rely on employees' memories. Perhaps there's documentation of evidence of over lubrication or motor failure due to a lack of lubrication. Don't forget failure mode and effects analysis (FMEA), perhaps the most crucial part of the PM process.
3. **Writing Your Procedures** – Review the owner's manual of the motor and other supporting documents. Regardless of the computerized maintenance management system that you have, remember these points when writing your PM procedure:

> How much money are you leaving on the table because you are not utilizing ultrasound technology?

- Keep it simple and short.
- Keep it safe.
- Keep it logical.
- Solicit input.
- Build accountability into the document.

Vibration, infrared and ultrasound are complementary technologies. Can you see it? How much money are you leaving on the table because you are **not** utilizing ultrasound technology? Ultrasound is not your father's, mother's, or grandparents leak detector for air and steam leaks. It's that and much more.

There is value in implementing a condition-based acoustic lubrication program, but training is key. Save time, money, the environment and possibly injuries or life by investing in ultrasound instrumentation and training.

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Do you ever sense that your plant's budget and variance practices may actually hurt the business? Here is what your gut is telling you and what to do about it.

Maintenance job plans are two-dimensional and activity-based. The foundation dimension, the determined tasks to each job plan, is activity. The other dimension, also determined by analyses, is the resources and their unit costs to be engaged or consumed by each activity.

The alternative to activity-based, two-dimensional job plans is unacceptable to maintenance professionals. Maintenance professionals would never accept the practice of one line job plans for which the total cost of labor, parts and materials, services, etc., are set by rule of thumb or by what management arbitrarily allows. It would be chaos.

However, that is exactly how plants budget their maintenance operations, leaving them without effective planning and control of spending in connection to business operations. Each year begins without a true two-dimensional, activity-based plan. Instead, you have only one line, dimensionless spending allowances by discipline and work type for each cost center. Worse yet, the subsequent process of comparing actual to budgeted spending allowances is unavoidably flagrant misinformation to which responses, unbeknownst to you, hurt the business.

This article introduces and explains the concept of two-dimensional, workload-based budgeting and variance control for maintenance operations. The explanation is made in contrast to the typically practiced dimensionless approach. In the context of the explanation and contrast, this article further explains why the dimensionless budget and variance control approach hurts the business.

MAINTENANCE BUDGET AND VARIANCE PRACTICES REDESIGNED

Richard G. Lamb

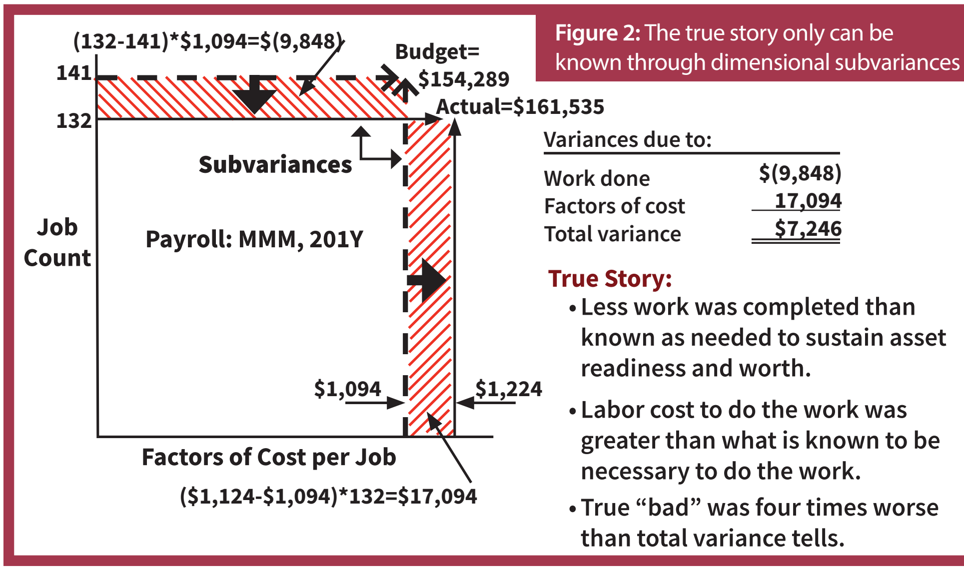


Figure 2: The true story only can be known through dimensional subvariances

The Dimensions of Budgeting

Typically, maintenance budgets are essentially a table of dimensionless spending allowances. The rows are one liners for each of the many work groups. The columns to the table are totals for main cost types, such as labor, parts and materials, services, etc.

So where do the line item totals come from? They are typically the past year's, projected into the budget year after adjustment. After adjustment may be another way of saying after being negotiated or changed by some arbitrary challenge to spend less while doing more. Sometimes, it is based on industry indexes, such as a percent of plant replacement cost. What is most unsettling is that other than how much you get to spend, there is no operational guidance in the budget.

Dimensionless spending allowances ignore the core rule of gravity in cost accounting, which is that all costs have two dimensions. Figure 1 shows the dimensions of job count to be workload and factors of cost.

The platform dimension for workload-based budgeting and variance control is workload. Workload is quantified as the number of jobs. All workload groups are bounded with respect to categories, such as cost center, work type, craft discipline, asset type and accountability.

The workload dimension must be quantified because there is a natural and direct connection between maintenance operations and the top most lines of business operations. At one end of the connection is the plant's assigned aggregate production plan. At the other is the maintenance workload as determined to assure the readiness of production assets, vis-a-vis the aggregate plan, while also protecting plant worth.

The other piece to workload dimension is to quantify the resources and their unit costs that will be engaged or consumed to execute the budgeted workload groups. As shown in Figure 1, the dimension can be called factors of cost. The factors of cost to the budget are derived according to the nature of each workload group.

Whereas the workload dimension ties to the aggregate production plan and plant worth, the factors of cost dimension have their own connections to business operations. First is the indirect connection to the top lines of business operations through the adequacy of the plant's resources made available to deliver the budgeted workload. Second is the connection between the plant's fixed expense and optimization of the body of resources with respect to the maintenance strategies and processes that will persist during the budget period.

In contrast to the dimensionless budget and variance, most of the plant's reliability and maintenance practices will be traceably reflected in the two-dimensional, workload-based budget and variance. Each element will be reflected in one or both dimensions. Each year's budget draws the baseline of activity and factors of cost that will be applicable during the budget period. Each variance report confirms performance against the baseline or offers a starting point to learn why your analysis of a baseline missed the mark.

Subvariances Tell the True Story

Without dimensions, you have no power to steer and control. The immensity of what is lost is best demonstrated by what is gained when you operate with dimensional budgets and variances.

Figure 2 is a conceptual depiction of what is called flexible budgeting in cost accounting. Conceptually, flexible budgeting is the overlay of two rectangles: budget and variance. In a perfect world, they would match each month throughout the budget period. However, that is rarely the case.

The crosshatch areas are the variance with respect to each dimension. The calculation of flexible budgeting is straightforward and shown in the figure for each variance. What is so important is that the calculation cannot be made on top of a dimensionless budget.

The figure's table of calculated variances dramatically demonstrates what is lost by the dimensionless approach. The capability to make decisions and take actions in response to the plant's true story is lost. Instead, plants are held to decisions and actions on the gross misinformation that total variances always are.

The table of variances for each budgeted workload group tells the true story. In this case, actual labor shows a budget overrun of $7,246. This is not huge, approximately 4.7 percent of the month's budget. But, when you pull back the curtain, the revealed true bad is almost four times greater than the total overrun. Especially unnerving is that one subvariance bodes poorly for the plant's ability to deliver its planned aggregate production or protect its worth.

First, less work was done than known by budget analytics to be necessary to sustain asset readiness and protect plant worth. Second, labor cost was greater than what was analyzed and concluded as optimal given the plant's current maintenance strategies and processes.

What if you do not know which way the budget line item subvariances are pointing? Of course, with dimensionless budgeting, you do not know because you cannot know.

Conclusion

Try to imagine or remember the consequences of dimensional blindness in your plant. Unbeknownst to its management, the ramifications logically translate to a business in decline. Or another view is that your competitors remain in the unbeknownst state while your plant is competitively ascending because you have gained the power to know the full story.

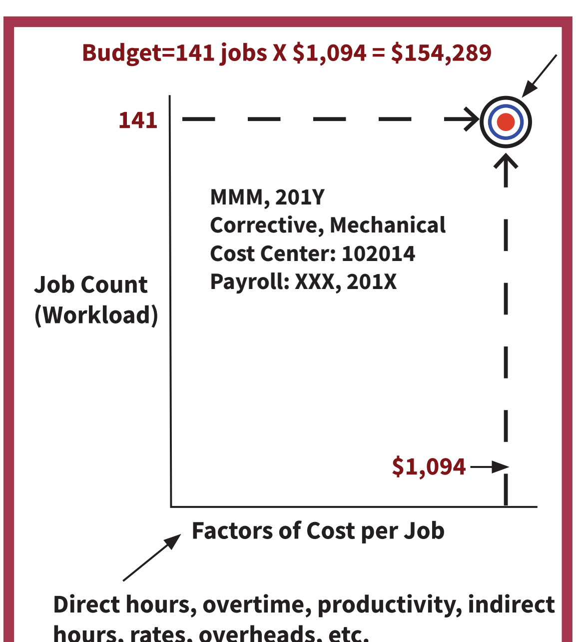
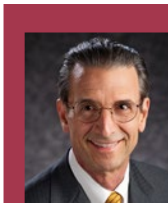
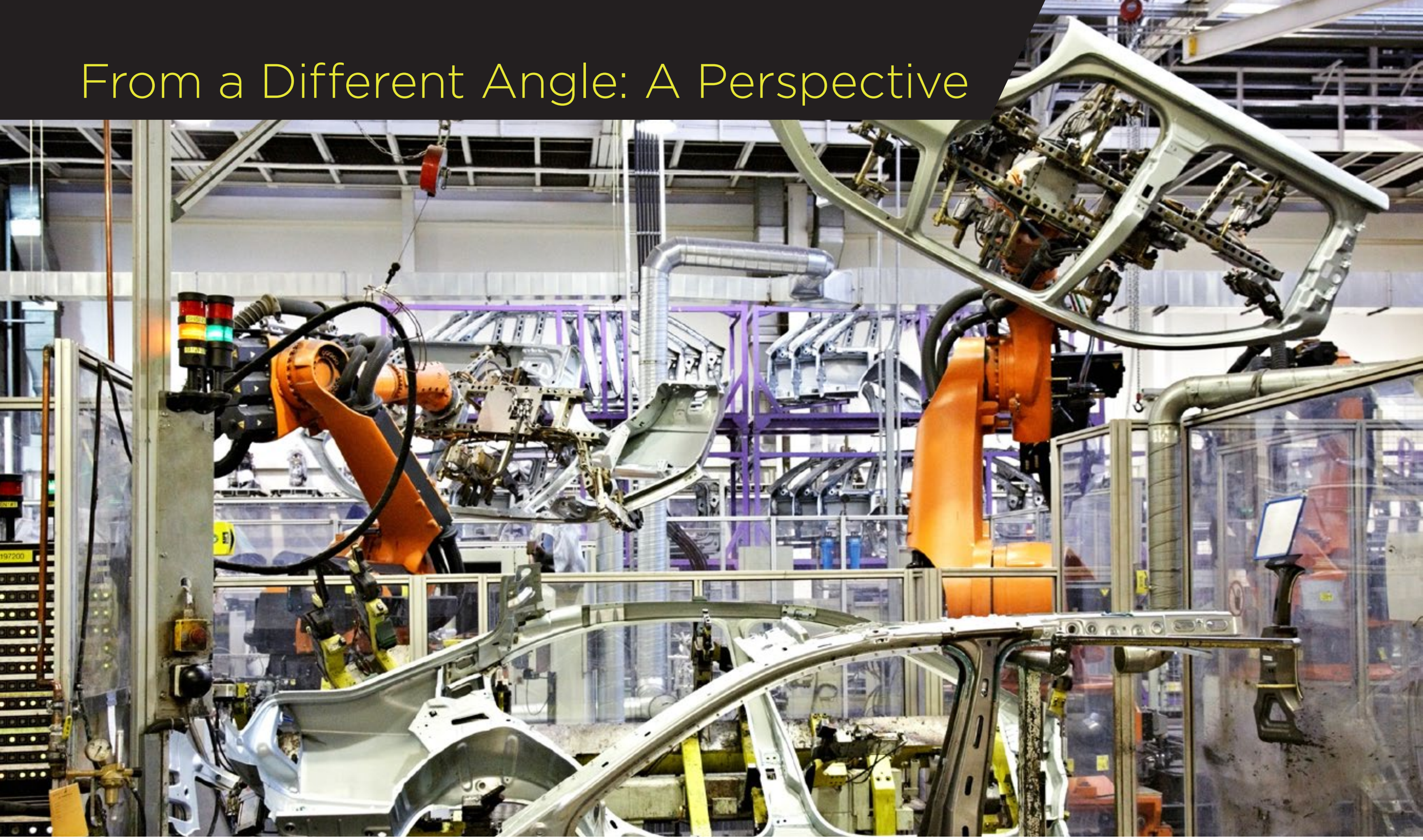


Figure 1: To be meaningful, budgets must be the intersection of two dimensions



***Richard G. Lamb**, PE, CPA, has long practiced in the field of maintenance and reliability following a career in business strategy, preceded by original design engineering. Richard has become an expert in data analytics and has authored two books and many articles. www.analytics4strategy.com*



OVER-OPTIMIZATION

Joel Levitt

Overzealous optimization is everywhere. By using mathematics and analytics, you can over-optimize the delivery of a product or service to the n^{th} degree. This is not always a good thing because it may not always serve the customer. In fact, it just might ruin the customer's day!

Optimization is a very good thing when it is used properly. Isn't that the dream of business process engineering? No doubt, the ability to optimize the costs of, for example airline seats, using yield management is a boon to the industry and the low cost tickets are a boon to everyone – although full planes are a nuisance for everyone, too.

The automobile industry, as a whole, has optimized the production of automobiles. No mass production plant in the world has more than a day or two's worth of parts on hand. Pioneered by the Japanese, but probably invented by Henry Ford at the Ford River Rouge Complex, this is called just-in-time (JIT) delivery of parts.

> "What the automobile industry has done with optimization is tremendous. It removed waste from its system."

What the automobile industry has done with optimization is tremendous. It removed waste from its system. But behind-the-scenes, there is a small army of people making sure the right things happen in the right cadence.

A major mine with over 100 large haul trucks, plus a bunch of other units, decided to apply JIT to spare parts. This could make a major difference in the cost of maintenance because, even more so than production, waste is the major cost of maintenance.

To do JIT in an automobile plant requires almost superhuman organizational abilities to ensure the right parts arrive at the right time and place. A single mistake can shut down the line and deplete profits for a week or more. To ensure downtime from a lack of parts doesn't happen, people and appropriately designed systems are tuned to manage the flow of parts virtually flawlessly.

Unfortunately, the designers of spare parts JIT at the mine understood only the surface issues and solved only them. They had no idea or chose to ignore the behind-the-scenes activity and systems. The result was a surprise to no one who either understood provisioning parts for repair or knew the inner workings of JIT.

Unfortunately, the mine's highly skilled maintenance planning department had to spend their whole time trying to reschedule work because parts didn't come in or trying to work around snafus created by the incomplete jobs. Scheduling was trashed even before the day started.

Frustration was high and, even with JIT, a warehouse filled up with parts for jobs that were delayed due to other parts being missing. To add insult to injury, when the final part was received, the other parts could not be located. As if that is not bad enough, the only thing the company lost was money!

Returning to the airline industry, over-optimization is leading to reductions in the size of the seats, the seat pitch, food and beverage availability, the value of airline loyalty and the quality of the customer experience. Among frequent fliers, expectations have gone down. But, over-optimization has made the airlines profitable; truly, that is something. It is a tough business that cutthroat competition has made difficult.

But one over-optimization raises concern. To optimize costs, major U.S. airlines now fly planes to China and elsewhere to perform major service. These maintenance shops are not inspected by the Federal Aviation Administration (FAA) and the mechanics are not subject to the same requirements as a U.S. maintenance depot. All this to save money.

If this creates a safety issue, it won't show up for four or five years. By that time, the airlines would have liquidated the trust in the integrity of the system that took 60 years to build. Maybe, instead of sleeping, everyone should take up praying to ensure safety on flights!

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

"Optimization is a very good thing when it is used properly. Isn't that the dream of business process engineering?"

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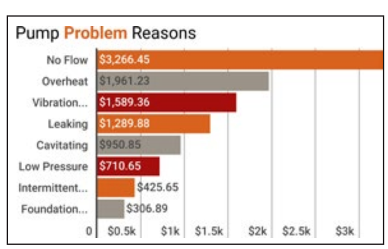

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2. Not all electrical discharge faults produce heat. Use ultrasound to hear what your infrared camera cannot see.
3. Electrical discharge activity is amplified by high humidity. When performing ultrasonic scans at substations, make note of the date and weather conditions.
4. Ultrasound travels directionally through air compared with audible sound. When scanning from a distance, therefore, it is important to inspect electrical systems from all sides.
5. Corona discharge produces no heat on electrical systems below 240 kV, so don't rely entirely on infrared to find problems.

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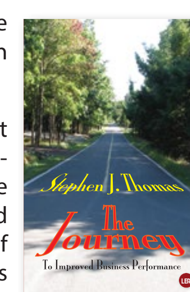
The Eight Elements of Change and the Four Elements of Culture



Change fails mainly for one reason: Those who initiate change initiatives work and think only about what can be called the "hard skill" level.

Hard skills are those tasks we perform every day as part of our jobs. Examples include reactive and even proactive maintenance. Trying to change or improve one of these tasks is a superficial approach to change and usually leads to failure of the change initiative. Think of hard skill change as the top of a pyramid. Below this level are two others that support it. Failing to address these levels will lead to failure of the initiative and, in turn, the skeptical workforce referred to previously. These two other levels, which are the foundations for hard skill change, are called the soft skills and the organizational culture.

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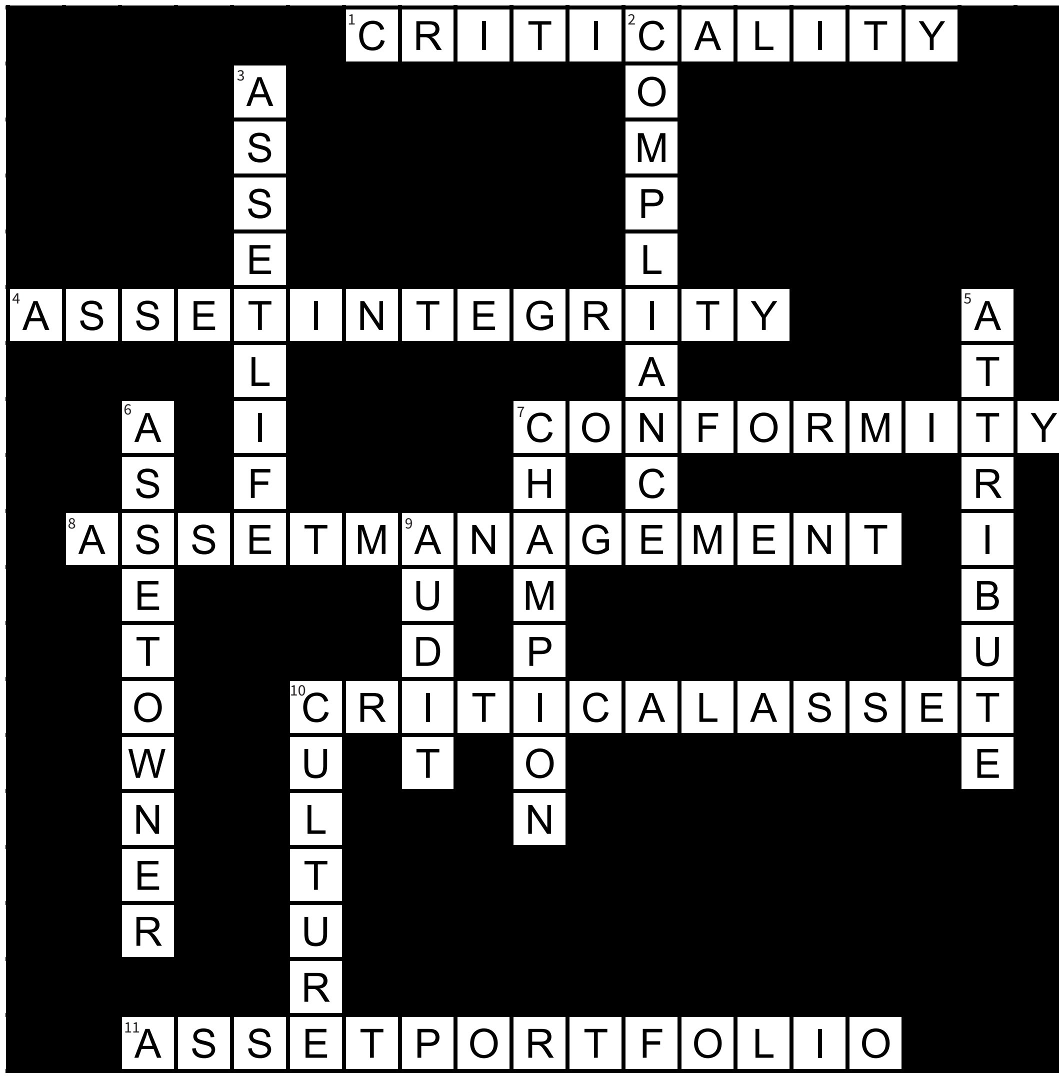

ACROSS

1. A ranking of assets according to potential operational impact
4. The fitness of an asset to perform its intended function effectively and efficiently without being degraded while protecting health, safety and the environment (two words)
7. Fulfillment of a requirement
8. An organizational process to maximize value from an asset during its life (two words)
10. An asset with the potential to significantly impact the achievement of the organization's objectives (two words)
11. Assets within the scope of the asset management system (two words)

DOWN

2. The state of meeting requirements, which may be prescribed specifications, contract terms, metrics, regulations, or standards
3. The period from an asset's conception to its end of life (two words)
5. A quality or feature regarded as a characteristic or inherent part of someone or something
6. A person or group of people who have the total responsibility for the operation and maintenance of asset(s), including capital improvements (two words)
7. One who facilitates a paradigm change in the understanding and practice of a specific discipline or cause
9. A systematic, independent and documented process for obtaining evidence and evaluating it objectively to determine the extent to which a criteria is fulfilled
10. A common set of values, beliefs, attitudes, perceptions and accepted behaviors shared by individuals within an organization

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