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COMMON SENSE:
IS IT COMMON?

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Reliability Excellence for Managers	General Managers, Plant Managers, Design Managers, Operations Managers and Maintenance Managers	Build a business case for Reliability Excellence, learn how leadership and culture impact a change initiative and build a plan to strengthen and stabilize the change for reliability. CMRP exam following Session Four.	SESSION 1 DATES: Aug 28-30, 2018 (CHS)	12 days total (4, 3-day sessions) 8.4 CEUs	$7,495
Risk-Based Asset Management	Project Engineers, Reliability Engineers, Maintenance Managers, Operations Managers, and Engineering Technicians.	Learn to create a strategy for implementing a successful asset management program. Discover how to reduce risk and achieve the greatest asset utilization at the lowest total cost of ownership.	June 12-14, 2018 (KU) Oct 2-4, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895
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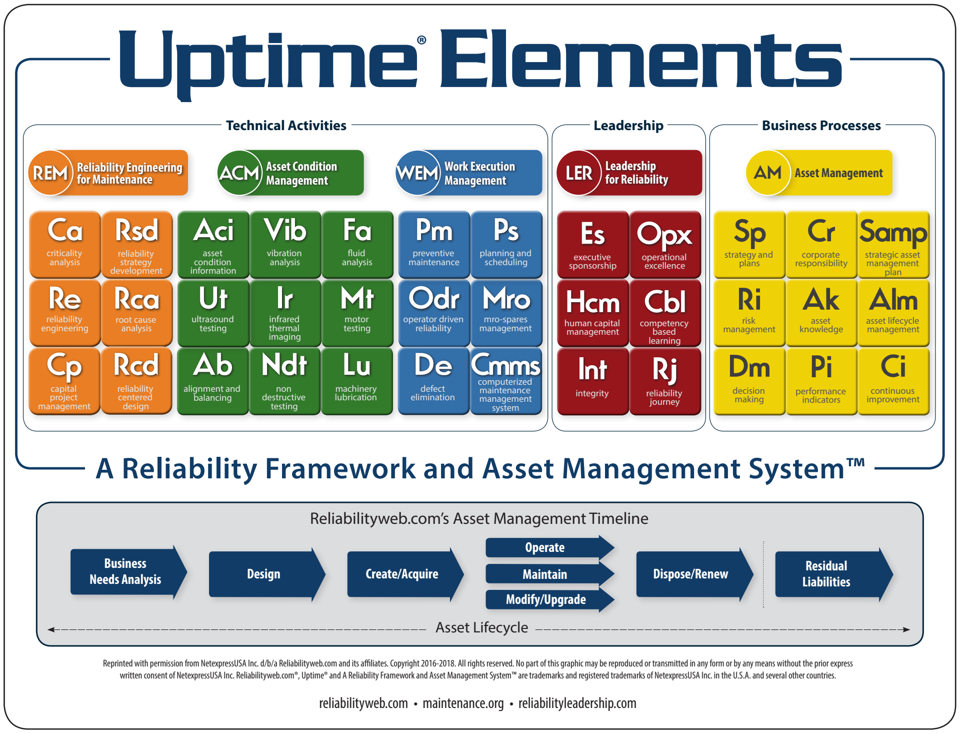

Uptime® Elements - A Reliability Framework and Asset Management System™ is in use at over 2,000 organizations around the work to engage and empower reliability culture.

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CEO/PUBLISHER
Terrence O'Hanlon
terrence@reliabilityweb.com

FOUNDER
Kelly Rigg O'Hanlon

EDITOR
Jenny Brunson

CONTRIBUTING EDITOR
Dave Reiber

CONTRIBUTING WRITERS
David Almagor, Umeet Bhachu, Athena Rhae Bisnar, Bryan Christiansen, Don Donofrio, Wayne Fieldhouse, Grahame Fogel, Rudi Frederix, Lee Harrelson, Uwoajega Joseph, Chad Kellner, Ron Moore, Cierrah Perrin, Ahmed Sow, Petrus Swart, Tacoma Zach

ASSOCIATE EDITOR
Sean Flack

DESIGNERS
Jocelyn Brown, Apolonia Lemus

PLANNER AND SCHEDULER
Lisa Imparato
lisa@reliabilityweb.com

SALES & ADVERTISING
Crystal Ward
Client Success Manager
crystal@reliabilityweb.com

Amy Harlan
Client Growth Specialist
amy@reliabilityweb.com

EDITORIAL INFORMATION
Please address submissions of case studies, procedures, practical tips and other correspondence to Terrence O'Hanlon
terrence@reliabilityweb.com

ARTICLE SUBMISSIONS
publishing@reliabilityweb.com

SUBSCRIPTIONS
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8991 Daniels Center Drive, Fort Myers, FL 33912
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SHALL WE PLAY A GAME?

That was the invitation from Joshua, the computer in the 1983 movie, *War Games*. Stephen Falken, the programmer who created Joshua, explained why he created the *War Games* simulation: "The whole point was to find a way to practice thermal nuclear war without destroying ourselves. To get the computers to learn from mistakes we couldn't afford to make."

In our search to find an effective way to communicate the power of engaging and empowering cross-functional team members through reliability leadership, we recently launched the Reliability Leadership® Game for the same reasons. This game is the first of its kind!

We have discovered that gaming is an effective way to deal with reliability cultural challenges that accelerate advances in reliability and asset management performance. One reason gamification is gaining interest is due to training research, which shows that adult learners only retain 10 percent of traditional content-heavy PowerPoint™ training, 20 percent from peer learning activities and 70 percent from experience-based learning. Live, in-person games fall under experience-based learning.

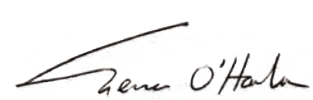
Here are some excellent reasons to play the Reliability Leadership Game with your team:

1. **Games break down silos.** As you know, many organizations with an interest in reliability work in silos, which can lead to communication issues and performance problems. The Reliability Leadership Game creates a new space to practice cross-functional collaboration using scenario-based situations.
2. **Meetings may be cordial or friendly, but often lead to nothing except talk.** The Reliability Leadership Game can engage people in important topics and create productive, hands-on dialogues that result in actions.
3. **Knowing and doing are often disconnected.** The Reliability Leadership Game creates a bridge between theory and practice by combining theoretical perspectives with simulated scenarios designed to shine a light on long-held, misplaced assumptions related to reliability.
4. **Change is difficult in the daily whirlwind as people get caught up in day-to-day tasks.** The Reliability Leadership Game creates a new space for scenario-based experimentation and reliability concept testing.
5. **Reliability is cross-functional and complex.** The Reliability Leadership Game accesses the challenges of reliability from multiple cross-functional perspectives, thus resulting in solutions for gaining clarity.
6. **Organizational structure and hierarchical relationships often prevent the crucial discussions that result in innovative approaches and solutions.** The Reliability Leadership Game shakes up traditional roles to create alternative links between people with a solution focus.
7. **Build trust through collaboration.** The daily whirlwind often leaves little room for personal relationships. The Reliability Leadership Game creates informal social experiences where everyone gets involved in quality social interaction, collaboration and high creativity through problem-solving.

If you follow our work, you know we always push the edge to find new ways to create collaborative, cross-functional teams with full executive support. The Reliability Leadership Game provides a powerful breakthrough in reliability performance. We hope that you can avoid nuclear war, or at the very least, unexpected downtime in your organization.

Shall we play a game?

Warm regards,



Terrence O'Hanlon, CMRP
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JUST LAUNCHED: The Reliability Leadership Game

Based in the popular Uptime Elements Reliability Framework and Asset Management System, the Reliability Leadership Game was initially launched at The RELIABILITY Conference in Las Vegas, NV on April 27, 2018.

The Reliability Leadership Game is used effectively to improve organizational performance. From facilitating better communication between employees and boosting innovation to breaking down silos and engaging staff during times of change. The Reliability Leadership Game is an essential guide for all organizations looking to advance reliability and asset management to gain competitive advantage.

The World's Most Perfect Work Order

The Reliability Leadership Institute® (RLI) hosted a highly interactive workshop to develop the world's more perfect work order. RLI members came together to explore, collaborate and create this perfect work order. The outcome? Stay tuned for the results in the upcoming months!

Reliability in the Spotlight: Two Educational Summits Shine

ARM Reliability Summit

The ARMS Reliability Summit was held in Austin, Texas, with a focus on best practice tools, methods, processes, frameworks, data, and technology. Companies, like Boeing, Raytheon, Olin Corporation, American Zinc Recycling, AbbVie, H-E-B, Triumph Group and more, participated in this 4-day event. Terrence O'Hanlon, CEO at Reliabilityweb.com, was the invited keynote speaker, along with Jason Apps, CEO at ARMS Reliability.

SD Myers' Electric Power Reliability Summit

The large reliability gap in the industrial power industry has been identified as a major issue, potentially representing a significant risk to operations. The Electric Power Reliability Summit brought together electrical system and reliability leaders from all over the country to tackle this problem. A special keynote presentation was delivered by Terrence O'Hanlon, CEO at Reliabilityweb.com.

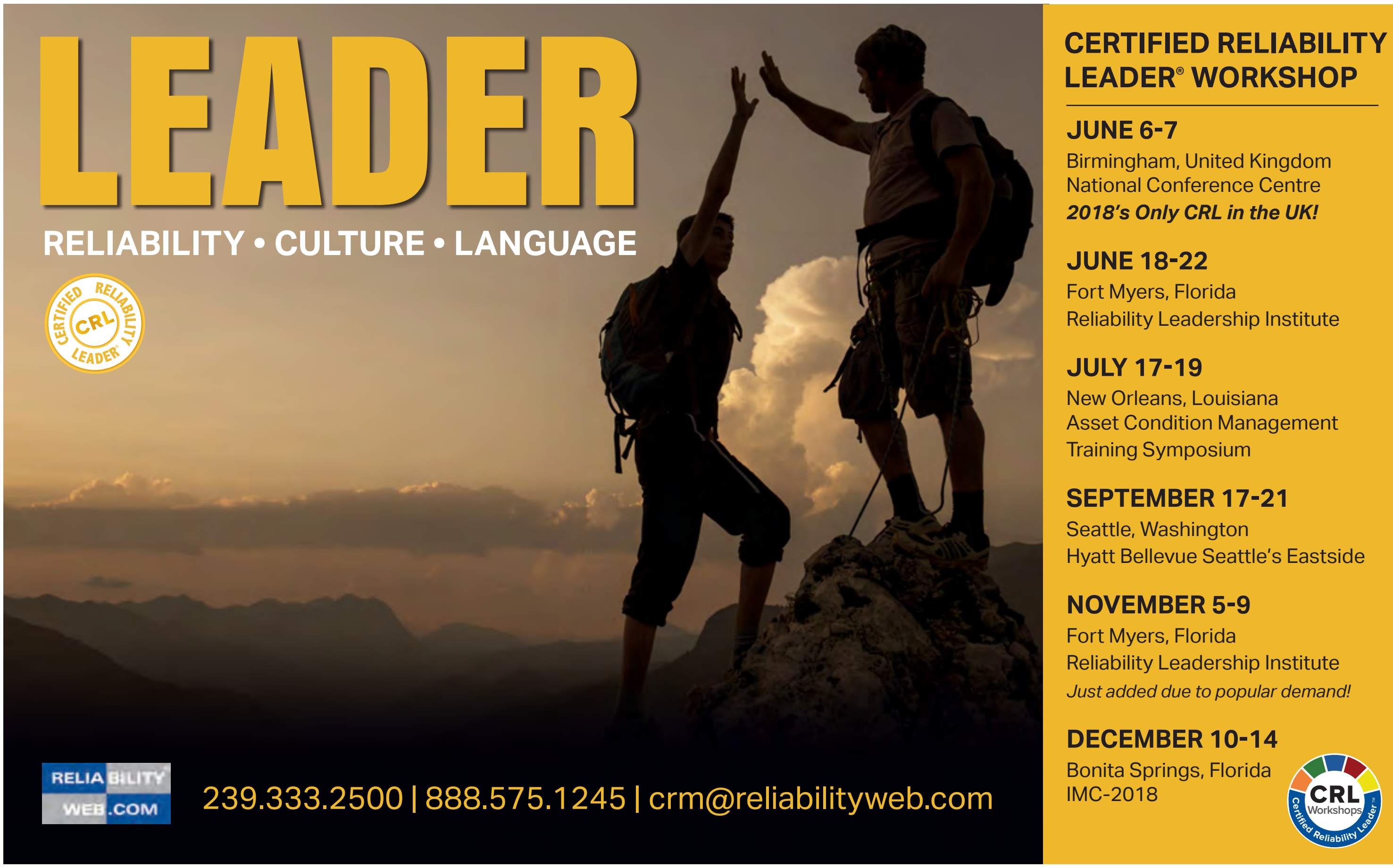
MaximoWorld on Track For Record Growth!

MaximoWorld 2018, (August 7-9), is on track for another record-setting year with participation from Maximo® users, IBM® Experts, Reliability Partners, Maximo Partners and innovative IoT and AI solution providers.

According to Terrence O'Hanlon, CEO of Reliabilityweb.com and MaximoWorld producer, "IBM has made some cutting-edget decisions on smart connected assets and systems to provide options for asset intensive companies, including world-class cloud deployment, Watson IoT, Asset Health Insights, asset management and of course work execution management. MaximoWorld is the only independent event with a focus on Maximo and includes stakeholders from around the world who are interested in advancing reliability and asset." For more information, visit: www.MaximoWorld.com

PRÜFTECHNIK Launches High-Speed Data Collector

PRÜFTECHNIK, a global condition monitoring and alignment products company, recently celebrated the success of their new VIBSCANNER 2 high-speed data collector at The RELIABILITY Conference 2018 in Las Vegas, Nevada. After only being out on the global markets a few months, the VIBSCANNER 2 won the 2018 Solution Award in the Asset Condition Management category. This is the company's second Solution Award in this category in three years.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COMMON SENSE: IS IT COMMON?

Ron Moore

The phrase, "It's just common sense," is used quite often to describe conclusions or circumstances that are obvious to most people, at least those within earshot. However, W. Edwards Deming, a well-respected management guru and quality expert, famously said, "There's no such thing as common sense. If there were, it would be common." So, at least from Deming's perspective, you have the answer to this article's question. Moreover, you've probably seen any number of instances where common sense just doesn't seem to have been applied, each instance lending credibility to Deming's opinion. That said, let's explore this further and perhaps try to begin to understand why he said this and why so often there are instances where common sense is not applied. Maybe it's just not as common as it should be.

The book, *Making Common Sense Common Practice: Models for Operational Excellence*, attempts to codify common sense as it relates to manufacturing and other industrial operations. It describes lessons learned from hundreds of people over decades of working in manufacturing, mining and other industrial operations. Decades were spent trying to understand and describe in a common sense manner what best practices are and how best to apply them. Most of what's in the book is just common sense, but it has taken decades to compile. Is it really that simple? Articulate a set of practices that would seem to be common sense, then have everyone follow those practices and, voila, world-class performance! If only it were that simple.

SO, WHY ISN'T IT?

PEOPLE

I DREAM A THOUSAND NEW PATHS.
I WOKE AND WALKED MY OLD ONE.
~CHINESE PROVERB

As you know, each of us is unique. Each individual brings a certain set of values, a unique personality, a set of goals, an educational and personal background, a set of experiences, personal and work responsibilities, and so on. All these are blended into an amalgam of who we are and they blend into our judgment, including what each of us considers common sense to be. What's common sense to you, given your background, might be a total mystery to someone else, or worse, you might be polar opposites.

Further, consider a large organization where there might be 500, 5,000, or even 50,000 employees or more. Further, consider the number of communication links among the various departments and individuals. Mathematically, the number of potential communication links grows geometrically with the number of employees. Consider the opportunity for error when each individual has a different view of what common sense is, not to mention the opportunity for error during those communications. How often have you heard that communication is a major problem within any given organization?

> How often have you heard that communication is a major problem within any given organization?

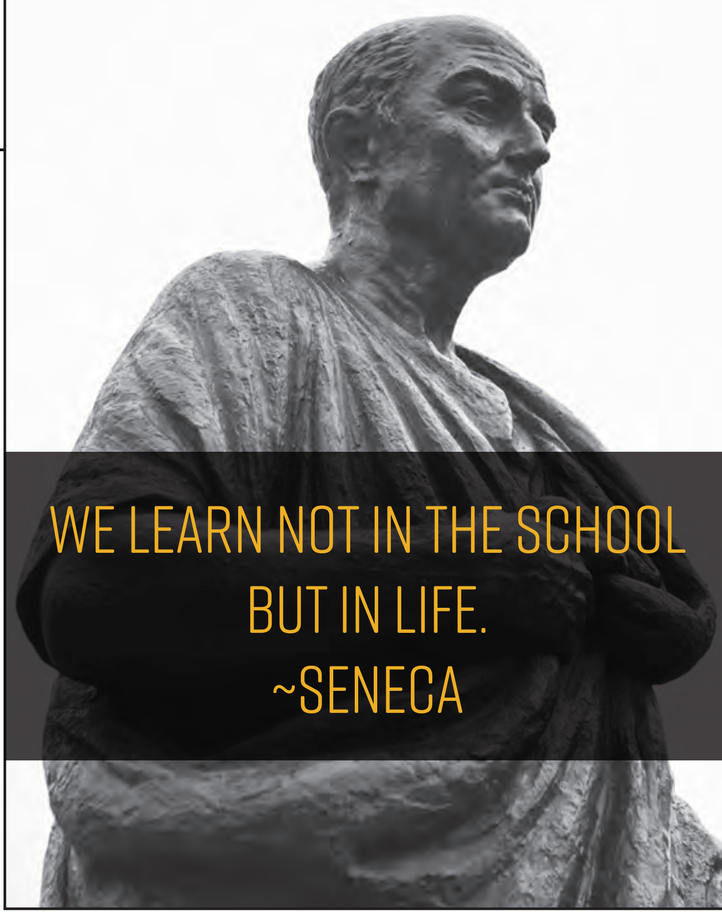
One only needs to observe the current political situation in the United States to see what happens when people apply different values to common sense. Take immigration, for example. Many think it's just common sense to allow the DACA children to remain in the U.S. with a path to citizenship, while others take a harder line and think since they're here illegally, it's only common sense that they have no right to be here. Similar examples can be found with the national debt, tax policy, gun control, policing, public education, the environment, or any number of issues. On each of these issues, individuals apply what they believe to be common sense, only to have others think that those who hold opposing opinions are, at best, ill-informed or, at worst, just plain stupid. Compromise, as our forefathers learned through incredibly difficult times, can be a very difficult, but very good thing. If only…

Let's take this thinking to the operational level. Each employee has a set of work objectives and standards, along with his or her background and personality. Likewise, along with this, each manager has certain goals and objectives, and measures. These individuals apply what they consider to be common sense in doing their jobs. But, what happens when these objectives conflict? For example, the purchasing manager has an objective to minimize purchasing costs and inventory, both in raw material and spare parts. The maintenance manager has an objective to minimize the risk of not having a spare part when it is needed, for example, for an unexpected equipment failure. The production manager has an objective to maximize the yield and efficiency of production. So, what happens if the purchasing manager reduces spare parts to reduce inventory, but to the point where parts are frequently not available when equipment fails or the parts are of inferior quality? What happens when the purchasing manager buys cheap raw material to save money, but this material is much more difficult to process through manufacturing, reducing yields and efficiency? In each event, the purchasing manager is trying to do what makes sense to achieve his or her objectives. And the other managers are doing what makes sense for them. But, it only makes sense for the business if it's good for the business overall, and therein lies the problem.

Another common example is when the production manager ignores the maintenance schedule in order to meet the production schedule. After all, it only makes sense to delay maintenance when an urgent production requirement is needed to satisfy a major customer. Until, of course, the equipment fails due to lack of adequate maintenance, at which time, it only makes sense to do the maintenance quickly to get the system back on line. Of course, when this happens frequently, the equipment soon falls into disrepair, making production demands difficult to meet. At that point, it only makes sense to blame maintenance for not keeping the equipment in good order. All this makes sense, doesn't it?

There are many more examples to offer, for example, between capital projects and operations and maintenance, between purchasing and capital projects, or between human resources and the various departments, but this should be sufficient to illustrate the fallacy of trying to apply common sense when organizations are not aligned and working as a team to achieve a higher business purpose. Each one has its goals and measures, and its view of common sense; they are often at odds and often change with the arrival of a new manager in any given department.

So, with these examples, common sense may not be so common, particularly if you don't think at a systems level, taking various influences into account and trying to optimize results. Clearly, there is a need for alignment in any given organization, with commensurate standards, practices and performance measures that reinforce that alignment for the greater good of the organization.



ALIGNMENT

In his seminal book, *Organizational Psychology*, Edgar Schein observed that as task interdependence increases, teamwork and collaboration become increasingly critical for organizational effectiveness. For example, there is huge task interdependence between production and maintenance, between shifts, between marketing and manufacturing, between purchasing and production/maintenance, and so on. The list is large.

So, how can you manage this task interdependence and create a greater sense of alignment and teamwork toward common goals? How do you make common sense more common by creating this shared sense of purpose?

First, every organization needs a set of what Schein calls "superordinate" goals that take priority over individual or group interests. While simple in concept, it is more difficult in practice, but you can begin by:

1. Asking managers when they are making decisions and setting standards and measures to consider and articulate the right thing to do for the business in light of overall goals.
2. Constantly reminding people to focus on the higher level goals.
3. Encouraging people to think at a systems level and not to optimize at the suboptimal level in their little silo. Rather, ask: What effect will this (decision, measure, action, etc.) have on the business?
4. Developing shared measures between various groups and partnership agreements to facilitate systems level thinking, collaboration and doing what's right for the business. This is discussed more in the next section.

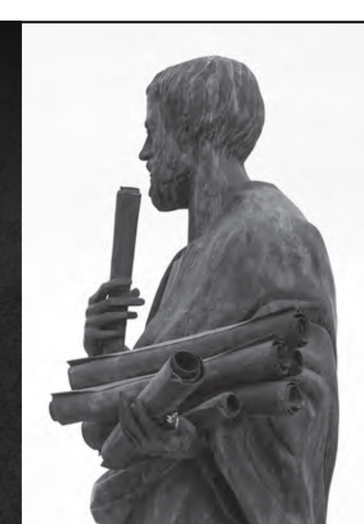
SHARED MEASURES FOR FOSTERING ALIGNMENT AND TEAMWORK

It is often the case that maintenance is held accountable for maintenance and repair costs, and preventive maintenance (PM) and maintenance schedule compliance. However, it is also the case that maintenance, through no fault of its own, does not have adequate control of these measures. For example, production often delays maintenance and PMs in the interest of production. While this is understandable, it puts maintenance in a position of being held accountable for schedule compliance when it doesn't really control the schedule. Moreover, it is often the case that poor operating practices related to start-up and shutdown, normal operation and basic operator care will result in lost production and equipment downtime. Again, maintenance has little control over these poor practices, but does bear the burden of the cost of them through maintenance cost overruns, delayed maintenance, or poor schedule compliance. Alternatively, it may be the case that maintenance will insist on doing certain PMs or other maintenance when this has a detrimental effect on delivery of the product. So, how can you better manage these competing interests? One suggestion would be to hold production ***and*** maintenance both accountable for maintenance and repair costs, maintenance/PM schedule compliance and on time delivery. If both are held accountable, then they must work together to balance competing interests and are much more likely to do the right thing for the business as opposed to the right thing for their department.

Another example is a situation that often arises between purchasing and maintenance. One of purchasing's goals is to minimize working capital in the form of spare parts holdings and stores. This is working capital that is not working. It represents tied up cash that could be made available for other business needs. Maintenance, on the other hand, wants to maximize spare parts to minimize the risk of not having the spare when equipment breaks down and be able to quickly support production in getting the plant back on line. The two objectives are contrary to one another. To manage this, hold both functions accountable for stores inventory turns, a measure of spare parts inventory relative to its use rate, and for stockout rate, a measure of the service level of the stores function. Getting the balance right so the greater business purpose is served is the right thing to do.

Although there are many other examples, those provided should serve the purpose of allowing you to develop measures that facilitate collaboration among the various groups so you can think at a systems level and do the right thing for the business. Common sense becomes more common.

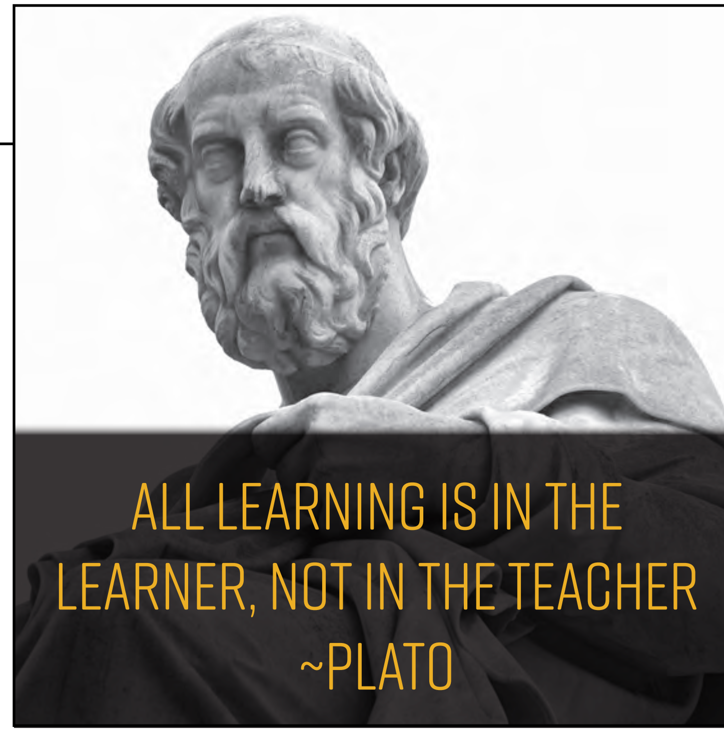
THE WHOLE IS
MORE THAN THE
SUM OF ITS PARTS
~ARTISTOTLE



CULTURE AND LEADERSHIP

All this makes you wonder whether any given organization has fostered a culture of teamwork, collaboration and system level thinking or one of individual and departmental achievement. The latter is more often than not the case in mediocre and underperforming organizations. The former is typically one of better performing, even superior organizations. It's up to the leadership of the organization to create a culture in which individuals and departments are expected to function with the greater good of the organization in mind.

Good leaders provide the overarching strategy and goals and the superordinate goals, and repeatedly communicate them. They then put systems and measures in place to assure the various business units and departments work toward those goals in a collaborative manner. If the leadership believes they merely need to set departmental goals and measures without considering the interactive effect they will have on the business, then it is not likely success will be achieved.



SUMMARY

Given the complexity of any organization, its individual and departmental differences and the frequent lack of an overarching strategy or common measures to facilitate collaboration, it's fair to say that common sense isn't all that common. Common sense is only common when the leadership of the organization takes the steps described in this article, among others, to ensure the entire organization is aligned and working as a team to support organizational goals. For those organizations that fail to do this, Deming was right–

"There's no such thing as common sense. If there were, it would be common."

__Ron Moore__ is the Managing Partner of The RM Group, Inc., Knoxville, TN. He is the author of the books, __Making Common Sense Common Practice - Models for Operational Excellence__, 5th edition; __What Tool? When? – A Management Guide for Selecting the Right Improvement Tools__, 2nd edition; __Where Do We Start Our Improvement Program?__; __Business Fables & Foibles__; and __Our Transplant Journey: A Caregiver's Story__, as well as some 70 journal articles.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THE HUMAN FACTOR IN

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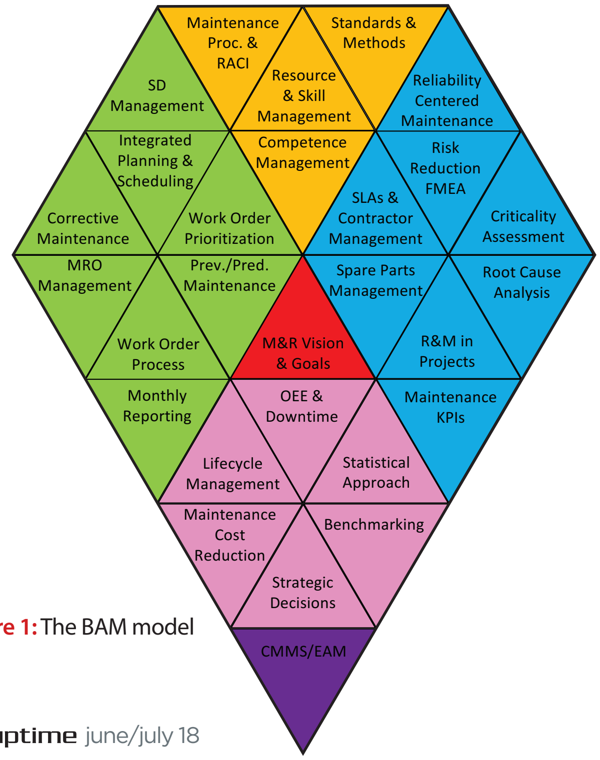

Figure 1: The BAM model

Many companies have started, are in the middle of, or have already finished an operational excellence exercise. Although these companies are in different industries, the strategy for optimizing their technical departments (e.g., maintenance, engineering, utilities, facilities) is about 90 percent the same. So, the approach does not change much in the different industries or in the different departments.

In the pharmaceutical industry, for instance, product safety is a major concern. In the food industry, there is the balance between availability and cost. In the automotive industry, uptime and productivity are key. So, while the principles and building blocks of excellence exercises are based on the same strategy, such as the Uptime® Elements, brilliant asset management (BAM) model©, etc., the goals vary from industry to industry.

Another important element is the maturity of the processes in place. The pharmaceutical industry and the nuclear industry are the farthest behind. This is mainly because every change in the production process takes a lot of time due to the in-depth validation process. Taking that into account, changes are discouraged and often aren't feasible.

So, one needs to adapt the approach to reach asset management (AM) excellence in various industries.

But…how about the human approach?

SOME FACTS

FACT 1

In 1850, the information available doubled every 45 years.

In the past, all the knowledge was owned by the boss (manager). The only place where you could learn was school. So, the boss went to school, read a lot of books (only available at school) and earned a degree. In other words, the boss was the smartest guy in the company – an example of the 2-D Age. Employees looked up to the manager because this person had all the knowledge. In other words, the boss had the power based on knowledge. All this had to do with availability of information.

In 1990, the information available doubled every three years.

In 2011, the information available doubled every two years.

Nowadays, the information available doubles/triples every year.

All information is now freely available. The bar to access information is so low to all people that anyone can learn. Since information is so accessible to all people, there has been a shift from the 2-D Age to the 3-D Age. Now, you can learn outside the classic classroom and know even more than your boss. All of a sudden, your boss isn't the smartest anymore.

FACT 2

Only 13 percent of the people worldwide are engaged in their work.

It's a disturbing number, to say the least.

Based on Gallup's nationally representative polling samples in 2011 and 2012 from more than 140 countries:

63% of the workforce is not engaged or are simply unmotivated and unlikely to exert extra effort.

24% of the workforce is actively disengaged or truly unhappy and unproductive.

13% of employees worldwide are engaged in their jobs, emotionally invested in their work and focused on helping their organizations improve according to additional data on the Internet.

Combining the three facts, one can discern that most people are not engaged and one important reason for that is their knowledge isn't used or is even neglected. The solution is simple. Engage and empower people by using their knowledge. That said, how can this be implemented in real life?

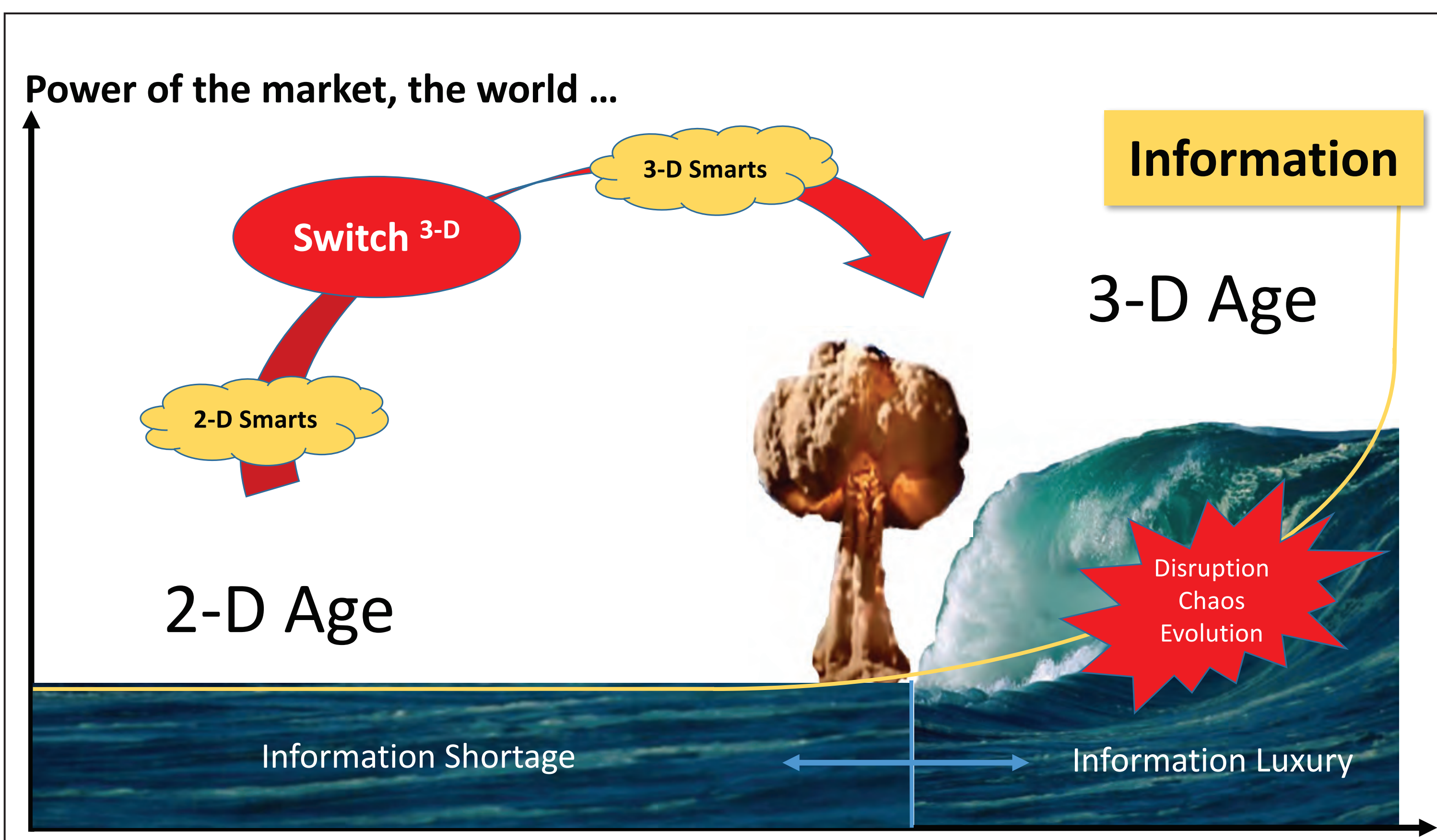

Figure 2: The transformation of information availability (Source: Jef Staes ©Fenestra bvba)

Let's start with the maintenance excellence (MEX) program used in a pharmaceutical company.

Maintenance Excellence (MEX) Program in a Pharmaceutical Company

The project contained five steps:

STEP 1: Conduct a survey. The purpose of the survey is to learn the maturity level of the maintenance department. The BAM model was used. It was learned that the work order flow was poor, especially work preparation and scheduling.

STEP 2: Establish a road map. After defining the maturity level and indicating the opportunities, develop a road map that describes the necessary steps to go forward.

STEP 3: Perform process mapping. Using the Makigami method, the existing situation (i.e., current state) is mapped out. It is then compared to how the current state would work in an ideal situation (i.e., dream state). The necessary steps to move from the current state to the future state are defined. This is done by asking the question: What do we need to improve/change to go from the current state to the future state?

STEP 4: Implementation. Implement the defined actions to reach the future state.

STEP 5: Follow up. Follow up and finalize the project.

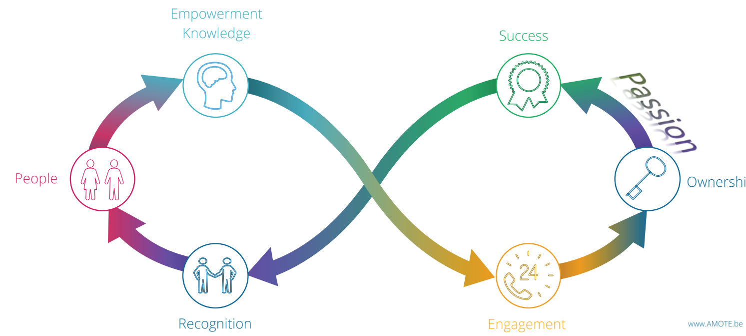

Figure 3: Engaging and empowering people for success

The survey conducted at the pharmaceutical company found that the main issues were located in the work preparation and scheduling processes. After analyzing and improving the process, a hands-on tool time (HOTT) analysis was performed. Changes were incorporated into the processes and implemented. After one year, another HOTT analysis was conducted and the results were stunning.

Before implementation, the average duration of a work order was four hours. After implementation of the changes, the duration was only three hours. The company managed 9,000 work orders on a yearly basis, with an average full-time equivalent (FTE) cost of $59.30. After the first year, the company realized a profit of $534K.

This was only possible by using the knowledge of the people. First, the knowledge of the people was used for the survey and second, the people were empowered to build the new work order flow, resulting in ownership of the results.

One lesson learned was that communication is key. If you don't explain why and what the purpose is, then people are skeptical from day one and will not (fully) cooperate.

The four essential areas to remember when working with people are:

1. Use the pull principle instead of the push principle. Use the knowledge of the people and empower them.
2. Each person has a personality. Define each person's personality using, for example, the Myers-Briggs Type Indicator (MBTI)®, and communicate it to the group. This way, everyone knows how to approach a specific person to get the best out of the individual.
3. Don't push people into cooperation. Ask who might be interested in helping out. There are always several people who are interested, at least 13 percent based on the research presented in Fact 2. Empower them. Give them the necessary tools (e.g., time, budget and coaching) so they can implement their ideas. You also may want to use coaching techniques, such as GROW, Harada, etc.
4. As soon as the first achievements are reached, make them visible. Build a wall of fame. Recognize the individuals involved. By doing so, other less engaged people will show interest.

When it comes to the human factor in asset management, keep in mind: Engaged people see an opportunity in every problem; disengaged people see a problem in every opportunity.

***Rudi Frederix** is General Manager at AMOTE vof located in Belgium. He has been involved in the asset management field for 25 years and has worked in a variety of industries, including automotive, oil & gas, chemical, food, pharmaceutical, mining, and nuclear energy. Rudi has a passion for project management, maintenance and reliability best practices. www.AMOTE.be*

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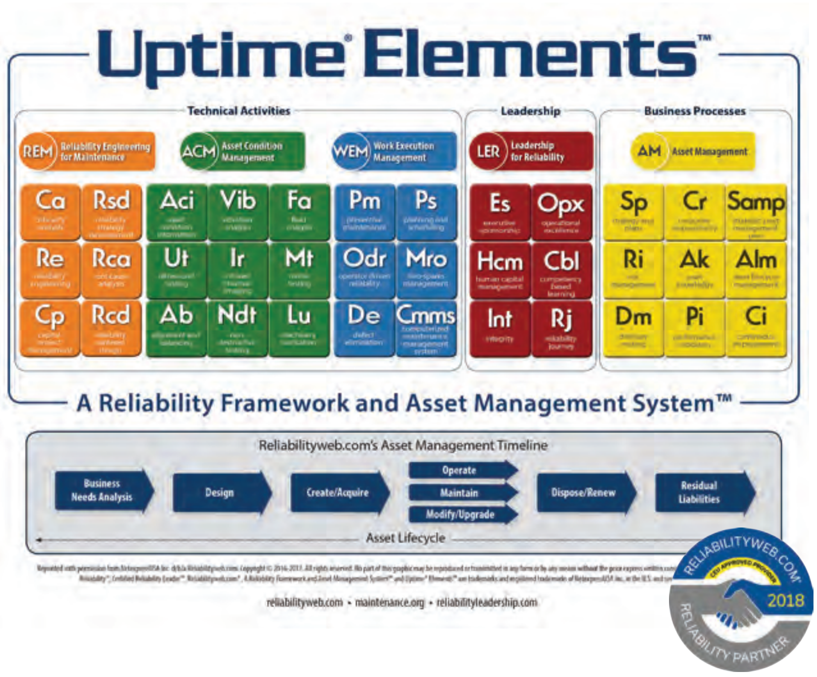

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PART 2

DOES RELYING ON CRITICALITY PUT YOUR ORGANIZATION AT RISK?

Grahame Fogel and Petrus Swart

This article is Part 2 of a two-part series focusing on risk as an enabler for asset management (AM). Part 1 (April/May 2018 *Uptime*) argued the case for moving away from criticality to an ISO31000 risk-based approach. This part will address how to effectively model asset risk in complex systems.

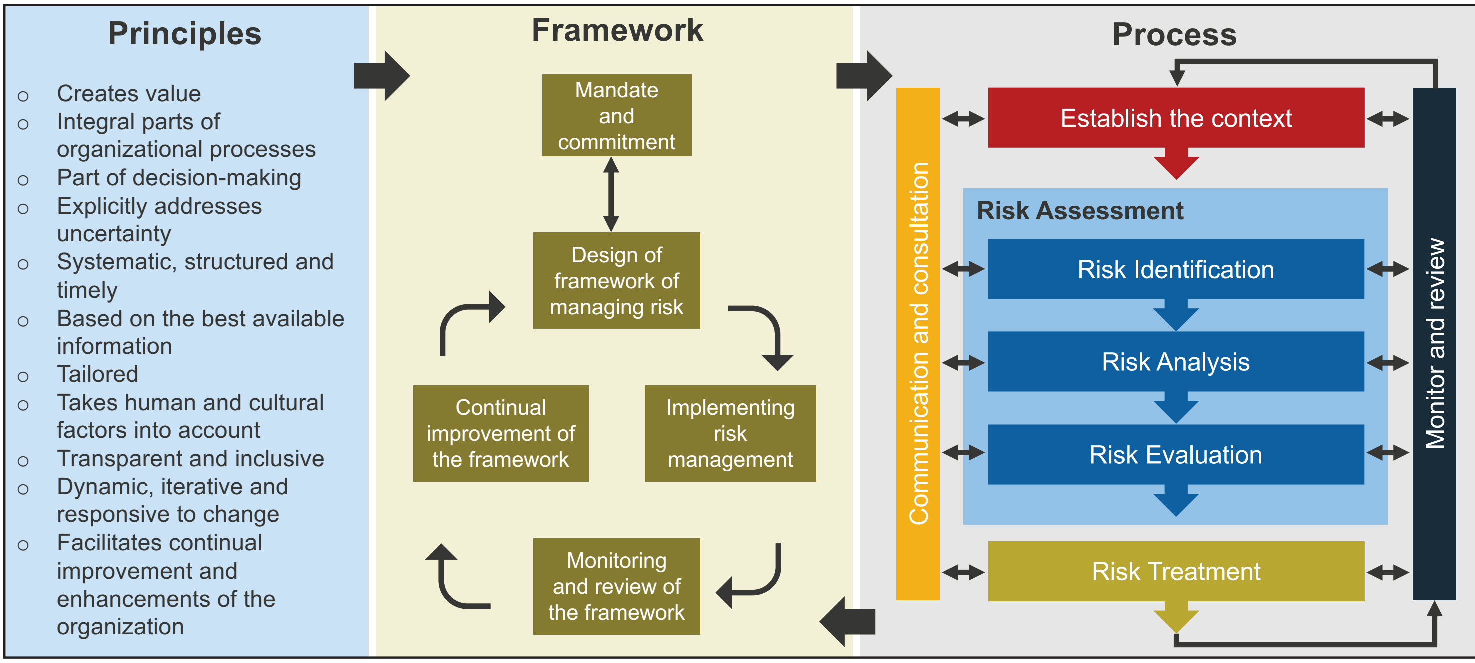


Figure 1: ISO31000 risk management system

The first part of this article, Part 1, started with a discussion on how rapidly the field of AM has evolved in recent years. It also brought attention to the fact that certain sections of the AM body of knowledge (BoK) have not managed to keep up with this pace of change. A notable example is criticality, which keeps being used and misused throughout literature, causing significant confusion among AM professionals. The confusion surrounding criticality stems largely from its synonymous use with risk, as well as the fact that both terms have an identical mathematical expression. Part 1 highlighted this confusion and subsequently called for AM professionals to move away from criticality and to adopt a risk-based approach instead.

Part 2 will describe a risk-based approach to asset risk. It will show how this approach aligns to the ISO31000 risk management process (Figure 1) and how it can help AM professionals and asset intensive organizations make better risk-based AM decisions.

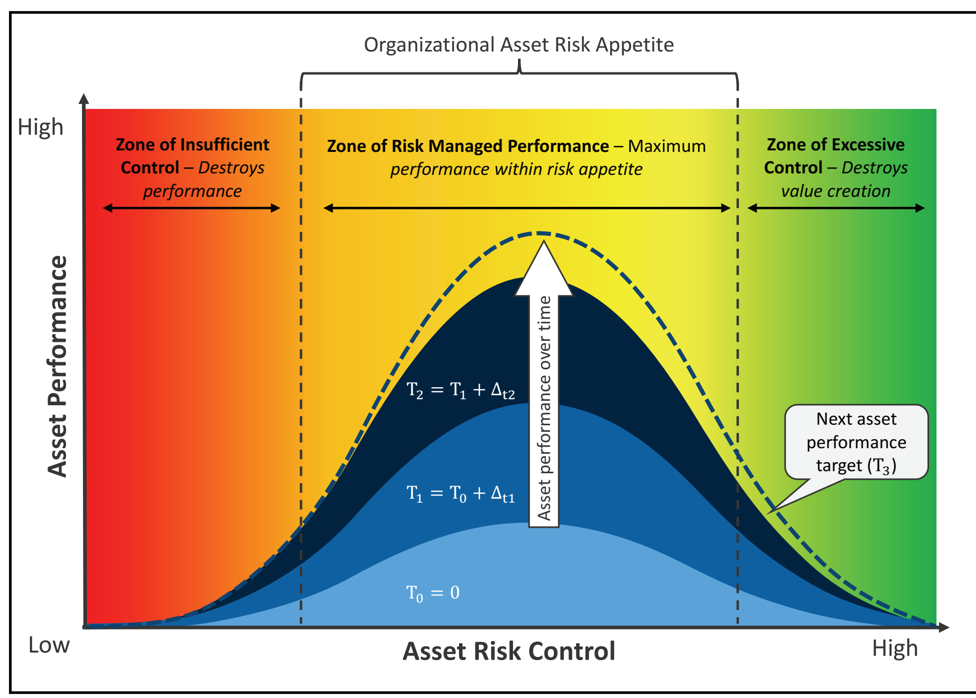


Figure 2: The risk managed performance approach

A Different Approach to Asset Risk

Risk managed performance (RMP) is an asset risk approach that aligns fully to the ISO31000 risk management system shown in Figure 1. The approach aims to provide organizations with an effective decision-making mechanism in order to strike the appropriate balance between asset performance and asset risk control, as illustrated in Figure 2 with the zone of risk managed performance. The goal is to first help organizations reach the RMP zone and then make incremental asset performance improvements over time. Within the RMP zone, the organization's asset portfolio operates within its asset risk appetite. This means the organization is neither guilty of destroying asset performance due to insufficient asset risk control nor destroying possible value creation by excessively controlling its asset risk.

Asset risk level and organizational asset risk attitude

The appropriate response for organizations to take with regard to their asset risk depends on the asset risk level, as well as the organization's asset risk attitude. The mathematical expression for asset risk level is given in Figure 3. This expression does not violate the ISO31000 definition of risk since asset condition does not mathematically alter the equation. Rather, it is an *optional* input parameter during the asset risk analysis process (see Figure 1) that can provide additional decision-making insight. The benefit of including asset condition will become more apparent later in this article.

An organization's asset risk attitude depends on a number of factors, such as the nature of operation, overall risk culture, aversion toward risk (i.e., risk appetite and tolerance levels) and how proactively it chooses to manage risk. The three asset risk matrices in Figure 4 are examples to explain

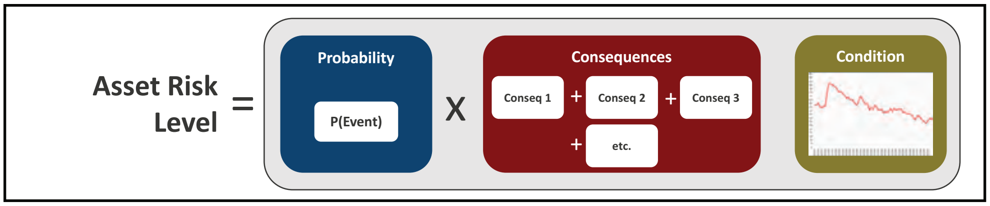


Figure 3: Mathematical expression for asset risk

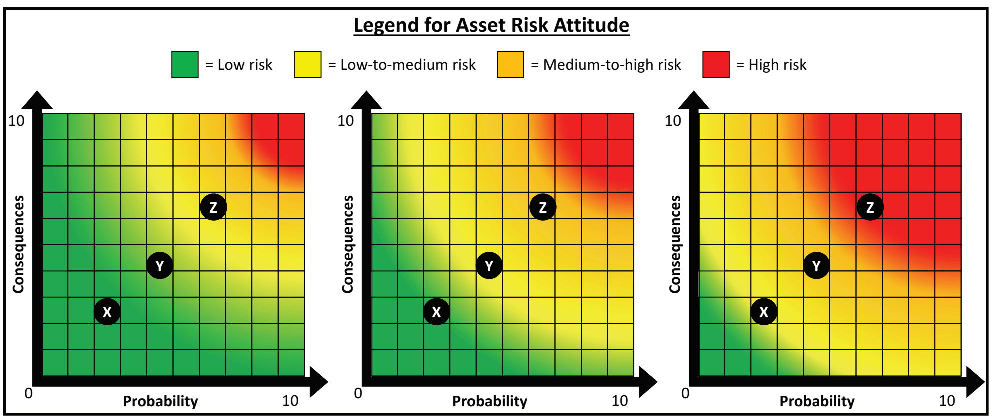


Figure 4: Asset risk attitude examples, left: low aversion to asset risk; middle: medium aversion to asset risk; and right: high aversion to asset risk

some of these points. Assets X, Y and Z are situated on the exact same position on all three asset risk matrices. This means the corresponding asset on each matrix has the same asset risk level. However, from left to right, the asset risk matrices are increasingly risk averse. One would expect the matrix on the left in Figure 4 to be used at a low-risk operation, whereas the matrix on the right would be commonplace at a high-risk operation, such as a nuclear power plant. Even though the corresponding asset may have the same asset risk level, the responses from each organization will differ in accordance to its aversion to risk. Take Asset Y in Figure 4 as an example. It is considered a low-risk item on the left matrix, a medium-to-high risk item on the middle matrix and a medium-to-high risk item on the right matrix. Moving from left to right, one can expect the effort and resources to be spent on asset risk mitigation to intensify as the risk aversion increases.

Asset risk Pareto analysis

A Pareto analysis can be extremely useful when it comes to representing asset risk. It follows the Pareto principle, which is commonly known as the 80/20 rule. In essence, it alerts AM professionals to those assets in which they should invest 20 percent of their time and effort in order to generate 80 percent of the benefit they would have attained by attending to the entire asset portfolio.

Figure 5 shows an example of an asset risk Pareto analysis. The figure contains a wealth of insight and shows the 20 percent of assets that contain 80 percent of the asset portfolio risk. Moreover, the inherent and residual risks of each asset illustrate the effectiveness of the organization's asset mitigating plans. At the same time, Figure 5 shows whether these mitigating plans are sufficient in reducing asset risk to within the organization's acceptable asset risk appetite levels. This is all shown as the backdrop of the organization's specific risk aversion, illustrated using conventional risk colors, ranging from red, indicating high risk, to green, indicating low risk.

Asset risk matrix

Introduced in Figure 4, a risk matrix is arguably the most popular way of representing risk. Figure 6 shows two examples of asset risk matrices. Both break down the asset risk level, shown in Figure 5 as a single value out of 100, into its constituents, namely probability and consequences. These two-dimensional risk matrices also show the same risk aversion in the backdrop and the organization's asset risk appetite. The difference between the two risk matrices is the size of the bubbles on them, which represent the condition of the assets.

In order to verify the asset register in preparation for an asset risk assessment (see Figure 1), proxy asset conditions are assigned to the assets by means of visual inspections during a plant walk down or from other sources, such as condition monitoring data. This does not have to be a full asset condition assessment. Using an asset condition proxy can give additional insight into the health of the assets. It might be discovered that some high-risk assets are in good condition, whereas some low-risk assets are in poor condition. This might contradict the traditional notion of the asset risk Pareto analysis, in which high-risk assets are attended to immediately, thus adding new insight and consideration to AM professionals' decision-making process.

Figure 7 plots the asset risk matrix on the right-hand side of Figure 6 in terms of the level of asset risk versus the condition of the asset. It is typically seen in practice that the majority of high-risk assets are known and numerous risk mitigating plans are in place to ensure these assets stay in a healthy condition. However, by overcommitting time and resources to high-risk assets, organizations often overlook their low-to-medium risk assets. This lack of attention can quickly lead to dete-

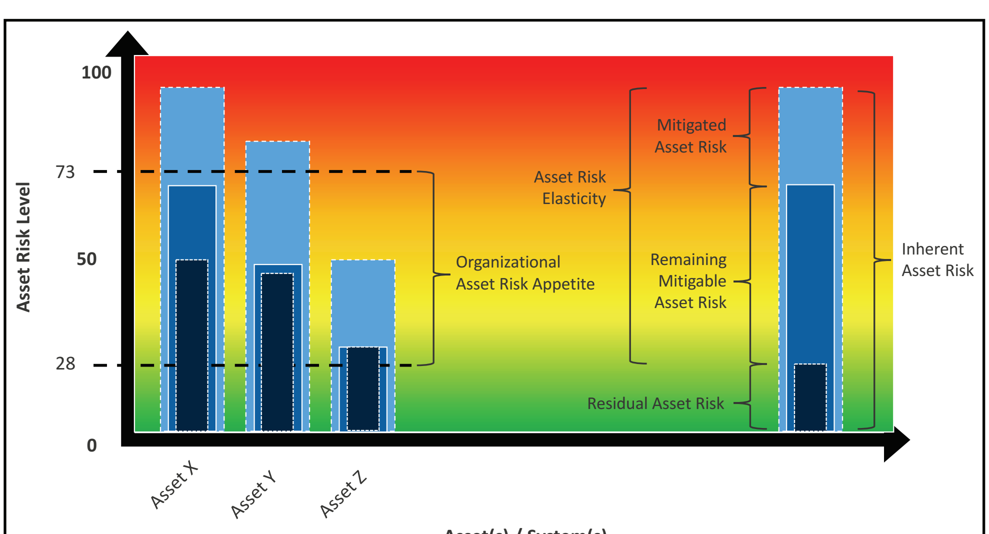


Figure 5: Asset risk Pareto analysis example

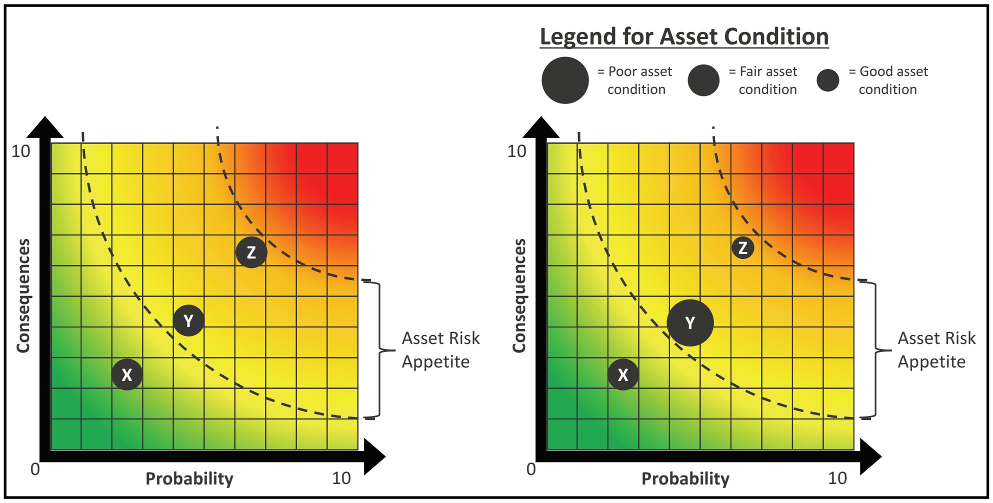


Figure 6: Asset risk matrix examples, left, excluding asset condition and right, including asset condition

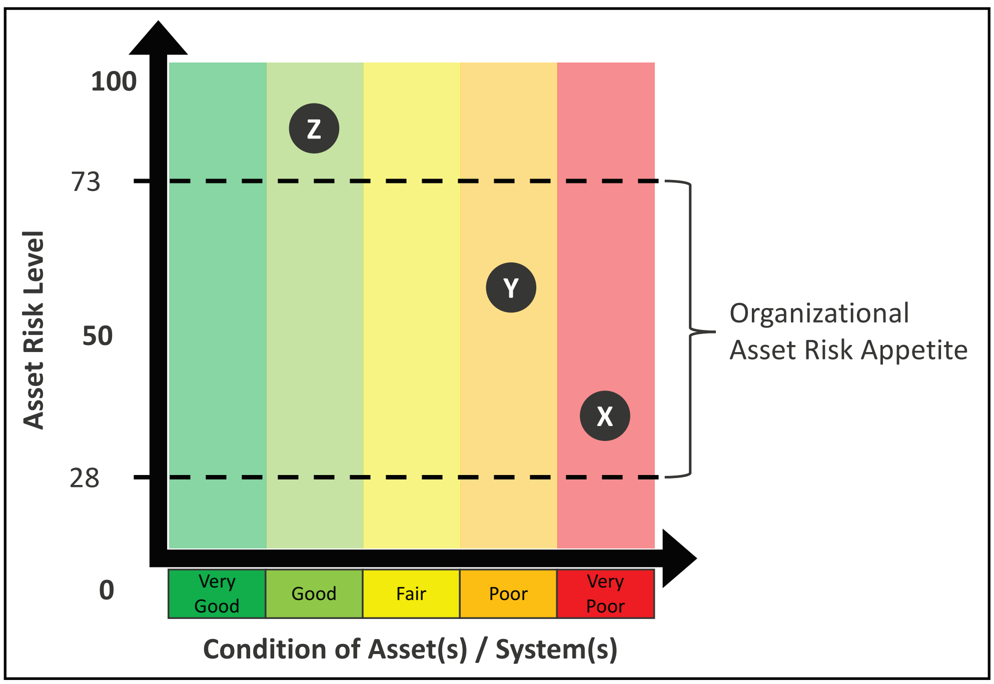


Figure 7: Asset risk level vs. asset condition example

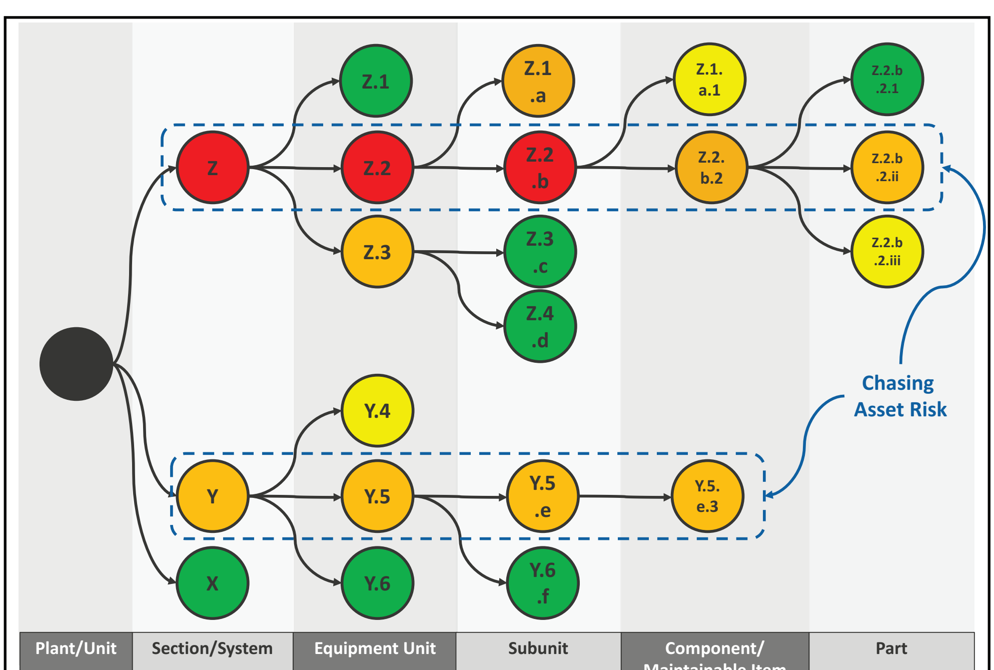


Figure 8: Risk-based asset hierarchy example

rioration, resulting in an unexpected asset failure. Since the asset conditions of lower risk assets are not in the decision-making framework, failure of these assets often comes as a shock and without the appropriate level of preparedness.

This attention paid to proxy asset condition is unlike most criticality analyses. Typically, a criticality analysis aims to provide insight on where to focus effort in terms of conducting asset condition assessments. However, this may be too late, as one can see the invaluable insight gained between the two risk matrices in Figure 6, as well as Figure 7. Getting a proxy for asset condition does not take significantly more effort and forms part of the risk assessment preparation process, during which the plant is walked down to verify the contents of the asset register.

> 80/20 Rule for AM: Invest 20 percent of time and effort in order to generate 80 percent of the benefit.

Risk-based asset hierarchy

Organizations are often challenged with choosing the most appropriate method of asset hierarchy construction. However, constructing asset hierarchies on the basis of asset risk can provide enormous practical advantages. For example, as alluded to in the asset risk Pareto analysis, the majority of asset risk may be limited to only a few assets or systems in the whole asset portfolio. Figure 8 shows an example of a risk-based asset hierarchy and how it can assist organizations to be more effective during their asset risk analysis process (see Figure 1).

Starting at the highest practical analysis level, which in Figure 8 is the section or system level, conducting the asset risk analysis will reveal the section/system with the highest risk. If the section/system risk level falls above the organization's asset risk appetite, the analysis can go one level deeper and analyze asset risk at the equipment level. This process continues until the organization is comfortable in reaching the appropriate level at which to mitigate the risk below its asset risk appetite. The process is termed "chasing asset risk" and is a very useful tool to visually illustrate asset risk since the color of each asset bubble indicates where the asset sits on the asset risk Pareto analysis (Figure 5) graph and the asset risk matrix (Figure 6).

As noted in the beginning of this article, effective risk management is a clear performance enhancer. With that in mind, constructing a risk-based asset hierarchy facilitates a direct

Table 1– ISO31000 Risk Treatment Options

Risk Option	Description
Avoid the risk	Discontinue the activity that provides the origin of the risk
Take on more risk	Use a calculated understanding of risk to exploit risk opportunities
Address risk source	Remove or modify the risk initiator to operate at a lower risk level
Change the probability	Through the combination of understanding the primary functions and failure modes, apply the appropriate range of reliability engineering tools and processes
Alter the consequences	Change the outcome of the event should a risk occur
Share the risk	Distribute risk or insure against risk outcome with another party or parties
Retain the risk	Accept the fact that in the real world, some risks will remain, but understand fully the retained risk that is in place

foundation to risk-based decision-making and management.

Thinking Like a Risk Manager

Risk management theory and practice is a well-trodden path and AM professionals can save time, effort, resources and confusion by aligning to the ISO31000 methodology and vocabulary. ISO31000 promotes seven options to managing risk, which are summarized in Table 1. Keep in mind that these risk treatment options are not necessarily mutually exclusive or appropriate in all circumstances.

> “The confusion surrounding criticality stems largely from its synonymous use with risk…”

By understanding the appropriate risk treatment options available, AM professionals can set forth a path to completion that consists of actions that can achieve their desired outcomes. For example, if one changes the probability of asset failure, it effects the frequency at which the failure may occur and, as such, may allow for a completely different tactical approach to managing the asset. This may be more cost and resource effective, thereby providing an amplified advantage.

Key Takeaways for AM Professionals

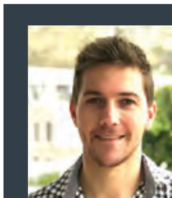
Risk management as a professional discipline is mature in its thinking and proven in its application. The ISO31000 process applied by risk managers is shown in Figure 1. There is no need or benefit for AM professionals to reinvent or modify this proven process, but rather to understand and align to it. Adopting this process bridges the divide between asset management and risk management principles and has a number of tangible advantages, which can be summarized as follows:

- It creates a consistent and unambiguous use of language based on international standards.
- It provides a coherent vocabulary for all organizations, their departments and other professionals, such as lawyers, regulators, insurers, etc.
- Using the terms, principles and guidelines in both ISO31000 and ISO55000 means organizations do not have to spend time and effort creating their own. This time can be spent on effectively managing actual risks.
- AM aligns with established risk literature and standards (e.g., ISO31000 and ISO Guide 73[1]) and, therefore, brings greater credibility to the field of AM.
- Executive managers and board members are tasked with managing enterprise risk. They are conversant with risk concepts and the contemporary language of risk. For AM professionals, conversing with these professionals with the appropriate risk vocabulary will make communication more effective and credible.

Reference

1. International Organization for Standardization (ISO). *ISO Guide 73: 2009 Risk management – Vocabulary.* https://www.iso.org/standard/44651.html

Grahame Fogel *is an internationally recognized expert in asset management. He has over 35 years' experience, ranging from power generation, through mining and into heavy manufacturing and pharmaceuticals. Grahame is a member of the IAM UK, SAAMA and a board member of the Association of Maintenance Professionals (AMP), and is an endorsed IAM PAS 55 Assessor. www.gauseng.com*



Petrus Swart *holds a Mechanical Engineering degree and a Master's in Engineering Management, both from Stellenbosch University in South Africa. His focus is on asset management and, more specifically, on linking asset management objectives with organizational financial objectives, thus creating a clear "line of sight" within organizations. Petrus has international consulting experience in the mining sector, as well as the food packaging industry. www.gauseng.com*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NO PART LEFT BEHIND: 4 SIMPLE RULES FOR EFFICIENT INVENTORY MANAGEMENT

Bryan Christiansen

"The thing to remember about inventory control is that it's about striking a balance between too much stock and too little."

Managing your inventory levels correctly can mean the difference between machinery that has broken down and is slowing down the assembly line or a smoothly running machine that is boosting productivity.

In today's competitive industry, no company can afford downtimes and delays in production due to missing parts. With increased competition, companies depend on their supply chain to be leaner, healthier and faster than the competition.

The thing to remember about inventory control is that it's about striking a balance between too much stock and too little. If you have too many tools and spare parts on hand, you're wasting company funds that could be better utilized elsewhere.

The only way to compete in the market today is to have just the right stock levels to meet demand, but not much more.

RULE 1 NOTHING IS ISSUED WITHOUT A WORK ORDER

If you look at an average business that requires parts, equipment and tools to be kept in stock, it likely has a computerized maintenance management system (CMMS) with an inventory module. The inventory management module usually comes standard with any CMMS, but it is often underutilized. The main reason for this isn't the difficulty in using the system, but rather technicians trying to save time in the short term by keeping parts outside the system or not returning tools for weeks.

The solution is not that difficult. The inventory control program is only as good as the inventory control process that is implemented by the stock manager. If enforcement of policies is lax, it will result in a gap between the actual inventory situation on the ground and the inventory showing up in the system.

An effective inventory control system has to provide the location, availability and purpose of every item in stock. If the business ensures the procedures for the receipt and issuance of all tools, parts and products are entered promptly, the figures of availability will be accurate.

A major headache for inventory managers is that once a piece of equipment becomes obsolete and is removed from service, the spare parts to support that equipment remain unused in stock because no one bothers to remove them. This issue also can be resolved by ensuring entry in the CMMS is performed religiously for every issuance and return. Doing so will allow you to get rid of surplus parts that are no longer useful and free up valuable storage space.

RULE 2 HAVE ENOUGH STOCK TO SERVICE DEMAND

In today's market, e-commerce giants like Amazon and Alibaba have raised the bar for customer service and logistics. Similarly, stores and inventory managers have internal customers who are more demanding and require faster service and support for their equipment than ever before.

Whether you're dealing with IT equipment or heavy machinery spares, your stock levels need to be up to the mark to allow your internal customers to succeed. For business owners or inventory managers, getting the supply chain right is critical to keeping your business running smoothly. The key to getting it right is knowing exactly how much inventory you have at all times and this is only achieved by ensuring inventory management processes are followed.

Knowing how much inventory to keep requires an ongoing analysis. A good maintenance management software will automatically send notifications when part levels are below custom set thresholds. This way, you immediately know when you are low on critical parts. If you know exactly how much of each item you have, when quantity levels get low, you can reorder more with enough lead time to prevent back orders. Tracking the consumption of parts, noting seasonal trends and forecasting demand all rely on accurate data being entered into the inventory control system.

RULE 3 DON'T OVERSTOCK

Sometimes, the feedback from other departments that have faced issues with parts being out of stock leads to the inventory manager overstocking an item, causing issues related to excess stock. Excess stock means you need more warehousing space, which is expensive. It also means a pinched cash flow that makes doing business more difficult and riskier.

Overstocking can even occur from failure to predict a drop in demand for a particular part. Challenges linked to overstocking include the equipment being rendered obsolete, the threat of lost or stolen items, degradation of items over time and so on. If a part remains unused and there is no further requirement for that part, the business has a few options to get rid of the excess inventory.

One way is to return the part or equipment to the vendor. This option usually results in a refund or a credit, but not for the full amount originally paid. Other options include liquidating or auctioning off the item, selling it to a competitor or discount store, or donating it to charity after writing it off.

To steer clear of such situations, manage your inventory system effectively to identify demand, minimum and maximum order requirements, and safety stock levels for each item. The CMMS should be able to monitor lead times and prices to make restocking quick and easy. A good CMMS has settings for a stale threshold. If a part is not used within x number of days, a notification will be sent to the manager. That way, if you have a part and you don't use it in a year, you can then decide if you want to remove it from your inventory.

RULE 4 KNOW YOUR INVENTORY

Often, the biggest issue inventory managers face is not about stock levels, but about knowing inventory levels accurately. Over time, delays in inventory reporting can add up to overstocked and out of stock issues.

Spare parts that aren't being consumed take up valuable storage space, while high demand parts are not readily available, creating problems for the production facilities. In time, a delay of even a few hours for critical industries, like utilities or factories, can be costly and lead to huge losses.

There are several disadvantages of inaccurate inventory data. They include greater difficulty in detecting and preventing loss and theft, damage to brand and reputation due to work delays, production shutdowns and reliability issues, and ripple effects on other operations, such as sales forecasting.

Even if your inventory levels are perfect when you start out, having gaps in your inventory data will quickly lead to an overstocking or understocking situation. A good way to prevent this is by attaching quick response (QR) coders to each part in the parts warehouse. This helps in performing manual inventory, making it that much easier.

Ideally, you should have just enough inventory to meet demand, given information about trends, season, departmental requirements and availability from vendors.

> "...The value of the output from the CMMS is directly proportional to the quality of the data entered."

CONCLUSION

The use of a CMMS is helpful, but only if standard operating procedures (SOPs) are strictly followed. Like any computerized system, the value of the output from the CMMS is directly proportional to the quality of the data entered. The CMMS will help track stock levels, report loss or theft and identify items that urgently need to be replenished.

The best inventory control method is to enforce these four rules to reduce uncertainty and waste. A good inventory control program allows businesses to outperform the competition and excel, while also cutting down on wasted time, energy and resources.

***Bryan Christiansen** is founder and CEO at Limble CMMS. Limble is a mobile first, modern, and easy to use CMMS software that takes the stress and chaos out of maintenance by helping managers organize, automate and streamline their maintenance operations.*
www.limblecmms.com

Cp capital project management

HOW MEDIMMUNE KICKED THEIR **COGENERATION PROJECT INTO OVERDRIVE**

Chad Kellner, Wayne Fieldhouse and Lee Harrelson

MedImmune is the biologics and biotechnology research and development (R&D) arm of the pharmaceutical and biopharmaceutical manufacturer AstraZeneca. MedImmune is the mind behind many popular pharmaceutical products on the market today, including Synagis®, a preventative treatment against severe respiratory infections in infants, FluMist®, an influenza vaccine administered as a nasal spray, Imfinzi®, an immunotherapy for cancer, and monoclonal antibodies Fasenra® and Siliq™.

MedImmune and AstraZeneca are no strangers to robust energy management. In 2014, their Gaithersburg, Maryland, campus qualified for a Silver Superior Energy Performance® (SEP), a certification for industrial facilities based off ISO50001's global energy management system standards. SEP certifications were developed by the U.S. Council for Energy-Efficient Manufacturing and are awarded by the U.S. Department of Energy (DOE) to industrial facilities that demonstrate a data-driven, transparent approach to energy management and excels in developing supporting systems.

According to the DOE, the Gaithersburg facility saved an annual $247,000 in "low- to no-cost operational improvements" as a result, after investing only $139,000, which the company reclaimed after seven months. The SEP certification project included, in part, the decommissioning of two unneeded boilers and the construction of a building certified by the Leadership in Energy and Environmental Design (LEED) program under the U.S. Green Building Council (USGBC).

WHAT IS A COMBINED HEAT AND POWER (CHP) SYSTEM?

CHP systems, also known as cogeneration plants, are energy generation assets that burn natural gas or other combustive fuel sources to produce both electrical and thermal energy.

Many hospitals, manufacturing plants, institutional campuses and other types of industrial and/or asset-intensive facilities use CHP systems.

MedImmune's efforts also earned it a Global Safety, Health and Environment (SHE) Excellence award and local certification as a green business through the Montgomery County Green Business Certification Program.[1]

But, MedImmune and AstraZeneca did not stop there. After extensive analysis of their facilities, they set out to accomplish an ambitious, three-pronged energy management project: the design, engineering and installation of combined heat and power (CHP) systems. This one CHP installation would help the companies make considerable progress across all three of the following areas of improvement:

1. Decrease facility operational costs

Pharmaceutical production is far less energy intensive than other types of manufacturing. Cement processing and steelmaking, for example, with their enormous crucibles burning around-the-clock, certainly require much more thermal energy and, thus, operate with much higher energy costs than the measured demands of pharmaceutical laboratories equipped with reactors, digesters and sterilizers.

Regardless, the American pharmaceutical industry still spends, in total, approximately $1 billion on energy every year, according to the latest DOE research.[2] These costs represent an opportunity for organizations within the industry, particularly research and development facilities like MedImmune, to optimize energy expenditures through intelligent technological investment and divert operational cost savings to the funding of scientific exploration.

2. Reduce corporate carbon footprint

Like others in its field, AstraZeneca has sought to reduce carbon emissions across the breadth of its operations. In an environmental sustainability report it published in 2015, the company said it had cut its carbon by 21 percent between 2010 and 2015.[3] On its website, AstraZeneca said it has decreased its carbon footprint by another five percent in the past two years.[4]

Industrywide, there is still much to be done. Leaders at AstraZeneca and MedImmune believe that on-site cogeneration will empower them to reach their current environmental sustainability goals regarding carbon emissions and do so faster than other alternative fuel sources, thus giving them new opportunities to set even more ambitious efficiency objectives for the future.

3. Increase power reliability and resiliency against outages

It is no secret that energy transmission and distribution infrastructure across the country, mostly erected in the mid-20th century, has long surpassed its lifecycle. The rising occurrences of extreme weather phenomena also pose a significant threat to asset reliability in the industrial sector.

The utility grid in Maryland is no exception. According to one estimate from 2016, the state experienced 57 outages over the course of the previous year, affecting more than 145,000 residents. Nearly half of the reported blackouts were caused by either equipment failure or human error.[5] On-site cogeneration would effectively strengthen MedImmune against these threats by allowing its facilities to generate their own energy as needed in the event of a blackout.

HOW A CHP SYSTEM WILL HELP MEDIMMUNE REACH THESE OBJECTIVES

A well-designed CHP installation can deliver several benefits in an effort to control energy usage.

First, CHP systems boast a higher efficiency than a typical utility grid connection. On average, energy transmission along a utility grid results in losses that occur as energy travels from the generation plant to the electrical load, sometimes many miles away. This method is only about 30 percent efficient.

On the other hand, CHP systems operate at 65 percent efficiency or greater. Apart from efficiency gains from the close proximity of the CHP system to the electrical load it serves, it also reclaims heat created in the energy generation process and can put it to use in the adjacent buildings. The addition of an absorption chiller on the CHP system would provide usable cooling from that waste heat, thus securing year-round thermal, as well as electrical loads.

CHP systems also allow users to capitalize on an economically advantageous spark spread. Spark spread is a metric that estimates the theoretical gross margin between the price of a unit of generated electricity and the cost of the fuel required to produce the same unit of electricity. In this case, low natural gas prices and high electrical rates make a CHP installation a viable, long-term financial investment for MedImmune.

Finally, an on-site CHP system gives users the option to operate independent from the energy grid. When the system is placed in island mode, users can generate electricity and heat without a direct connection to a utility. Resiliency against power outages is valuable to any facility reliant on uninterrupted uptime, let alone an organization like MedImmune that conducts important and costly pharmaceutical research.

> "…The American pharmaceutical industry still spends, in total, approximately $1 billion on energy every year…"

THE SCOPE OF THE PROJECT

After consulting with specialists from GenesisSolutions, a business management group, and Buch Construction, MedImmune decided to install a 2.5 megawatt natural gas-fired reciprocating internal combustion CHP system.

The system would initially connect to a medium voltage switchgear serving a portion of One Medimmune Way called Area 6 in the Gaithersburg campus. Energy analysis showed that Area 6 had the largest electrical load and available switchgear capacity to tie in a new CHP unit. However, before connecting the CHP system to the existing campus-wide energy infrastructure, eight different utility electrical services feeding into adjacent campus buildings would require consolidation with the two Area 6 services onto a single campus-wide medium voltage switchgear with two new redundant utility feeders. A parallel switchgear would be added to tie together two existing 3 megawatt diesel generators to the proposed CHP unit. This would allow the MedImmune campus to respond quickly to an immediate outage, as well as sustain long-term generation during a prolonged outage event.

Installation also would require connecting the CHP system to distinct existing heating plants on the MedImmune campus. Stakeholders targeted two optimal areas where connections would provide an operational benefit to the project and retain cost efficiency.

Area 6 contains three, 26,000 pound-per-hour steam fire-tube boilers. The design team also discovered a recently installed steam cross-connect, which effectively tied multiple steam distribution systems together. With this recent system upgrade, the new CHP system could connect to the Area 6 boiler plant since it was located closer to the proposed cogeneration site and could still serve the steam loads throughout the entire campus. Exhaust gas from the proposed CHP system would feed a new heat recovery steam generator (HRSG) boiler to produce steam at about 100 pounds per square inch to preheating coils in the air handling units, process equipment and hot water heat exchangers via this existing piping network.

Since the CHP also produces about 5,500,000 BTUs per hour of 200 degree hot water, the design included a new hot water riser up through the building to connect to the existing 1,600 gallon-per-minute Area 6 hot water reheat system. Finding space for the piping and coordination installation of this riser in an operating lab environment was a major design and construction challenge that benefited from effective project management by involving contractor, engineer and owner to evaluate solutions.

Although analysis showed that most of the heat produced by the CHP could be used to heat the building, the design included provisions for a future 500 ton double-effect absorption chiller that uses steam and hot water to produce chilled water to maximize year-round CHP efficiency. This component was planned to supplement the existing Area 6 cooling plant with its two, 1,600 ton water-cooled electric centrifugal chillers and an 800 ton water-cooled electric centrifugal chiller.

Because of the proximity to both electrical and thermal loads, project stakeholders ultimately agreed that the Area 6 location would be the best location to construct the new CHP system.

PROJECTED RESULTS

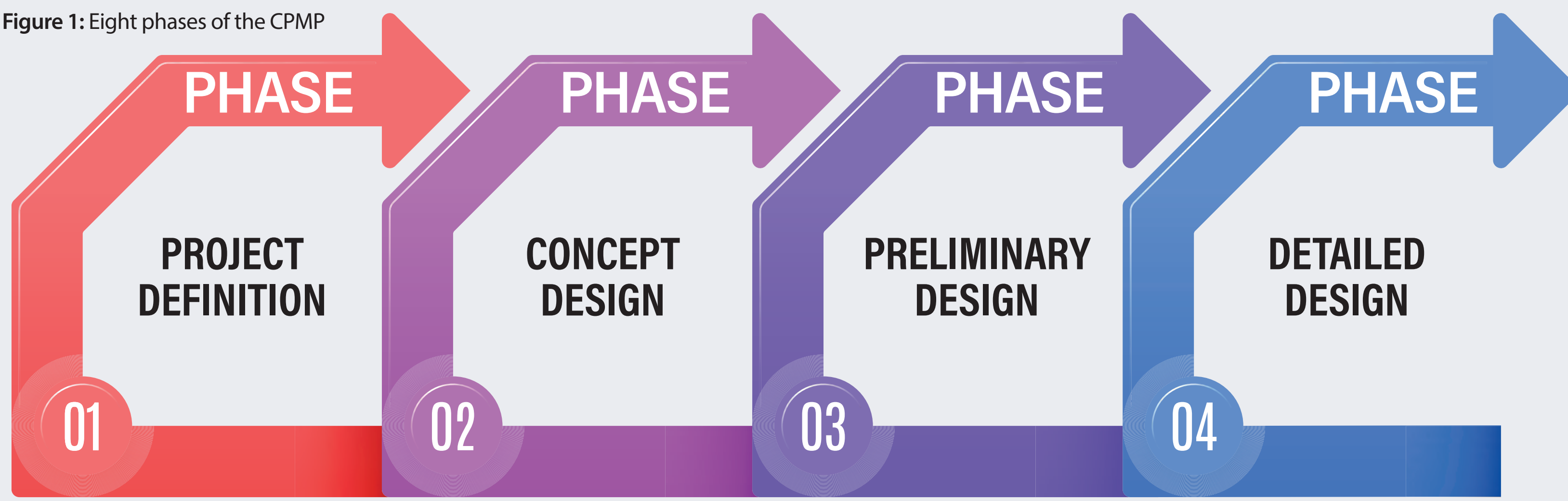
So, in the end, what would the sum of this effort deliver to MedImmune and AstraZeneca in hard numbers?

To uncover the answers, specialists reviewed the proposed design drawings, conceptual system designs and simulated energy outputs, then constructed a financial model for determining the energy cost savings potential. This model incorporated the cost of energy consumption, maintenance, construction and capital parameters.

Part of the analysis included the creation of a custom-built building energy model developed with help from MedImmune's building automation system, which tracked historical electricity consumption and thermal performance. Specialists also analyzed alternatives to the proposed CHP, such as gas turbines, microturbines and fuel cells, as well as alternately sized cogeneration assets. Specialists ultimately concluded that the proposed 2.5 megawatt CHP engine was the best choice once all campus loads were consolidated.

If the project went according to plan and the equipment proposed operated to specification, MedImmune would decrease its annual electrical consumption by about 14.4 million kilowatt hours per year and save more than $900,000 in energy costs and $550,000 in operational costs annually.

Figure 1: Eight phases of the CPMP



01 Project Definition

- Request for Engineering Department Assistance Form

02 Concept Design

- Project Scope Document
- User Requirements
- Concept Design Report
- Environmental, Health and Safety (EHS) Checklist
- Project Summary Schedule
- Conceptual Cost Estimate

03 Preliminary Design

- Team Charter
- System Impact Assessment
- Approved System URS (User Requirement Specification)
- Approved Basis of Design Document
- Document Approval Matrix
- EHS Project Plan
- Project Summary Schedule
- Control Budget
- Monthly Status Report
- Quarterly Capital Expenditure (CapEx) Forecast

04 Detailed Design

- Project Execution Plan
- Component Impact Assessment(s)
- Documented Enhanced Design Review
- Hazard and Operability (HAZOP) Assessment (or similar)
- Issued for Construction (IFC) Documents
- Approved System Functional Requirement Specification (FRS)
- Construction Safety Plan
- Approved Commissioning Plan
- Approved Validation Plan or Change Control
- Integrated Project Schedule
- Trending Cost Estimate
- Monthly Status Report
- Quarterly CapEx Forecast

After factoring in construction and maintenance costs, the investment in the CHP system project would pay for itself in as little as eight years.

But, let's be honest. How many engineers, project managers and their respective teams have said, "if all goes according to plan" before eating those words later when their complex projects run well over time, over budget and light-years out of scope? Going into this project, it was possible this could easily become such an undertaking.

So, how did MedImmune prevent the project from succumbing to all the traps other large-scale capital projects have fallen into in the past?

INTRODUCING THE CAPITAL PROCESS MANAGEMENT PROCESS

The Capital Process Management Process (CPMP) goes into great detail by defining the lifecycle management requirements for new or modified facilities compliant with the current Good Manufacturing Practices (cGMP) by way of eight phases and their related documents. See Figure 1.

CPMP not only covers cGMP-compliant facilities, but also related equipment and utility systems used in the manufacture of clinical trial materials, active ingredients, drug substances, commercial pharmaceutical products and vaccines at those facilities.

As the name suggests, CPMP was built with a specialized focus on developing comprehensive and compliant frameworks for large-scale projects that incorporate advanced computer systems and multiple functional teams.

Note: Project teams can also adopt a simplified alternative CPMP for smaller, less complex projects with low capital costs.

THE PRIMARY DISCIPLINES OF CPMP

To help in understanding at a glance the value of CPMP to complex capital projects, the entire methodology has been distilled into three key components:

1. Collaboration among team members

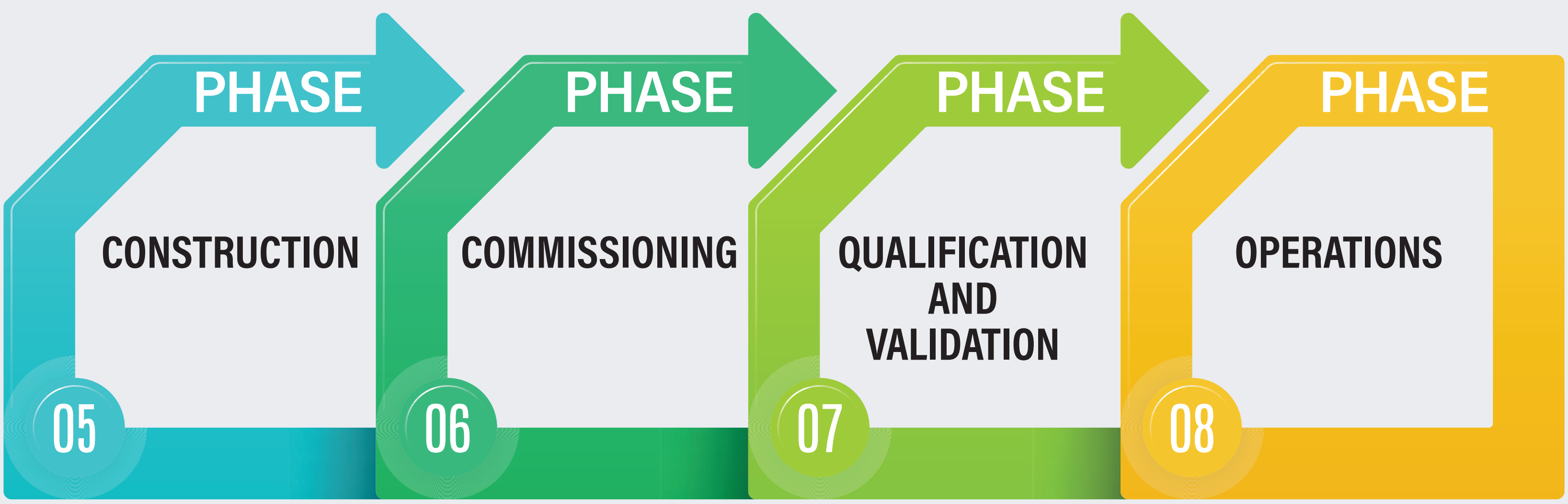
Under CPMP, there is no such thing as over communication. CPMP cannot exist in a project environment that lacks cooperation and coordination between team members.

That is why CPMP mandates at the outset the creation of a project team, as well as the designation of the respective duties members uphold:

- **Project Sponsors** – Initiate projects by justifying them to decision-makers, crafting budgets and obtaining approval from aforesaid authorizing bodies. Throughout the project, they act as overseers.
- **Project Leaders** – Represent Project Sponsors as the team member responsible for project execution from the justification stage through initial production. They lead Project Engineers/Managers.
- **Project Engineers/Managers** – Supervise day-to-day actions regarding design, construction and commissioning. They may also support validation and qualification processes as needed.

The following are brief descriptions of project functions under which team members serve:

- **Project management function** pertains to project administration, planning and execution.



- Operational Readiness Review(s)
- Punch List Report
- As-built Documents Issued
- Approved Commissioning Test Plan(s)
- Integrated Project Schedule
- Cost at Completion Forecast
- Monthly Status Report
- Quarterly CapEx Forecast

- Approved Care, Custody and Control Transfer
- Record Documents
- Turnover Package
- Approved Commissioning Summary Report
- Integrated Project Schedule
- Cost at Completion Forecast
- Monthly Status Report
- Quarterly CapEx Forecast

- Approved Qualification Protocols
- Approved Validation Summary Report
- Integrated Project Schedule
- Cost at Completion Forecast
- Monthly Status Report
- Quarterly CapEx Forecast

- Project Closeout Report
- Postmortem


Bad decision


Good decision

- **User Group/Operations function** is concerned with compiling input on design specifications, assessing impact and performing operational training.
- **Engineering function** includes system design to the exact specifications set forth by Operations team members, safety reviews of said designs and document preparation for commissioning, qualification and validation functions.
- **Construction function** is responsible for asset construction and installation, along with equipment preparation and corroboration between asbuilt drawings and finished product.
- **Commissioning function** ensures installed equipment/utility systems are compliant, meet quality standards and are functioning as designed.
- **Technology/Validation function** inspects systems and system performance against established specifications.
- **Environmental, Health and Safety function** performs initial safety checks on facility, equipment and utilities, as well as performs a review of the project design before project commencement.

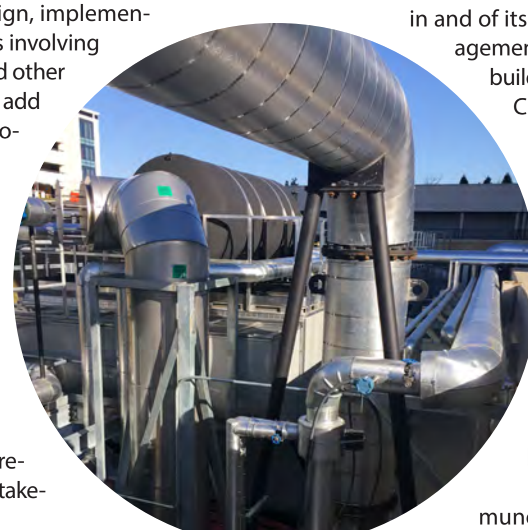
At the very minimum, each of these functions must have representation within the team from the start of the project for the CPMP to work. Depending on the nature of the project and agreement among project team members, additional functions may include **Information Systems, Maintenance**, **Regulatory Affairs** and **Purchasing**.

2. Compliance and safety

A moment of discovered noncompliance with government or regulatory authorities can stymie a project nearing completion or unravel a completed project. What's more, injuries sustained during project implementation can do the same, as well as deprive the team of a valuable member or members.

Capital projects, in particular, are at risk because of their many layers and moving parts, which is why CPMP insists on the highest standards for equipment use. All assets, built or tools utilized in the building process, must be the right design, size and capacity.

CPMP also promotes best practices in design, implementation and construction of cGMP capital projects involving assets that may come into contact with drugs and other chemicals. Equipment surfaces must not react to, add to, absorb, or in any discernible way affect in-process materials or components.



3. Precise documentation

Every capital project has its fair share of paperwork. Documentation, when utilized well, can act as a series of gateways. A system of mandatory forms in place can stop team members from racing ahead without necessary information, or force them to reflect on whether the proper checks and balances have been administered.

CPMP uses several unique documents and related resources that are spread among all project stakeholders to ensure accountability. They are:

Project Scope Document (PSD): General accounting of the project as a whole. Includes the official description of the project, designations for all team members and a detailed itinerary of its implementation. Management will review and approve the project as it is presented in the PSD.

Document Approval Matrix (DAM): Essentially, an index for document assignment. DAMs outline which team members are responsible for generating, reviewing, approving and storing each specific CPMP document.

Impact Assessment (IA): Every established system within a given project requires a delineated boundary, as well as analysis confirming those boundaries have not been crossed. IAs look for direct, indirect, or no impact on the product.

User Requirement Specification (URS): An appraisal of the expected performance of constructed or purchased equipment or systems. URS may include data regarding capacity, materials of construction, operational characteristics, cleaning requirements and more.

Conceptual Design: Design stage to generate various alternatives for evaluation. The project team then selects the concepts to be taken forward into the Basis of Design stage.

Basis of Design: Approved document(s) that define(s) the user requirements, critical functions, or critical parameters for facilities, equipment and support systems, and descriptions of system boundaries.

Enhanced Design Review: Documented review and verification of the proposed design. Determines whether the design is suitable for its intended purpose and conforms to operational and regulatory expectations.

Functional Requirement Specification (FRS): A document that delineates the operational characteristics of the equipment/system, as well as any design or construction details that have cGMP implications. It is utilized as the basis for any design, Factory Acceptance Tests (FATs), Site Acceptance Tests (SATs), commissioning and validation activities.

Engineering change management (ECM): The process of determining the impact of proposed or actual changes on cGMP facilities, equipment and utilities. Changes made after the approval of the final design review through the Operational Qualification (OQ) report approval are subject to ECM.

THE RESULTS OF THE CHP PROJECT

By the end of MedImmune's CPMP, it had achieved all the goals it had set out to accomplish. Cogeneration allowed the organization to use natural, gas-fired electricity more efficiently, reduce energy-related expenses by leveraging spark spread and prevent uptime losses by creating an emergency on-site energy generator, all while still connecting to its regional utility.

Apart from operational and efficiency gains acquired by MedImmune and AstraZeneca, the implementation of the CPMP methodology was, in and of itself, a testament to the very best the project management discipline has to offer. The project team finished building, installing and reviewing all components of the CHP project *five months ahead of the original projected completion date*. MedImmune is currently progressing toward a formal modified version of the system to utilize for all capital projects.

Currently, MedImmune is considering a second, unrelated CHP project, an exciting prospect made possible thanks to the initial electrical consolidation effort initiated after the first CHP project. Such an opportunity would further MedImmune's vision of a research and development facility powered by environmental sustainability impervious to outages and unencumbered by high energy costs.

Since the completion of the first CHP, MedImmune, with assistance from its engineering and asset management specialists, has laid out a scope for additional CHP technology, including intelligent automated sequencing controls that would switch the system in and out of island mode as necessary and activate the system automatically without manual intervention.

A COLLABORATIVE EFFORT

This project would not have been possible without a collaborative effort among many individuals.

Chad Kellner, MBA, CMRP, the director of site operations, engineering and budgeting for MedImmune is recognized for his insight and supervisory role throughout the scope of the project. In fact, each member of the Med-

Immune team who participated in the CPMP process deserves recognition for their astute user input into the design of the CHP plant and cooperation throughout this immensely complicated endeavor.

No capital project is accomplished by a single person, contractor, or organization. The success of this project is due to a few incredible leaders. Special gratitude to the following individuals for their support and assistance:

- Mark Battaglia, Senior Manager, Facilities Projects at MedImmune Engineering;
- Andy Hernandez, Principal Electrical Engineer, AstraZeneca Engineering;
- Jeff Williford, Project Manager and John Pearson, Superintendent, at Buch Construction;
- Phil Miller, Foreman at Heffron Company;
- Chuck Barber, Project Manager and Shawn Neylon, Foreman, from JE Richard Electrics, Inc.
- Bob Hayes, Commissioning Engineer, formerly of the commissioning firm MBP.

These professionals came to the worksite every day with a smile, a kind word and plausible suggestions for any and every issue that was encountered.

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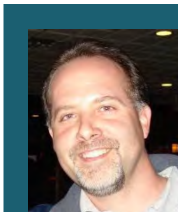
__Chad Kellner__ is the Director of Site Operations Engineering & Budgeting for MedImmune. Chad leads a team of multi-disciplinary engineers and designers to deliver state of the art, energy-efficient office, lab and manufacturing facilities for biologics research and development.



__Wayne Fieldhouse,__ PE (NJ), is a Principal Reliability Engineer and Project Leader for GenesisSolutions, An ABS Group Company. __Lee Harrelson,__ PE, LEED ® AP, a Principal Engineer at CMTA Consulting Engineers. Wayne developed the standard operating procedure for the Capital Project Management Process, along with his former colleague, George Wolf, PE. Lee and his team were the masterminds behind the system, components and controls. www.GenesisSolutions.com www.cmta.com

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RalGeo Consulting Inc, Calgary
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IRISS
Salameh Ghaleb Alabed
Jordan Bromine Company
Abdulelah Alsaeed
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Honda of Indiana
Nathan Andress
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Simon Boyce
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Steven Boyle
Grifols Diagnostic Solutions Inc.
Steven Brannan
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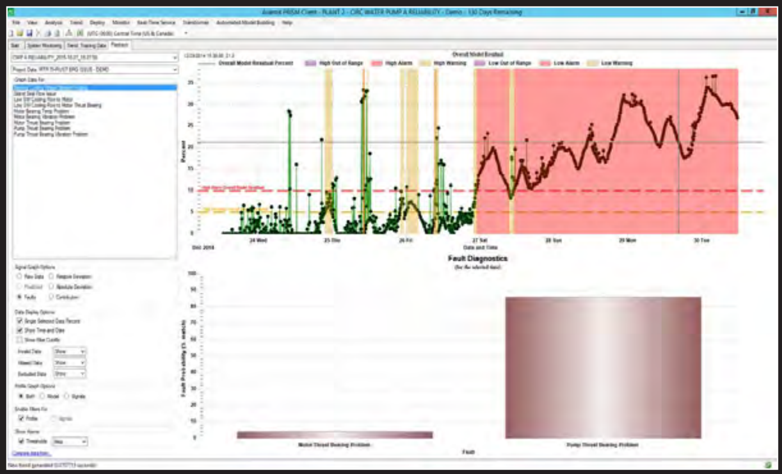

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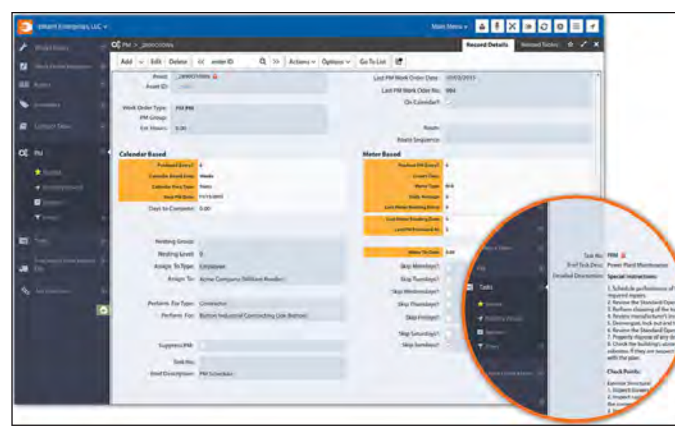

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Uwoajega Joseph

INFORMED MODEL FOR SELECTION OF MAINTENANCE STRATEGY

The absence of documentation and the presence of poor strategic maintenance methodology admittedly leads to running assets/plant on a run to failure strategy. In an effort to address such a situation, this article presents best practices and informed factors that asset managers and maintenance personnel must consider in order to select the right maintenance strategy for their asset or plant.

It is worthy to note that the maintenance strategy used for most assets is a function of how critical the asset is in the day-to-day operation of the plant, the availability of its parts, the value of the asset and the operating context of the organization.

Let's explore some informed factors to consider.

1 The maintenance strategy should be customized.

This implies that it should consider all relevant factors of the situation at hand. For example, the needs of the company. The maintenance strategy selected should be unique to each company, but the underlying structure needs to be developed so that it can be comparable.

2 The strategy should follow work processes.

Here is how semantic scholar Antti Salonen describes the different parts of the schematic flow of the work process:

- Company vision and mission – The strategy should be based on the company's vision and mission.
- Formulation of the strategic goals of the company – These goals should be supported by all functional strategies. Regarding the maintenance strategy, it is essential to consider not only the overall strategic goals of the company, but also the goals of production, which is the customer to the maintenance organization.
- Define the strategic goals of maintenance – The strategic goals of both the production department and the company should be considered and the goals should reflect both effectiveness and efficiency. This is done in order to satisfy all stakeholders.

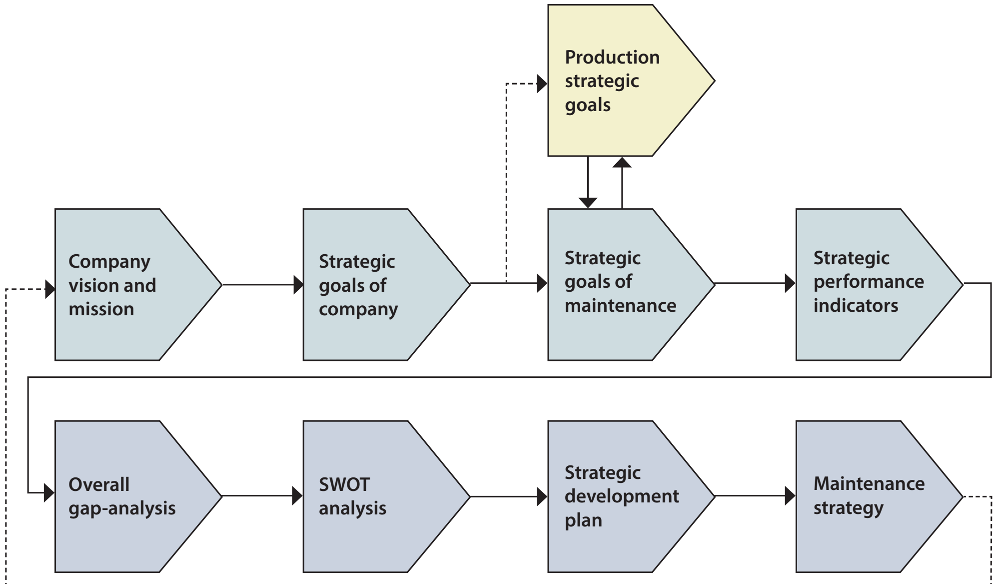

Figure 1: The schematic flow of the work process

- Tie the strategic goals to strategic performance indicators – The performance indicators are measured in order to evaluate the fulfillment of the strategic goals. Preferably, all stakeholders, such as the production department and the owners, should be involved when choosing the performance indicators. With this approach, acceptance of the strategy among the stakeholders will increase.
- Perform an overall gap analysis – Address current or potential gaps in maintenance performance. Once this is done, identify factors that may potentially influence the gap between current and desired levels.
- Perform a strengths, weaknesses, opportunities, threats (SWOT) analysis – Address the identified gaps in relation to the factors considered strategic for the development of the maintenance function. From the results of the SWOT analysis, make a list of actions to be taken.
- Determine a strategic development plan – This plan can be set up by prioritizing the actions identified from the SWOT analysis.
- Formulate the maintenance strategy – When the strategic development plan is in place, the maintenance strategy can be formulated.[1]

❸ The maintenance strategy should be selected in relation to the production and business activities.

This means there is a need to understand how the maintenance function will affect the dynamic need of the production department. This is due to the fact that production and maintenance objectives are inseparable. Production and maintenance objectives also need to be compatible with the company's objectives in order to choose the right maintenance strategy that fits the business and the asset.

In Figure 2, the larger circle illustrates the strategic thought process of the maintenance manager. This thought process starts with the maintenance objective of the plant or the assets.

❹ A maintenance strategy should function as a road map that allows and includes alternatives; it is not meant to go in just one direction.

The maintenance strategy must remain flexible so it can change with the company's situation. The road map can be created based on results from benchmarking and observations of the company's own best plants.

❺ In order to formulate a maintenance strategy and produce a maintenance plan, the following questions need to be answered:[3]

- What should be done?
- Which are the most important items or critical assets?
- What are the legal requirements to be considered?
- When can the work be performed in order to avoid loss of production?
- In which frequency should surveys, inspections, work and tests be carried out?
- Where does the money come from?

❻ A model for the formulation of a maintenance strategy.[4]

Maintenance should be considered as a partner within the business, with the shared overall aim to produce and sell products at an acceptable margin of profit. For this to be achieved, it must be understood that all functions within the business contributes to profitability. Thus, the maintenance function should align with the overall business goals. Before developing or selecting a maintenance strategy, the need for change should be established. Within the maintenance philosophy, change should be embraced as a major expectation and constituent. The maintenance strategy development process starts with stating the maintenance philosophy, which is an expression of the maintenance function's role within the company and the chosen approach for how to fulfill it.

The next step is to consider the aims and objectives of the maintenance function. The aims can be at corporate, production and maintenance levels, and the objectives must respond to the driving forces from production.

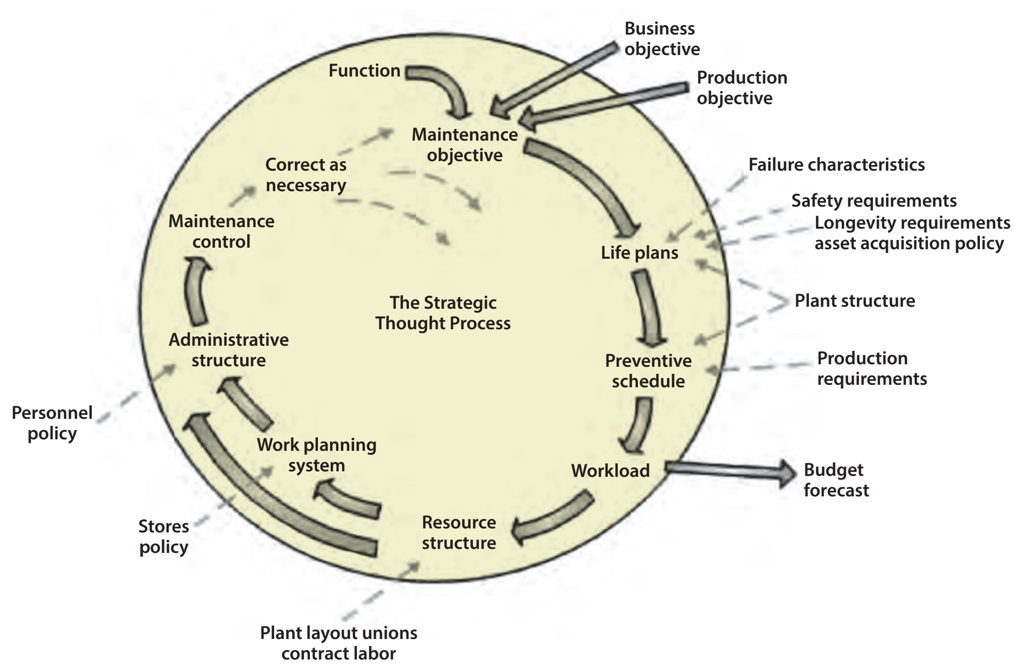

Figure 2: A business-centered model (BCM) for selecting the right maintenance strategy[2]

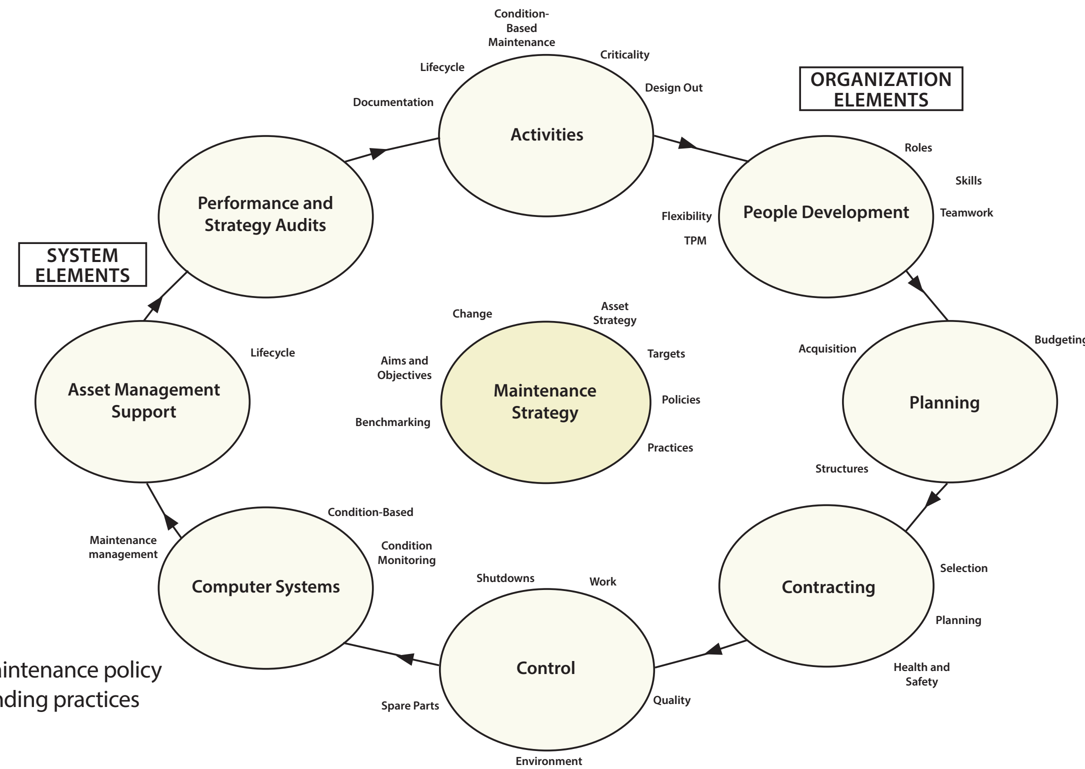

Figure 3: Range of maintenance policy sectors and corresponding practices

The third step is to assess and evaluate maintenance practices and issues. Figure 3 represents the range of maintenance policy sectors and corresponding practices to consider for this assessment, which, after completion, may be used to develop a maintenance program. Then, tactics for how to integrate existing practices with new ones should be developed.

The last step is to determine the implementation plan.

7 Other informed factors to consider are:

- Condition or nature of the assets/plant;
- Passing of time or the age of the asset;
- Failure rate triggers which type of maintenance strategy to be chosen;
- Each unit of the equipment or facility;
- Cost reduction or effectiveness;
- Work environment and safety;
- Criticality of the asset and the kind of equipment to be maintained.

Conclusion

In summary, the type of maintenance strategy selected should depend on the critical nature of the equipment, availability of spare parts, size and nature of the organization, available technology and the organizational maintenance policy.

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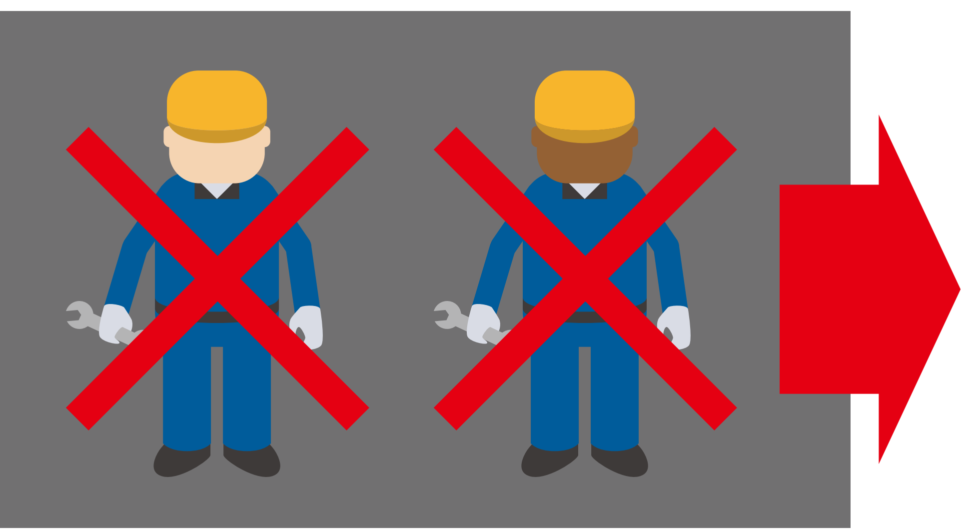
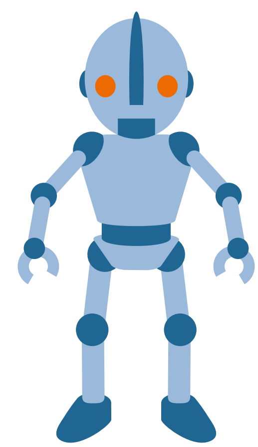
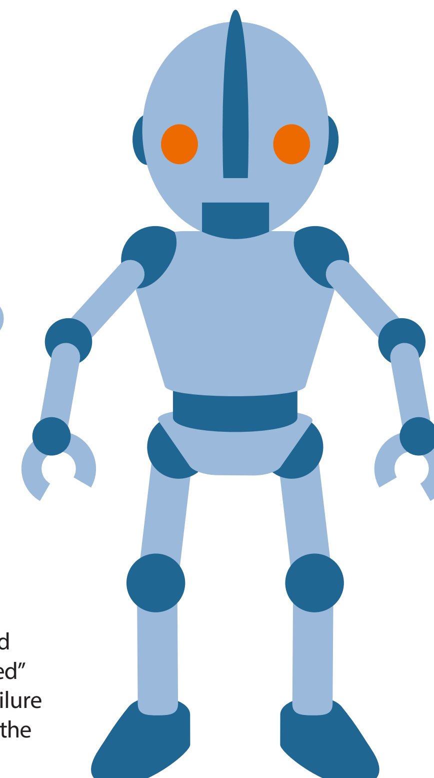
***Uwoajega Joseph** is the Field Service Engineer/Team Lead for Nigerian Agip Oil Company. Nigerian Agip Oil Company has the production capacity of 75,000 bbl of crude oil and 475 mmscf of gas production per day. Uwoajega is a seasoned professional with 12 years of experience in the oil and gas industry. https://www.eni.com/en_NG/home.page*

WILL IIOT TECHNOLOGIES REPLACE FACTORY MAINTENANCE WORKERS?







Dr. David Almagor

The idea that smart factory technology will displace humans has generated considerable discussion. In a July 2016 report, McKinsey & Company estimates that "59 percent of all manufacturing activities could be automated."[1] In an article that can be applied to the field of industrial analytics, the MIT Technology Review[2] suggests that unlike past experience, technologies are providing solutions that are more humanlike and could, therefore, eliminate jobs that so far have withstood automation.

Given the uncertain outlook, let's review innovations in machine learning for predictive analytics and analyze the potential impact of maintenance activities.

Background: Machine Learning for Predictive Analytics

The application of machine learning to industrial analytics is part of the technological transformation termed Industry 4.0 or the Industrial Internet of Things (IIoT). Theoretical concepts that were previously limited to the narrow confines of academia are being commercialized rapidly.

Machine learning uses artificial intelligence to detect abnormal industrial machine degradation and failure before they occur. Vast amounts of data generated from sensors embedded in plant equipment are analyzed in real time. Algorithms are trained to identify anomalous sensor behavior or patterns of anomalous behavior. Based on these analyses, time to failure (TTF) and root cause failure analysis (RCFA) are provided.

Within the marketplace, there are numerous commercial solutions based on different approaches to machine learning. The most well-known is supervised machine learning. With supervised machine learning, the algorithm is "trained" on each failure pattern. When a new failure pattern is analyzed, the algorithm labels the pattern based on its prior training.

Unsupervised machine learning is an alternative whereby the learning algorithm does not need to be trained with data labels. Instead, vast amounts of data are analyzed and the algorithm itself generates the label. It is considered a more robust methodology because few resources are required for training the algorithm.

Regardless of methodology, machine learning for industrial analytics is a transformative technology that upends existing maintenance processes.

Industrial Analytics versus Reactive Maintenance

Although industrial plants are not always forthcoming with this information, it is estimated that at least half of all maintenance activities occur only after asset failure is imminent or has already occurred. Reactive maintenance is the most expensive form of repair because there is insufficient time to schedule repairs. Delays can be caused by several factors, including:

- Traveling to the repair site;
- Delays for spare parts or rental equipment;
- Repair instructions or receiving relevant documentation;
- Waiting for machinery to be shut down before work can commence;

- Additional delays for support to arrive at job site.

Reactive maintenance occurs under the pressure of a downtime incident. A delay in returning machinery to its useful state can result in lost productivity and revenue. In some cases, the pressure leads to mistakes or quick fixes. Without the benefit of RCFA, crews often rely on clumsy trial and error approaches.

With machine learning for predictive maintenance, early warning and time to failure are provided for degradation or failure. Production loads can be slowed while spare parts are ordered and scheduling is optimized. With the benefit of RCFA, most guesswork can be eliminated.

The result? Less disruptive maintenance and limited asset downtime.

Industrial Analytics versus Preventive Maintenance

Regularly scheduled preventive maintenance (PM) is based on time or equipment usage. PM scheduling is determined by:

- Original equipment manufacturer (OEM) guidelines as per equipment manuals;
- Mean time between failures (MTBF) probability estimates;
- Regulatory compliance;
- Equipment condition;
- Schedule optimization.

With regularly scheduled maintenance, equipment utilization is maintained. However, maintenance activities carry an inherent risk of human error. These include errors in equipment reinstallation or reassembly, mistakes that damage the asset undergoing repair or adjustment and failure to follow best practices for repairs.

According to a study[3] on fossil fuel power plants, the majority of maintenance outages occurred in less than a week after a maintenance outage (1,772 of 3,146 maintenance outages occurred after a planned or forced maintenance outage). The conclusion was that "in 56 percent of the cases, unplanned maintenance outages were caused by errors committed during a recent maintenance outage."

One of the underlying assumptions for preventive maintenance is that as assets age, they wear out. However, research suggest that only 11 percent of maintenance repairs are based on age-related factors. Most asset failures are considered random and are not associated with a predefined failure pattern.

Finally, there are costs associated with planned machine shutdown. These include the direct cost (e.g., labor, spare part, etc.) and the economic cost from lost production.

Machine learning for predictive asset maintenance, on the other hand, can eliminate or reduce unnecessary preventive maintenance. This

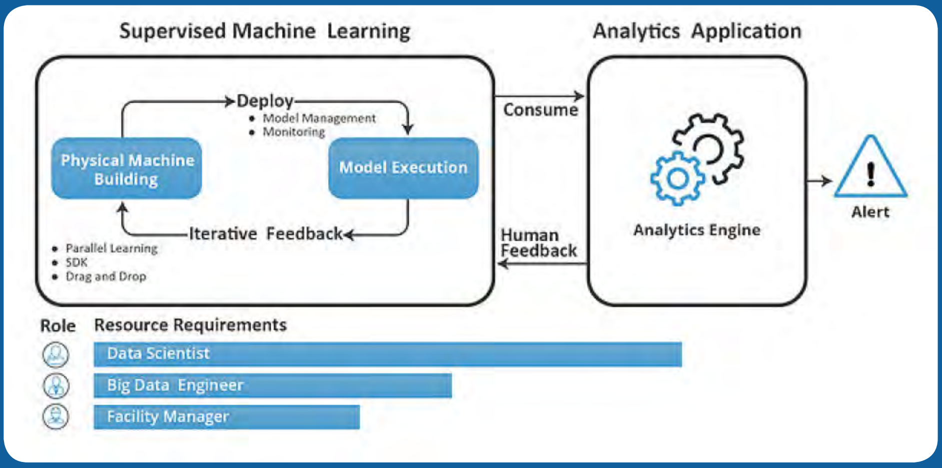


Figure 1: Well-known solutions based on supervised machine learning (Source: Presenso)

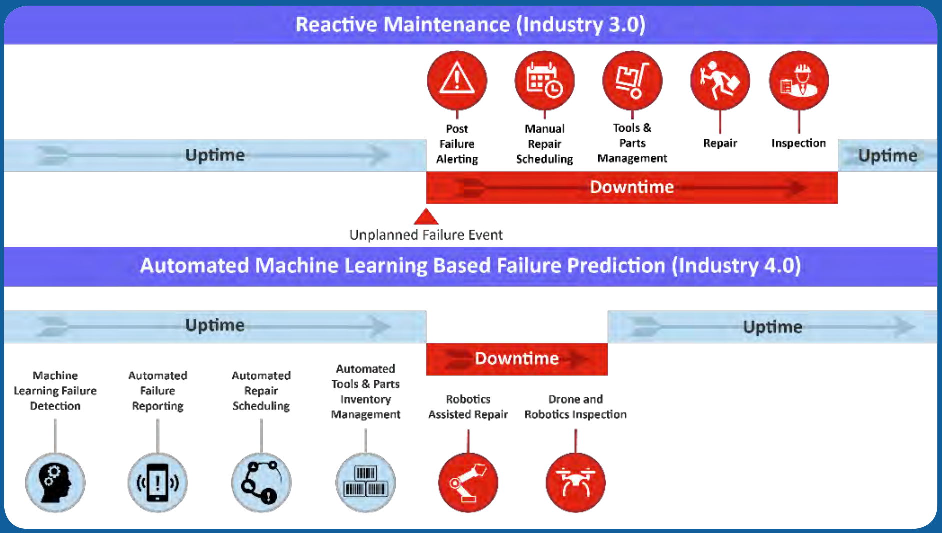


Figure 2: Reactive maintenance occurs under the pressure of a downtime incident (Source: Presenso)

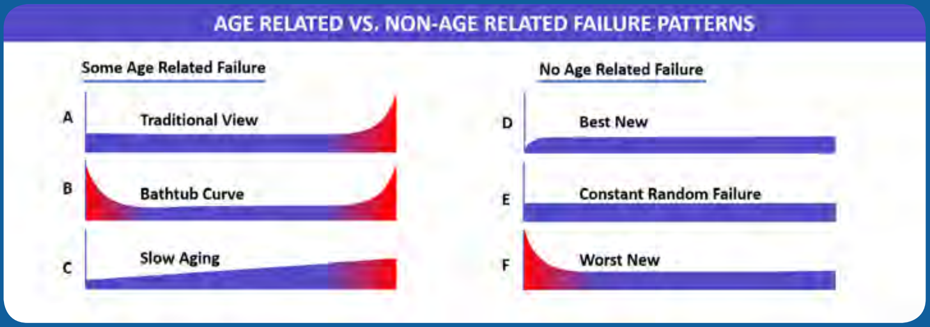


Figure 3: Age related versus no age related failure patterns

is because with machine learning, maintenance is based on an algorithm that triggers an alert of an evolving failure event. With RCFA, maintenance is targeted to the specific equipment that requires repair.

Preventive maintenance applies man-made rules for maintenance that are based on historic data, factory maintenance practices, or even scheduling convenience. It is not a precise discipline and, as a result, it is the cause of significant instances of over maintenance, under maintenance, or faulty maintenance.

How Machine Learning for Predictive Maintenance Impacts Employment

In demonstrating the advantages of machine learning for predictive maintenance, the assumption is that over time, there will be a shift toward this solution type and a reduction in both reactive and unnecessary preventive maintenance.

Expectations point to a drop in the overall level of employment in operations and maintenance (O&M), with no significant areas of potential offsetting increases.

The *Journal of Business and Media Psychology* suggests that, "maintenance would likely be subject to further automation, whereby increasing complexity arising from integrated process and system architectures would most probably require more demand for cross-functional management control capabilities and capacities in troubleshooting and improvisation."[4] It is likely that in the era of Industry 4.0, maintenance workers will require greater levels of skills and training, especially when robotics and automation become standardized within the maintenance mix. Nevertheless, at the current pace of innovation and investment, the overall number of O&M workers is likely to decline.

New Roles in the Smart Factory

If workers are replaced, will new roles emerge?

The Boston Consulting Group (BCG) suggests that new jobs will emerge, such as robotics coordinator and industrial data scientist. At the same time, existing jobs, such as assembly line worker, service technician and machine operator, will change. BCG's expectation is that a machine operator "will require less machine and product specific training, but will need enhanced capabilities for utilizing digital devices and software and accessing a digital knowledge repository."[5]

Will Data Scientists Replace Factory Workers?

Many analysts expect a significant demand for industrial data scientists. The BCG study assumes there will be a need for more data scientists and lumps together several big data processes for this role: extracting data, analyzing data, identifying correlations and drawing conclusions on RCFA.

However, another school of thought believes this commonly held view is based on outdated assumptions about the role of Industry 4.0 technology. Simply stated, technology solutions based on big data will replace the need for facility level or even remote industrial data scientists. The quantity and scope of big data that forms the basis of an industrial analytics solution exceeds the bandwidth of internal resources and requires a dedicated technology platform. Solutions that are applicable to industrial plants need to be easily accessible and visualize asset degradation without the input of plant experts.

According to one study[6], 40 percent of companies are struggling to recruit and retain data analytics employees. With no obvious solution to this labor shortage, many industrial plants will even lack the option of competing for this limited pool of talent. Ultimately, market forces will shift the burden from internal resources to third-party technological solutions that require limited in-house expertise.

Overemployment or Underemployment? Perhaps Both

A research paper published by professors from the University of Bath and the University of Liverpool reaches a disturbing conclusion:

"At present, educational systems appear not to be adapting fast enough to respond to future labor demands imposed by Industry 4.0. If not addressed, this challenge may result in the required skills being undersupplied, thereby fueling disparities between labor supply and demand, which consequently may cause unemployment levels to rise."[7]

The rise of automation will eliminate repetitive and manual tasks, ranging from production line to maintenance. The World Economic Forum released a comparison of the Top 10 job skills needed in 2015 versus 2020, as shown in Table 1.

Even during this short time period, there is an increased expectation for skills, such as creativity, emotional intelligence and cognitive flexibility, and a drop in need for quality control, negotiation and coordinating with others.

Although this study is directional and not specific to Industry 4.0, it points to the growing need for soft skills, such as critical thinking. The future maintenance worker will not be a data scientist, but he or she will need to interpret machine-generated big data analysis.

Realistically, manufacturers cannot rely on educational institutions to fill the skill set gap and will need to find ways to reskill their employees and equip them with the tools needed to succeed. In this way, the efficiencies gained by IIoT predictive maintenance can offset the job roles required for the smart factory.

Conclusion

In the new era of Industry 4.0, a shift from reactive to predictive maintenance is now technologically feasible. Furthermore, many preventive maintenance practices need updating. Change will not happen overnight and as long as there are industrial plants, machinery will break down and humans will be involved in the repair process. However, given the disruptive nature of Industry 4.0 and machine learning, it is likely that maintenance-related employment levels will decline.

Table 1 – Top 10 Skills

2020		2015	
1	Complex Problem-Solving	1	Complex Problem-Solving
2	Critical Thinking	2	Coordinating with Others
3	Creativity	3	People Management
4	People Management	4	Critical Thinking
5	Coordinating with Others	5	Negotiation
6	Emotional Intelligence	6	Quality Control
7	Judgment / Decision-Making	7	Service Orientation
8	Service Orientation	8	Judgment / Decision-Making
9	Negotiation	9	Active Listening
10	Cognitive Flexibility	10	Creativity

(Source: The Future of Jobs Report, World Economic Forum)

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Dr. David Almagor *is the Chairman of Presenso and a serial entrepreneur with over 30 years of experience in managing complex R&D, as well as business entities. Dr. Almagor was previously the founder and CEO of Panoramic Power. He is an author of more than 40 publications and a coauthor of five patents.*
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Re
reliability engineering

UTILIZING PROCESS DYNAMICS TO INCREASE MACHINERY RELIABILITY

Umeet Bhachu and Ahmed Sow

CASE STUDY

Plant and refinery problems require accurate measurements to assess plant productivity and reliability. In fact, as management guru Peter Drucker stated, "You can't manage what you can't measure," forms the basis to many real-world problems, from engineering optimization studies to troubleshooting plant machinery and equipment. Drucker's statement also alludes to the fact that you cannot know whether or not you are successful unless success is defined and tracked.

This case study concerns itself with a problem that many operating plants and refineries may be facing as a result of standardization, optimization of cost versus design, or simply older construction and the nature of refinery design. It also reflects on the value of utilizing process engineering tools to help address issues with machinery monitoring, reliability and troubleshooting.

The Problem

The problem at hand concerns a centrifugal API 610 between bearing (BB) pump in heavy vacuum gas oil (HVGO) service. The pump's datasheet provides all the relevant information connected to the maximum, minimum and rated operating conditions. As a result of various concerns, particularly connected to pipe strains and thermal wrapping of the pump's casing during commissioning, the original equipment manufacturer (OEM) requested the clearances of the pump to be opened up due to seizure of the pump on start-up. Once the clearances were opened, this introduced additional hydraulic instabilities in the pump, adding to an already reduced seal mean time between failures (MTBF).

The Challenge

The challenge in this case was connected to accurately being able to monitor and measure pump performance and hydraulic dynamics to understand what exactly was going on during machinery operation. Plants typically monitor flow; as per API 610, the preferred operating margin for a centrifugal pump is between 70 and 120 percent of the pump's best efficiency point

(BEP) during pump operation. However, not many plants monitor the actual head the pump generates during operation. Part of this situation is complicated by the fact that many older plants and even some new plants do not have the necessary instrumentation, such as suction pressure transmitters mounted on the inlet of the pump or discharge instrumentation mounted on common headers, leading to issues of accurately understanding pump operation. Often, this leads to a standstill situation in a live plant when it comes to understanding, measuring and troubleshooting machinery. Usually, multiple iterations need to be done, costing time and resources to diagnose a problem with a given asset.

This case study presents one way to address the challenge of lacking instrumentation by utilizing other process variables, establishing a direct link to the pump's parameters (suction pressure in this case) and then working along to develop a model to monitor and measure machinery performance without additional cost and resource utilization.

Calculation

Basic process engineering fundamentals can be utilized to model process flow around the pumps in operation. This is done by mapping the head versus flow on the pump's performance curve.

Total discharge head (TDH) of the pump is computed by:

$$TDH = H_{discharge} - H_{suction} + H_{friction} \quad \text{(Equation 1)}$$

Where:

TDH: Total discharge head in meters (m)
$H_{discharge}$: Discharge head (m)
$H_{suction}$: Suction head (m)
$H_{friction}$: Friction loss (m)

TDH is a representation of the ability of the pump to both meet the system's requirement at a given flow and overcome pressure drops. Equation 1 is the summation of the static head with the friction loss head. The static head is the difference between the discharge head and the static head. Friction loss represents the pressure drops across the pipe and fittings; it can be represented by Darcy's law.

$$H_f = f.\frac{L.v^2}{D.2.g} \quad \text{(Equation 2)}$$

Where:

f: Friction factor
L: Length (m)
v: Fluid velocity in meter per second (m/s)
D: Internal diameter (m)
g: Standard gravity (m/s^2)

It is a factor of the length of the pipe, the diameter of the pipe and the friction factor based on the velocity across the pipe, as seen in Equation 2.

In the simple case where pressure transmitters are installed on both the suction and discharge line, Equation 1 can be used to calculate the TDH. In this case, it is possible to calculate both the discharge and suction head given that you know the specific gravity of the fluid using Equation 3 to convert the pressure readings into head.

$$H = \frac{P}{SG.g} \quad \text{(Equation 3)}$$

Where:

H: Head (m)
P: Pressure (suction/discharge) (Kpa)
SG: Specific gravity in kilogram per meter (kg/m^3)
g: Standard gravity (m/s^2)

In some instances, there is a pressure transmitter on the suction line, in others, on the discharge line (a more frequent scenario) and in some older plant installations, there is a possibility that there are no transmitters located on the suction line and a pressure transmitter located on a common header that is being fed by multiple pumps.

CASE 1

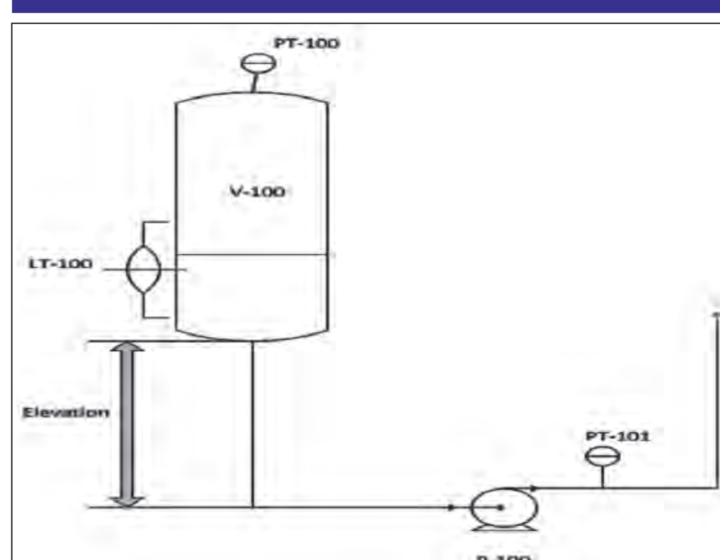


Figure 1: Pumping system flow diagram with no pressure transmitter on suction side

A scenario with only a pressure transmitter on the discharge line is illustrated in Figure 1. Vessel V-100 is connected to pump P-100. Also in Figure 1, a pressure transmitter, PT-101, is on the discharge side of the pump, but there is none on the suction side. It is possible to calculate the suction head using the pressure measured by PT-100 (pressure inside V-100) and LT-100 (liquid level inside V-100), factoring in the friction loss or piping loss and adding the elevation between V-100 and P-100, as shown in Equation 4.

$$H_S = \frac{P_V}{SG.g} + L_V + h - f.\frac{L.v^2}{D.2.g} \qquad \text{(Equation 4)}$$

Where:

H_S: Suction head (m)
P_V: Vessel pressure (KPag)
SG: Specific gravity (kg/m^3)
g: Standard gravity (m/s^2)
L_V: Liquid level inside the vessel (m)
h: Elevation (m)

Using PT-101, the discharge head is:

$$H_D = \frac{P_D}{SG.g} \qquad \text{(Equation 5)}$$

Where:

H_D: Discharge head (m)
P_D: Vessel pressure (KPag)
SG: Specific gravity (kg/m^3)
g: Standard gravity (m/s^2)

Combining Equations 4 and 5:

$$TDH = \frac{P_D}{SG.g} - \left(\frac{P_V}{SG.g} + L_V + h - f.\frac{L.v^2}{D.2.g}\right) \qquad \text{(Equation 6)}$$

CASE 2

Figure 2 illustrates a scenario with a pressure transmitter on the suction line of the pump, but not on the discharge line. Process fluid is being pumped by P-100 toward E-101, where it is heated before being sent to the reactor R-101. The pressure transmitter PT-101, located at the entrance of the reactor, can be used to calculate the discharge head of the pump, as shown in Equation 7. The discharge head is a factor of the elevation between the center line of the pump and the pressure transmitter, as well as the pressure drop across the pipes, as well as E-101.

$$H_D = \frac{P_V}{SG.g} + L_V + h + f.\frac{L.v^2}{D.2.g} \qquad \text{(Equation 7)}$$

Given PT-100 on the suction line, the suction head can be calculated:

$$H_S = \frac{P_s}{SG.g} \qquad \text{(Equation 8)}$$

Where:

P_S: Suction pressure (Kpa)

Combining Equations 7 and 8:

$$TDH = \left(\frac{P_V}{SG.g} + L_V + h + f.\frac{L.v^2}{D.2.g}\right) - \frac{P_s}{SG.g} \qquad \text{(Equation 9)}$$

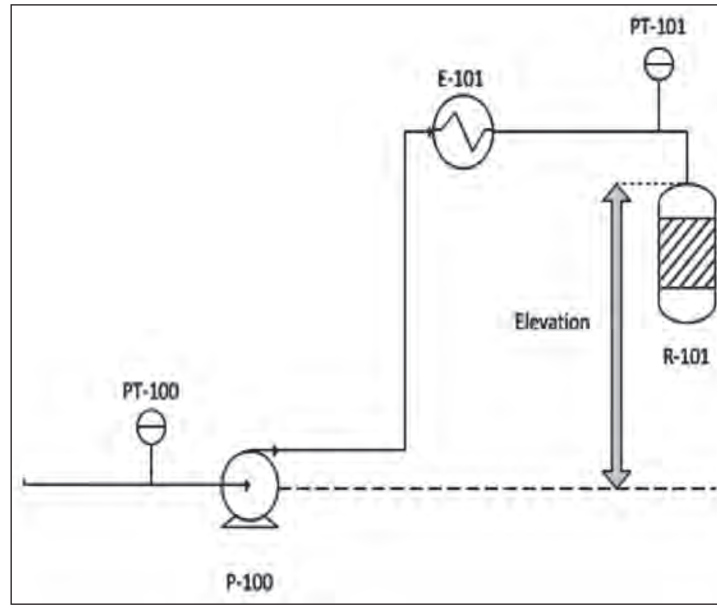


Figure 2: System flow diagram with no pressure transmitter on discharge side

CASE 3

Figure 3 is somewhat similar to the scenario mentioned in Case 2, where there is no pressure transmitter on the discharge line of the pump. The difference is with the location of pressure transmitter PT-200, which is on a different stream in a different area and is combined with the discharge stream of P-100 before being sent to E-101.

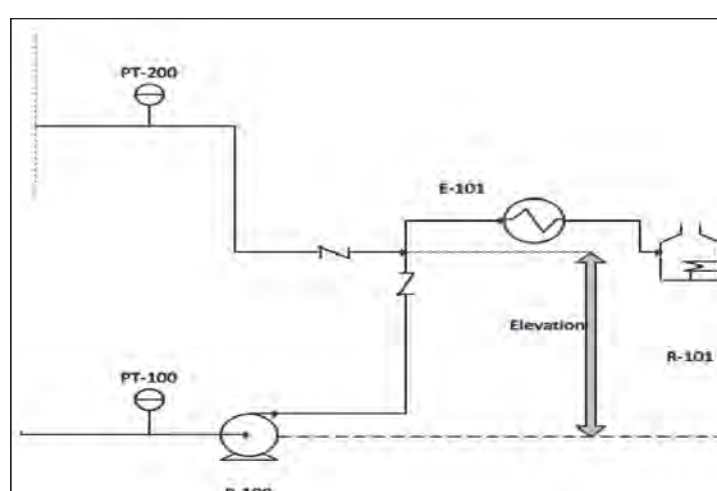


Figure 3: System flow diagram with no pressure transmitter on discharge side

CASE 4

Another scenario is where there is no pressure transmitter on the discharge line, as illustrated in Figure 4. In this system, a fluid is being pumped to furnace F-101 before being sent to the reactor R-101. On the suction side, PT-100 provides the pressure reading, while on the discharge side of the pump, a pressure transmitter is not installed. Therefore, you have to calculate pressure on the discharge using PT-101. Since the pressure transmitter is located after the furnace, the process fluid is a two-phase mixture. Therefore, it is not possible to apply Darcy's Law (Equation 2), which only applies to liquids. Empirical models based on either homogeneous models or nonhomogeneous models, such as the methods used by Friedel, Lockhart and Martinelli[1], can be used to calculate the piping losses. These calculations are out of the scope of this paper, however, a reference link is provided for further reading.

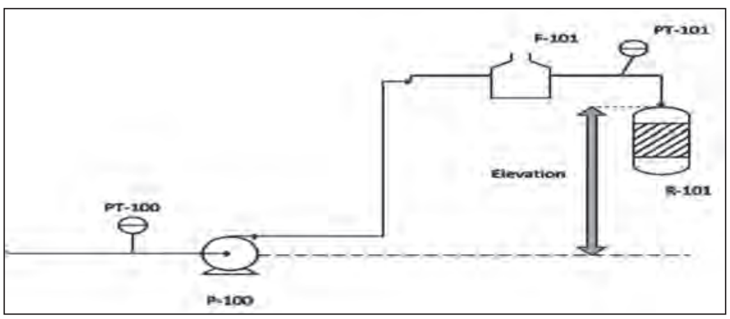


Figure 4: System flow diagram with no pressure transmitter on the discharge of a pump

Value of Generating Real Time Head Flow Curves

A lot of valuable pump operation data can be gathered from monitoring real-time performance of the pump. Typical points to consider during analysis, troubleshooting and performance of the machinery include:

1. If the pump is generating lesser head than the original curve, this can point toward issues connected to mechanical wearing of the pump's components, recirculation and other performance degradation effects, such as opening up of the pump's clearances.
2. It is relatively easy to ascertain hydraulic issues by comparing the operating performance of the pump. This includes incorrect impeller trims, vibration-related issues and off margin operation from the best efficiency point (BEP).
3. Speed changes; if the pump is running off a variable frequency drive or turbine drive, then speed changes can be correlated to an increase or decrease in the head being generated by the pump in real time.
4. Process-related fluctuation can be determined indirectly by seeing a time varying trend on the head versus flow curve.
5. Trending of motor amperage on the performance curve can provide valuable information on impeller sizes and other hydraulic factors that are specific to the pump. High flow impellers would draw more energy than low flow impellers.
6. Pump rerating can be better addressed when real-time pump operating can be understood. This helps in minimizing underrating and overrating of newly rated pumps and ensures better operational reliability.

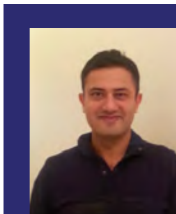
Conclusion

In any operating plant, consideration should be given to utilizing process engineering tools and, in the absence of relevant instrumentation, real-time equipment monitoring should be encouraged. Plant deficiencies, such as a lack of instrumentation, should not impede cost-effective ways to improvise on existing problems.

Process modeling simulation software can be utilized in conjunction with rotating equipment problems to address, monitor and troubleshoot issues that would otherwise require a reactive approach, like shutting down equipment and impacting production downtime. While calculations and analysis in a running plant should be kept to a minimum to address problems on a fast and efficient basis, accurate modeling and an understanding of the process surrounding any rotating equipment is critical in helping to improve reliability.

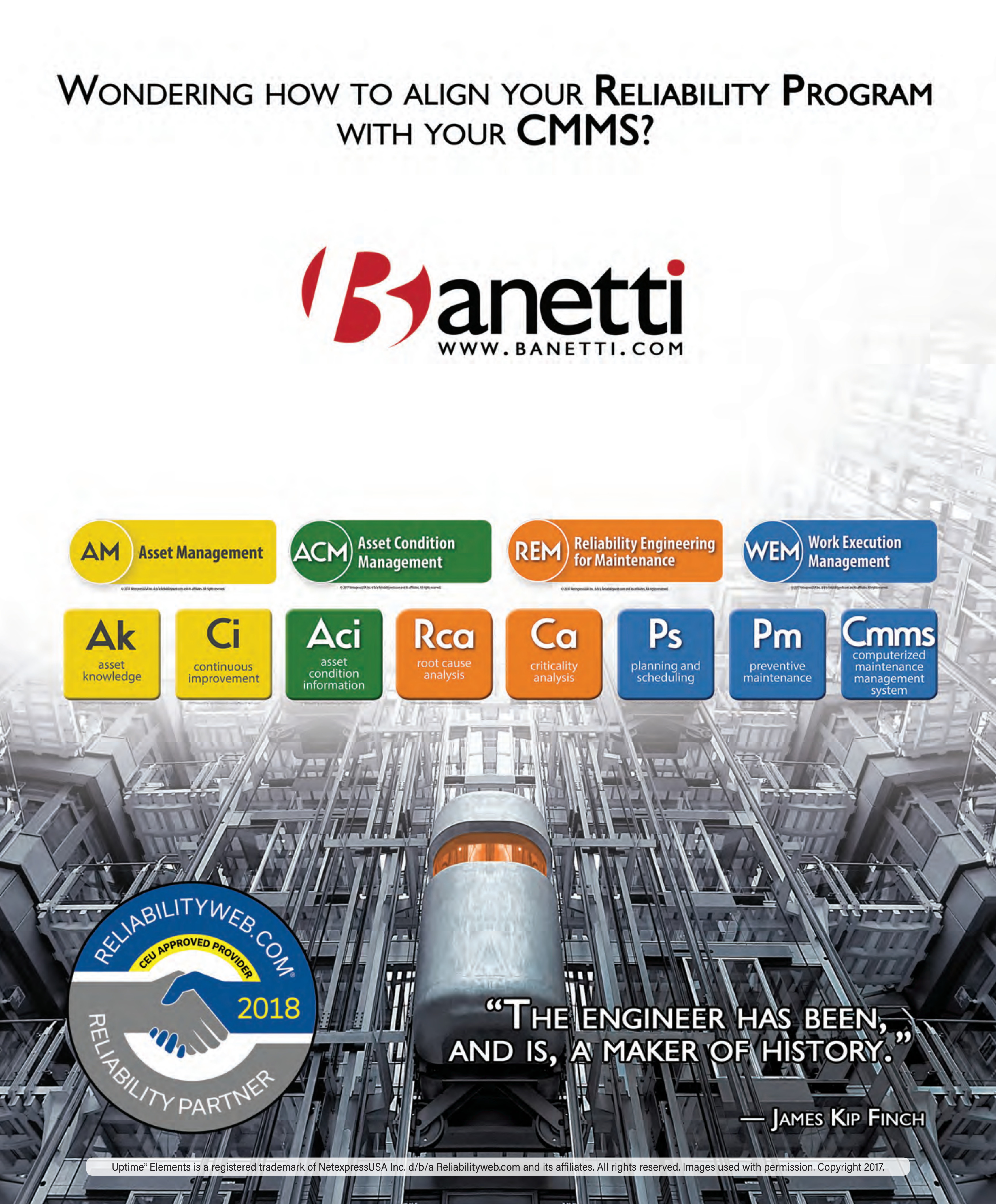
Reference

1. http://ltcm.epfl.ch/files/content/sites/ltcm/files/shared/import/migration/COURSES/TwoPhaseFlowsAndHeatTransfer/lectures/Chapter_13_PART_1.pdf



Umeet Bhachu, *P.Eng., is the Technical Authority for the rotating equipment Engineering & Turbomachinery Division at Canadian Natural. His work has included reliability simulations, technical assessment and maintenance of plant rotating machinery. Umeet is an ISO CAT II vibration analyst and holds both PMP and CMRP certifications. www.cnrl.com*

Ahmed Sow *is currently an engineer in training and works with the reliability group at Canadian Natural. His responsibilities include plant equipment performance monitoring and optimizing plant reliability tools. He holds a BASc in Chemical Engineering from the University of Ottawa. www.cnrl.com*



WONDERING HOW TO ALIGN YOUR RELIABILITY PROGRAM WITH YOUR CMMS?
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Aci asset condition information
Rca root cause analysis
Ca criticality analysis
Ps planning and scheduling
Pm preventive maintenance
Cmms computerized maintenance management system
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Cmms computerized maintenance management system

HOW ENTERPRISE ASSET MANAGEMENT CAN TRANSFORM YOUR ORGANIZATIONAL PRACTICES

Dr. Cierrah Perrin

Enterprise Asset Management (EAM) offers a myriad of benefits to an organization, primarily an asset-heavy company. But did you know EAM software can help businesses get organized?

Intensified regulatory regimes are forcing infrastructure operators to increase efficiency and operational excellence. Implementing EAM not only helps contain operating costs but can also significantly improve productivity and asset performance through better organization. Of course, investing time and money to implement EAM software can tremendously reduce equipment downtime, as well as provide better processes to maintain and manage a company's vital assets.

This article illustrates the primary organizational advantages of using EAM software and how it can help companies.

What Is EAM?

EAM is a revolutionary asset maintenance and general management solution that addresses the need for continuous monitoring of a company's assets. Powered by state-of-the-art innovations, an EAM software solution makes sure that asset-intensive enterprises get a holistic view of their assets across all locations, facilities, business units, or departments. EAM software comes with an array of benefits, including speedy maintenance routines, easier contract management, better organization, simplified asset tracking, and much more.

Organizational Change Benefits

EAM systems can transform the way asset-intensive companies do business. It's designed to offer a unified platform for managing physical assets across an organization. EAM solutions keep your most critical assets and resources performing at maximum efficiency, regardless of industry. EAM offers a broad range of robust features to manage, track and get insights into your asset performance and costs through the entire asset lifecycle.

EAM solutions serve every facet of your organization that has to do with asset management. It incorporates functions, like investment strategies, portfolio planning, design & construction, maintenance, rehabilitation, replacement and disposal of assets.

Increased Visibility

Immediately, EAM software offers a company the right tools to organize its asset portfolio quicker and more efficiently. Simply put, this software enables enterprise firms to reduce the burden of paper handling. The problem with inefficient and paper-based systems is they only allow companies to capture limited information about their assets and how they manage them.

EAM, on the other hand, offers increased visibility of all company assets through effective reporting and insight, allowing a company to identify areas of improvement and excellent performance.

> "...EAM systems keep your most critical assets and company resources performing at maximum efficiency"

With well-organized and easily accessible asset information, preventive maintenance (PM) can be scheduled so the company can more effectively assign and monitor their maintenance crews. Also, clear visibility and traceability enhance the company's compliance and service level agreements (SLAs).

By realizing tangible performance, a company can drive real change. EAM, therefore, helps organizations identify problems faster, keep a tab on performance indicators and deal with issues before they arise.

Benefits Beyond Asset Management

The benefits of this comprehensively designed software go beyond essential asset management. It provides every employee, every department, and every location with a one-stop shop for all information about the company's physical assets. This includes lifecycle costs, maintenance histories, energy usage, purchase orders, warranty catalogs, and audit records, to name a few.

All-in-One System

Use various applications in a unified EAM solution to manage contracts, purchase orders, and request for proposals (RFPs). Accounting can use it to handle MRO invoices and budgets. Materials managers can use it to manage inventory and storerooms/warehouses.

Integration Options

With system integrators, you can integrate EAM with building automation systems and supervisory control and data acquisition (SCADA) to get real-time information about energy usage and the condition of assets across all units. Also, EAM can integrate with enterprise resource planning (ERP) systems to ensure current and precise financials. Business intelligence integration offers executives a holistic view of asset performance and costs.

How EAM Transforms Organizational Practices

From its benefits, to promoting an asset-driven environment, it's clear that EAM can transform organizational practices. Here are several ways EAM systems can take your organizational practices to the next level.

From Reactive to Proactive Maintenance Practices

EAM is designed for a preventive approach. EAM software allows you to get on top of maintenance and asset management, and work toward a PM strategy. The system can prompt you when assets need maintenance and repairs. Once set up, the system can automatically generate work orders, purchase orders, RFPs and much more based on the schedules you've generated, thus enabling on time work order completion.

Go Mobile

Mobile technology is changing asset and cost management in a big way. The good thing is, for many EAM system, there's a corresponding mobile app for iOS, Android and Windows operating systems to make maintenance and asset management on the go possible. Technicians can check repair histories, audit trails, access parts catalogs, implement new work orders, place purchase orders, and so forth. Everything can be done on a mobile platform, a transformation in organizational practices.

Standardize Best Practices

With EAM, you can establish workflows and checklists to set up consistency and best practices in your organization. This can be highly beneficial, especially for condition monitoring, troubleshooting, accounting, and cost management.

Get Rid of Maintenance Backlog

One practice that can reduce productivity, increase operating costs and cause frequent downtime is a runaway maintenance backlog. It has crippled many organizations that could otherwise operate at maximum efficiency. With an EAM system in place, maintenance backlog can be a thing of the past.

EAM helps companies keep a balance between maintenance costs and resources, allowing them to clear the backlogged work. It also captures small hiccups that otherwise may have been overlooked, preventing the need for emergency maintenance and compliance issues.

Improve Health and Safety Practices

Robust health and safety practices are indispensable for the well-being of the workers, as well as the assets. Modern EAM systems come with powerful health and safety management tools. Acting as a central repository for health and safety information, the EAM facilitates inspection rounds and monitors everyone's safety certification. This way, accidents and unplanned incidents can be a thing of the past.

Keep Up with Changing Technology

With constant updates in technology, asset-driven enterprise firms have to change the way they serve and operate to remain relevant in today's world. For that, EAM software incorporates the latest technology trends. This way, the organization can use technology and take advantage of innovations to offer clients better services and more choices, as well as eliminate business units from keeping inefficient and out-of-date processes.

Change Decision-Making Practices

Managing a top-notch and efficient asset-driven environment requires a myriad of business, operational and technical strategies. In fact, a firm that wants to find effective ways to save money and truly increase efficiency must know its operating costs and how it can improve upon them.

EAM software is a crucial resource to gain insights into your asset-driven operations and know how your facilities are performing, as well as what steps to follow to accomplish your company's goals. In this way, an EAM software solution removes the guesswork out of making important organizational and operational decisions.

Realize Real ROI

Efficient and well-organized systems offer up to a 60 percent reduction in paperwork. That signifies great improvement in maintenance turnaround times, increased work orders, reduced operating costs, and maximized revenue.

In addition, EAM systems eliminate the need for costly emergency repairs, increasing asset lifecycle and uptime through predictive maintenance, condition tracking, and preventive upkeep. Without preemptive inspections, companies can save money on fines and negative publicity. With more efficient and streamlined processes, they can save on administrative overhead.

Efficient EAM solutions, combined with appropriate business processes, help organizations to refine their work processes, enhance working conditions, and spot areas for improvement. Thus, moving forward, they can make insightful changes in the right areas - and with the right people - to run efficiently and smoothly all year long.

__Dr. Cierrah Perrin__ is a Principal Business Architect within Digital Asset Performance at DXC, with almost a decade of experience in providing solutions for large, complex IT projects. She is growing her career as a SME and practitioner in Enterprise Asset Management strategy and solutions. Dr. Perrin holds a doctorate in Organizational Leadership and Change. www.dxc.com

Mt motor testing

DEVELOPING AN EFFECTIVE ELECTRIC MOTOR TESTING PROGRAM

Don Donofrio

It is estimated that almost half (45 percent) of global electricity is used by electric motors. Electric motors drive a considerable amount of equipment in almost all industries, from power generation to water and food supply to consumer products. The importance of electric motors in modern society cannot be understated. It is because of this vital role that it pays huge dividends to keep your electric motors running efficiently through a quality reliability program that includes energized and de-energized electric motor testing (EMT).

Electric motor test instruments have become extremely effective reliability and diagnostic tools for motor and motor circuit testing. Significant improvements in motor longevity and overall plant reliability may be achieved through proper implementation of this established technology. But, as with any new program, there will be growing pains. These start immediately upon receipt of your test equipment.

Who should conduct the testing?
When should testing be conducted?
Are procedures in place?
If not, what procedures need to be developed?
What should be tested?

There are eight steps that, if followed, will enable successful and effective EMT for your reliability program.

Personnel Preparation

As with any endeavor, the key to success is knowledge of the task to be performed. With EMT, this means a thorough understanding of the equipment to be used, including test capabilities, diagnostic strengths and weaknesses, and in-depth knowledge of the equipment to be tested.

Equipment capability information is usually provided by the motor tester manufacturer through initial training. A comprehensive knowledge of motor operation and failure modes is also necessary, but it's not something easily obtained and is rarely provided by test equipment manufacturers. Apprentice training, experience and specialized training are the most effective means of gaining the necessary knowledge.

Developing proficiency is another challenge. This is where you don't want to learn by your mistakes. Making erroneous calls and missing significant problems will detract from the credibility of the equipment, the technician and the reliability program. Most industrial facilities have spare motors on hand, so when first starting to test, test warehouse spares, then expand to acceptance

Figure 1: De-energized testing is important as it provides an opportunity to test insulation

testing. This will provide you with the time to learn software and test capabilities and develop the proficiency to test operational motors with competence and expedience.

Preparation for Equipment to Be Tested

What equipment should be tested? Perspectives can vary widely in answer to this question. Criticality is in the eye of the functionary at your facility. What is critical to production may not be as critical to the maintenance or safety departments. The best way to address criticality is from four basic perspectives:

Operational criticality – Straightforward and based primarily on operating voltage:

1. Medium / high voltage / frequent starts;
2. Medium / high voltage;
3. Low voltage / frequent starts / high horsepower;
4. Low voltage / high horsepower;
5. Critical variable frequency drive (VFD) powered motors;
6. Nonredundant critical motors.

Medium and high voltage equipment cost significantly more to repair or replace and may require prolonged lead time for replacement. Frequently started motors, at any voltage, fail more regularly than motors that run continuously or start infrequently. Motors driven from VFDs normally run hotter and are subject to more rapid thermal degradation of the insulation. Some motors of fractional horsepower may be critical. For example, a 1/4 HP lube oil pump for a 6000 HP sleeve bearing motor is as critical as the 6000 HP motor.

Safety criticality – Quite simply: Can someone be killed or injured if this equipment fails?

Logistical criticality – This is based on availability of repair facilities and replacement parts. In this

Figure 2: Surge and Hipot testing tests insulation between turns, coils, phase and to ground

world economy, parts may have to be manufactured halfway around the globe. This creates a prolonged downtime for the failed equipment and a possible significant effect on the process.

Environmental criticality – Asks the question: Will failure of this equipment cause environmental damage, such as a toxic effluent release or excessive air pollution?

Get all the key players involved to determine equipment criticality. Sit down and discuss priorities, maintenance difficulties, safety and logistical issues and come up with a list of critical assets. Once an equipment list is developed, it should be organized into routes. Plan so a maximum number of assets can be availed in each location. Jumping around reduces productivity. Routes should have a recurring periodicity based on criticality.

Preparation of Test Equipment

In order to perform motor testing effectively, the test equipment should be in optimal condition. The tester should be in calibration with the most recent updates to the operating software. (Note: When updating software, be aware of possible compatibility issues. New software updates should clearly explain any operating system (OS) that is and is not supported.)

Software upgrades are essential. Many times, they correct inaccuracies or provide important safety procedures or steps. The associated equipage should be inspected and tested, as applicable, to prevent problems when in the field conducting tests. Conduct a check of the equipment the day before testing is scheduled. A simple generic checklist will help with the readiness of the equipment:

Checklist for Effective Testing

- All batteries operable and charged
- Deep cycle batteries as required
- Test leads are free of any nicks or cuts in the insulation
- Voltage clips or test clips are clean and free of any foreign debris or corrosion
- Voltage clips or test clips are snuggly threaded or make a tight fit on test leads
- Current probes have good batteries, if applicable
- Inspect power cords for nicks and breaks in the insulation
- Current probes' jaws are clean and free of any foreign debris at both the top and hinge point
- Current probe spring tension is good
- Test lead connection points on the test instrument are clean and free of dust and foreign debris
- All electrical and data port cables on your test instrument are properly connected

Check Operational Status of the Tester

Prior to the acquisition of any test data, a quick operational test of the motor test instrument should be conducted. The use of a small test motor or stator will verify that the acquired de-energized test data is accurate or repeatable.

To verify accurate energized data, perform a quick power quality test. Place all current probes on one phase cable and run the test. Compare bus phase voltages to acquired voltages and confirm all amperage readings are the same. Once you feel comfortable that you are collecting reliable data, begin your testing route.

Figure 3: Samples of hand-held instruments

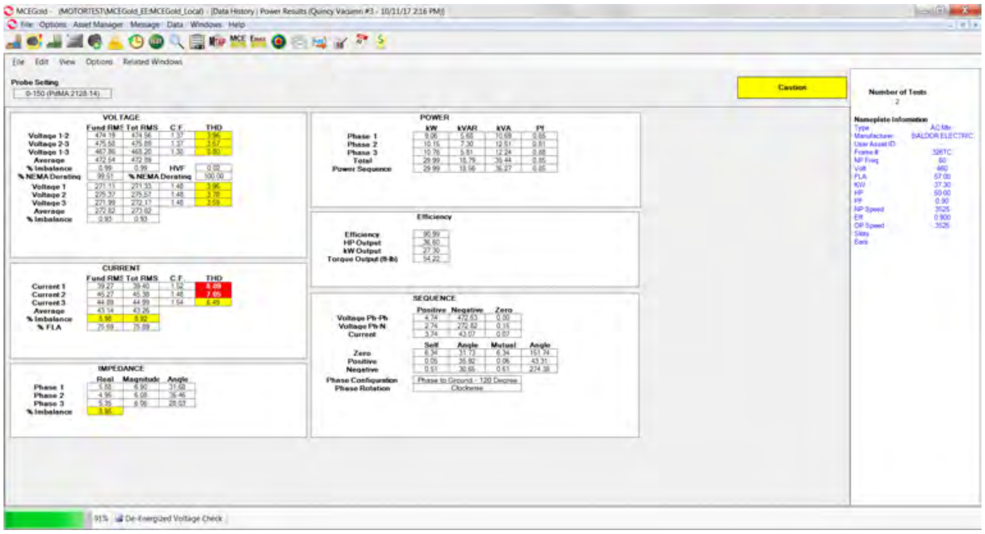


Figure 4: Power quality data showing high harmonic distortion in phase to phase and neutral voltage

Figure 6: Infrared provides correlation for indications of unbalanced resistance or current

Maximize the Amount of Circuit Under Test and the Amount of Load on the Circuit

If you are devoting the time to conduct testing, you should test as much of the circuit as possible. De-energized testing is usually conducted downstream of the de-energized contactor. With de-energized testing, connections made upstream will identify circuit anomalies between the connection point and the motor. Once identified, circuit isolation can be conducted and the source localized.

Energized testing should be performed from the starter cabinet. Connections should provide at least one local level of circuit protection above the point of connection; for example, connect on the load side of the main breaker or load side of the fuses. Energized testing can be used to observe voltage and current fast Fourier transform (FFT) data to isolate spectral peak sources from upstream or downstream of the test connection point.

Verify or Confirm Identified Anomalies

When a potential problem is identified, it is just that, a potential problem. You should take steps to validate that it is, in fact, a problem. Sometimes, erroneous data or unique characteristics of the equipment under test may give indications of a fault. You should perform all possible equipment checks and run additional correlative tests to validate your indications. Let's say, for example, your test data indicates a possibly high resistance connection. Check your test lead connections and rerun the resistance tests. If you get a current unbalance, check equipment loading to ensure the unbalance is not due to insufficient loading. If the load is sufficient, save the data and run a quick power quality test, with all the current probes on one phase to make sure you do not have a defective probe. If you have field pole pass (Fpp) frequency sidebands indicating possible rotor bar anomalies, check for swirl effect, current modulation, increased current draw for a given load and reduced inrush current with longer start duration. These simple checks and correlative measures can prevent erroneous data that leads to bad calls, which can cast doubt on either you, the technology, or both.

When Possible, Correlate with Other Technologies

When possible, you should correlate acquired data with other technologies. This helps confirm the existence of a problem and helps quantify the severity. Sometimes, reliability technicians tend to try to be a "one-man band." But, working together as a *reliability group* will yield immeasurable results. Reliability technologies are like a set of wrenches or sockets, they all have specific purposes, but overlap.

Figure 5: Vibration monitoring is a great correlative test

When different wrenches or sockets are used together, you can work on most anything. The same with reliability technologies; when used together, you can diagnose most any problem. The proper use of vibration, ultrasound, oil analysis, infrared and electric motor testing can provide a maintenance environment that has minimal undiagnosed failures, resulting in maximum productivity and/or reliability.

Generate Effective Reports and Communications

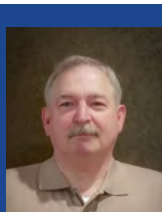
Believe it or not, reporting is probably the most important aspect of an effective motor testing program. The report is your deliverable. It can be the basis on how you are judged as a motor test technician. If you are a service-oriented company, you already know or should know this. In-house programs tend to sometimes neglect or minimize reporting, which works to the overall detriment of the program. Budget expenditures are based on perceived value of the desired item. If your motor testing program does not appear effective, you may not receive the funding level you require.

Not only do you have to generate effective reports on identified anomalies, you need to generate updated reports on the overall success of the program. Work with management to establish performance metrics or key performance indicators (KPIs). Bar graphs showing the number of identified and corrected anomalies should be posted in high visibility venues. Display monthly and yearly discrepancy counts; hopefully, it shows a marked decrease. Display the budget reductions for motor rewind and replacement or the number of rejected motors not put into service that may have failed prematurely. Specific examples will help you illustrate your point. Use the data you gather to not only identify and repair problems, but also to demonstrate the effectiveness of the program.

Communication, in addition to effective reports, is key to your program's success. You should have a network of communication established between you and middle and upper management, maintenance and production departments, and other predictive maintenance (PdM) technology personnel.

Communications with planning, safety and logistics departments are also important for procedural and material support. Integrate your electric motor testing results into the site's enterprise asset management (EAM) reporting to further support these types of communication. Other areas where communication is important are with the motor shops, motor manufacturers, the tester manufacturer and your electric motor testing knowledge provider.

An effective motor testing program should be part of an effective reliability program. The use of these steps will provide your program with a significant and highly effective tool as part of a world-class maintenance program.



Don Donofrio *is Technology Lead for EMT and Power Quality Analysis at The Snell Group. He brings 42 years of knowledge in the operation, maintenance and testing of electric motors and motor circuits. Don has been involved in the development of a series of innovative EMT training courses and instructs both Energized and De-Energized Motor and Motor Circuit Analysis courses, as well as Level I Infrared Thermography. www.thesnellgroup.com*

Q&A

Athena Rhae Bisnar

Engineering Planning and Control Manager, Asian Terminals, Inc.
CGBSS, CIE

Working for one of the world's largest terminal operators, continuous improvement is… continual. *Uptime* magazine had the opportunity to speak with Athena Rhae Bisnar, Engineering Planning and Control Manager for Asian Terminals, Inc. Athena is a catalyst of continuous process improvement, a leader in quality, and an asset management implementer.

The planning and control team, headed by Athena, was able to improve and develop enterprise asset management service (EAMS) management and utilization, equipment condition, and flow of work execution through the delivery of asset hierarchy, leaner reports generation, reliability-centered maintenance, and a competency-based learning program, and reengineered procedures of work order management and maintenance planning and scheduling. Currently, the team is focusing on the standardization of maintenance tasks in compliance with global engineering, data quality improvement programs, cost-efficient project management and long-term planning.

Asian Terminals, Inc. (ATI) is a Philippine Stock Exchange-listed port operator, developer and investor, and part of the port network of global trade enabler DP World, ATI's strategic foreign shareholder partner. DP World is the fourth largest terminal operator globally. ATI provides comprehensive and reliable terminal and logistics services for cargoes and commodities across markets.

Q: As engineering planning and control manager, explain your role at Asian Terminals, Inc.?

As an engineering planning and control manager, it is my duty to drive continuous process improvement in the engineering division. My role also covers reliability-centered maintenance and condition-based monitoring, supports the asset management program's implementation and manages effective maintenance planning through data analytics, quality control application, systems utilization and learning and development management.

Q: What is the aim of your work?

The ultimate goal is to attain and sustain an 80 percent / 20 percent distribution of planned and unplanned maintenance hours as a minimum performance measure.

Q: How did your career lead you to this point?

It happened one step at a time. First, my passion for quality and statistics started during my undergraduate years as an industrial engineering student. Then, I found my interest for the logistics industry when I went to Taiwan as an exchange student where I was given an opportunity to take maintenance reliability and global logistics subjects. The experience exposed me to the ideas of total productive maintenance (TPM), total quality management (TQM), failure rates, and such. So, right after my graduation, I only applied to quality-related positions in the logistics industry.

ATI is my first job after graduating and I started as a management trainee. ATI's management trainee program is a six-month, operations-engineering intensive internship with the goal to provide analysis and proposals on areas for improvement. Using the define, measure, analyze, improve and control (DMAIC) approach and various quality tools, I was offered the assistant manager (AM) for quality position in the engineering division.

While I was in the AM position, process thinking and 5S practices were successfully implemented. After six months in that position, the engineering division had a reorganization and I was assigned as the head of the planning and control department, where my previous function had to be integrated into the department's existing objectives. Knowing that reliability is just one of the products of a quality work culture, reliability is a culture of quality.

Q: What is the culture of reliability within your organization?

The reliability culture in our organization is still very young. Key personnel are continuously being trained, existing processes are being reviewed and aligned with the reliability framework, and the reliability principles are currently being campaigned. The commitment from top management is helping us build on this culture. Maturity for a reliability culture will not happen overnight, but it will be surely attained with driven and committed individuals.

Q: What advice do you have for women who choose technical careers? Do you have any strategies to share for advancement in this industry?

My advice for all the women who have chosen technical careers is to keep an open mind and keep learning. Gone are the days when knowledge and skills were only available for men. Nonetheless, each gender has its strengths and weaknesses and the best way forward is to promote cooperation and supplement each other.

Q: Who has been your biggest influence or mentor?

My passion for quality has always been influenced by my professor in college, Mr. Henry Palaca. But, the one who has been mentoring me and guiding me in this reliability journey is my boss, Mr. Christopher Joe Styles.

Q: Where do you see yourself in 10 years?

Ten years from now, with the continuing explosion of data and advancement of technology, I see myself managing a team of data scientists who analyze data and develop solutions that promote reliability and efficiency of machine and workers.

Q: What is your "must read" book for anyone in this industry or in a similar role?

Not specifically for someone in the industry, but someone who is in a leadership position, I would say a must read is *Start with Why* by Simon Sinek. I highly recommend this to every leader who wants to have a team that is composed of purpose-driven individuals.

WIRAM
Women in Reliability and Asset Management

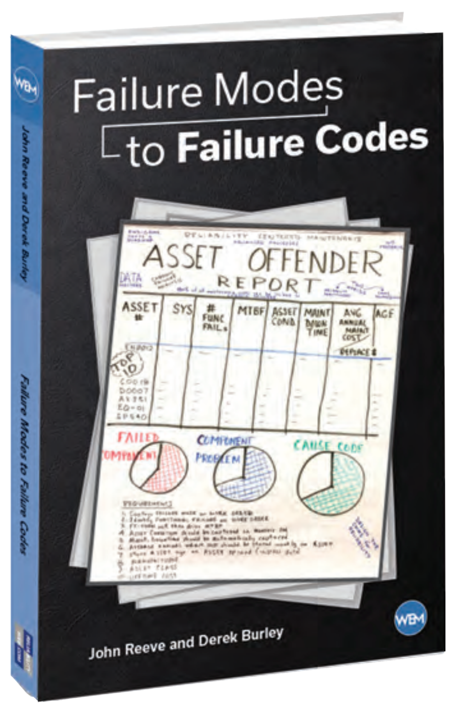
For more information and to join: maintenance.org

FAILURE MODES TO FAILURE CODES

Written by John Reeve and Derek Burley
Reviewed by Tacoma Zach

Many organizations struggle under the false assumption that simply implementing a computerized maintenance management system (CMMS) will establish effective asset management programs and/or reliability programs. These organizations then experience significant frustration when they are not able to achieve the expected improvements in reliability, overall equipment effectiveness and return on assets.

This book identifies some of the sources of this frustration. First, is the assumption that a CMMS out of the box will deliver results. Reeve and Burley advocate for and describe thoughtful CMMS configuration for appropriate failure data collection that delivers useful reporting. Next, they address the universal challenge of CMMS data quality, with helpful points on how to improve this. Finally, the main focus of the book is about the opportunity to dramatically improve the operation and reliability of assets through appropriately managed and applied failure analysis built on the foundation of better failure data tied to failure modes.



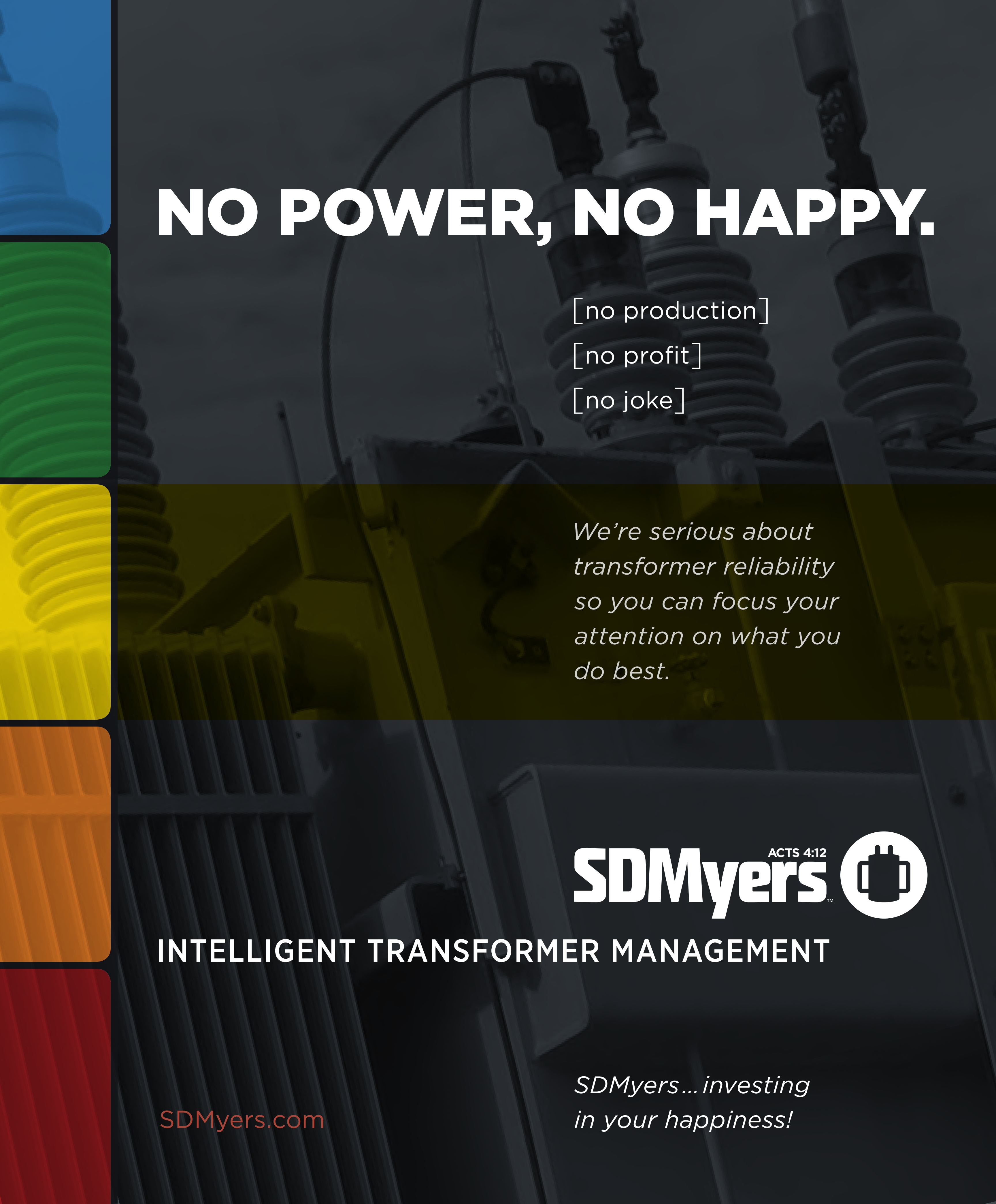
"The goal is to link every maintenance strategy to a failure mode that you are trying to prevent."

I wholeheartedly agree with Reeve and Burley in their central thesis that asset strategies can be better determined through a formal failure analysis. They state: **"The goal is to link every maintenance strategy to a failure mode that you are trying to prevent." (p. viii)** They correctly note that many organizations jump too quickly to time-based, preventive maintenance strategies as the primary and often only strategy to prevent failure.

This book helpfully draws the line from the objectives of an organization through the aim of an asset management plan to the specifics of how to configure your CMMS to collect and report data in a way that supports making better decisions and managing assets better. Reeve and Burley outline a road map for extracting information from data – information that can become knowledge that supports decisions. Chapter Three, which explains reliability-centered maintenance (RCM) and failure modes with insights from an RCM facilitator is particularly valuable for understanding how a CMMS needs to be configured to support failure mode management.

However, in the prescriptions for asset strategies (or decisions) based on failure analysis, there is potential for some confusion around setting priorities. While there is an appropriate discussion of Pareto analysis and addressing bad actors, the question of a bad actor's criticality and actual risk posed to business is somewhat overlooked. Importantly, the authors do state that a criticality analysis should precede a reliability-centered maintenance/preventive maintenance optimization (RCM/PMO) analysis, something many organizations get in the wrong order at great expense. The addition of a more complete description of how understanding criticality and risk informs the development of asset strategies based on the results of chronic failure analysis would round out this useful book.

Failure Modes to Failure Codes is a clear voice for recognizing the value of failure mode management to improve reliability. It describes a useful approach to structuring your CMMS to support this aim. It is very detailed and offers value to any organization in pursuit of improved asset management, regardless of the level of sophistication of their existing efforts.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