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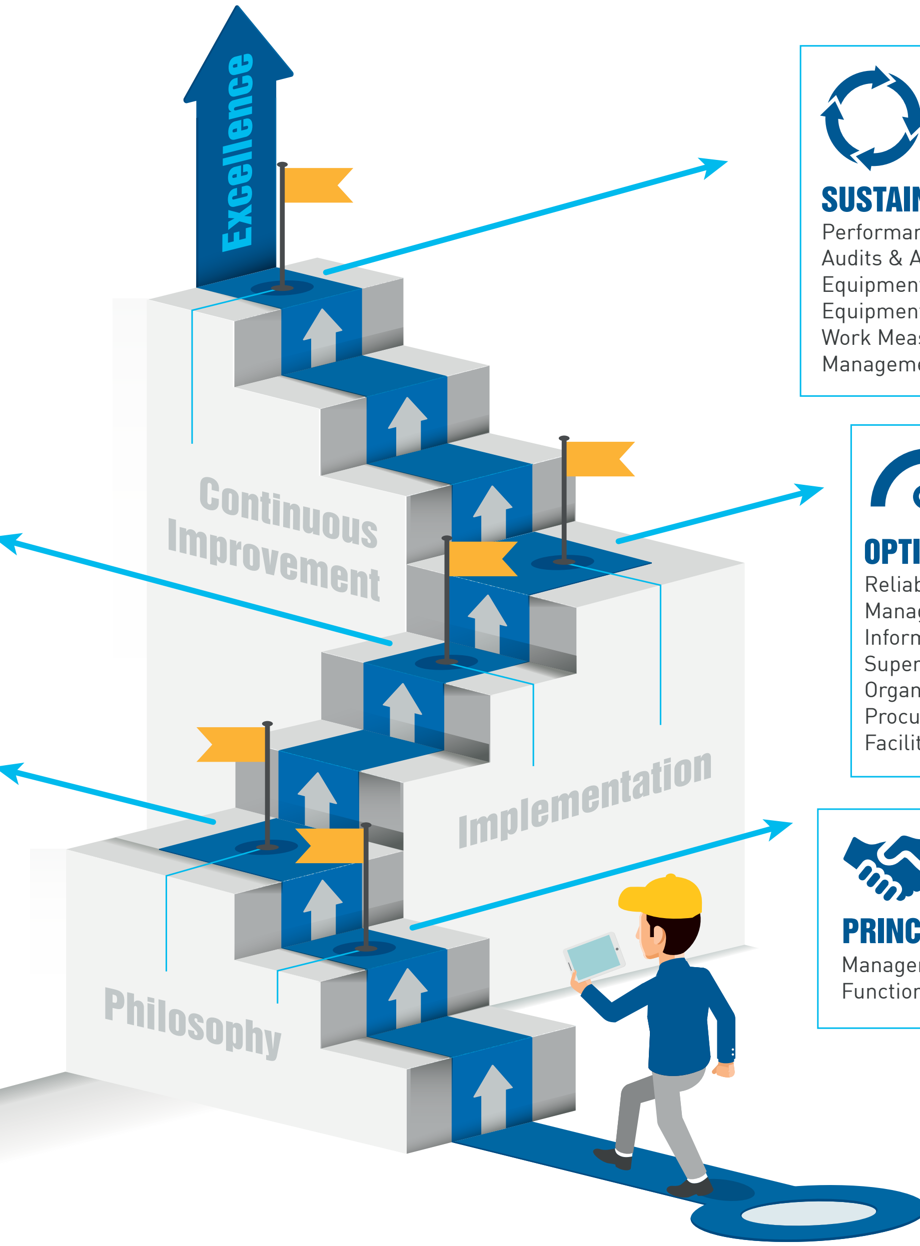

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ON THE COVER
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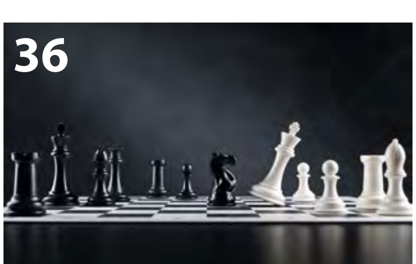

Elements

Editorial

Reliability Is a Two-Party System

I hope my fellow Americans are recovering from a very long election season and that my friends in other countries do not judge the process based solely on information available through media filters. Americans come together in many ways, even with political differences.

In a two-party system like the one that dominates the U.S. political system, 48 percent on one side and 48 percent on the other side is a natural outcome.

That got me thinking about the two-party *reliability* politics I find inside most organizations.

If you attend a Reliabilityweb.com® conference like IMC or The RELIABILITY Conference™, you are probably a card-carrying member of the Reliability Party. Most of the other attendees think like you, are working toward the same goals and are challenged by the same issues.

The Reliability Party members know that leadership is the key to engaging, empowering and aligning the workforce.

They know that maintenance done perfectly will still not avoid failure. They support cross-functional defect elimination to stop the defects from design, build and install, defects from operations, defects from workmanship and defects from material in order to create a culture of reliability.

They know there is a precision operating domain that exists beyond the preventive or predictive domains.

There is another political party called Blissful Ignorance Party. Their platform states that maintenance is responsible for reliability. They think the majority of things are reliable when they are new, and they drive toward unreliability as they age or wear out. They think work execution is the key to reliability. They do not accept that operations, HR, IT, sales/marketing, commercial, purchasing, quality, engineering, capital projects and senior management play major roles in enabling or disabling reliability.

Look around to see if the Reliability Party and the Blissful Ignorance Party may exist in your organization.

Take a lesson from the recent U.S. election. You do not need any more than 50.1% of the votes to make a major change. Focus on creating a shadow network of informal Reliability Party leaders who connect to enable defect elimination and reliability leadership throughout the organization.

Leaders have spent time building up their bank accounts for integrity, authenticity and responsibility so when the time comes, people are ready and willing to follow and elect their party of choice.

Join the Reliability Party and Make Reliability Great Again!

Warm regards,

Terrence O'Hanlon, CMRP
About.me/reliability
CEO and Publisher
Reliabilityweb.com
Uptime Magazine
http://reliability.rocks

uptime®

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

FOUNDER
Kelly Rigg O'Hanlon

EDITOR
Jenny Brunson

CONTRIBUTING WRITERS
Roberto Barrera, Aaron Black, Daniel Brennan, John Crossan, Ana Maria Delgado, Robert S. DiStefano, Ramesh Gulati, Burt Hurlock, Alan Knight, Roger D. Lee, Peter Lempriere, Dr. Adrian D. Nembhard, Richard Overman, Victor C. Owunne, Nathan Pettus, Doug Plucknette, Dr. Jyoti K. Sinha

ASSOCIATE EDITOR
Sean Flack

DESIGNERS
Jocelyn Brown, Apolonia Lemus

PRODUCTION PLANNER AND SCHEDULER
Andrea Zapata

SALES & ADVERTISING
Crystal Ward
Client Success Manager
crystal@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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For subscription updates
subscriptions@uptimemagazine.com

Uptime Magazine
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Leadership for Reliability

RELIABILITY® IN THE NEWS

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2016 *Be Inspired* Award Winners

Richard Ruth (center), Product Manager–Services, Danfoss Group receives a *Be Inspired* Award from Alan Kiraly and Sandra DiMatteo, Bentley Systems.

Michael Salvato, Program Manager, Enterprise Asset Management, MTA

Bentley's Year in Infrastructure 2016

Uptime® Magazine had the honor to attend Bentley's *Year in Infrastructure 2016* Conference and Awards Ceremony on November 1-3 in London, United Kingdom. Bentley Systems is a global leader dedicated to providing comprehensive software solutions for advancing infrastructure. The event included presentations from the *Be Inspired* Awards finalists, industry forums and special keynotes from Bentley leaders exploring the future of infrastructure and advancing the technology in asset performance.

Each year, Bentley gathers the world's leading companies in infrastructure design, construction and operations to acknowledge their advancements and recognize the best of the best. This year, over 300 nominations from 80 countries were received for the 18 *Be Inspired* Awards.

Danfoss Group, a Danish global producer of products and services used within infrastructure, food, energy and climate, won the award for "Innovation in Asset Performance" based upon their smart store solution. The company's solution helps customers optimize food safety and maximize energy efficiently. Their story was featured in the April/May 2016 issue of *Uptime*. To read more about Danfoss Group and their award-winning program, visit www.uptimemagazine.com.

Congratulations to All 2016 Be Inspired Winners!

Certified Reliability Leader Workshop Traveled the World

- Fort Myers, Florida
- New Tecumseth, Ontario, Canada
- London, United Kingdom
- Pleasanton, California
- Abu Dhabi, UAE

For upcoming 2017 locations and dates, see pages 48-49.

Greenfield Ethanol representatives with the Emerson Reliability Program of the Year judges

Emerson's Reliability Program of the Year Award

Former Uptime Award winner, Greenfield Ethanol, won Emerson's Reliability Program of the Year Award presented at the Emerson Exchange, October 24-28 in Austin, Texas. Judges included Klaus Blache, Director, University of Tennessee RMC; Paula Hollywood, Analyst, ARC Research and Terrence O'Hanlon, CEO and Publisher, *Uptime* Magazine.

Rhys Davies to Lead Asset Management Black Belt Training

Rhys Davies, Director, Discursive and Chairman of ISO TC251 (ISO55001) will lead the Uptime® Elements™ Asset Management Black Belt course at the Reliability Leadership Institute, February 28–March 2, 2017, in Fort Myers, Florida.

Contact crm@reliabilityweb.com for more details.

Maintenance TIPS

Keep the Air Your Machine Breathes Clean and Dry

It is important to stop airborne contaminants from entering tanks, drums, or machine reservoirs. The good news is this is one of the easiest problems to address through high quality desiccant breathers that strip particles and moisture from the air. Whenever there's an exchange of air, either due to volume changes or thermal siphoning, a desiccant breather should be used. This includes on bulk and tote storage tanks, drums, transfer containers and all critical in-service equipment.

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

Learn Why Operators Are Your Facility's MVPs

Football season may be in full swing, but the most valuable players we're talking about is right inside your facility. Plant operators play a critical role within processing manufacturing facilities. In order for your operators to be successful, facilities must first start with the defining of routine operator rounds, which include daily surveillance activities, documentation for trending, swapping spare pumps and more.

Properly trained operators with effective operator round guidelines can provide the following benefits:

- Avoidance of downtime and catastrophic failures through early detection;
- Minimization and/or removal of external, often random failure causes;
- Assurance that all operators perform at a consistent level;
- Improved process reliability and increased plant availability.

PinnacleART • (281)-598-1330 • www.pinnacleart.com

Rolling Element Bearing Wear

First stages of bearing defects will produce telltale, non-synchronous vibration frequencies called "bearing tones" and their harmonics. Bearing tones at 0.006 inches per second peak (81 VdB) or higher are considered significant. Sometimes a new bearing will produce bearing tones, possibly because of damage during installation, shipping, or defective manufacture. If the bearing defect is very small in size, such as a crack in one of the races, the vibration signature will show harmonics of the bearing tone with little or no fundamental frequency present. If the defect begins as a spall over a larger area of the race, the bearing tone fundamental will usually be higher in level than the harmonics. As the defect becomes worse, the overall level of the bearing tones will increase, as will the overall broadband noise level.

Glenn D. White • Introduction to Machine Vibration
www.reliabilityweb.com/bookstore

The 13 Ingredients in a Successful Job Recipe

People	1. Person(s) with the right skill(s) – physically, mentally 2. Safe job steps and procedures 3. Identification of hazards and mitigation 4. Custody and control of the asset 5. Safe access to assets, work platforms, humane working conditions
Materials	6. Correct parts, materials, supplies, consumables 7. Correct special tools 8. Adequate equipment to lift, bend, drill, weld, etc. 9. Up-to-date drawings, wiring diagrams
Administration	10. Proper permits and lock-outs 11. Proper waste handling management 12. Testing plans 13. Clean, paperwork, returns

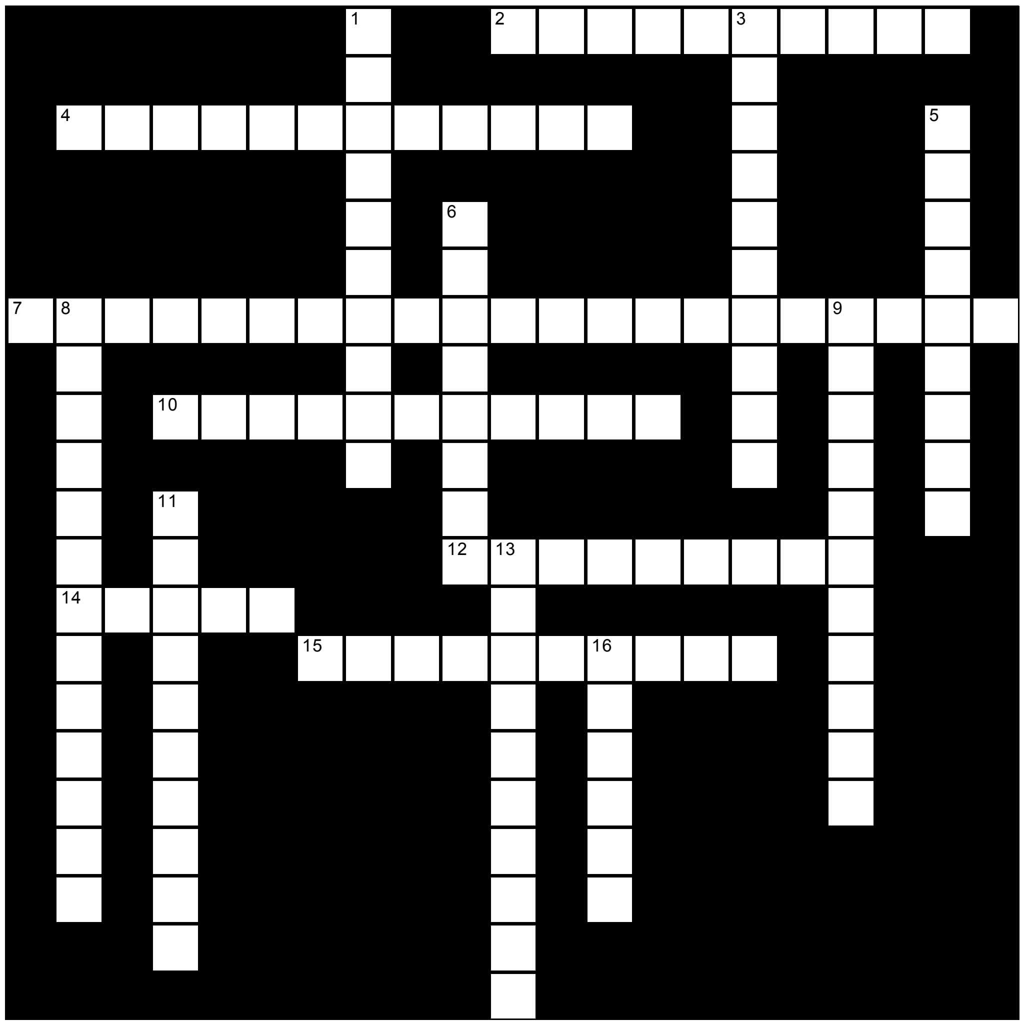
Life Cycle Engineering • (843)-744-7110 • www.lce.com

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

uptime® Elements™

Created by Ramesh Gulati

Crossword Puzzle



ACROSS

2. A basic problem-solving tool that uses unbiased ideas of group members to generate a list of possible options
4. The series of activities in a project network diagram that determine the earliest completion of the project
7. A philosophy of leadership, teamwork and problem-solving resulting in continuous improvement throughout the organization
10. A type of energy that is considered to be environmentally friendly and non-polluting, such as hydro, geothermal, the wind and solar power
12. A document that recommends methods to be used to accomplish an objective
14. A Japanese word for a workplace where the value is created
15. A bar chart of scheduled activities that shows the duration and sequence of activities and resources planned

DOWN

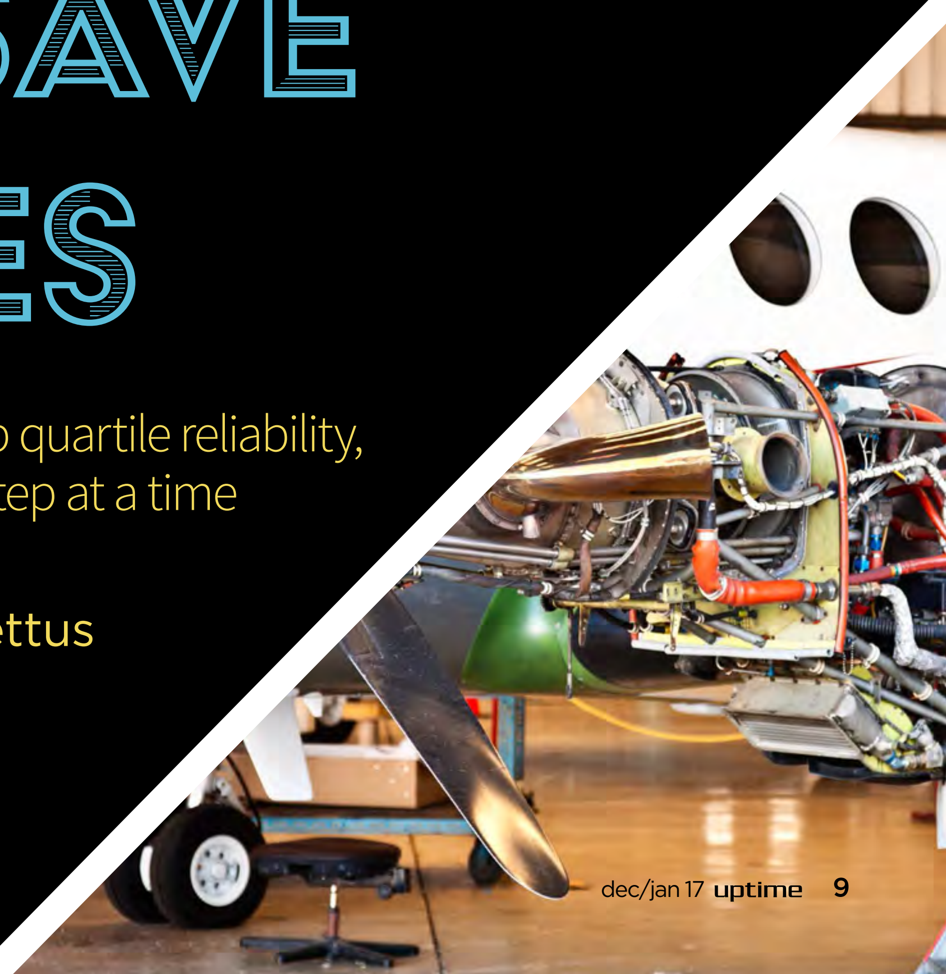
1. The lowest temperature at which vapor from a sample of a petroleum product or other combustible fluid will "flash" in the presence of an ignition source
3. A process of determining which jobs get worked on, when and by whom based on priority, resources, and asset availability
5. A graphical summary of the process steps and flows that make up a procedure or process from beginning to end
6. A process of determining the resources and method needed, including safety precautions, tools, skills and time necessary to perform maintenance work efficiently
8. A change from one way of thinking to another
9. A management practice of sharing information, rewards, and power with employees so they can take initiative and make decisions to solve problems and improve performance
11. Knowledge, awareness, skills, and abilities required to perform a task or job safely and consistently to a required standard
13. The use of sonic technology to discover asset problems
16. An event or situation that may lead to an emergency or disaster

See page 64 for answers.

THE CULTURAL SHIFT THAT CAN SAVE LIVES

Embracing the journey to top quartile reliability, one person and one step at a time

by Nathan Pettus



An interesting statistic reveals that 65 percent of the American population feels certain they are better at math than half the general population. While both ironic and funny, it is also quite telling of how people naturally tend to overestimate the likelihood of positive outcomes compared to less desirable results. It is simply human nature to hope for the best outcome. For the most part, there is no real harm in believing one's math skills are better than they really are. But, when you overestimate the reliability of equipment that you count on every day to perform your various jobs, the results are not just surprising – they can be dangerous.

Relative newcomers to the emerging discipline of reliability likely failed at times to hold themselves accountable to this standard. Looking back on engineering designs you participated in, you probably see now that instead of a reliability approach, you relied on your own personal and hopeful belief in yourself, others and the equipment's ability to perform. You're not alone in that regard. Just like Americans and their assumed math prowess, probably close to 75 percent or more of Fortune 1000 CEOs would rank their company in the top 25 percent of all companies when it comes to reliability and safety. But, of course, only 250 of them would be correct. Ultimately, safe and reliable operations come through design diligence and careful planning, and these only come through individuals' behavior.

Consider this article a simplistic first step in changing your own behavior. Take a stand and officially holding yourself accountable in this area. It's a challenge you need to take because people's lives may depend on it.

Reliability – A Newcomer's Perspective

There are a number of well-defined disciplines with measurable and recognizable contributions to positive plant performance, among them finance, engineering and safety. Mechanical engineers think they have a firm grasp on what it means to have a reliable design, machine, or system. Quite simply, it should not break before the design criteria specification, whether that might be 1,000,000 fatigue cycles under a bending moment and torque or some other established measurement read learned from one of the many college textbooks. But, when you look at a company that focuses on a customer's reliable operations, you really start to have meaningful conversations on the topic.

Through these conversations, you begin to realize that you did not actually "get it." In fact, much like those college textbooks, you may find the subject rather complex, esoteric and, if you're being brutally honest with yourself, a bit confusing. Sure, you understand the terms and jargon, but it simply does not resonate on a personal level. Terms like overall equipment effectiveness (OEE), availability, P-F curves, mean time between failures (MTBF), mean time between repair (MTBR), etc., are all important, but they are engineering definitions. They do not really get to the heart of the matter. They don't resonate with those outside the day-to-day equipment operation, which is what is required for reliability to become a first-class discipline, like safety, human resources, or finance.

To help bridge this gap, take a step back and think in a different, perhaps more simplistic, way. Ask yourself: What does it mean to be reliable at its very basic foundation? You probably use the term almost everyday with your family, friends and coworkers, so it clearly has a "human" definition and meaning for everyone – simply doing or performing as expected. When a system, person, or object acts as it is supposed to in your mind, regardless of whether you were told or assumed what to expect, you deem it reliable and trust that it will continue to act in the same manner. It's that simple.

> "Every decision has **reliability** factored into the final outcome."

Why does this matter? Well, if everyone thought and discussed reliability in this human and simplified light, it would help, even force, all parts of an organization (e.g., operations, IT, HR, finance, engineering, sales, marketing, etc.) to feel connected to a broader mission — delivering on what is expected. This is the concept behind the "Big R" known as reliability. It's looking at reliable operations across the whole enterprise in a holistic way. Everyone and every department plays a role in making their workplace trusted and reliable. This should be a critical goal in every facility because you simply cannot have safe operations unless you have reliable operations. But to achieve that holistic, Big R

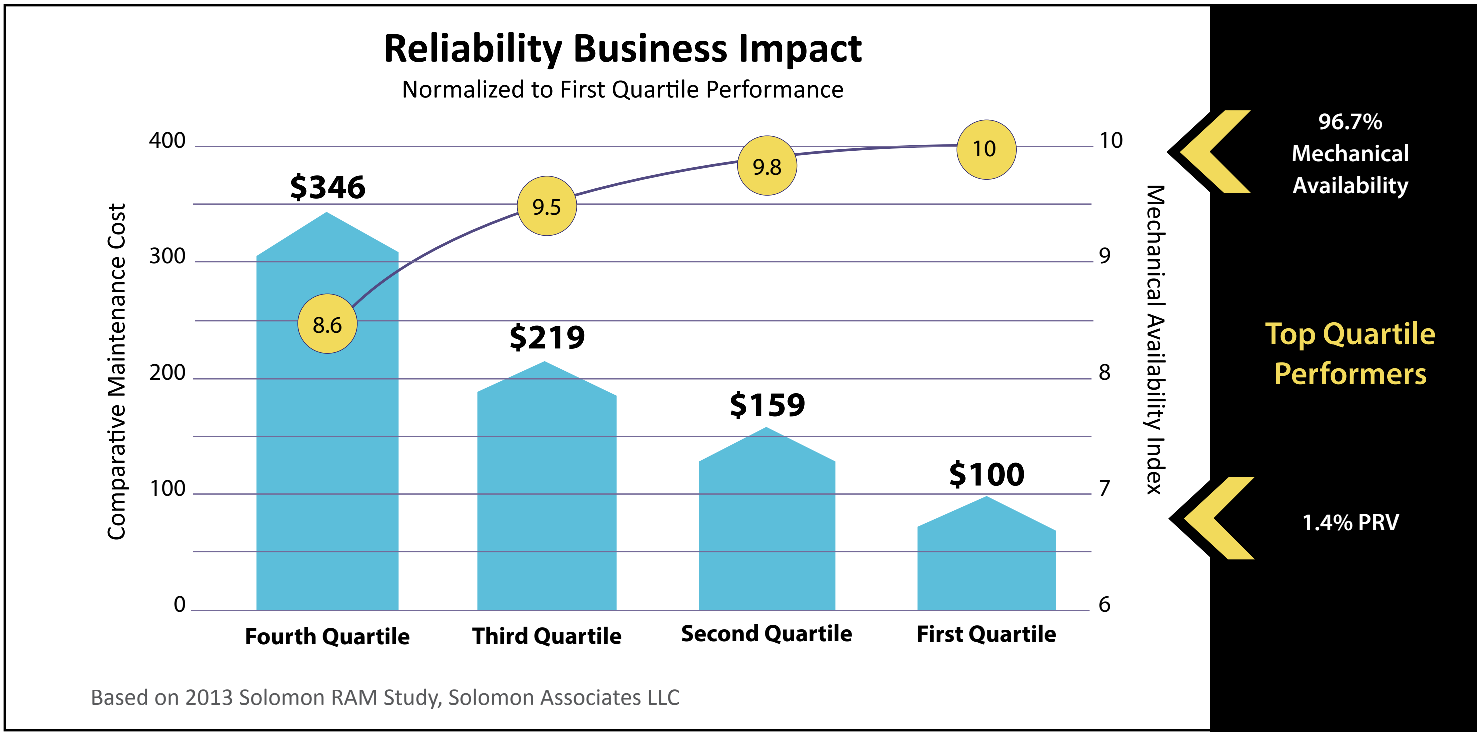
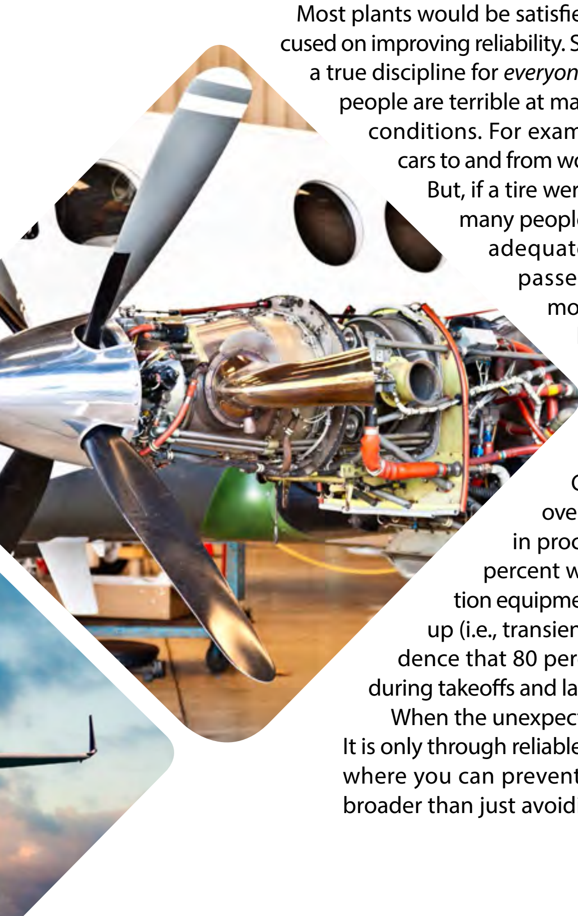


Figure 1: Double the benefit, reduce costs and increase production through Big R

reliability, you first have to start in small ways, say "little r" reliability. Implementing both Big R and little r reliability is critical to performing in the top 25 percent of your industry peers, or achieving top quartile reliability.

Big R – A Holistic Approach to Trustworthy Operations



Most plants would be satisfied with a few departments focused on improving reliability. So, why must reliability become a true discipline for *everyone* in an organization? Because people are terrible at managing unexpected, transient conditions. For example, most people drive their cars to and from work every day without incident. But, if a tire were to blow out at 70 mph, how many people would manage the situation adequately to keep themselves and passengers safe? Probably, a few more would think so than actually could. When an unexpected, fast acting situation occurs, most people do not actually respond as well as they think they would. Couple that with the fact that over 50 percent of safety incidents in process industries occur in the 10 percent window of time when production equipment is shutting down or starting up (i.e., transient conditions). It's not a coincidence that 80 percent of airline fatalities occur during takeoffs and landings.

When the unexpected happens, people get hurt. It is only through reliable systems working as designed where you can prevent the unexpected. But, this is broader than just avoiding a mechanical breakdown. Trustworthy equipment requires everyone to design, plan and act in a predictable way. That is why looking at reliability more broadly matters. Certainly, there are obvious business and financial benefits from operating a plant more reliability. But most importantly, implementing Big R reliability across the enterprise will keep people from getting hurt. This way of thinking is also the true determining factor for achieving top quartile reliability.

> "It is only through **reliable systems** working as designed where you can prevent the unexpected."

The Airline Industry – Your North Star

There is good news for those in the process industry. There are shining examples of entire industries that have gotten the Big R approach right. Foremost is the commercial airline industry. Think about the last time you flew on an airplane. As the plane accelerated down the runway and lifted off, were you tempted to take a quick nap? The fact that most people would even consider this speaks volumes about how much they trust that entire industry.

Planes do crash and when they do, the first reaction most of the time is to assume pilot error.[1] Actually, most of the time, it is pilot error. How can this be true when there are literally millions of parts to an airplane, many of which could cause a catastrophic failure? Yet, people still board their flights and, for the most part, trust with 100 percent certainty that they will get where they are going in one piece. Why?[2] Because planes are actually as reliable as

anything you deal with in your daily life. There is a very simple reason why this is so — the folks at Boeing and Airbus, in fact the entire industry, take a Big R look at their enterprises.

According to those who have worked in the airline industry, from the very first new employees orientation, the importance of their role in overall human safety through reliable processes is a cultural institution. Every decision has reliability factored into the final outcome. Procurement thinks about reliability when it negotiates supply contracts. Human resources ensure potential hires have a certain inherent quality to care about their role in the big picture. Even finance factors reliability into its quarterly reports. Reliability is just part of the culture. This is Big R. It's what your organization should strive to mimic because the human benefits are substantial.

Having an inherent culture of Big R can overcome industry turnover. With the large number of impending baby boomer retirements, it is feared that the number of industrial accidents are going to escalate at an unacceptable and alarming rate. Experience can mask a lot and allow seemingly reliable operations in very unreliable environments. When the experienced baby boomers leave, their knowledge is unsustainable unless you have institutionalized Big R.

All the Benefits of Big R

Obviously, any benefit pales in comparison to those that impact human safety. But, there are some measurable financial benefits to taking a holistic approach to reliability. Achieving top quartile performance through reliable operations can be called a double return on investment (ROI) driver. This means working on reliable operations for your facilities creates two (double) positive financial benefits.

Figure 1 shows that plants in the top quartile spend only 34 percent on their maintenance budgets compared to their peers. This is counterintuitive, but true nonetheless. Reliable plants do not need to fight reactive-based fires, which, as you know, cost a ton of time and money. Top quartile facilities proactively address only those assets that need attention and they do it in a planned, intentional way. This saves money and the data proves it. Spend less on maintenance and have more reliable equipment, a true win-win.

Additionally, top quartile performers see about 16 percent more production each year than those in the bottom 25 percent. When talking about facilities that produce millions of tons of product a year, this obviously has a huge financial impact to their bottom line. Often times, top quartile companies do not necessarily document or track these impacts unless some internal audit or ROI analysis exposes it, but the benefit is real and consistently proven across all verticals (e.g., oil and gas, power, refining, chemical, pulp and paper, life sciences, etc.). Facilities that approach reliability holistically excel and their performance persists long term. Whenever you read about a plant closing, which is usually depicted in the press as due to cost structures or inefficiencies compared to peer facilities, you have to wonder if those jobs could have been saved if someone had looked at the overall reliability program. In some cases, one could assume the answer is yes.

But, the financial impacts are just the icing on the cake. What is really important is that anyone can walk into any factory or process facility around the globe and feel as safe as they do when they board an airplane. Organizations have a way to go, but a Big R approach is the path forward. It is an undisputed fact that plants with the highest availability due to reliable equipment also have the best safety records. The two go hand in hand and correlate explicitly.

It all goes back to reducing unexpected transient situations. Keep things in steady state and generally humans can stay out of trouble. However, getting there is non-trivial and involves all workers. When every employee in every conversation thinks about reliability to the same degree as others do about safety or cost controls, you will achieve this level of trustworthy operations. Then and only then can leaders or stewards say they have achieved their goal of reliable and safe facilities. It's a matter of conscious capitalism, an act for safety's sake that also has the benefit of making more money. You can't get much better than that.

Little r – Changing the Mind-set One Step at a Time

Okay, so it has been established that everyone should care about their work in driving reliable, trustworthy outcomes. That's great, but everyone also

" Ultimately, safe and reliable operations come through design diligence and careful planning, and these only come through individuals' behavior. "

> **"It is an undisputed fact that plants with the highest availability due to reliable equipment also have the best safety records."**

has their own jobs to do and those jobs require employees to perform tactical, everyday tasks. This is where the concept of little r reliability comes in, by realizing that big changes come from small changes. The butterfly effect is real. A small disturbance in one area can have dramatic, unforeseen impacts down the line.

This is good news because no one in a large company could ever make a difference otherwise. There are many examples where one person started a major change in company dynamics from a seemingly small initiative. You have probably heard stories of a single individual taking a small step (e.g., an entry level procurement clerk asking for improved reports on supplier quality metrics) that leads to major changes in overall company policy. Little r reliability is about taking a small step, no matter how seemingly tactical or even insignificant, toward broader trustworthy operations.

Starting small is really important. Often times, if you try to focus on the big picture, you just never start. No one would take up running by signing up for a marathon. You run one mile first, then two, and so on and so on. Eventually, you run a marathon. When the small goals seem achievable, you are more likely to be successful achieving your bigger goals.

Reliability is no different. Perhaps some companies can start with the big picture in mind and leverage the vision of a CEO or other leader to transform the entire business in one fell swoop. Most facilities will need to take smaller steps, such as working the oil analysis process into some documented order, or ensuring there is a reliability training system in place for human resources to educate employees. Each and every tactical progression sets an example and has potential for positive impacts beyond the initial intentions. Who knows what one of those newly trained employees might go on to accomplish in the journey towards Big R reliability!

The important thing is for all employees to believe that reliable operations mean you are safer and more profitable, and from time to time, each of them can take a stand to improve reliability. Don't just take the cheapest option, take the most reliable option. Don't just walk by a pump, find out if that pump is critical to the overall operations of the plant. If it is, make sure it is part of a proactive reliability program.

A Shared Challenge and Path Forward

You have likely heard the Albert Einstein definition of insanity: "Doing the same thing over and over again and expecting different results." Change requires change. If those in the process industry are going to make their plants and facilities safer and more profitable, they, as individuals, will have to take a stand. You have to stand up in meetings, in e-mails, in conversations about how having reliable, trustworthy operations is important and matters.

This is not difficult, but it is also not trivial. Everyone has too much to do already and this is yet another thing to worry about. However, reliability does truly impact so many facets of the overall business that it is worth the time. And, in reality, it is not that difficult. Simply ensuring in the next budget cycle that there are line items to repair or improve older equipment, or selecting new vendors based on quality metrics versus just price are two small examples of how you can start this journey.

In the end, reliability can be broken down into five simple steps:

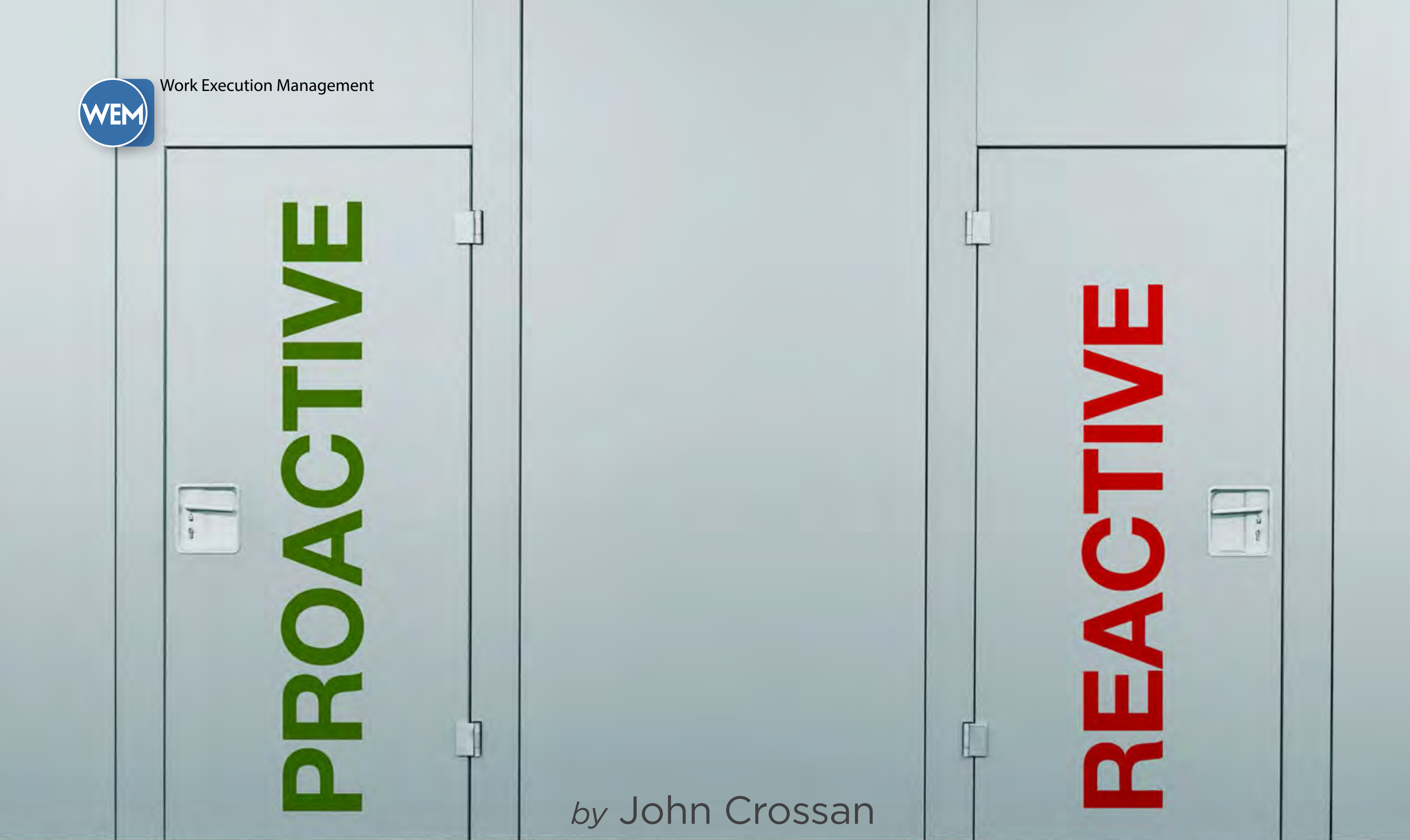
1. Understand what you have (i.e., what equipment and processes exist in your facility or business);
2. Know the current state (i.e., health) of that equipment or process;
3. Recognize what that state tells you to do (i.e., what action should be taken?);
4. Take that action;
5. Repeat.

If everyone looks at jobs, facilities and companies with this simplified model, the result would be a much more reliable, predictable world. One that is more profitable, but much more importantly, one that is safer.

Endnotes

1. While there are many sites providing plane crash statistics and attributing the main cause to pilot error, www.planecrashinfo.com provides a very detailed summary of causes dating back to the 1950s. The site specifically notes that even when weather or mechanical error plays a part, it is pilot error that is ultimately to blame.
2. "Is it safe to fly?" (http://www.garfors.com/2015/03/is-it-safe-to-fly-dangerous.html) and based on aviation statistics reported be The Economist in "Danger of death!" (http://www.economist.com/blogs/graphicdetail/2013/02/daily-chart-7), the average of fatal crashes in 2010-2014 worldwide was one in 2,925,000 flights, or 0.000034% risk.

__Nathan Pettus__ is the Vice President and General Manager of Emerson's global Reliability Solutions business, first joining Emerson in 1998. Nathan provides leadership to Emerson's machinery health technologies and services, delivering improved safety and availability to Emerson customers. He recently expanded his leadership role to include a wider range of reliability technologies and services. With the end goal of helping customers achieve top quartile reliability in their facilities. www.emersonprocess.com



by John Crossan

Do We Really Want to Be PROACTIVE? (Part 1)

As we struggle to move from reactive to proactive maintenance, maybe at some point we just need to stop and ask ourselves the basic question:

"Do we really want to be proactive in maintenance? Really? Honestly?"

BRIEFLY RESTATING THE DIFFERENCE:

REACTIVE MAINTENANCE is dealing with loss issues due to equipment malfunction that show up unexpectedly and repairs have to be done immediately, on a crisis basis, in a very inefficient, unplanned, unscheduled way.

PROACTIVE MAINTENANCE is monitoring equipment for signs of deterioration and performing the necessary repairs and adjustments, when needed, in an efficient, planned, scheduled way, before a loss issue actually happens.

Who wouldn't want to operate in the Proactive Mode?

Unless, maybe, you feel reactive behavior is actually useful in some ways?

One way would be

Managers Using Crises As A Way To Keep Organizations Energized…

Organizations and people seem to naturally get complacent over time. We fall into ruts in performance and behavior where we don't like to push ourselves outside of the routine.

Procrastination seems to be a natural human tendency. "Why do something that will take some different kind of effort today?" Something that might lead to issues we haven't had to deal with before. Something that might be difficult and stressful.

We don't want to disrupt an environment that feels comfortable and safe.

So the status quo just gets stronger and stronger, and we feel more and more powerless and incapable of changing it.

We drift into the "Just Show Up Every Day" mode then wonder why we're bored, feel insignificant and don't seem to get much satisfaction from our work.

Visiting plants, it's evident how purposeful, or not, people seem to be in their overall manner. Do they look and talk like they value their time and their contribution? Do they look and talk like they feel someone else values their contributions? Or does it seem like there's just nothing of any immediate importance or concern? "Lack of a sense of urgency" is the term we use most often.

A few years back, a friend was very excited when he joined a large, well-known technical organization, but then left after barely a year, disappointed with the inertia of so many there who refused to, or just couldn't, change their thinking and processes. And the company was just gradually fading.

So, it's a manager's job to keep an organization energized. To keep everyone moving onward and upward out of the ruts. To maintain that sense of urgency. To build a culture where people are concerned when things are just not happening the way they should be, or could be, and they go ahead and systematically do something about it.

Energizing an organization is not an easy thing to do and crises, real or fabricated, and a push for immediate fixes are one way to do this.

A popular saying a few years back was: "A crisis is a terrible thing to waste."

Forcing the organization out of its routine behavior to deal with the crisis. Pushing people out of their comfort zones to do things, right now, that weren't in their plans for the day. It's a way to emphasize the importance of dealing with problem issues. Of getting the needed improvements made. It breaks us out of the ruts. Out of the "business as usual" attitude.

And we've grown used to quicker being better. We've found ways to eliminate non-value adding operations and the time they take. Order Processing Times, Changeover Times, Product Development and Introduction Times, etc., have all dropped dramatically over the last decades.

We are not patient in our customer service expectations. "We hate to wait."

It just feels better when something gets done right away.

Military history, which we love to apply to industry, has examples of brilliant commanders who won by acting quickly and unexpectedly. (But many more who lost by being too slow.)

And we all know from our own experience that if something isn't acted on fairly quickly, the chances of it actually getting done fall off rapidly as time passes. Other issues come along and this one gets pushed back or forgotten.

So, pushing an organization to act quickly is absolutely the right thing to do. (Most of the time.)

But it has to be done correctly, otherwise it can make it harder to get an organization to act proactively. Harder to take the time to "Do it right."

It gives the impression that we always need immediate action, regardless of the issue.

The proactive process takes work and it takes time, and we're constantly told we have to eliminate both to be efficient.

We're coached that issues should only surface once and be dealt with decisively, immediately and completely.

I've sat in daily production meetings and listened to intense questioning on how fast current issues can be fixed, with not much emphasis on taking time and focusing efforts to understand the issue and correcting the underlying process deficiency that caused it to occur.

And there's usually little interest in reviewing yesterday's issues. What was found? And what preventive measures might be put in place to prevent the issue from recurring?

Fixing today's crises preempts everything else (and again crises that probably wouldn't have even happened if basic proactive processes were in place).

It's difficult to build a proactive culture when people feel they must always completely deal

To build a culture where people are concerned when things are not happening the way they should be, or could be, and they go ahead and systematically do something about it.

with issues immediately, or face criticism and embarrassment in meetings, or perhaps worse. It can also become a competitive forum for the politically ambitious to display their ability to get their repairs dealt with quickly by diverting the most valuable resources, whether warranted or not.

Back to the military, George Armstrong Custer probably would say he wished he'd taken a little more time to better assess the situation.

While this affects all plant processes, particular damage can be done to the Maintenance System Processes. Things that typically happen in the crisis repair mode, even if the issue has already been mitigated (as they usually are), include:

- **We bypass the maintenance planning and scheduling process** that would get the repair done effectively and efficiently, normally at the earliest on next week's schedule, but based on its priority in the overall plant scheme of things.

  We jump in and try to make the complete fix when we don't exactly know what the problem is and whether we have what we need to fix it.

  And we disrupt the other work and the personnel we had scheduled, which perhaps means giving up some hard to come by downtime opportunities.

  But to some, a maintenance work management system is just administrative bureaucracy. We should be able to get it done right now, or something is wrong. And the planning role is just a misuse of a good technician who could otherwise be making repairs.

  So, now we're wasting our limited maintenance resources.

- **We pull maintenance technicians away from performing preventive maintenance (PM) inspections** to deal with the issue. This obviously would seem to be the right thing, as inspections really don't need to be done immediately.

  The problem, then, becomes that we never seem to be able find that right time to do them.

  So, now we're doomed to dealing with even more surprise crises.

- **We use our "Best" individuals**. Pull them away from whatever they're working on to deal with the crisis. Bypass the less developed individuals who could be learning from this. That would just slow things down.

  Also, as our mechanics are usually our best technical troubleshooters, so best to use them to solve operational issues, rather than waste time developing the operators.

  So, we're wasting developmental opportunities that will increase our resources.

- **We add to our Parts Inventory.** If we don't have the part in stock, then immediately add it to the in-house stocked items list. So we can fix it quicker next time. (And now we just accepted that it will happen again.)

  Even though we may have previously made the decision not to stock it, as we can get it pretty quickly from a vendor anytime we need it.

  So, we're again wasting valuable resources.

- **When we've made the repair, it's done.** It's over. It's fixed.

  So, what's the point of taking time for a follow-up review of what happened?

  Probably not even time to document the issue and what we did.

  On to the next.

  No discussion of what can be done to prevent it from recurring. So, history will undoubtedly repeat itself. And again, we're wasting a capability development step.

PROACTIVE

Of course, you will always have to make some immediate crisis repairs, so you have to have that capability developed, but you need to recognize that immediate repair is a very ineffective, inefficient activity.

Of course, we will always have to make some immediate crisis repairs and we have to have that capability developed, but we need to recognize that immediate repair is a very ineffective, inefficient activity.

The numbers usually quoted are that emergency or generally unplanned maintenance work:

- Costs four to 10 times more than planned work;
- Takes four times longer;
- Is usually not the best solution (Not the way we would do it if we had time to think about it and get organized.);
- Usually needs to be redone.

This just eats up our resources. We will never have enough people, parts, or money. And worse, we're hurting our overall reliability.

Demanding immediate action is an effective way to disrupt the organization, but not always the right approach. People know what is really a crisis and what isn't, and managers lose credibility when they make every issue a crisis.

The work just never gets done really well or efficiently. The issues don't get fixed permanently. Processes are not improved. There is never time for learning. And people get discouraged and burn out.

We prefer hyperactivity to lethargy, but neither is good.

The best, most effective managers, I worked with, over the years, were the ones who always seemed to know about every production issue, every quality issue, every safety issue, every personnel issue, as well as every other issue in the place, and they were concerned about them and communicated their concern.

But, they also acted, and expected, and constantly coached, others to act in an appropriate and balanced way. Fostering the proactive approach and processes.

Not insisting that permanent repairs must be done right now, but emphatic that they be dealt with correctly; that the maintenance process gets them scheduled, done and not forgotten.

And, there was never any excuse for ignoring a problem situation.

Part 2 of this article addresses:
How Do We Do Both?

- Deal effectively with issues in a proactive way;
- Keep the organization energized.

***John Crossan** consults in manufacturing and maintenance improvement. He spent 40 plus years with major companies in operations and engineering. For much of the last 14 years of this, he mainly focused on improving operations by fostering the installation and ongoing implementation of basic manufacturing and maintenance processes, incorporating lean concepts, across some 30 varied plants in the U.S. and Canada.*

REDEFINING RELIABILITY THROUGH LEAN PRACTICES

by Aaron Black

The concept of reliability changes from business to business. No one definition is correct because reliability needs change from one business to the next. However, personnel in charge of a reliability program should have a clear answer to what reliability means to them. This article helps define what reliability means to an organization, shows where flaws can develop in the program, explains how reliability responds to evolving business needs and demonstrates how lean principles can relate to these processes.

WHAT IS RELIABILITY?

To date, reliability has focused on rigid metrics and goals. The problem with this is that it doesn't provide the flexibility businesses need to thrive. Assigning unyielding metrics based on the current data set limits programs to only what can be envisioned in the present. If reliability programs cannot change, they quickly become outdated as the business environment changes. Static reliability programs can shift from a useful, cost-saving system to an expense.

To combat this, a program champion is needed to guide reliability efforts. The program champion concept has been bandied about a great deal over the years, but the general perception is someone who understands reliability principles and how to apply them correctly. This person has the knowledge and experience to identify critical information gaps, especially when current activities are not sufficient for the required task. A program champion should be empowered to adjust a reliability program to the needs of the business.

Additionally, technicians need to understand the concepts used in their reliability programs and how other reliability tests complement the testing they perform. They do not need to be experts in the science behind the analysis they perform, but with the proper training and encouragement, can assist the program champion in triaging results and suggesting when additional testing could be beneficial.

WHERE DO YOU GO FROM HERE?

After assembling the right personnel, a program needs to be put together. A basic reliability program is easy to set up using articles, instructions and other resources available today, but it must be based on goals that will aid the overall success of the business. The program champion or an executive needs to examine how equipment reliability will best serve the short- and long-term goals of the business and develop reliability goals that serve the business's needs.

However, this is easier said than done. There are many questions that need to be resolved in order to customize an effective reliability program. What are the goals that management wants to accomplish? Are they attainable within the budget? What are the tools available? Are there informational gaps? In many cases, the answers to these questions are more complex than expected. The key to success is not just finding the answers, but to reevaluate at set increments to make sure reliability measures are working and the goals are attainable.

WHAT ABOUT LEAN?

Flexible reliability programs need an environment where program champions and technicians work together and balance each other. Lean processes provide the flow and structure needed for effec-

> "reliability has focused on rigid metrics and goals"

tive, lasting, process change. However, to apply a lean idea properly, you need to understand the term. Like the often misunderstood program champion term, many use lean concepts ineffectively.

A fundamental flaw in the application of lean practices starts with how you use the term. Lean is not a destination. It is a process, a way of thinking and shorthand for the concept of continuous improvement. It is sometimes defined as doing more work with fewer resources, but a more accurate definition would be performing tasks in the most appropriate way for a specific situation. Fairly often, more work is done using fewer resources, but the real goal is to improve the overall outcome.

Lean applies to reliability by helping the program change and making sure the change is appropriate to the situation. Changes in lean organizations are more organic because they only occur when the reliability program has a need for change. Lean helps an organization see the need for change and make the correction. The two do not always move in the same pattern, but the lean process helps a reliability program remain relevant to business goals.

When a reliability program is static and has no process to make changes, the staff discovers better ways to perform their jobs, but they need to circumvent the outdated goals of the reliability program in order to do what's best for the company. If they remain devoted to the reliability program's goal, it can ultimately work against the business and absorb resources needed elsewhere. While savvy companies will see the disconnect and correct it, others will question the validity of predictive maintenance and return to their preventive or reactive reliability strategies.

This is such a common occurrence, it is practically cliché. Facilities that have experienced this are easy to spot when talking to employees. They report programs that start and do well before slowly trailing off to a quiet death. Nobody truly understands why a sound concept failed, so it is revived again years later in a new initiative and the cycle begins again.

The reliability world needs to be closely aligned with the people using the equipment, working on the production line and those trained on lean principles. A reliability program champion with lean training or a lean champion working in a reliability program is the most effective at creating and sustaining a successful program. These champions naturally identify principles disconnected from company goals, perform a failure analysis and enact the change needed to address what caused the failure. In addition, they follow-up on the fix to see if it worked and identify what else needs to be done.

WHAT'S NEXT?

This collaboration between lean and reliability can and does happen. The combination is incredibly impactful, so it's easy to see the concept becoming the next major focus in maintenance. Leaders in this up-and-coming field will be able to streamline their reliability programs and become effective in ways businesses have only just begun to see.

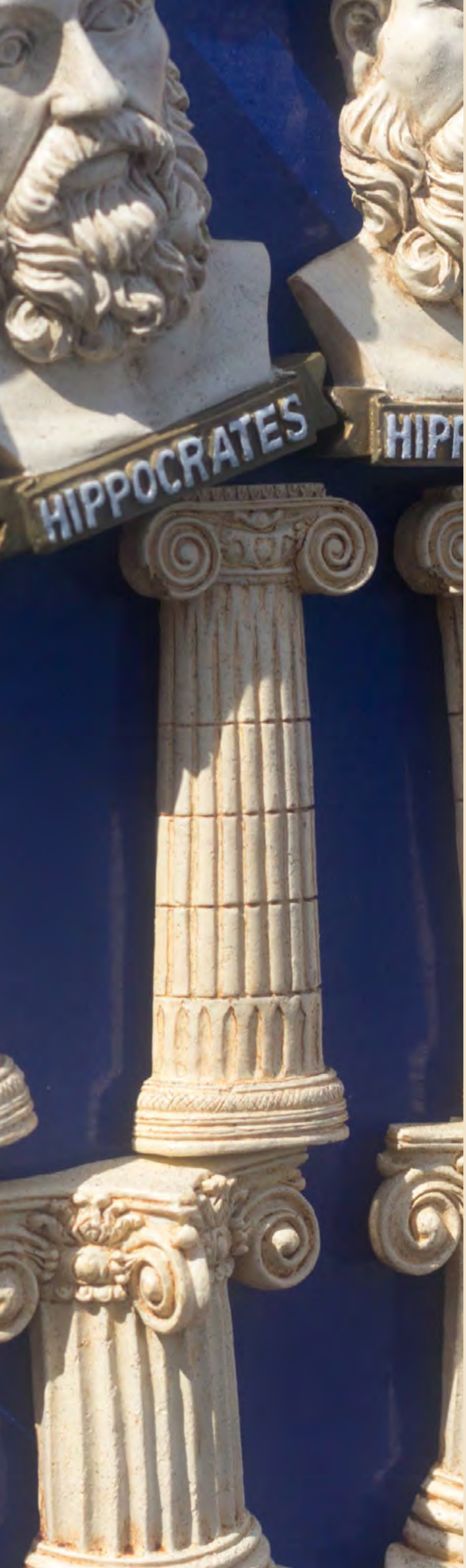
Aaron Black *has 20 years of experience in oil analysis and reliability in both a laboratory setting and in-the-field work, with an overall specialty in microscopic analysis. A member of the POLARIS Laboratories® team since they opened in 1999, Aaron collaborates with customers to improve the impact, uptime and reliability of their equipment and maintenance programs. www.polarislabs.com*

DO NO HARM:

THE HIPPOCRATIC OATH APPLIED TO RELIABILITY

by Alan Knight and Ana Maria Delgado

The Greek physician Hippocrates (c.460 BC – c.370 BC) is credited with an oath that was meant to provide certain ethical standards a physician was to uphold. While maintenance is not of the magnitude as being a doctor, organizations would do well to apply portions of the Hippocratic oath to their maintenance practices. Two such examples are: "…*to teach them this Art, if they shall wish to learn it, without fee or stipulation; and that by precept, lecture, and every other mode of instruction, I will impart a knowledge of the Art to my own sons, and those of my teachers, and to disciples...*" and "*I will follow that system of regimen which, according to my ability and judgment … and abstain from whatever is deleterious and mischievous.*"[1] This article focuses on the latter, "*and abstain from whatever is deleterious and mischievous,*" or in 21st century vernacular: Do no harm.



Two key ingredients of any reliability effort are precision installation and maintenance practices.

Maintenance reliability professionals have a responsibility to their superiors to deliver results that improve the bottom line via increased uptime and productivity. But they also have a responsibility to those technicians who are expected to assist them in the process of increasing asset uptime and improving reliability. Regardless of your certification or the acronym attached to your signature block, without the technician's solid understanding and performance of the basics, you will not achieve either goal. Two key ingredients of any reliability effort are precision installation and maintenance practices. Without them, you will find yourself replacing the same motors, pumps, etc., repeatedly.

From the reliability-centered maintenance (RCM) teachings of Stanley Nowlan and Howard F. Heap, both engineers at United Airlines, and John Moubray, the originator of RCM2, it is learned that there are six distinct failure curves. Furthermore, as many as 68 percent of failures can be attributed to infant mortality or failure induced at start-up/installation.

More recent studies by RCM practitioners, such as Doug Plucknette in the manufacturing industry in the early 2000s, are consistent with these early studies at 67 percent. Regardless of the study or your preferred practitioner, the fact remains that infant mortality is the largest contributor to component failure and its largest contributor is inducing failure modes as a result of improper installation. Experience in the trades can attest to the fact that what people don't know, they don't know. Or to reference psychologist Abraham Maslow, if all one has is a hammer, everything looks like a nail. Maintenance technicians rely on the knowledge they possess – right or wrong – and the tools they have at their disposal – good or bad – to perform the work with which they are tasked. It is the job of reliability professionals to properly educate their technicians and give them the right tools to be successful.

One method to ensure their success and prevent inducing infant mortality when installing new components is utilizing precision practices. Some examples include:

- Precision alignment – shaft and sheave;
- Torque specifications and tools;
- Quantitative job plans;
- Standards;
- Training.

In the reliability arena, a familiar concept is the P-F curve, where P is the point where the defect occurs and F is the point of failure. If improper methods are employed during installation, point P might begin the moment power is supplied to the asset after repairs. By using precision alignment and installation techniques, you can utilize another curve: the I-P-F curve, where I represents installation. The concept behind this curve is to extend the line from I to P as far as possible utilizing precision techniques. There are many precision installation techniques, but for the sake of this article, the focus will be specifically on precision shaft alignment.

An article in the April 1999 "Maintenance Technology" magazine[2] gives a very thorough reporting of results from a study performed by the University of Tennessee Reliability and Maintainability Center, where researchers performed experiments to determine the effects of misalignment on bearing life. In summary, one of the

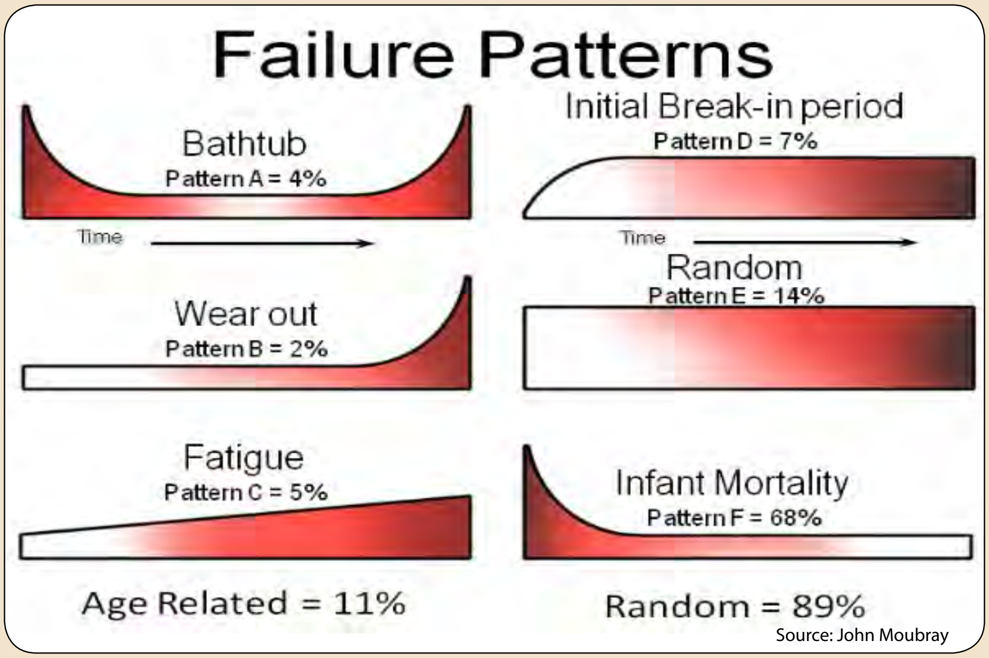


Figure 1: Failure patterns

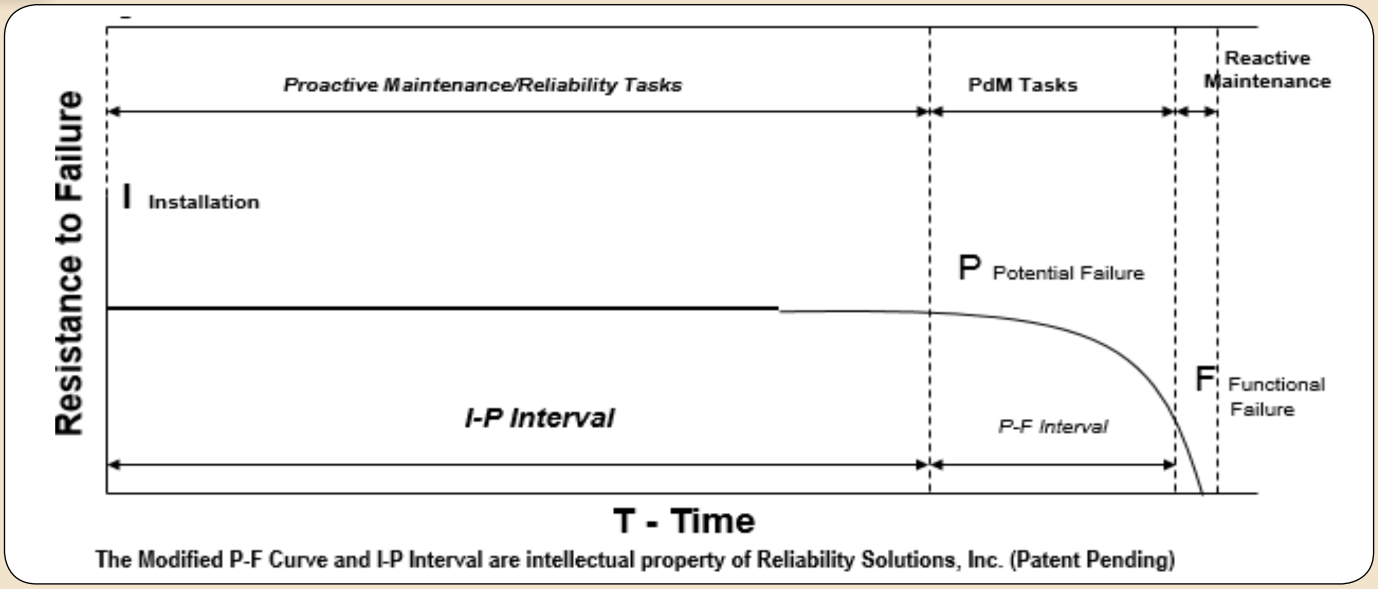


Figure 2: I-P-F curve

study's conclusions was that as little as 1-3 mils (.001"-.003") can reduce bearing life by 10 percent due to increased load on the drive end bearing, depending on the type of coupling used to connect driver to driven component. Also, with some types of couplings, as little as 5 mils (.005") can cut bearing life by as much as 50 percent. Think about it, you can reduce inboard bearing life by *half* with improper installation techniques.

In addition to being detrimental to bearing life, misalignment has been shown to increase energy consumption as much as nine percent[3] and reduce lubricant film thickness by as much as 75 percent in journal bearings.[4]

Besides aligning the shafts, a critical step in installation is detection and elimination of soft foot. Soft foot causes machine frame distortion and results in an uneven air gap between the rotor and stator in a motor and can result in additional increases in power consumption of up to 17.4 percent.[3]

In fact, many machine failures and defects can be eliminated up front by correctly installing and aligning shaft and belt-driven equipment by, among other things:

- Making sure the foundation is properly sized for the weight and operating conditions of the asset.
- Ensuring the baseplate is properly bolted or grouted to the foundation; both should be flat and level.
- Centering equipment horizontally on the baseplate, with equal amounts of shims placed under each foot. Installing jack bolts is also recommended to facilitate horizontal movement of the machines.
- Tightening all anchor bolts to the proper torque.
- Requiring precision alignment of the machines to proper tolerances prior to releasing the asset to operations.
- Selecting the right length and material belt and its pitch angle, then correctly installing the belts and sheaves.
- Correcting all three types of misalignment – vertical angularity, horizontal angularity and axial offset – as part of the precision alignment process.

Armed with this knowledge, how can you, in good conscience, *not* provide your people with the right tools for, and training in, proper installation techniques, such as precision shaft alignment? When you think about it, very few people set out on a path to do poor work. Most maintenance technicians are no different than doctors, lawyers, or engineers in that they want to be the best at what they do. They each have a deep sense of pride in their work and skills and most will readily accept tools, training and techniques to make their jobs easier.

In conclusion, one more observation: Precision maintenance, in and of itself, is not the golden ticket to world-class reliability, but used properly, it is a powerful weapon in your arsenal in the battle against unplanned downtime. It allows your technicians to be more productive and proactive, thanks to a reduction in rework and urgent repair work. Best of all, it allows you to apply the Hippocratic oath and "do no harm."

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Alan Knight *is the reliability manager at Mueller Company in Albertville. He has 30 years of experience in the maintenance and reliability fields as a mechanic, vibration analyst, and reliability professional. He holds certifications as a Level III vibration analyst and Level II infrared thermographer, as well as CMRP from the Society to Maintenance and Reliability Professionals and CRL from the Association of Asset Management Professionals. Alan currently resides in Ashville, Alabama. www.muellercompany.com*

Ana Maria Delgado *is a Certified Reliability Leader (CRL) and the Marketing Manager at LUDECA, Inc. (www.ludeca.com) in Doral, Florida. She is responsible for creating awareness of the benefits of proactive condition monitoring through the use of maintenance technologies, such as precision laser alignment, vibration analysis, balancing and ultrasound, to increase machinery reliability. www.ludeca.com*


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USING DIGITAL TECHNOLOGY to Revolutionize Turnarounds

> *This type of approach lets managers keep their finger on the pulse of the turnaround and make objective, data-driven decisions.*

by Peter Lempriere

When industrial companies have to take facilities off-line for essential maintenance or upgrades, careful management of the process is key. These turnarounds, or TARs, can be complex and require meticulous planning and solid execution because delays only mean more lost production and higher costs.

That's no small challenge. TARs typically involve a large influx of contractors that can double or even triple the number of people on a site. They can also involve working with sophisticated heavy machinery, managing complicated materials logistics and operating in difficult environments. Companies have found that the ability to draw on the experience of previous TARs to guide a current effort is vital. But too often, that information is not captured effectively or is simply too vague and the people who worked on the last project have moved on to other roles.

All of this means that during the execution of a TAR, managers find it difficult to keep track of the effort and cannot respond quickly to unexpected problems, potentially affecting productivity and the overall duration and cost of the TAR.

But now, digital technology is supporting dramatic improvements to TAR management. By drawing on this technology, managers can have a near real-time view of their TAR, and use it to keep workers and the project on track.

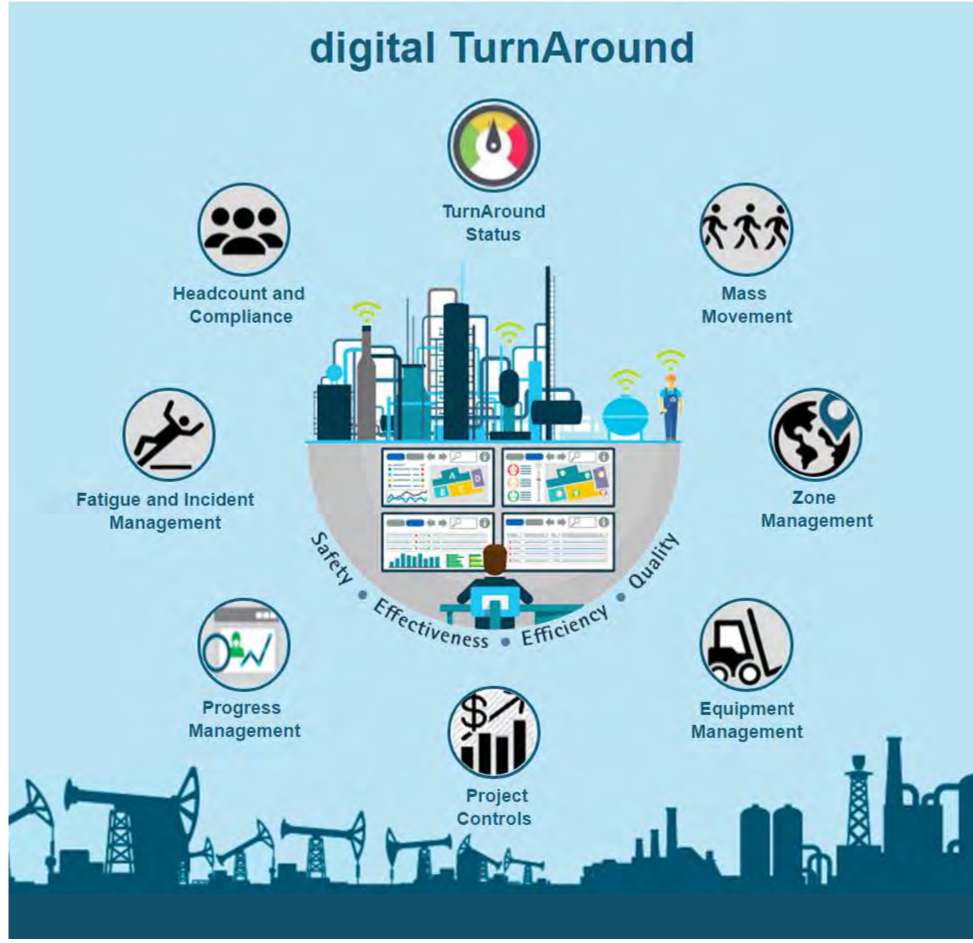

Figure 1: Combining industrial pervasive wireless, location tracking applications and event analytics, companies can track movement trends, progress, worker fatigue and more on the digital turnaround platform

How It Works

With a digitally enabled TAR solution, radio-frequency identification (RFID) tags are worn by workers and attached to mobile equipment. These tags are linked via Hazardous Area compliant Wi-Fi connectivity to create a pervasive network, with receivers set up to enable triangulated location accuracy to within 10 to 15 meters. This data is integrated into a TAR analytics platform, combined with current site-related data, and integrated into the analytics platform.

The resulting information is then displayed on a set of interactive dashboards that provide a concise view of key factors, such as mass or individual movement, time spent in different geofenced zones, potential worker fatigue and project progress, among others. Delivered as a service, this platform is set up on-site in or near the TAR command center.

This type of approach lets managers keep their finger on the pulse of the turnaround and make objective, data-driven decisions and take quick action during the TAR event. They can see factors, such as the time workers spend on the site, where workers spend that time, trends in the movement of people and potential fatigue risk factors. They can also identify inefficiencies in near real time and then drill down into the data to discuss root causes of problems and ensure accountability of relevant stakeholders. In addition, the system can capture all this information and store it to provide lessons learned to support future TARs.

The technology enables TAR managers to be much more responsive. They can work with factual data, such as the amount of time that working teams spend waiting at permit facilities, or going to and from workplace zones at shift changes and rest periods. They can quickly identify pinch points associated with the time required to retrieve materials and tools from logistics areas. When excessive delays are seen, managers can identify interventions that proactively remove the barriers affecting productivity by, for example, securing extra permit authorizers; staggering start, finish and break times to reduce congestion; or even moving storage and tooling facilities closer to the work area.

In addition, managers can gain important insight, with the ability to filter data by vendor, role, or discipline to understand, for example, the amount of time that frontline managers are physically within the work area zones. That's important because experience has shown that having leaders spend more time in the field rather than in the office is vital to supporting safety, quality and productivity.

A Record of Results

Although a relatively new innovation, this type of service has been applied successfully to five major TAR events that involved event budgets as much as $150 million, tracking of up to 5,000 personnel and nearly two million hours to date. Results have been impressive: Each of these events was completed 15 to 25 percent below the labor execution budget.

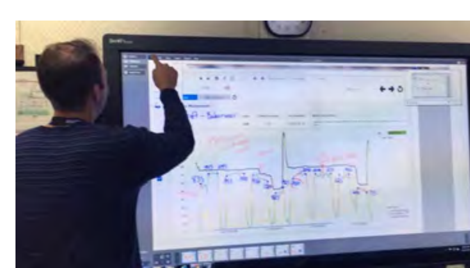

Figure 2: Interactive dashboards allow TAR managers to perform root cause analysis in near real time by drilling down into key data to identify underlying issues responsible for inefficiencies or project delays

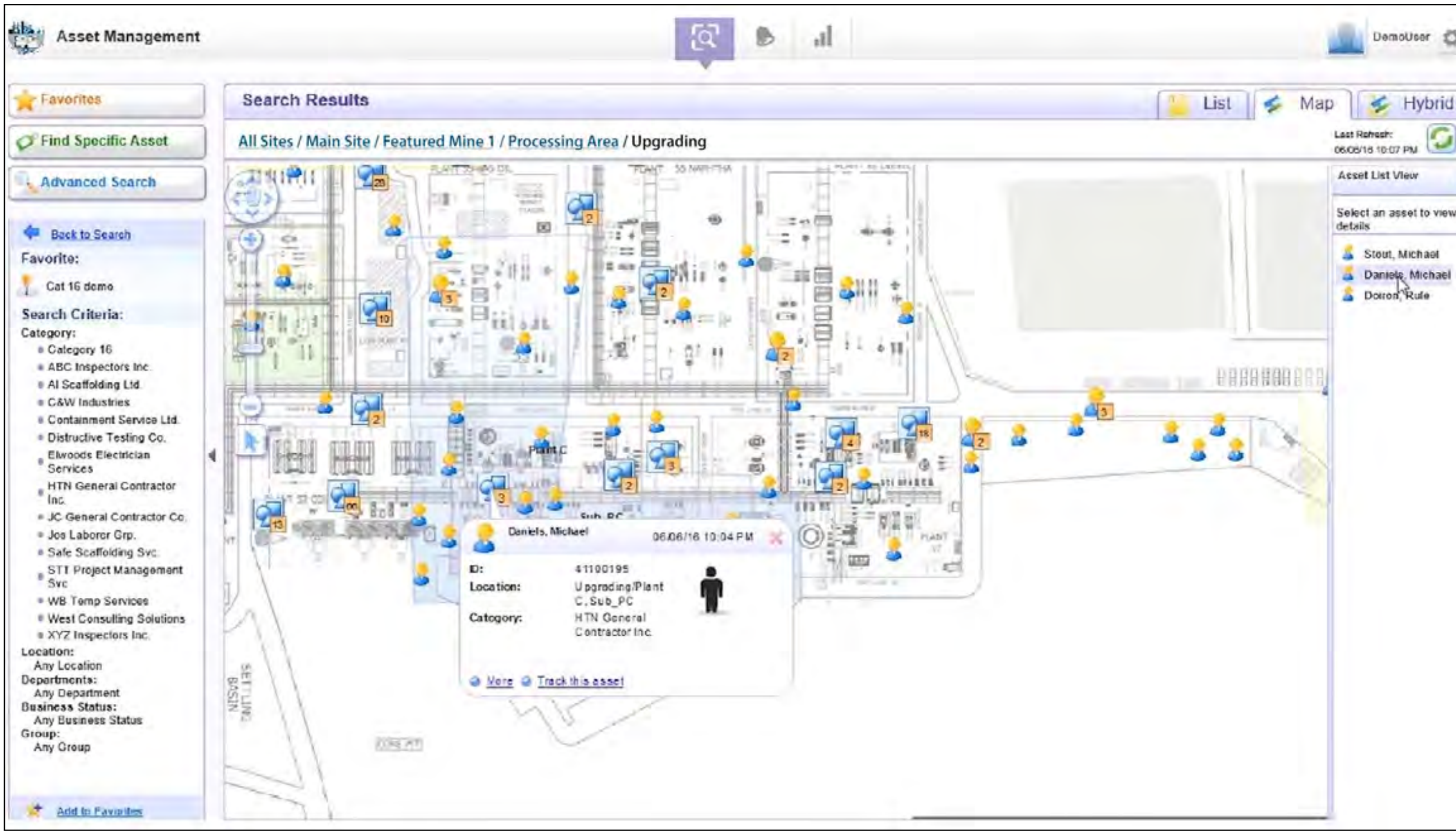

Figure 3: Interactive screens display geo-location data from RFID tags, allowing managers to track workers' locations on-site in real time

This approach can also bring significant benefits in terms of safety. It provides a comprehensive view of who is on-site and where they are, regardless of what their duties are or which vendor employs them. And in the event of an emergency, workers can be accounted for and missing individuals located within minutes, versus traditional muster methods that can take more than an hour.

Within industrial plants, an accurate view of what is happening on-site is critical.

Having this pervasive network in place opens the door to other safety measures, as well. For example, RFID-enabled badges can be equipped with worker-down alarm buttons and motion detection capabilities. These can alert the control center when there is a problem, then managers can identify the individual by name, company and discipline and see where the worker is on the site, allowing emergency teams to respond with speed. The RFID technology also can be incorporated into continuous gas monitors, allowing real-time work environment exposure alarms to be sent to the control center and automatically logged into the company's incident system. The company can then easily analyze that data in later investigations.

Across industries, digital technology is being used to continuously improve asset and process management, enabling predictive analysis and the ability to move beyond reactive responses. Now, that kind of innovation is being applied to TARs. Indeed, it is easy to imagine how this type of TAR solution could be applied even more broadly to support day-to-day maintenance operations and capital projects.

Within industrial plants, an accurate view of what is happening on-site is critical. Today's digital technologies can enable real-time decision-making, capture operational data for continual improvement and improve accountability in operations. It's clear that digital solutions open up tremendous opportunities in the pursuit of safety, productivity, cost management and high performance.

***Peter Lempriere** is a Senior Manager within Accenture's Asset and Operations practice based in the London office. Peter is a charted Manager and Engineer, having 29 years of oil & gas experience with major upstream and downstream assets. He consistently pursues continuous improvements securing positive results within engineering, maintenance and operations functions to increase reliability and operations efficiencies.* www.accenture.com

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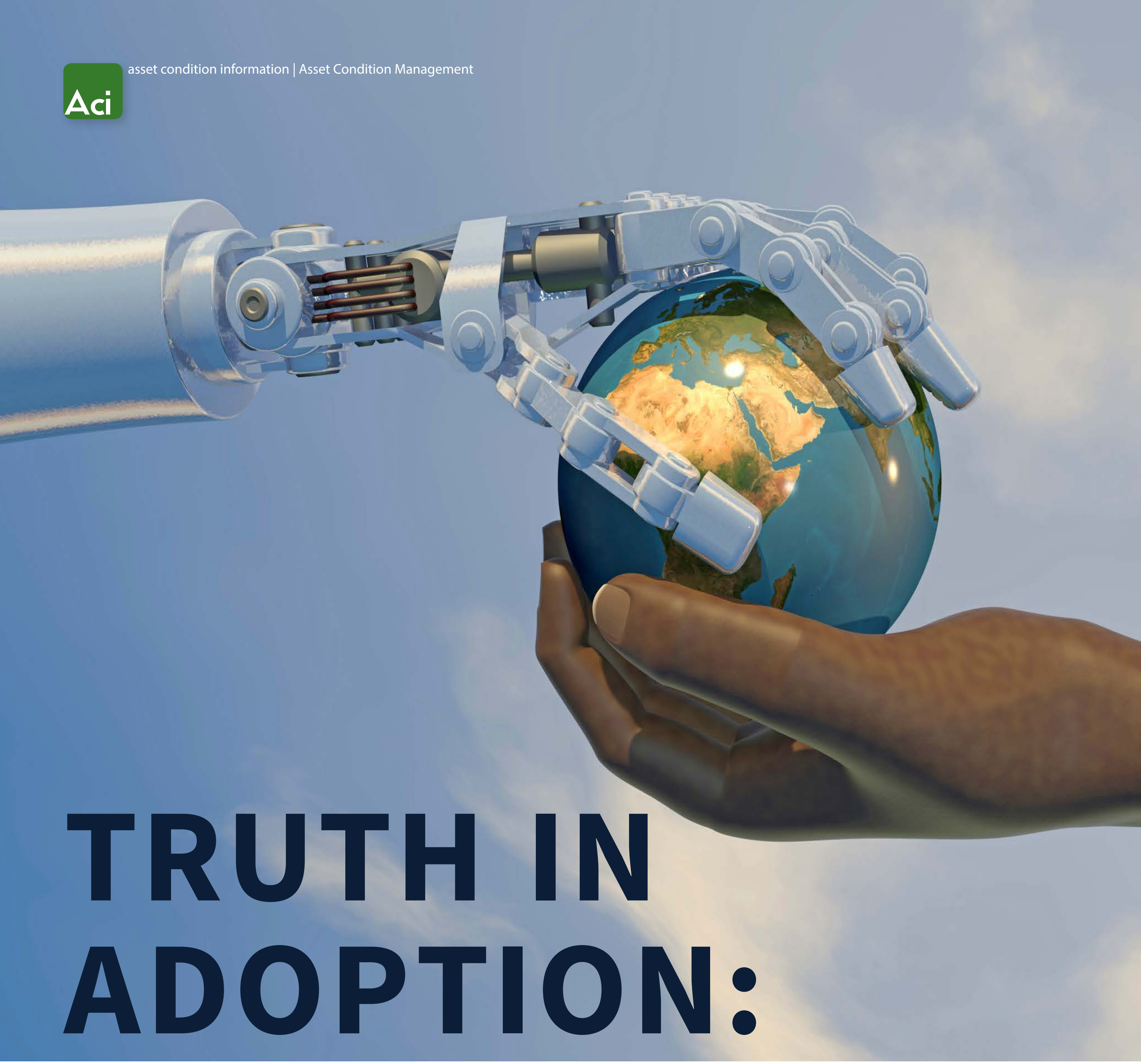

TRUTH IN ADOPTION:

HOW FAR IN THE FUTURE IS IoT FOR ACM APPLICATIONS?

by Burt Hurlock

Judging from the independent perspectives of three very different industry observers, the Internet of Things (IoT) for asset condition monitoring (ACM) applications is quite far into the future. *Plant Services*, a mainstream industrial trade publication, Gartner, Inc., a prominent global market research organization, and Russell Reynolds Associates, a leading global executive search firm, have each recently published surveys and opinion pieces that offer the perspective of industry insiders on the outlook for IoT ACM applications. The consensus is that the market may not be as ready or willing as its suppliers would have everyone believe.

As of August 2016, Gartner's *Hype Cycle for Emerging Technologies* placed the Internet of Things at the very peak of the hype cycle, poised to descend into the "trough of disillusionment," just behind machine learning, which Gartner shows leading the way into the trough, slightly ahead of IoT. More recently, Russell Reynolds Associates published the results of its *Digital Pulse* survey of executives, which rated the chances for a moderate or massive digital disruption in 13 major markets. The industrial sector placed dead last. And finally, in recent years, *Plant Services* has asked plant managers and maintenance engineers to rate their ACM programs, which should, arguably, be improving by virtue of more powerful and scalable technologies and cloud offerings. For two consecutive years, the data shows that ACM spending is increasing and satisfaction is decreasing, with less than 20 percent of respondents classifying their programs as effective or very effective.

How should one interpret the dissonance between industry headlines (the hype) and the facts on the ground? Will industry ever cross the chasm between self-evident value propositions and the low rate of adoption?

Before the demise of IoT for ACM gets exaggerated, it's important to understand what vendors are asking customers to do. The self-driving car may be a simpler way to think about the problem. Are you likely to be the first to buy a self-driving car? The second? The hundredth, the thousandth? Not likely and it's probably not because you drive a Lamborghini or love to drive. It's because at some fundamental level, you don't trust it. You won't trust it. There's the concern that a bug with a lethal flaw will reveal itself for the first time only after you're in the car. And therein lies a basic human need that no amount of technology will cure – control.

Put another way: What would it *take* for you to buy a self-driving car? How much experience data would you need? Or, does it have nothing to do with the experience data? If it's truly about control then all other things being equal, like cost, mileage and safety, experience data doesn't matter. The operator has but one requirement – the option to turn the damn thing off, override the system and take back control if necessary. Call it trust, but verify.

To engineering purists this defeats the whole purpose. Why it's important for the purists to lock out the user, who has relied on a largely effective positive control use case for more than a century, is anyone's guess, but it forces a standoff. The purists say, "This is better by any number of objective measures," while the user says, "I don't care, unless I know I can default to what I know." Surely, there's a middle ground. There is, but it has to be reached the human way.

> "And therein lies a basic human need that no amount of technology will cure – control."

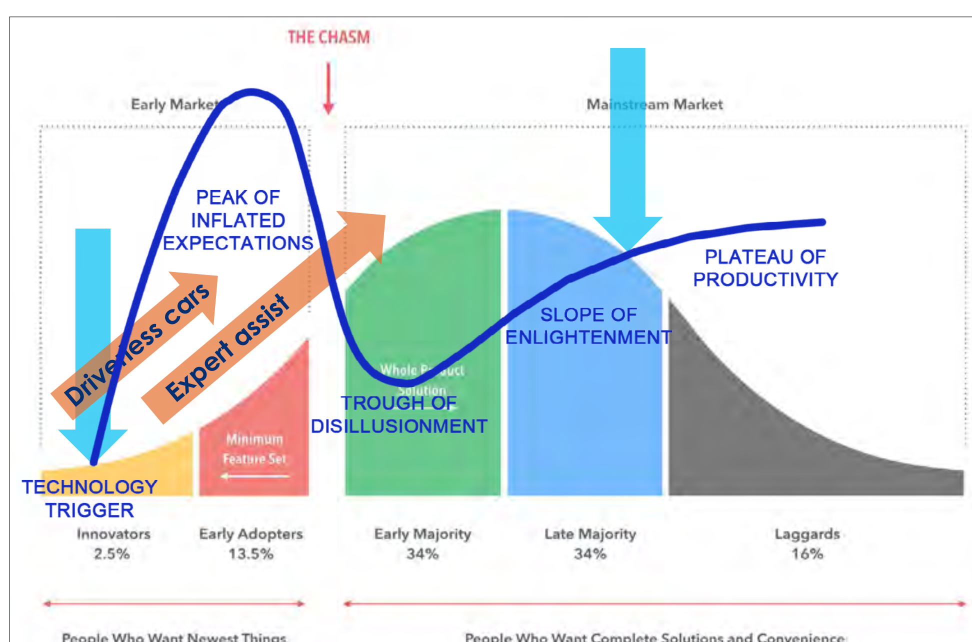

Figure 1: Hype cycle for emerging technologies

> If trust between people takes interaction over years, why should it be different for technology?

At what point does one say, "I trust this or that person unconditionally?" The answer is deceptively simple and lies at the heart of human nature and experience. Trust evolves. It takes time and develops over a series of reaffirming events. Trust is learned, not decreed or ratified. If trust between people takes interaction over years, why should it be different for technology?

It's not. Most people, especially the kind of leaders and decision makers who would contemplate abandoning an 80 percent solution for a 100 percent solution, thrive on control, accountability and confidence in knowledge and understanding that may have taken decades to amass. The idea of abdicating any level of decision-making to an algorithm is anathema. At one level, the loss of control runs contrary to every natural instinct of a leader. At another level, it begs the question of human relevance, possibly even their relevance. It may be irrational, illogical and self-serving, but any commercial offering that runs contrary to human nature faces diminished prospects for adoption.

In the words of the Cat in the Hat, "would you, could you" buy a self-driving car if it were interactive, if it solicited your opinion, welcomed your feedback, or asked for your help? Before you answer, think about how people who do that make you feel. Do you prefer someone imperious and self-centered over someone who wants to know what you think? Like approachable people, the technology needs to communicate. It needs to be likable. Adoption of behavior changing technologies needs to bring the user along by fostering collaboration between operators and technology that builds trust by creating opportunities for reaffirming events.

Gartner's trough of disillusionment is, in fact, only the middle point in its *Hype Cycle for Emerging Technology*. The next phase is the "slope of enlightenment," followed by the "plateau of productivity." If IoT applications of ACM follow Gartner's curve, the industrial sector's present dismissal of

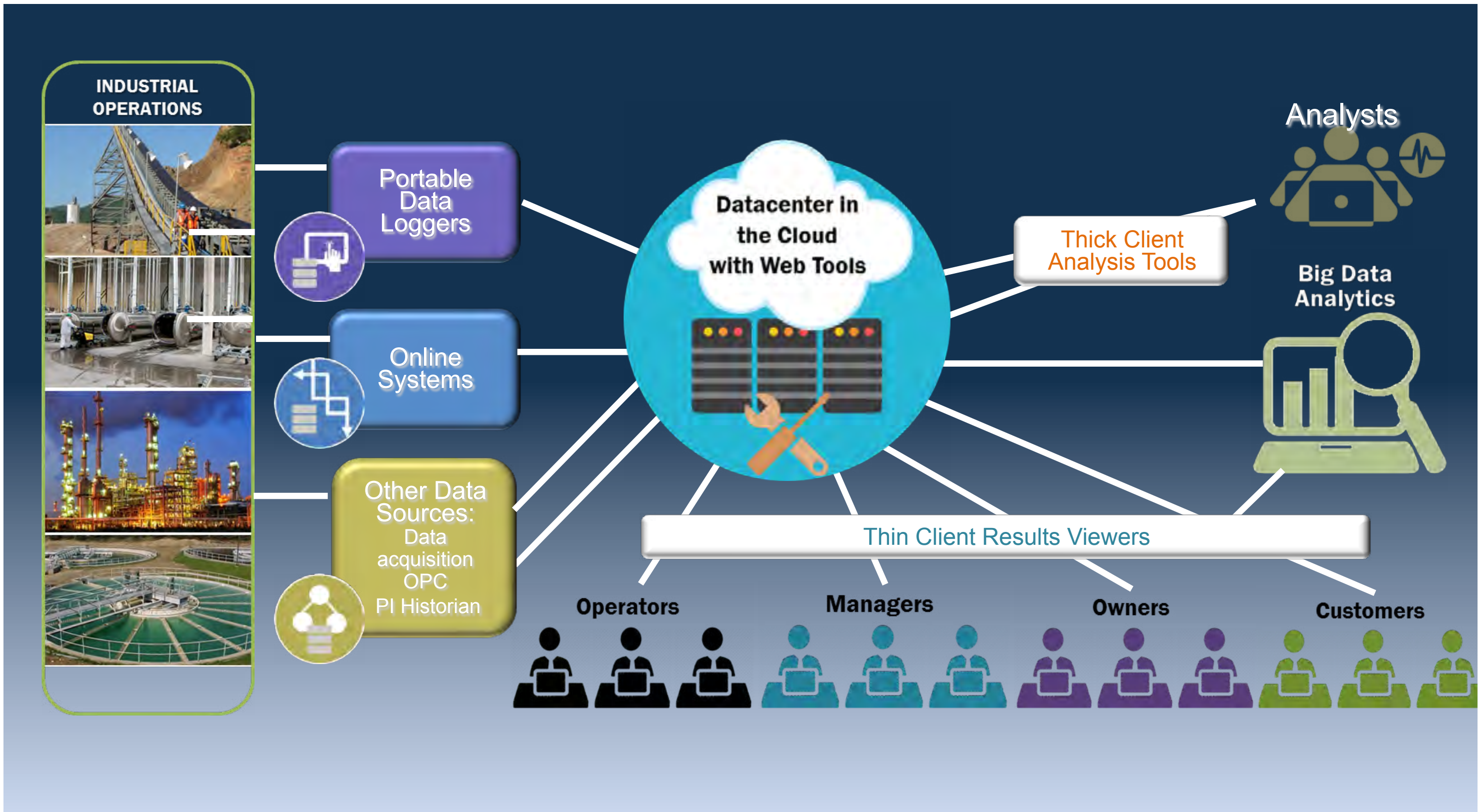

Figure 2: Expert-assisted PdM with IIoT scalability

an "imminent moderate or massive digital disruption" is altogether predictable; a common side effect of the hype that should be expected while the market wrestles with issues of control and trust.

The importance of that wrestling match, however, cannot be underestimated because it's the only way today's operators of cars or plants will develop the confidence to migrate to a new model. The transition will involve advances in efficiency that will move only as fast as operators permit until efficiency and automation become indistinguishable, and even then, operators may still demand the ability to override the system even if they never use it.

That today's computing power already far exceeds any human being's ability to keep pace was proven in 2011 by IBM's Watson, which deftly defeated perennial champions of the television game show, Jeopardy!™ Yet, Watson is still in search of a market. Is the missing link to adoption a human interface, a mechanical analog for the same process by which people come to trust each other, or something else?

Once again, the race for the self-driving car may be instructive. The automobile industry thinks of automation in four categories: a totally autonomous vehicle with zero human interface, like Google's™ purist vision, being Level 4 and an *almost* autonomous vehicle requiring some human oversight, like Tesla's automation initiative, being Level 3. Guess which one is already on the road, in use by consumers, and which one is "years, but not decades away." The rumor is that one of Google's challenges is making the behavior of a Level 4 vehicle "more human" because *always* keeping a safe distance from the car ahead and *always* ceding the right of way to a car changing lanes drives the occupant berserk. The user experience of the purist vision conflicts with human nature. It's not what a driver would do, whereas the Level 3 user experience can supply the purist's baseline *and* provide for human nature to express itself. If adoption is the measure of success, Level 3 is winning.

Tesla's expert assist model has many analogs: modern commercial and military aircraft, trains, grocery checkout counters and banking branches. None *requires* the expert assist and yet the expert remains ever present. Even Facebook™ recently conceded that its algorithms bend to the touch of human hands. If these analogs offer a glimpse of how IoT applications of ACM will evolve, they beg the question of how realistic all the hype is around cognitive computing, smart algorithms and the brave new world of fully automated, closed loop, self-diagnosing and self-repairing smart machines. In a technical sense, it's *mostly* possible, but will human nature permit it? The truth will be in adoption.

Burt Hurlock *is CEO and a board member of Azima DLI, working closely with the sales, engineering, and technical services teams on strategic growth initiatives and on advancing the company's scalable enterprise applications of machine health analytics. Hurlock has spent more than 20 years as a founder, builder, adviser, and turnaround executive for a number of venture-backed professional service businesses. He is a graduate of Princeton University and Harvard Business School. www.AzimaDLI.com*

Reliability and the MRO Supply Chain: 4 Essential Tools

by Daniel Brennan

Many companies continue to struggle with the maintenance, repair and operations (MRO) issue by ignoring or at least tolerating the existence of the MRO storeroom and the necessary operations around it. Few companies work to improve the MRO function in the supply chain and some do not even consider MRO storeroom management as part of plant operations at all. Others are striving to strike a balance in managing MRO.

In his book, ***Outsourcing MRO…Finding a Better Way***, George Krauter writes, "MRO represents the highest percentage of cost recovery opportunity….and should be a major target for reliability and profit improvement."

There is little doubt that MRO storeroom operations, MRO storeroom solutions, MRO supply chain management, or however you label it, is gaining attention from the corporate offices to the production floor. If it hasn't already reached that point at your company, it will.

Why?..... Reliability.

Traditionally, functions assigned to storeroom operations include basic procedures – stock keeping unit (SKU) issuance, min/max measurement, purchasing, receiving and stocking, spot buys, etc. – that enable manufacturers to track part usage and, at least, gain a better understanding as to how much money is being spent on MRO with the goal to optimize cost and increase reliability. While a step in the right direction, these procedures are basic at best. At worst, when not sustained, these same steps can be a drain on production efficiency, returning the storeroom into a worse disarray than before the process started.

Today, as technology evolves and companies grow more sophisticated in MRO supply chain management, it's imperative that operations around the storeroom and the peripheral services associated with it keep pace and maximize efficiency.

There are some encouraging signs as to how companies are recognizing the need to change and are taking specific actions to improve. Here are four critical tools necessary to deliver improved MRO inventory management and reliability.

> Companies are questioning, "Why are we buying parts we do not need?"

1 MRO Supply Chain Services

Gone are the days when the definition of supply chain stops at the receiving dock. Today, companies are using advanced technology to source, purchase, track, measure and evaluate MRO spare parts as those parts move through the supply chain, from the manufacturer through distribution, to the company's MRO store and finally to consumption or the end of shelf life, whichever comes first. To relieve some of the obvious duplications in distribution and associated costs, more and more companies are placing an MRO service provider on-site to manage the MRO storeroom operation.

Supplier relationships are also being redefined; there is downward pressure on total cost of ownership, not just price, driving the need to provide additional services and value. For example, suppliers and original equipment manufacturers (OEMs) often would recommend stocking far more spare parts than is typically required under the guise that more is better, or at least stronger protection against downtime. Companies would follow such recommendations for fear of nullifying the warranty.

But, it only takes a little time to track the lack of usage of some of these spare parts to realize that money is being lost because of these unused parts and there is no true return on investment. It is exactly this activity that is forcing companies to pay attention, monitor the flow of materials through their facilities and hold departments – maintenance, engineering, reliability and others – accountable for MRO costs. Companies are questioning, "Why are we buying parts we do not need?"

As a result, strategic sourcing professionals are forging new relationships with suppliers, where creativity and trust are mandatory. Piece price as king is dead. Buried. In its place are strategic supply chain agreements and relationships that enable both parties to follow the complete supply chain and adjust where and when necessary.

3 Master Data Leadership

Supply chain research shows that an estimated 85 percent of all data management initiatives fail to meet their objectives. That marks the difference between data enrichment and data leadership.

Data enrichment is the process of naming all like parts with a consistent and complete description to eliminate the existence of multiple SKUs and to accurately order and issue the required part.

Data leadership, however, is all of that and more. Enriched data combined with data leadership, particularly governance and stewardship, is master data leadership, which analyzes and uses that data in ways few have seen before, thus returning value through improved maintenance effectiveness, stronger asset management and overall reliability.

Among the goals of master data leadership are:

- Eliminating data redundancies / standardize descriptions;
- Sharing inventory across multiple sites;
- Reducing inventory and the number of SKUs;
- Connecting assets to supply chain data;
- Reducing spot buys; it's likely already in the storeroom under a different description;
- Reducing substocks by building trust and defining duplicated inventory;
- Having the correct parts on hand when needed.

To be successful, master data leadership must be implemented and sustained by an entity with experience and expertise in all categories of MRO and OEM parts. It is not a task recommended for inexperienced staff.

2 Asset Services

A second important tool is the need to connect asset management to MRO supply chain management. This awakening is typically driven by service providers through reliability engineers who are well aware of the need to change. Companies are seeking providers who know how to tie spare part consumption to MRO inventory management to deliver mean time to repair (MTTR) reduction, reliability measures and other continuous improvement initiatives.

Optimum MRO asset management must include activities, preferably from a provider who operates on-site, such as:

- Workflow process analysis;
- Asset hierarchy and bill of material (BOM) development reflected in spare parts inventory intelligence;
- Maintenance planning and coordination that consistently includes communications with the on-site provider;
- Technical procurement that relates to reengineering and commercialization of OEM spare parts.

4 EAM/CMMS

As Tracy S. Smith wrote in the article, "ERP and EAM: Partners Not Competitors" in the June/July 2014 issue of *Uptime* magazine, asset management is "a key driver of an organization's financials and the guts of the operation." He couldn't be more correct.

This is why companies are spending so many resources on reviewing and implementing enterprise asset management (EAM) or computerized maintenance management system (CMMS) technology. EAM/CMMS technology is readily available, but many existing EAM systems look at MRO as a low priority category and, as a result, fail to meet the needs of on the ground maintenance reliability teams. Many systems fail to be in sync with individual maintenance reliability goals; many provide unfriendly operating situations that result in work-arounds and, eventually, inaccurate data.

EAM/CMMS applications for MRO must be customized to each user's situation to meet specific reliability goals and track performance data. Any on-site provider of supply chain services, asset management and master data leadership should be able to provide the proper EAM/CMMS process to support every client's initiative.

CONCLUSION

The expanding role of MRO in achieving a reliable plant requires expertise in managing four essential activities: supply chain services, asset management, master data leadership and customized EAM/CMMS. These must be added to the traditional standard operating procedures of MRO storeroom management.

This collective concept can be labeled, "The New Integration." It is new to the existing world of MRO management and requires a coming together of the provider and plant disciplines to achieve plant reliability goals.

__Daniel Brennan__ is the marketing manager for Synovos. He has presented extensively on the topic of MRO maintenance reliability to professional chapters of ISM, APICS and SMRP. He has also presented at Reliable Plant, the International Applied Reliability Symposium and other events. He is a graduate of Rowan University. www.synovos.com

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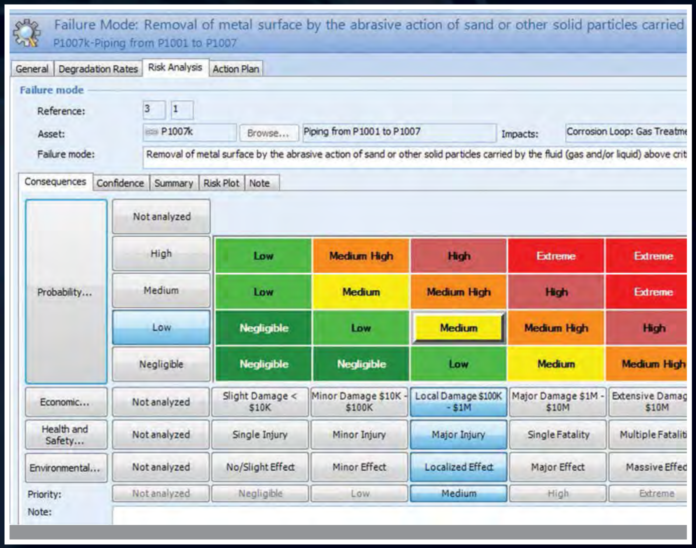

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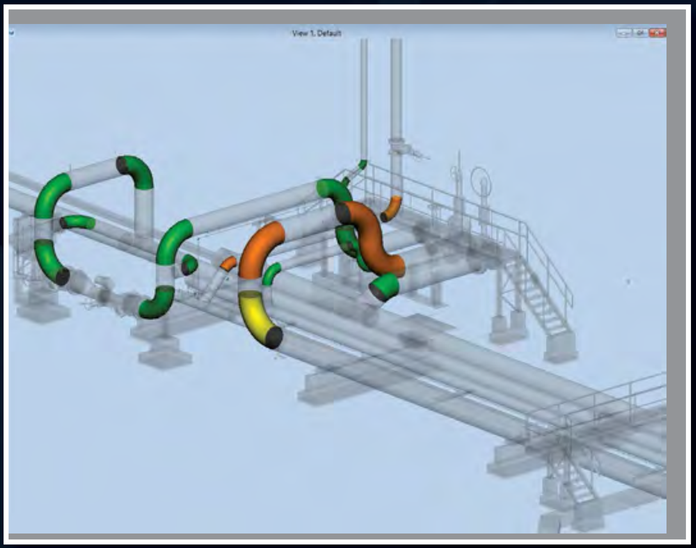

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STRATEGY of

by Roberto Barrera

Asset Management Seen as a Chess Game

Chess is a challenging game that tests a player's ability to think methodically and strategically in order to beat an opponent. It involves specific knowledge and skills, along with a strategy. Engineers could probably say with confidence that all the attributes used to win a chess game are applicable to their work. They are especially prevalent when maintaining equipment. Chess attributes can help you successfully implement effective asset management strategies and help you win the game against your competitors.

When implementing asset management in an organization, it is not always about the tools and the systems available. In today's world, organizations have recognized that it is essential to use other dimensions to help with the implementation. This article explains these "out of the box" dimensions mentioned in PAS55 Standards for Asset Management and compares these attributes to chess strategies.

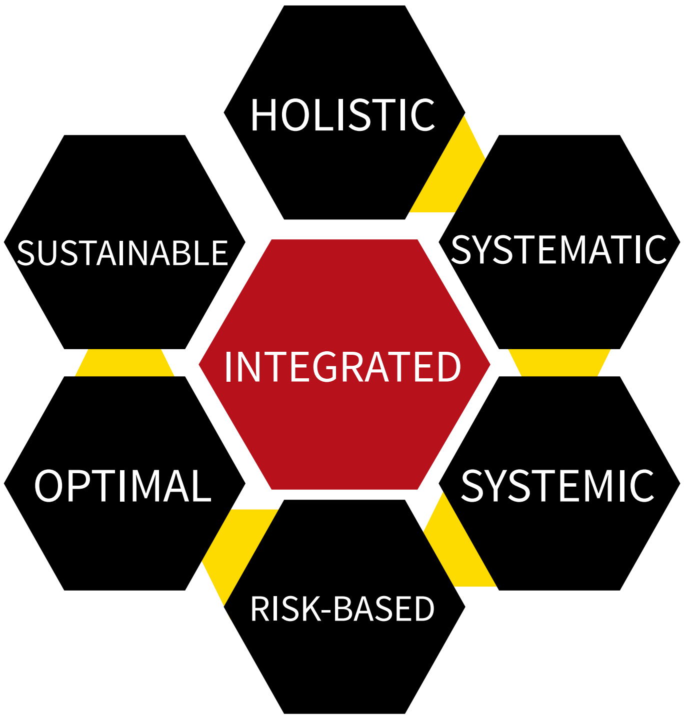


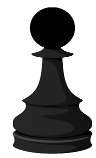
Figure 1: Key attributes for successful asset management implementation (Extracted from PAS 55-2:2004)

In a chess game, players need to evaluate the position of all chess pieces and plan for immediate and future actions to reach the strategic objective: Maintain the king's safety. The king is considered the most important asset on the chessboard and should be defended and protected. In order to accomplish this, players take into account different factors, such as the value of other assets and the position of all the pieces on the chessboard, to establish a strategy that leads them toward the main objective. This type of planning requires a disciplined approach to minimize the loss of pieces and defend the king, keeping him alive. Similarly, based on PAS55, effective implementation of asset management requires a disciplined approach to enable an organization to maximize value and deliver strategic objectives through managing its assets. This needs to be accomplished over their entire lifecycle to "keep them alive."

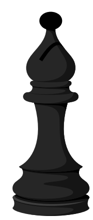
In chess, strategic players set up all moves from the first to the last. Whenever they move a piece, they often have planned for many moves ahead and account for many potential moves. Similarly, in asset management, it is necessary to consider the entire lifecycle of the assets. This includes the selection of appropriate assets during the design phase, efficient operations and maintenance of those assets, and adoption of an optimal renewal and decommissioning program. An effective asset management strategy will provide many benefits associated with several key principles and attributes during the entire lifecycle of the assets.

Figure 1 shows the seven key principles and attributes associated with the benefits of asset management.

Holistic: In chess, a holistic approach involves the use of all 16 pieces with their respective moves along the chessboard. Similarly, in asset management, the strategy must be multidisciplinary (all the pieces) and focus on all the different points of view and options (all possible "moves") in order to win. If you play only with the pawns, or in this case with a few stakeholders at your organization, it is unlikely you will gain victory. By using all your pieces in an aligned organization, you increase your odds of winning. By aligning and using all departments with one purpose, you are able to explore every move and decide your best strategy.



Systematic: In order to win the chess game, a rigorous rational, methodical and structured way of playing is used. In an asset management strategy, using a systematic approach allows you to promote consistent, repeatable, and auditable actions and decisions. An approach lacking a systematic plan promotes chaotic decisions, like in a chessboard, resulting in losing the game. Before the game begins, there needs to be an organized plan to guarantee standardization on every move made during the "game" lifecycle. As in chess, asset management needs to be implemented and managed in an organized, planned and consistent way.



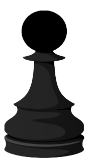
Systemic: All chess pieces must be put in the game. In asset management, the pieces are all your assets. All assets must be globally considered and managed. Consider all elements that add or reduce value to avoid confusing or ambiguous strategies that could affect reaching your main objectives. The same way a chess game cannot be won using only bishops or knights, organizations should not use only individual assets, nor isolate and manage them separately. Consider all assets, including their performance and risk (i.e., cost) of losing them.

Risk-Based: On the chessboard of asset management, all risks have to be evaluated. All decisions, actions and plans must be based on this risk-based approach. Pieces cannot be moved and actions cannot be executed if the probability of an expected outcome is unknown. Once the risks have been identified, resources, costs, effects and actions must be considered and prioritized in order to implement necessary control measures. And all of this must be done before choosing the next move. A good asset management chess player is characterized as a proactive person. This person is always looking three or five moves ahead. Thinking this way can avoid additional costs to health, safety and the environment.

Optimal: In addition to considering risks in both chess and asset management, every decision and move made must ensure the least impact to the other pieces on the board so they can continue the battle and survive short- and long-term challenges. Asset management plans must include clear methods to obtain the best results from the assets. In order to do this, it is necessary to examine all factors, such as cost, risk, performance, durability, availability and reaction time. All these factors need to be compared, analyzed and balanced to guarantee optimal results.

Sustainable: Good chess and asset management players do not win by making random moves. Thinking before every move and maintaining a strategy can ensure them victory in the long term. Every single move on the chessboard will impact the entire lifecycle of a chess game. In asset management, you must consider all long-term consequences of short-term activities. In chess, when good players make a move, it usually has a long-term effect. However, when the contender counterattacks, the player initiating the move must be prepared to maintain or modify the strategy. In asset management, taking the first action or decision will have long-term consequences. Adequate provisions should be maintained for future requirements or changes. These often include environmental, financial, or human performance adaptations to improve and sustain the strategy over the entire lifecycle without loss.

> "By aligning and using all departments with one purpose, you are able to explore every move and decide your best strategy."



Integrated: By definition, integration is the combination of two or more things to create something new. For asset management this means all parts must be combined and aligned. It's the same in chess. It is very important to recognize interdependencies between the pieces in a chess game. In asset management, integrating individual capabilities increases the possibility of achieving success. Winning the game requires a combination of individual attributes coordinated to deliver a team-based approach. In chess, a player can't win by only using knights and pawns. This would compare to using only supervisors or human resources personnel in an organization. To win the game or be successful in an implementation, the player must use all the attributes of all the pieces. Often, some pieces might need to be sacrificed, others will be exchanged, others may hide, but all with a purpose to win the game.

Similar to an effective asset management strategy, a skillful chess player uses a holistic approach to integrate all the different attributes during the lifecycle of the game. In chess, after the opening moves, the player starts unfolding the plan or strategy to reach the specific objective of winning the game. Many players will resign even before the end of the game. This resignation happens when the strategy and implementation are not effective or were not adapted to the circumstances of the game.

The same resignation can happen during an asset management program. The lack of consideration of key principles can create barriers that will make the asset management implementation harder or impossible. In addition to not considering the key principles outlined in the PAS55 suite of standards, there are other factors that can promote failure of an asset management strategy. These risks include: not knowing what assets you have and their capabilities (lack of knowledge in the capabilities of your chess pieces); lacking or exceeding maintenance (under/over use of chess pieces); employing improper operations (game rules ignorance); and underestimating your asset capabilities (undervaluation of the power of your chess pieces).

When considering an asset management strategy, consider the game of chess. Preparation, along with holistic integration, can help produce a successful outcome and keep your king alive.

__Roberto Barrera__ is an EE with 19 years of maintenance experience. During his career he has worked with a variety of different industries and recently, Roberto has worked in all plant lifecycles and developed extensive knowledge about customization, implementation and management of maintenance and reliability programs. He works at GP Strategies as a Manager and as an M&R Engineer. www.gpstrategies.com

HOW TO KNOW IF AN

INSPECTION IS TECHNICALLY FEASIBLE

by Richard Overman

The SAE International standard for reliability-centered maintenance (RCM)[1] says an inspection[2] should be done if it is technically feasible and worth doing. The hard part is identifying when a task is technically feasible.

Under the SAE's standard, the criteria for technical feasibility of an inspection are:

1. A potential failure condition can be identified.
2. A degradation interval can be defined.
3. The degradation interval is relatively stable.
4. A task can be performed at intervals less than the degradation interval.
5. The reaction interval is long enough for predetermined action.
6. Safety, environmental and economic criteria are met.

This article primarily focuses on criteria 4 through 6. The first three criteria involve what is called the interval between potential and functional failure (P-F interval) or the degradation interval. Figure 1 is an illustration of the P-F interval. Briefly, the P-F interval is the time it takes for the failure to progress from potential failure (Point B on Figure 1) to functional failure (Point C on Figure 1). The inspection interval cannot be any longer than the P-F interval. The P-F interval can be either calculated or estimated. This article describes how to calculate the inspection interval within the P-F interval.

Criterion 4 states that the task can be performed at intervals less than the degradation interval. If the degradation interval is too short for the proposed inspection to be reasonably performed, then the inspection is not technically feasible.

Criterion 5 states that the reaction time must be long enough for a predetermined action to be taken. When an item is found to be in a potential failure condition, it must be operational until it can be repaired or replaced before it functionally fails. If the response to finding a potential failure is to shut down the item, then the inspection has provided less value. The main reason for the inspection is to give a warning so the repair can be planned and scheduled at the most opportune time to minimize loss of production. Therefore, the degradation interval and the inspection interval must be long enough for the repair to be planned and scheduled once the potential failure condition is found.

Finally, the last criterion states that safety, environmental and economic criteria are met. The first step in answering this criterion is to define the safety, environmental and economic limits. Economic limits are pretty straightforward and will be addressed later. The safety and environmental limits are more complicated. The key to the safety and environmental lim-

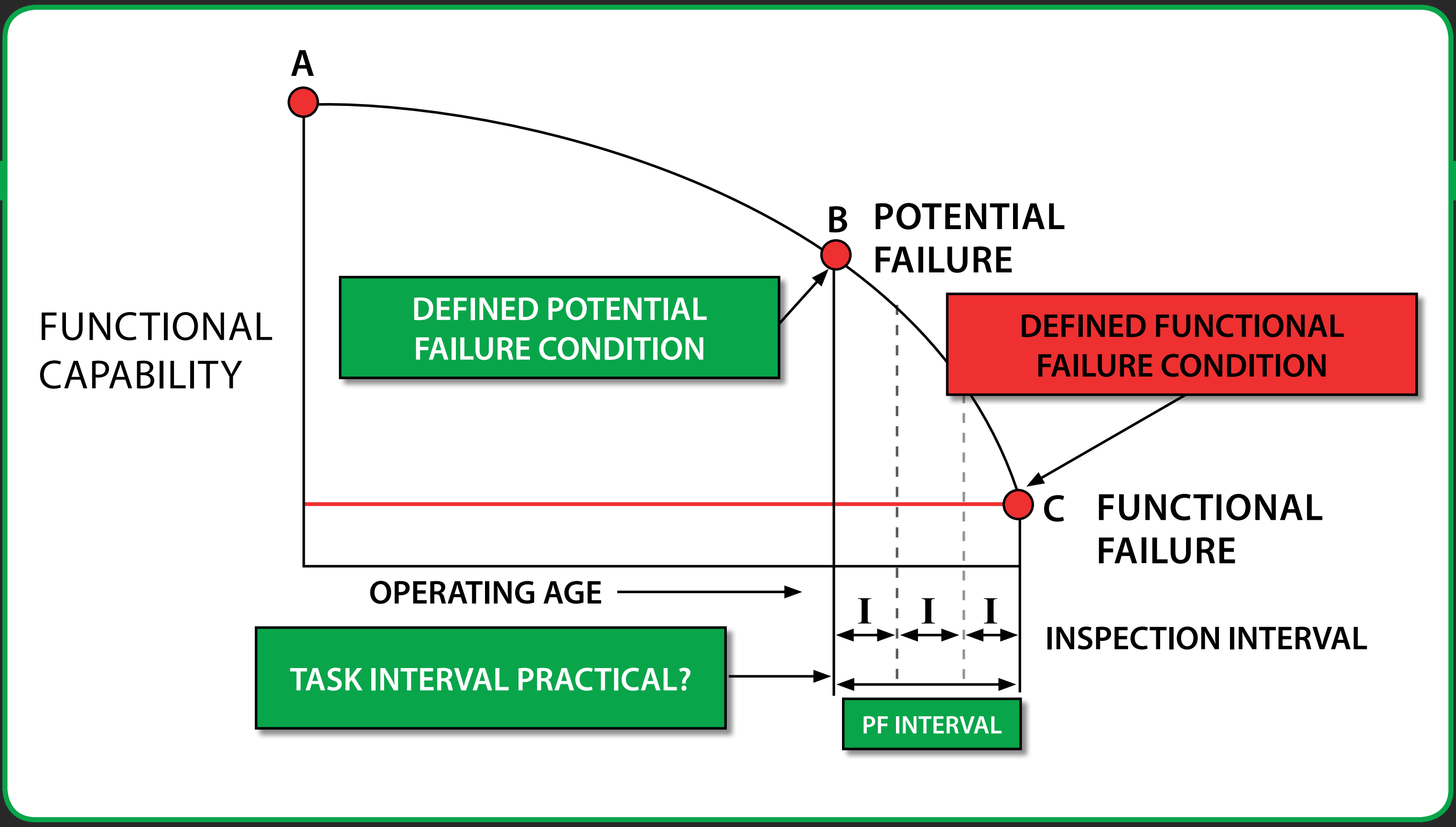


Figure 1: P-F interval

its is identifying the tolerable probability of allowing a functional failure (P_{tol}). This is difficult because management's first response is that no failure is tolerable. Unfortunately, reducing the probability of failure to zero is impossible. Therefore, a practicable probability must be identified. Some industries have standard probabilities that can be applied. Other industries do not. At any rate, corporate management must specify a P_{tol}. The second piece of information needed is the probability that a potential failure will be found by one inspection, assuming the potential failure exists. This is identified by the Greek letter theta (Θ). This will depend on how easy it is to find the potential failure condition and the skill of the people performing the inspection.

Let's say, for the sake of illustration, that P_{tol} is one in a million ($1x10^{-6}$) and that Θ is 0.9. In this case, the probability of missing an existing potential failure condition with one inspection is 1-Θ or 0.1 (1-0.9). So, there is a 10 percent chance a potential failure condition will go undetected the first time. The second time the inspection is performed, there is also a 10 percent chance the potential failure will be missed. However, the chance the potential failure will be missed both times is 0.1 x 0.1 or 0.01. This also can be written as $(0.1)^2$. If the potential failure is missed, the item will continue down the degradation curve toward functional failure. Therefore, the probability of functional failure, or the probability of actual failure (P_{act}) after two inspections is 0.01. It can be shown that P_{act} is equal to $(1\text{-}\Theta)^n$, where *n* is the number of inspections. Now, if you set P_{tol} equal to P_{act}, you come up with this equation:

$$P_{tol} = (1\text{-}\Theta)^n.$$

Solving for *n* in the next equation gives you the number of inspections that must be performed within the degradation interval to reduce the probability of failure to the tolerable level.

$$n = \ln(P_{tol})/\ln(1\text{-}\Theta)$$

Finally, the inspection interval (I) is the degradation interval (D) divided by *n*, as shown in this equation:

$$I=D/n.$$

It must be understood that the use of mathematics here can imply a level of precision that does not exist. Recall that the degradation interval is an estimate and theta is an estimate. While you make the best estimate possible, these estimates must be conservative in nature. It is also important to understand that this method assumes that a potential failure exists every time the inspection is performed. This is not always the case, but assuming the potential failure always exists is an additional level of conservatism.

Some practitioners have taken the view that if nothing is found after performing a task a certain number of times, the inspection interval can be lengthened. Such a view must be avoided, as it demonstrates a fundamental lack of understanding the degradation interval. Let's say, for example, the degradation interval is six months and the inspection interval is quarterly (three months). This means there are two inspections within the degradation interval. Now, let's say the view taken is that if no potential failure is found after four inspections, the inspection interval can be doubled. So, if no potential failure condition is found after performing the inspection for a year, the inspection interval is increased to six months. At this point, there is now one inspection within the degradation interval. If a potential failure is not found during two more years of inspections, the inspection interval is increased to annually. Now, the item can go into a potential failure condition and go to functional failure between inspections, and the actual probability of failure is greater than one.

Moving on to failures with economic consequences, in these cases, for the task to be cost-effective, the cost of the functional failure (C_{ff}) must be greater than the cost of the scheduled maintenance task (C_{sm}) plus the cost of repairing the potential failure (C_{pf}). This is illustrated by:

$$C_{ff} > C_{sm} + C_{pf}.$$

It can be shown that the value for *n* (the number of inspections within the degradation interval) to satisfy this equation is calculated by the next equation (the derivation of the equation is beyond the scope of this article). All the terms in this equation have been previously defined, except $MTBF_{nsm}$, which is the mean time between failures, assuming no scheduled maintenance is in place, and P-F is the degradation interval.

$$N = \left[\frac{\ln\left(\dfrac{\dfrac{(-MTBF_{nsm})CSM}{P-F}}{(CFF-CPF)\ln(1-\Theta)} \right)}{\ln(1-\Theta)} \right]$$

Using this equation, if the value for *n* is greater than one, the inspection is cost-effective and the inspection interval is calculated using the I=D/n equation. If the value of *n* is between zero and one, the task is not cost-effective, but if there are other considerations that would argue for having the task, *n* can be assumed to be one and the inspection interval would be the same as the degradation interval. Do not use the I=D/n equation if *n* is between zero and one, as this would make the inspection interval longer than the degradation interval. If the value of *n* is negative, the task is not cost-effective at any interval.

Conclusion

To be a useful task, an inspection must be able to detect a potential failure condition with enough warning to be able to do something about it before functional failure occurs. It also must be able to reduce the probability of failure to a tolerable level or be cost-effective on its own. This is the essence of the technically feasible question.

Endnotes

1. SAE JA1011- Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes, 1999.
2. An inspection task is known by many synonyms: Predictive Maintenance, On-Condition task, condition based maintenance, etc. For this article, an inspection is any task (using technology or human senses) that is performed to determine if an item is showing indications of failure but has not yet functionally failed.

Richard Overman, *CMRP, CRL, has over 30 years of experience in working with companies and facilities to improve their organization, as well as their equipment maintenance and reliability. He is an expert in process design, FMECA, RCM, lifecycle cost analysis, and other aspects of equipment maintenance and reliability. Richard is the author of* Reliability Centered Asset Management (www.reliabilityweb.com/books). www.coreprinciplesllc.com

A Glimpse at the

***Editor's note:** From 1996 to 2000, the author had the privilege of doing a greenfield construction and start-up of a chemical plant in Asia. Part of the land was still being reclaimed from the ocean when he arrived. This article describes how he and the work team developed work processes to do things in the way they had always wanted to do them.*

Sometimes, necessity drives people to take positive actions to address unusual circumstances. Such was the case with construction of the chemical plant on Sakra Island, which was part of a Singapore industrial complex made up of five separate islands that were being combined into one island by reclaiming land from the sea. When construction started, everyone knew that the plant would only have ferryboat access until a road could be completed several years in the future. Because of its isolation, it would take first responders and support resources a minimum of four hours to provide any help. Therefore, the personnel on site for each shift had to be trained in the qualifications to safely handle any situation that might occur (e.g., fix minor failures, patch until help arrived, shut down and isolate, etc.).

The implemented solution defines a very effective maintenance and operating process that was developed to address the immediate needs on Sakra Island, but also can ensure optimum performance and competitiveness in today's economic environment for any location. Maintenance excellence, built on a true partnership with operations, is the missing link to being the leader in the world market of tomorrow. A site leadership team (i.e., operations, maintenance, stores/purchasing and site functional groups as core members) drives activities to make maintenance a site issue. Maintenance must be viewed as an investment to add production capacity through more reliable equipment operation and personnel capacity through more efficient wrench time. Because of its positive impact on safety and quality, the focus on reliability is then given top priority.

The site's best practice that had the most positive impact was the operator and mechanic cross-training process. The concept of shift maintenance coordinators (SMC) was created since skilled maintenance mechanics were in short supply in Singapore at the time. These SMCs were mechanics who had electrical, instrument, or mechanical (EIM) skills and then were trained in the remaining skills they lacked so they could provide full support knowledge. This provided each shift with a maintenance leader with EIM skills.

Being isolated on the island, the maintenance philosophy had to be that maintenance is a 24-hour a day job, just like operations. Since there were not enough mechanics to provide shift maintenance coverage, it was necessary to train operators in the maintenance apprenticeship skills to the helper level as part of their orientation training. Each shift crew had one SMC who counted as part of the total operator allotment. The SMC reported directly to the operations shift supervisor and was part of the shift team.

This site has since progressed to the point where the SMC has been operationally crossed-trained and functions as an operator on nights. This has contributed to the site being able to greatly reduce total head count and overtime as attrition occurred. Site staffing has been reduced from 160 to 105. The SMC is the maintenance mentor who leads by doing and showing. The shift supervisor decides which operators are assigned to help the SMC based on plant operations and area of knowledge. One operator per shift is

FUTURE

by Roger D. Lee

> Maintenance excellence, built on a true partnership with operations, is the missing link to being the leader in the world market of tomorrow.

assigned to serve as the backup for the SMC as the individual's development and performance progresses.

Due to the shortage of skilled mechanics available to be hired, the plant decided to totally outsource its maintenance function, but would only have coverage on days. Operators, supported by their SMC, were taught enough maintenance skills to allow them to handle emergency situations and make necessary repairs or equipment isolations to keep the plant in safe operating condition until permanent repairs could be performed by the contract mechanics on days. For shift repairs, the SMC orders and collects the needed parts from stores and plans the tasks to be done. Each shift has a crew toolbox maintained by the SMC, who also maintains the computer equipment data for repairs made during the shift.

The maintenance staff developed a list of routine and preventive tasks the shift performs. History has proven that shift operators are closest to the equipment on a continuous basis and can prevent major failures by paying proper attention to warning signs and taking quick action. An understanding of maintenance allows the operators to better operate each piece of equipment and prevent potential damage by regulating its operating conditions.

Development of troubleshooting skills by the shift personnel was required to identify and prevent small problems from becoming big ones. Shift operators take routine data trap vibration readings at night to allow the maintenance staff to analyze the data for repairs by the contract mechanics. Preventive maintenance (PM) activities, like proper oil levels, are worked into the operator's job routes. Operator maintenance efforts are directed by their SMC and focus on required jobs that could impact safety, production, or quality if not properly addressed. In small sites, teamwork is required on each shift and between shifts and day personnel to maximize onstream time, product quality and overall safe operations.

The results of implementing this work process allowed the plant to achieve a maintenance and reliability (M&R) cost as a percentage of asset replacement value (ARV) of 2.69 percent in 1999, the first year of operations, compared to the company's history of a new plant start-up average of 6.13 percent. In 2004, the site progressed to 1.32 percent.

The annualized maintenance costs during the 1999 start-up and construction was $6.28 million, but decreased to $2.2 million in 2003 and to $1.85 million in 2004. The maintenance personnel head count for checkout and start-up went from 46 in 1998 to 28 in 1999 when the last unit went into operations and then 12 for normal operations in 2004.

Here is the present performance for this plant in 2015 to show the long-term successes:

- → Achieved above 90% capacity utilization since start-up;
- → Achieved above 99% YTD prime production since start-up;

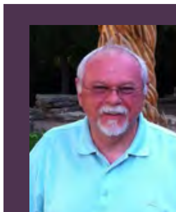
- Excellent unplanned production loss control of < 0.5% average per year;
- M&R cost control accomplishments: under budget since start-up with average M&R cost of 1.5% ARV over last 15 years (1.17% in 2013 as best year);
- 68% reduction of maintenance contractor monthly average head count since start-up, with eight full-time equivalent (FTE) as the target;
- Low maintenance overtime, with 4.6% average total overtime and 0.8% average unplanned overtime;
- High maintenance overall work schedule and PM schedule attainment above 97%;
- Monthly work orders per FTE went from 38.5 in 2007-2009 to 60 in 2011-2013;
- Work orders completed per year with the same head count craftspeople went from 3,611 in 2007-2009 to 5,188 in 2011-2013.

This example can be used to create a great opportunity to obtain productivity gains as you develop improvement plans for your site. These concepts have been expanded into a maintenance vision, philosophy, strategy and processes that can be made available to you to consider for your application.

The approach uses centralized planning with decentralized execution. You plan and schedule to improve how you do your work. Another planning and scheduling best practice is to have the shift crew going on long weekends to provide jobs to be done when they return on days so they can be available with expert input and support. This also allows lead time for developing plans.

Once all the components described in this article are achieved, maintenance will be in tune with site needs and will proactively initiate corrections and enhancements. Maintenance will be an established, well coordinated effort, with all parties having an active role in work identification, priority setting and completion of tasks. Through proper proactive systems using the appropriate predictive technologies, reliability is improved to ensure that equipment is available and in optimum condition to perform whenever needed. These reliability enhancements will reveal the "hidden" plant for extra capacity with minimum capital expenditures.

This maintenance transformation will deliver a competitive advantage to the industries that choose to implement it.



***Roger D. Lee** is the Director of RDL Solutions, LLC, a general consulting firm to help companies improve efficiency, cost control, productivity and reliability. Roger has 42 years of experience in the chemical and refining industry with a variety of clients across the world. He currently resides in Hockley, Texas.*

2017 RELIABILITY LEADERSHIP AND ASSET MANAGEMENT EVENTS

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	EXAM* 26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
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5	6	7	EXAM 8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	EXAM 23	24	25
26	27	28				

MARCH

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APRIL

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30						

MAY

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JUNE

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30	31					

AUGUST

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24	25	26	27	28	EXAM 29	30

OCTOBER

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29	30	31				

NOVEMBER

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19	20	21	EXAM 22	23	24	25
26	27	28	EXAM 29	30		

DECEMBER

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24	25	26	27	28	29	30
31						

1 DAY TRAINING

2 DAY TRAINING - INTERNATIONAL
*1 DAY INTERNATIONAL

2 DAY TRAINING - EN ESPAÑOL
**4 DAY EN ESPAÑOL

4 DAY TRAINING

BLACK BELT

CONFERENCE

NOTE: Agenda for planning purposes only. Event locations and dates subject to change.

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2017 RELIABILITY LEADERSHIP AND ASSET MANAGEMENT EVENTS

- 1 DAY TRAINING
- 2 DAY TRAINING - INTERNATIONAL
  *1 DAY INTERNATIONAL
- 2 DAY TRAINING - EN ESPAÑOL
  **4 DAY EN ESPAÑOL
- 4 DAY TRAINING
- BLACK BELT
- CONFERENCE

JANUARY

JAN 26 – 1 DAY INTERNATIONAL
Certified Reliability Leader *Overview* and Exam
Rosenheim, Bavaria, Germany

JAN 30-FEB 3, 2017 – 4 DAY
Certified Reliability Leadership
Advanced Workshop and Exam
Reliability Leadership Institute
Fort Myers, Florida

FEBRUARY

FEB 8 – 1 DAY
Certified Reliability Leader *Overview* and Exam
Gwinnett County Water
Atlanta, Georgia

FEB 22-23 – 2 DAY EN ESPAÑOL
La Red Confiabilidad Symposium
featuring the Certified Reliability Leader
Introduction Workshop and Exam
Monterrey, Mexico

FEB 27 BLACK BELT
Uptime Elements Reliability Framework
Assessment/Benchmarking

FEB 28-MARCH 2 BLACK BELT
Reliability Leader Black Belt:
Asset Management (AM)
Reliability Leadership Institute
Fort Myers, Florida

MARCH

MARCH 8-9 – 2 DAY EN ESPAÑOL
La Red Confiabilidad Symposium
featuring the Certified Reliability Leader
Introduction Workshop and Exam
Lima, Peru

MARCH 14-17 – 4 DAY
Introduction to Maintenance Management
Aligned to Uptime Elements
Reliability Leadership Institute
Fort Myers, Florida

MARCH 22-23 – 2 DAY INTERNATIONAL
Certified Reliability Leader
Introduction Workshop and Exam
Australia

MARCH 27-31 – 4 DAY
Certified Reliability Leadership
Advanced Workshop and Exam
Reliability Leadership Institute
Fort Myers, Florida

APRIL

APRIL 5-6 – 2 DAY INTERNATIONAL
Certified Reliability Leader
Introduction Workshop and Exam
Singapore

APRIL 10 BLACK BELT
Uptime Elements Reliability Framework
Assessment/Benchmarking

APRIL 11-13 BLACK BELT
Reliability Leader Black Belt: Reliability Engineering for Maintenance (REM)
Reliability Leadership Institute
Fort Myers, Florida

APRIL 24-28
The RELIABILITY Conference
co-located with *IoCM-2017 Internet of Condition Monitoring Symposium*
Las Vegas, Nevada

APRIL 25-28 – 4 DAY
Certified Reliability Leadership *Advanced*
Workshop and Exam (at The RELIABILITY Conference) Las Vegas, Nevada

MAY

MAY 15-19 – 4 DAY
Certified Reliability Leadership
Advanced Workshop and Exam
Reliability Leadership Institute
Fort Myers, Florida

JUNE

JUNE 5-6 – 2 DAY INTERNATIONAL
Certified Reliability Leader
Introduction Workshop and Exam
London, United Kingdom

JUNE 6-9 – 4 DAY
Introduction to Maintenance Management
Aligned to Uptime Elements
Reliability Leadership Institute
Fort Myers, Florida

JUNE 14-15 – 2 DAY EN ESPAÑOL
La Red Confiabilidad Symposium
featuring the Certified Reliability Leader
Introduction Workshop and Exam
San Juan, Puerto Rico

JUNE 19 BLACK BELT
Uptime Elements Reliability Framework
Assessment/Benchmarking

JUNE 20-22 BLACK BELT
Reliability Leader Black Belt:
Leadership for Reliability (LER)
Reliability Leadership Institute
Fort Myers, Florida

JULY

JULY 25 – 1 DAY
Certified Reliability Leader *Overview* and Exam
Metropolitan Council
St Paul, Minnesota

AUGUST

AUGUST 1-3
MaximoWorld
August 3 - Certified Reliability Leader
Overview and Exam
Orlando, Florida

AUGUST 14 BLACK BELT
Uptime Elements Reliability Framework
Assessment/Benchmarking

AUGUST 15-17 BLACK BELT
Reliability Leader Black Belt:
Work Execution Management (WEM)
Reliability Leadership Institute
Fort Myers, Florida

SEPTEMBER

SEPT 6-7 – 2 DAY EN ESPAÑOL
La Red Confiabilidad Symposium
featuring the Certified Reliability Leader
Introduction Workshop and Exam
Querétaro, Mexico

SEPT 12-15 – 4 DAY
Introduction to Maintenance Management
Aligned to Uptime Elements
Reliability Leadership Institute
Fort Myers, Florida

SEPT 25-29 – 4 DAY
Certified Reliability Leadership
Advanced Workshop and Exam
Reliability Leadership Institute
Fort Myers, Florida

OCTOBER

OCT 17-18 – 2 DAY INTERNATIONAL
Certified Reliability Leader
Introduction Workshop and Exam
Kuala Lumpur, Malaysia

OCT 20 – 1 DAY
Certified Reliability Leader *Overview* and Exam
Kansas City BPU
Kansas City, Kansas

NOVEMBER

NOV 6-10 – 4 DAY EN ESPAÑOL
Certified Reliability Leadership
Advanced Workshop and Exam
San Juan, Puerto Rico

NOV 13 BLACK BELT
Uptime Elements Reliability Framework
Assessment/Benchmarking

NOV 14-16 BLACK BELT
Reliability Leader Black Belt:
Asset Condition Management (ACM)
Reliability Leadership Institute
Fort Myers, Florida

NOV 21-22 – 2 DAY INTERNATIONAL
Certified Reliability Leader
Introduction Workshop and Exam
Dubai, UAE

NOV 28-29 – 2 DAY EN ESPAÑOL
La Red Confiabilidad Symposium
featuring the Certified Reliability Leader
Introduction Workshop and Exam
Santiago, Chile

DECEMBER

DEC 11-15
The 32nd International Maintenance Conference *The Intersection of Asset Management and Reliability*
Bonita Springs, Florida

DEC 12-15 – 4 DAY
Certified Reliability Leadership
Advanced Workshop and Exam
(at IMC-2017) Bonita Springs, Florida

NOTE: Event locations and dates subject to change.

RECIPROCATING PUMPS: System Modification for Maintenance IMPROVEMENT

by Victor C. Owunne, Dr. Jyoti K. Sinha and Dr. Adrian D. Nembhard

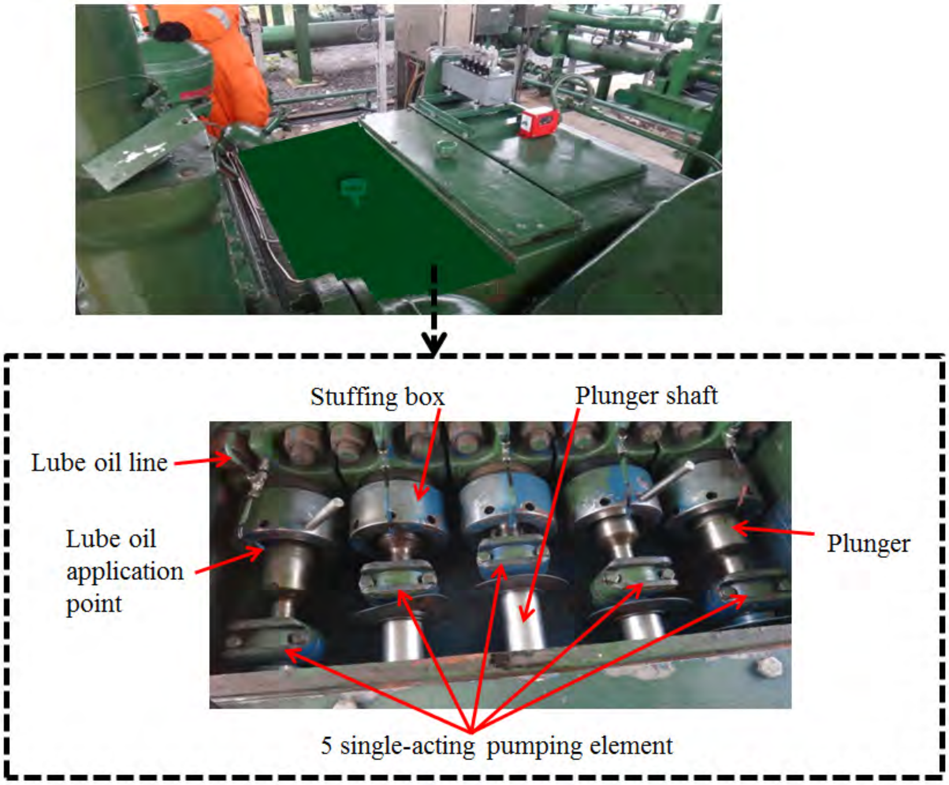

Figure 1: Spiking pump (SP) at the plant

System modification is an economically viable option to restore mechanical integrity, achieve optimum operation and reduce maintenance costs. This is realized through the development of a system modification program for a reciprocating pump with recurring leakage failures.

Introduction

Energy companies are actively seeking cost-effective alternatives to high cost items and/or processes. This article demonstrates how a cost-effective remedial solution for a recurring leakage failure of a reciprocating pump was established through the development of a system modification program. This program was strategically formulated by coalescing different maintenance techniques, processes and tools.

Case Study

A reciprocating pump in an oil and gas plant, referred to as a spiking pump (SP) in this article, was used in the transfer of condensate from a condensate tank into a gas pipeline (see Figure 1).

Prior to deploying the SP into service, an energy company had sustained significant financial

Table 1: Spiking Pump Technical Specifications

Criteria	Detail
Manufacturer	National Oilwell Varco (NOV)
Pump type	Quintuplex plunger pump
Pump model	300Q-5L
Drive type	Oil lubricated crank drive
Power source	Electric motor
Plunger diameter	2.75 in (69.8 mm)
Plunger stroke length	5 in (127 mm)
Weight of SP	7000 lbs. (3175 kg)
Pump speed	1105 rpm
Power (at 400 rpm)	300 hp (224 kW)
Suction pressure	13.1 psi (90 kPa)
Discharge pressure	1340 psi (9240 kPa)
Pumping temperature	200°F (93.3°C)
Volumetric flow rate (at 400 rpm)	257.1 gpm (973.2 l/min)
Designed for (application)	Oil service

losses and extended business interruptions from sabotages on its condensate pipelines. Through efforts to mitigate these losses, it established a process change. The process change entailed transporting condensate as a mixture with natural gas in its gas pipelines. To implement this process change, a reciprocating pump was needed to inject condensate from the condensate tank into the gas pipeline to meet the high discharge pressure requirement.

A reciprocating pump was available, however, it was designed for oil service. A reciprocating pump conducive for condensate service was unavailable and had a 48 weeks lead time to supply. Since condensate sales were a major income stream for the energy company, procurement was not viable. The available SP was deployed for condensate service. However, this change initiative was not governed by management of change (MOC). The technical specifications of the SP are shown in Table 1.

Being a quintuplex pump type, the SP had five single-acting pumping elements. It uses five parallel cylinders acting in timed sequence to smooth the output pressure pulsation. The SP has a high pumping capacity because of its multiple plungers. Quintuplex and triplex pump types have the same components; the only variation is the number of single-acting pumping elements. Based on this fact, a 3-D model of a triplex pump was used to enhance insight on the components of the SP (see Figure 2).

The Problem

The process change was effective in eliminating all financial losses (i.e., about $15 million a year) stemming from condensate pipeline sabotages. However, the process change caused unreliability in the condensate service system. The SP had recurring leakage of condensate from its gland packing, with mean time between failures (MTBF) of five days or about 120 running hours. Consequently, the SP's unreliability had financial implications: maintenance costs of $360,000 a year for routine replacements of gland packing and production loss of $720,000 per day for unplanned downtimes.

Investigation

An investigation was undertaken to ascertain the root causes of the SP's recurring leakage failure. Figure 3 shows the overall summary of the investigation process that was used to identify the root causes of the leakage failure and ascertain the best remedial route that was technically feasible and financially viable.

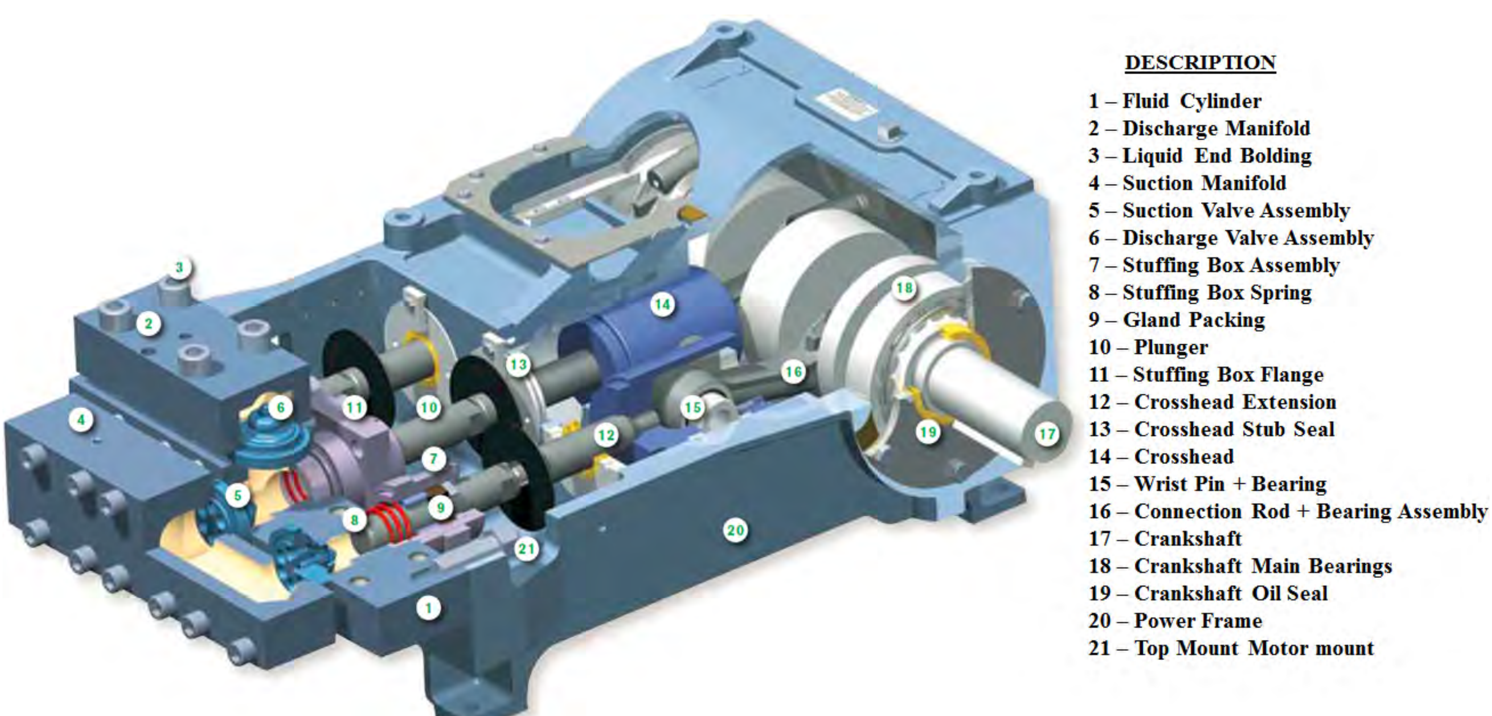

Figure 2: 3-D model of a reciprocating pump (Source: Reciprocating Pumps; SPX, 2012)

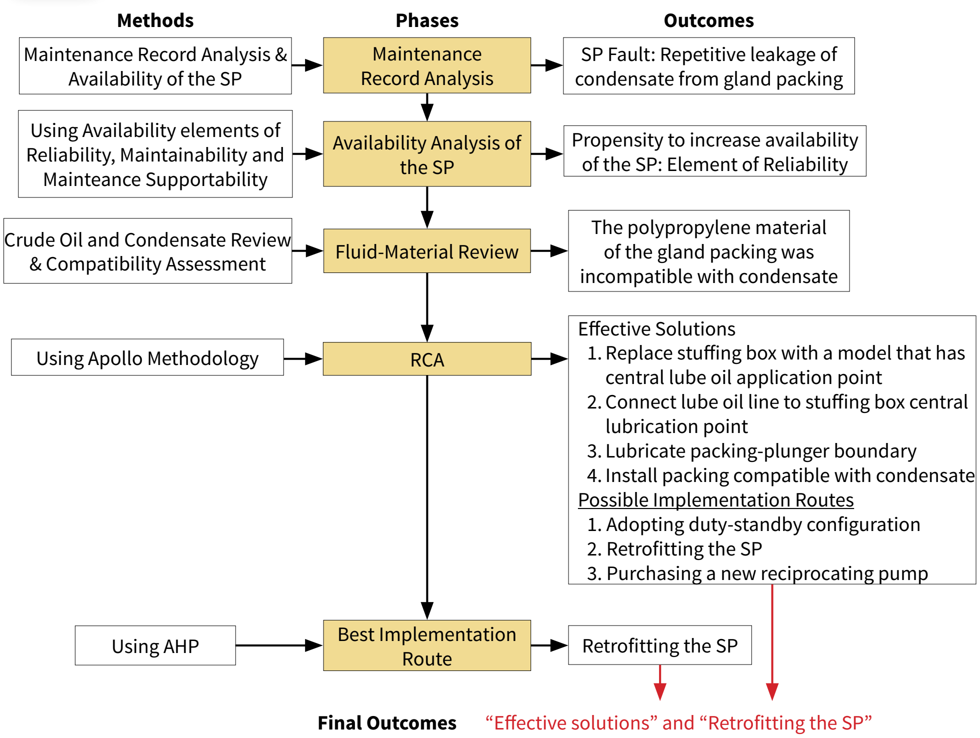

Figure 3: Investigation process for SP's recurring leakage failures

The maintenance record of the SP was extracted from the computerized maintenance management system (CMMS). An analysis of the maintenance record authenticated that the recurring leakage of condensate from the gland packing was the prime failure of the SP.

The unreliability of the SP was a consequence of its recurring leakage failures, thus, its current operational availability was below the baseline. To resolve this, an availability analysis was performed to identify the direction in which to seek solutions. The relationship between elements and availability performance were identified as follows:

- **Technical System** — Reliability and Maintainability
- **Maintenance System** — Maintenance Supportability

These three elements – reliability, maintainability and maintenance supportability – were used to drive the availability analysis. Availability analysis results determined that the most effective improvement initiatives for the SP would be found in the element of reliability. Therefore, remedial solutions were formulated with a prime focus on reliability.

A fluid material review was undertaken to review the properties of condensate, ascertain its impact on the SP's internal components and assess its compatibility with the materials of the internal components. The outcome of this review affirmed the incompatibility of the gland packing material (i.e., polypropylene) and condensate.

Root cause analysis (RCA), being an effective tool for cause and effect analysis, was used to identify the root causes of the leakage failure and effective solutions that would permanently remediate the failure. The Apollo RCA methodology was adopted because it produced an evidence-based understanding of the recurring leakage problem. It was ascertained that the plunger was running dry through the gland packing, causing rapid wear of the packing materials. This wear propagated clearances, leading to significant leakage of condensate through the packing gland.

From all the findings, the following were established as root causes for the recurring leakage failure:

- No central application point for the lube oil;
- Gland packing material was in direct contact with the plunger;
- Polypropylene gland packing material was incompatible for condensate service.

From these root causes, the effective solutions formulated were:

- Replace stuffing box with a model that has a central lube oil application point;
- Connect lube oil line to stuffing box central lubrication point;
- Lubricate packing plunger boundary;
- Install packing compatible with condensate.

The potential implementation routes for these effective solutions were established as:

- Option 1 – Adopting a duty/standby configuration for the SP;

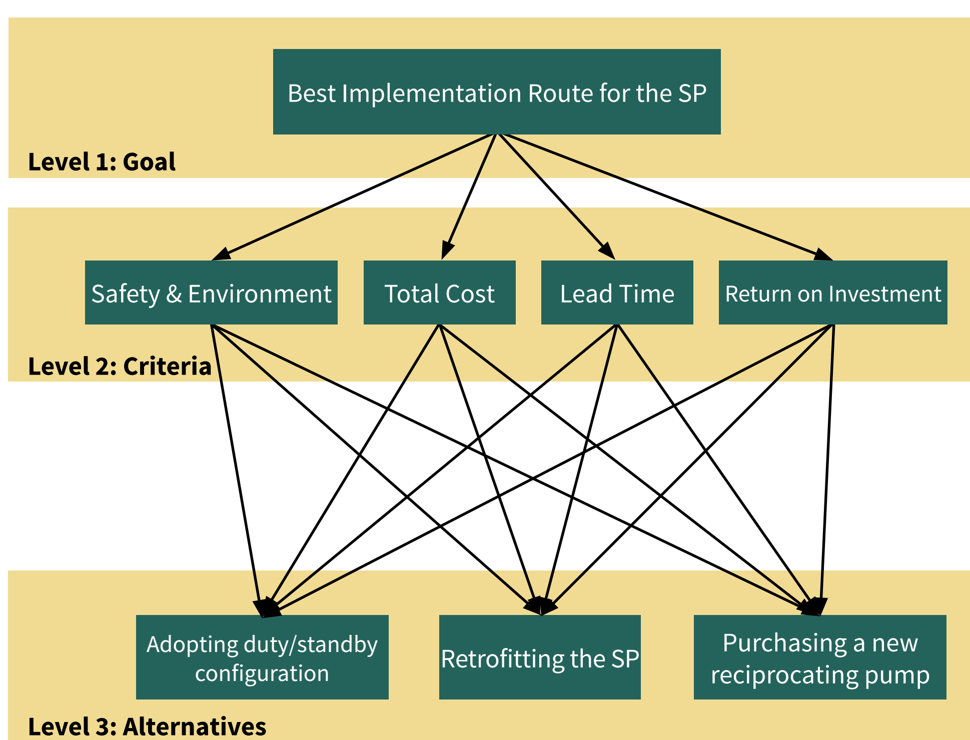

Figure 4: AHP decision model for best implementation route

- Option 2 – Retrofitting the SP;
- Option 3 – Purchasing a new reciprocating pump.

These established implementation routes were subjected to multiple criteria decision-making (MCDM) using analytic hierarchy process (AHP) to ascertain the best implementation route as shown in Figure 4. The multiple criteria included:

i. Safety & Environment – zero accidents, zero incidents and zero loss;
ii. Total Cost – all direct and indirect costs involved;
iii. Lead Time – the time frame between initiation and completion;
iv. Return on Investment (ROI) – the financial benefits and economic gain.

A pairwise comparison of criteria with respect to goal was performed. Furthermore, a pairwise comparison of alternatives with respect to each criterion was performed. This yielded a comparison matrix with composite weights for each criterion/alternative combination.

Retrofitting the SP emerged with the highest overall score (composite weight) in the comparison matrix, making it the most technically feasible and financially viable implementation route.

System Modification Program

To restore mechanical integrity to the SP and reduce its maintenance cost, a system modification program was developed. The development of the program was based on effective remedial solutions and best implementation route.

To effectively encompass all essential attributes required for the development of the system modification program, a one layer CIMpgr process model was adopted to model the system modification program. A CIMpgr process model is a graphical diagram that illustrates object to object relationships, their functions and entities, and gives better insight on data flow by classifying them into inputs, outputs, resources and controls. Figure 5 delineates the CIMpgr process model for the system modification program. The CIMpgr model articulated all inputs, controls, resources and outputs (ICRO) variables and provided a holistic line of sight for the system modification program.

The backbone of the system modification program was a 3M process: modification, monitoring and maintenance. The system modification program model is shown in Figure 6.

The modification element of the 3M process encompassed the redesign of the SP's stuffing box in accordance to the remedial solutions, as well as the selection of a new gland packing material, which was compatible with condensate. The current and redesigned SP stuffing box are compared in Figure 7. A square ring (i.e., packing style) braided aramid fiber with a lubricant coating (i.e., material) was the selected gland packing material because it was compatible for either condensate or oil service.

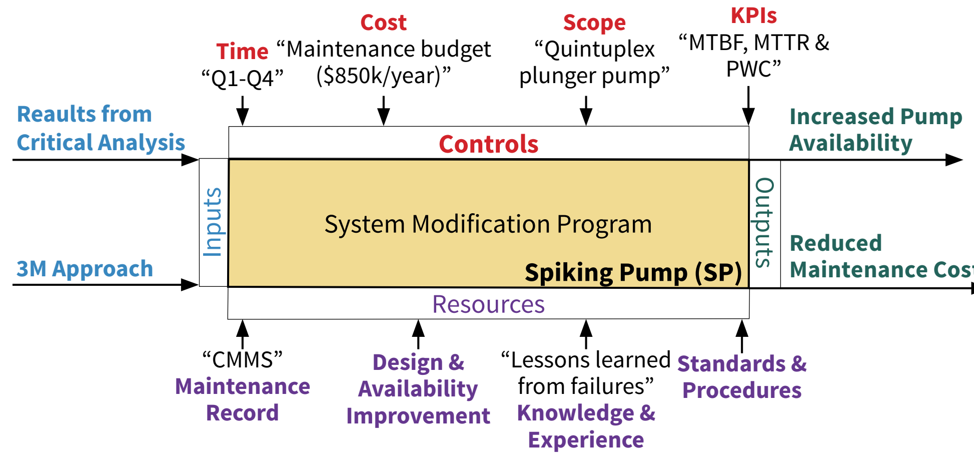

Figure 5: CIMpgr process model for the system modification program

With the current stuffing box, when the plunger undertook a suction stroke, lube oil was drip fed on the plunger, as per original design for oil service. During the discharge stroke, the high viscosity of the oil (i.e., the pumped fluid) was supposed to slightly oppose the movement of the plunger. This opposition was to reduce the speed of the plunger and facilitate lube oil smearing, resulting in good lubrication at the packing plunger boundary. However, in its present application for condensate service, due to the low viscosity of condensate, there was minimal opposition to the plunger movement. The lube oil, which was drip fed on the plunger, was scraped off by the first packing ring of the gland packing. This resulted in poor lubrication at the packing plunger boundary, high friction between the packing and plunger, and packing and plunger wear.

With the redesigned stuffing box, the lube oil application point is at a central end. During the suction and discharge strokes, lube oil is drip fed on the gland packing to soak it. Based on the fact that the gland packing will always be soaked when the plunger passes through, a significant increase in lube oil smearing efficiency on the plunger is realized. This results in good lubrication at the packing plunger boundary and insignificant friction between the packing and plunger.

The monitoring element encompassed a condition monitoring (CM) system developed for the SP to facilitate a proactive maintenance approach. The selected techniques for monitoring were pressure and visual inspection. The operation limits – baseline, alarm and trip – were established for each parameter.

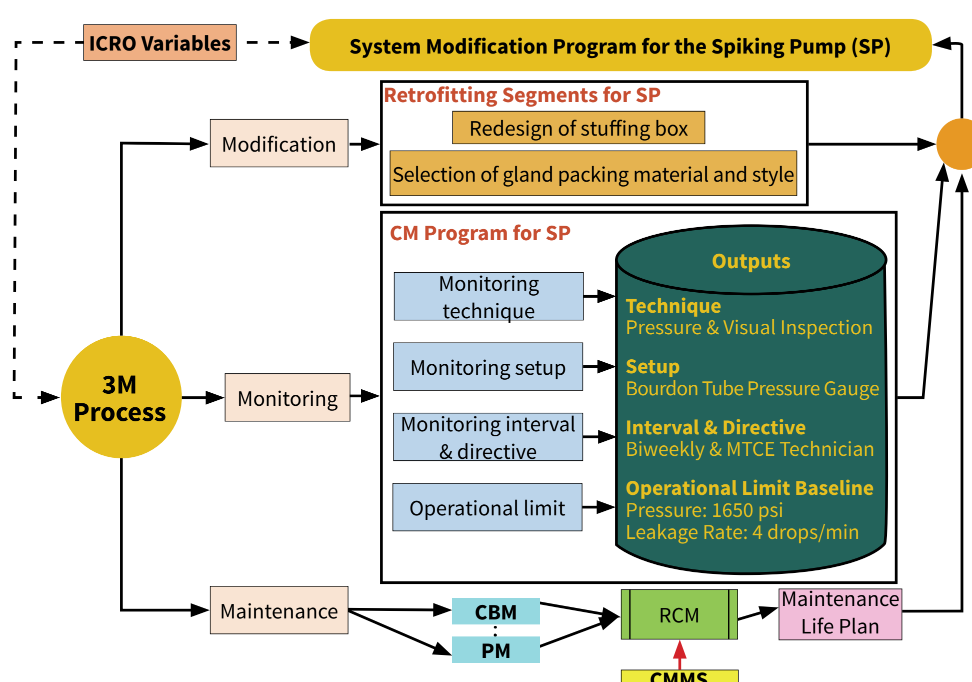

Figure 6: System modification program model for the SP

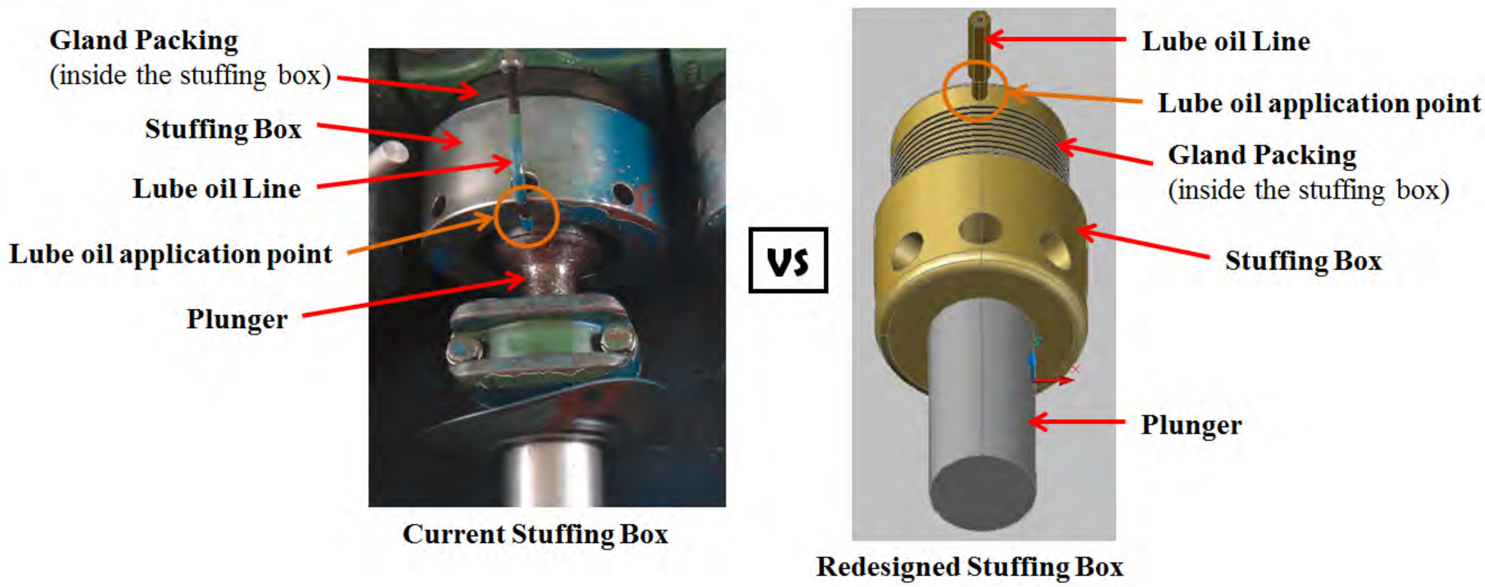

Figure 7: Current stuffing box versus redesigned stuffing box

The maintenance element encompassed the development of a maintenance life plan for the SP. Reliability-centered maintenance (RCM) was deployed to formulate the maintenance life plan for the SP.

Conclusion

For any given equipment failure in an organization, there are many routes to take to achieve remedial solutions. However, in order to maintain competitive advantage, the best route must be adopted. The best route is the option that would prevent failure recurrence at minimal cost.

In the case of the SP, the identified implementation routes were adopting a duty/standby configuration, retrofitting and a new purchase. By subjecting these implementation routes to multiple criteria, the retrofitting option emerged as the best route. Thus, system modification was undertaken on the SP. The SP's system modification program was theoretically evaluated to have a potential of increasing the availability of the condensate service system by 26.7 percent and yielding a capital expenditure (CAPEX) savings of about $140,000 to $330,000. Such an increase in availability will minimize the lifecycle cost of the SP.

Furthermore, all change initiatives for equipment and/or processes must be governed by a MOC to ensure risks and/or hazards are not inadvertently introduced or increased by the change initiative. It is evident that if the process change was steered by MOC, recurring/imminent problems with the SP would have been averted earlier. Hence, no significant cost implications would have been sustained.

> "The best route is the option that would prevent failure recurrence at minimal cost."

Acknowledgment

The work presented in this article is an excerpt from a "Reliability Engineering and Asset Management (REAM)" Master of Science dissertation from the University of Manchester, England.

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Victor C. Owunne *is a mechanical/piping engineer with a multinational oil and gas contractor. Victor has been involved in numerous projects on oil and gas production facilities in Northern Alberta, Canada. He has extensive knowledge and experience with various processes and equipment in the oil and gas industry.*

Dr. Jyoti K. Sinha *is Program Director, Reliability Engineering and Asset Management MSc and Head, Dynamics Laboratory, School of Mechanical, Aerospace and Civil Engineering at the University of Manchester, England. He is involved in and solved a number of industrially applied research projects related to vibration-based condition monitoring and maintenance of machines and structures over the past 27 years. www.mace.manchester.ac.uk*

Dr. Adrian D. Nembhard *is a consultant mechanical engineer who specializes in systems engineering. Dr. Nembhard currently consults for various industries in Jamaica and the Central American and Caribbean region, including oil and gas, bauxite-alumina, sugar and power generation.*

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N/A

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Reliabilityweb.com

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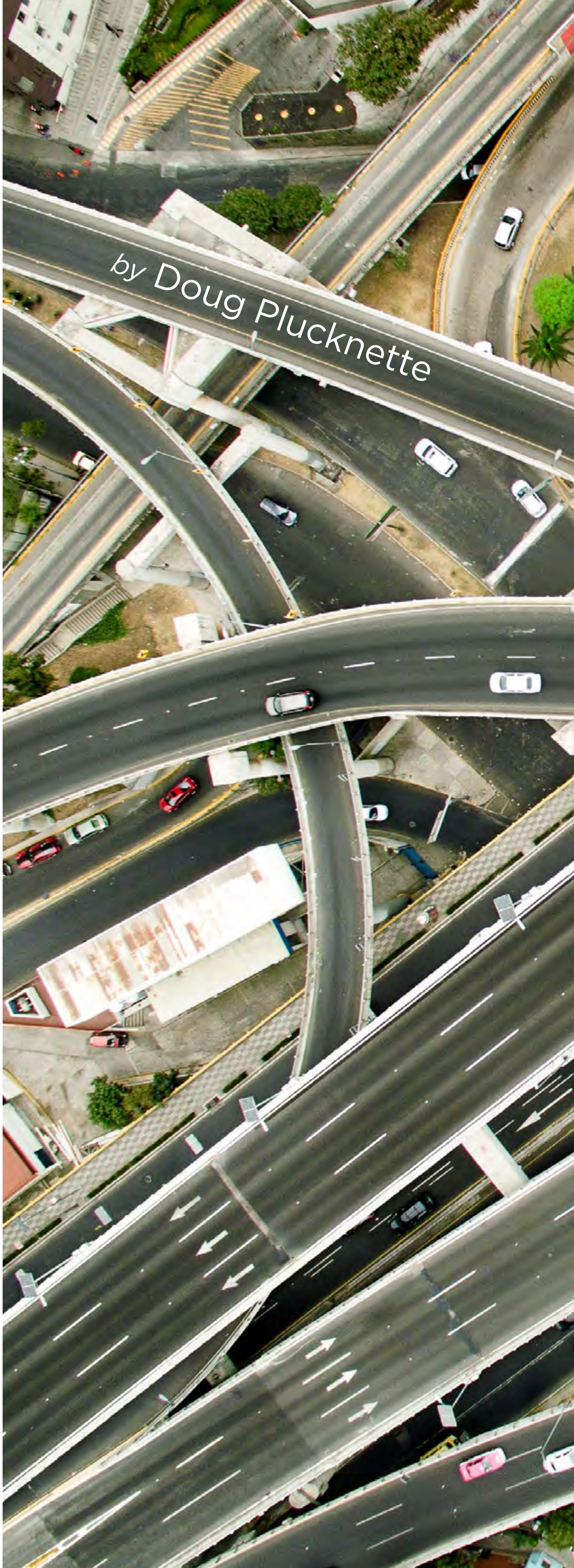
Asset Management

The Importance of Planning to Sustain CONTINUOUS IMPROVEMENT



Leaders. They used to be represented at almost every maintenance reliability conference around the world. They were seen as the best in asset management with a seemingly limitless number of case studies that clearly showed the benefits of root cause analysis (RCA), condition monitoring, reliability-centered maintenance (RCM), planning and scheduling. Their people gave presentations that clearly showed the value of the foundational elements of walking down your assets, developing an accurate equipment hierarchy and performing a thorough criticality analysis.

And then the clock ticked.

Father Time simply aged a few leaders. The time everyone hopes for, known as retirement, showed up and left a few key positions open for new leadership.

Everything changed. The new leaders had a different vision; one that might not necessarily be wrong, but clearly different from the past. Suddenly, they no longer had time for RCA; the rising number of assets in alarm on condition monitoring reports was simply a sign of aging equipment and the number of backlogged work orders required the maintenance group to work Saturdays to ensure the important things were getting done.

In less than one year, the leaders had fallen so far that they stopped recording the measures they proudly presented at conferences 18 months earlier.

What Went Wrong?

The easy and incorrect answer is to blame it on change; the incompetence of new managers failing to understand the importance of a sound asset management strategy. This couldn't be further from the truth.

The blame here should fall squarely on the shoulders of those who developed the asset management program and those who were left to carry it on.

If You Don't Plan to Sustain Your Efforts, They Are Doomed to Fail!

Everyone would agree that change is inevitable. The trick is to ensure future change brings continuous improvement to the company.

If you are leading the pack in terms of asset management and equipment reliability, should you then ignore those things to focus on operator care or Six Sigma quality? Of course not, but this is the trap several companies fall into.

As you venture into your latest continuous improvement effort with the hope of making positive change, do you take the time up front to create a vision of what that change will look like and how you plan on sustaining that change when the next improvement effort starts?

Start With Your Current State

Looking at asset management/equipment reliability, what were some of your key measures before you started the effort?

Some Key Measures

- Maintenance spend
- % Emergency maintenance
- % Demand maintenance
- % Corrective maintenance
- % Preventive maintenance
- % Condition-based maintenance (CBM)
- Unit cost of key products
- Overall equipment effectiveness (OEE)/Total effective equipment performance (TEEP) of critical assets
- Maintenance cost/Asset replacement value
- Spare parts inventory value
- Maintenance crew balance (e.g., planners, tradespeople, supervisors, CBM techs)

With these numbers in hand, compare and rank your company against others in your industry for each measure.

Do you actually know where you started before you began your latest effort to improve?

Very rarely do companies take the time to measure where they started before they begin their effort. When companies were informally surveyed as to why they didn't make the effort, the most common answer was the cost of benchmarking. If this is a concern for your company, there are tools available to meet your needs.

Create Your Vision

Looking one, five and 10 years into the future, where would you like your company to be in terms of each of the key measures? This is where a good benchmarking exercise really comes into play. In addition to the previously noted key measures, benchmarking, if done correctly, can point out some critical skill sets and behaviors that need to be changed to achieve your future state.

Starting with that one-year vision, which areas do you need to improve to make that first goal a reality? This is where the planning begins. Remember to start with the stark reality that **change isn't free**! If you are going to spend money with a simple promise to improve, you must then also show how you plan to get a return on investment for the money spent.

The same process must be used as you look ahead to five and 10 years. What should this change deliver and how will the change pay for itself and still provide long-lasting benefits for the company?

Test the Internal Waters

One of the sure signs your effort will struggle to survive even the slightest changes is if it cannot be repeated internally. There have been dozens of companies who had tremendous success with RCM Blitz® at one company site, yet could not get a single task implemented at another. If you want to sustain the gains from an improvement effort, you first must prove it can be successful at another site. This shows you have what it takes to get other managers to understand and implement the changes.

Why is this so important?

A large percentage of today's managers want successful change to be their idea, brainchild, or effort. You need people to understand that the changes that need to be made will be different from site to site. The road map to success will never take the exact same route from one plant to the next. Think about it for a minute. What are the chances of every site your company owns having the exact same strengths and weaknesses? Some will have done a great job setting the foundational elements, while others will have a group of tradespeople trained to work with precision maintenance techniques. The journey will be different for each site, but the things you need to do the same across the board are measure, benchmark, set a vision and communicate.

Regularly Publish and Communicate Success

While the company that inspired this article did a fantastic job communicating its success to the conference community, it doomed its efforts by believing the program would stand on its own without the real data that told the story of the journey. It's as if the company expected the people it trained (e.g., planners, schedulers, CBM technicians, supervisors and tradespeople) to somehow tell a corporate manager that the changes he or she was about to make would ruin 10 years of hard work in a matter of months.

Without the story and the data showing how far you have come, the successes that provided a return on investment and what would happen if you reverse course for the sake of change, your effort will soon be on life support simply because someone thought you needed to go in a different direction.

Efforts do not have to compete. In fact, they should complement one another. One sure sign of a great leader is the ability to sustain the gains of his or her predecessor while heading up a new continuous improvement effort.

Halting the Trend

If one request could be granted today, it would be to give companies, managers and teams the guidance and advice needed to keep failed efforts from ever happening again. This does not have to happen every time someone makes the decision to move on, take a break, or retire. The formula is simple and the computer makes it even easier. If you skipped step one, go back in time and measure. If you have not benchmarked your company against others, today is the day to start. If you never created a vision for change, it is time to get started. And if you need to show a return on investment, know that it is possible to get it all done in six months. You simply need to be disciplined enough to get started.

The reality is that everyone wants their name associated with some kind of meaningful change. As you look to make your change, be smart enough to understand that the person selected to fill your shoes will not think to sustain your efforts unless you have a plan in place to show the data, tell the story and sell the need to continue!

Doug Plucknette *is the Principal, RCM Discipline Leader for Allied Reliability Group. Prior to his work as a consultant, he worked nineteen years at Eastman Kodak Company in Rochester. Mr. Plucknette is the founder of RCM Blitz™ that provides reliability-centered maintenance training and services to numerous companies around the world. www.alliedreliabilitygroup.com*

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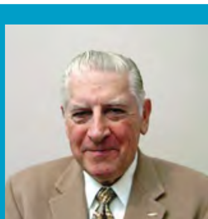
Rhys Davies **Danielle Humphrey**

ISO55000 Asset Management - A Biography

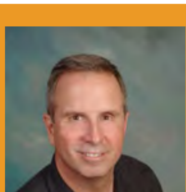
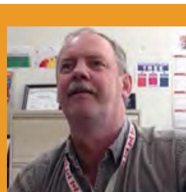
The publication of the ISO55000:2014 Asset Management suite of standards in January 2014 marked a major milestone in the development of the discipline of asset management. This book has been produced to complement the ISO55000 suite of standards. It specifically provides some background history to its development to provide context to the set of requirements. It also provides the authors' personal interpretation of their intent.



Jack Nicholas

Asset Condition Monitoring Management

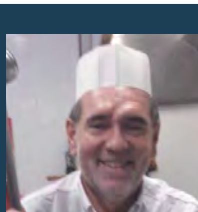
This book offers up-to-date information needed by decision makers and implementers interested in starting a new, or upgrading an existing, ACM/PdM program, while aligning it with the most advanced thinking on asset management. It describes evolving technology, hardware and software, use of the Internet of Things (IoT), integrating ACM/PdM with SCADA, and managing the massive amounts of data resulting from it among many other practical factors and ideas needed for success.

Ricky Smith **Doug Stangier**

Preventive Maintenance Made Simple

How many times have you heard that you need to simplify or optimize your preventive maintenance (PM) program? Preventive Maintenance Made Simple is written for most maintenance reliability leaders and engineers who are looking for ideas to improve, optimize and rationalize their current PM program. The book includes processes and components that, when combined and implemented into a struggling PM program, would bring immediate improvements to said program.



Luis Amendola

The Ingredients for Building Your Dream

Creative Leadership, Physical Asset Management and Asset Management Capacity and Culture

In this book, the author has put all his effort and hopes in surprising asset managers and appealing to their most creative side, always searching for company developments that will take them to the top. The author talks about life experiences he has had throughout his trajectory in industry, executing all the roles in physical asset management. He proposes a new approach that combines two of his passions: asset management and good eating.

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TERRY WIREMAN

SPECIAL FEATURE

28 Books Later: A Look Back on Lessons Learned

At The RELIABILITY Conference 2016 in Las Vegas, world-renowned author and maintenance expert, Terry Wireman, announced his retirement. Wireman is the very definition of a prolific writer, authoring numerous textbooks, white papers, and articles. Following his announcement, Wireman received Reliabilityweb.com's Lifetime Achievement Award. Take a trip down memory lane as we revisit some highlights from Wireman's storied career.

It all started years and years ago in a galaxy far, far away...

Wireman's journey began with a millwright apprenticeship in 1970. With on-the-job and classroom training, the apprenticeship consisted of an 8,000-hour investment over four years. This kind of strong trade apprenticeship that Wireman was involved in is almost non-existent today. He eventually graduated the program in 1974. It wasn't until 1983, though, that Wireman published his first article. Appearing in "Power Transmission Design Magazine," he contributed a series of five articles for it over that year. The articles covered maintenance and proper alignment of couplings. This is where Wireman's writing career started, writing about maintenance.

SPECIAL FEATURE

In addition to articles, 1983 also saw Wireman's first book being published. Titled "Industrial Maintenance," it was used as a training program for industrial millwrights. "Industrial Maintenance" ended up getting state adoption for several vo-tech systems in the United States. Life started getting crazier for Wireman as he began writing more textbooks. A total of eight were produced around that time. Some of these titles include "World Class Maintenance Management" and "Total Productive Maintenance."

The next big step in Wireman's writing career came with the six-book "Maintenance Strategy" series. Wireman credits Terrence O'Hanlon for helping getting it off the ground and motivating him to keep writing. Each book in the series focuses on a specific area of maintenance reliability. Wireman wrote the books to cover basic blocking and tackling one needs to do to be successful. For example, "What do we need to do if we were to implement a preventive maintenance program? What would it look like?" While it might seem like a massive undertaking, Wireman remembered having much fun while writing it. He even taught the material at some universities.

That's where many of the workshops come into play, which Wireman also enjoyed due to the interaction he had with people. But don't think that Wireman gave up on magazines throughout all this. For 15 years, he was the Maintenance Editor for "Engineer's Digest" on a freelance basis. He also did a short stint at "Lubrication & Fluid Power Magazine" and "Maintenance Technology Magazine" as the Editorial Director. In recent years, Wireman has started gravitating more to "Uptime Magazine." Any article that he's published recently has been through "Uptime."

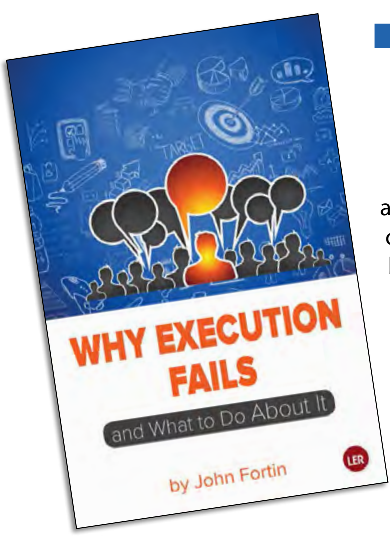
After finishing his presentation, Wireman mentioned that it was time to leave it all in the past and ride off into the sunset. While that might be true for him, Wireman's body of work will still be with us for a very long time.

~Sean Flack, Associate Editor

Thank you for everything you have given to this industry and for your friendship.

WHY EXECUTION FAILS AND WHAT TO DO ABOUT IT

Written by John Fortin • Reviewed by Robert S. DiStefano



The premise of "Why Execution Fails and What to Do About It" by John Fortin is based on statistics about the high failure rate of change initiatives, particularly those requiring cultural changes in the attitudes of the workforce. Most of these types of change initiatives fail to deliver the promised benefits that spawned the effort in the first place. Mr. Fortin suggests that the factors for success lie in the execution phase, and while some failures are rooted in poor planning and poor visioning, I agree with Mr. Fortin's proposition. In my view, based on nearly 40 years of experience in the maintenance reliability field, his premise is well-founded.

Mr. Fortin has developed, honed, implemented and proven a sound model, which he coined DELTA FORCE, on the front line of significant change initiatives in the reliability field. The success he has achieved on projects well-known and recognized in the reliability community is testament to the effectiveness of the DELTA FORCE model.

In this easy to read book, Mr. Fortin lays out his model for execution excellence in simple terms, which is one of the keys to this very useful book. Many of the elements of DELTA FORCE are recognized as accepted elements of the organizational change and behavioral sciences fields, but Mr. Fortin has packaged them in a very simple way to not only develop and communicate the vision of the desired future state, but, perhaps more importantly, to emphasize the imperatives necessary for the execution phase to actually deliver the desired results. Some of the elements of DELTA FORCE are rooted in a very sound understanding of human behavior, including soft things like respect among team members and following through on promises – which go directly to a crucial overarching theme of every significant change initiative: integrity. This model emphasizes integrity at many levels and, in my view, is one of the keys to the success of the model.

Things like leadership and assessing an organization's readiness for change are fundamental building blocks of successful change initiatives and Mr. Fortin wisely embraces these and other proven methods for readying an organization. But a novel approach to maximizing individual and team contributions, referred to as the iDEA model, helps elicit, harness and promote honest discussion and evaluation of all ideas brought to the fore by team members. The iDEA model encourages participation and provides honest evaluation feedback to the participants, clearly closing the loop regarding how that idea was evaluated in the context of the initiative and whether and why it will or will not be incorporated into the initiative. These are all good human interfaces, which are crucial to participant ownership and enthusiasm.

Finally, the model deals effectively with sustainment of the changes after the lion's share of the initiative has ended, a crucial and often missing ingredient in failed change initiatives. It is all too easy for an organization to slip back into old habits. However, the model addresses the reality that permanent change requires sustained pressure and attention for an extended period of time before the new ways of thinking and doing are embedded in the culture and become the new status quo.

I was impressed with the success of the projects where Mr. Fortin honed and perfected this execution excellence model. I was equally impressed with the book's concise capturing of the critical elements necessary for execution excellence. The book is an easy read and I believe it will serve as a very handy guide to leaders of change, both new and old. It certainly will have a markedly positive influence on organizations that are endeavoring to deliver business value through reliability change initiatives.

I congratulate Mr. Fortin on an excellent contribution to the body of knowledge in our field and I recommend this book wholeheartedly.

John Fortin *is the Vice President, and Global Director for Asset Management and Reliability at CH2M. John is an asset management and reliability practitioner with over 30 years of facilities 'lifecycle' experience including design, construction and O&M. He is internationally recognized for his leadership in strategy development, implementation and change management approaches.*

Robert S. DiStefano, *CMRP, now retired after a 40 year career, is the past Vice President & General Manager of Reliability Consulting at Emerson Process Management, and was previously Founder, Chairman and CEO of Management Resources Group, Inc. (MRG). Bob is credited with being one of the earliest leaders to recognize and emphasize the links between corporate business performance and asset management.*

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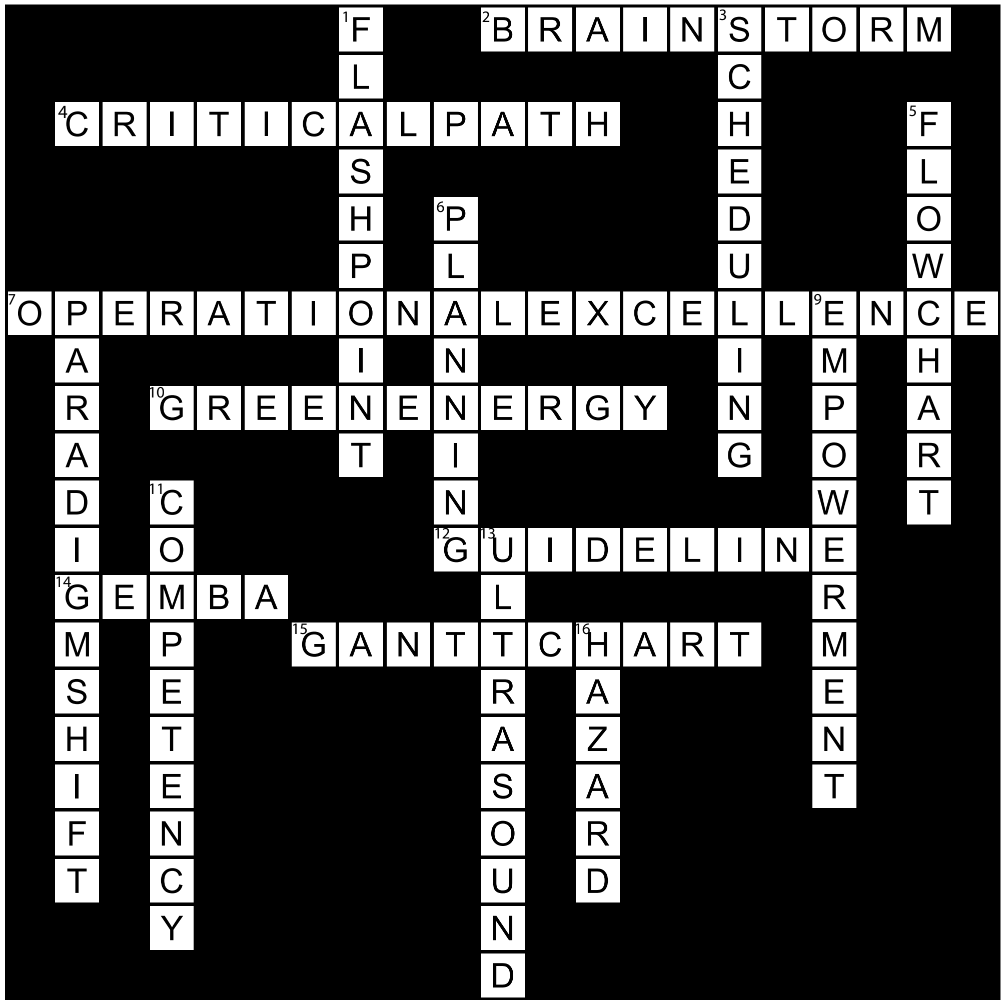
Crossword Puzzle



ACROSS

2. A basic problem-solving tool that uses unbiased ideas of group members to generate a list of possible options
4. The series of activities in a project network diagram that determine the earliest completion of the project
7. A philosophy of leadership, teamwork and problem-solving resulting in continuous improvement throughout the organization
10. A type of energy that is considered to be environmentally friendly and non-polluting, such as hydro, geothermal, the wind and solar power
12. A document that recommends methods to be used to accomplish an objective
14. A Japanese word for a workplace where the value is created
15. A bar chart of scheduled activities that shows the duration and sequence of activities and resources planned

DOWN

1. The lowest temperature at which vapor from a sample of a petroleum product or other combustible fluid will "flash" in the presence of an ignition source
3. A process of determining which jobs get worked on, when and by whom based on priority, resources, and asset availability
5. A graphical summary of the process steps and flows that make up a procedure or process from beginning to end
6. A process of determining the resources and method needed, including safety precautions, tools, skills and time necessary to perform maintenance work efficiently
8. A change from one way of thinking to another
9. A management practice of sharing information, rewards, and power with employees so they can take initiative and make decisions to solve problems and improve performance
11. Knowledge, awareness, skills, and abilities required to perform a task or job safely and consistently to a required standard
13. The use of sonic technology to discover asset problems
16. An event or situation that may lead to an emergency or disaster

Answers from page 7.