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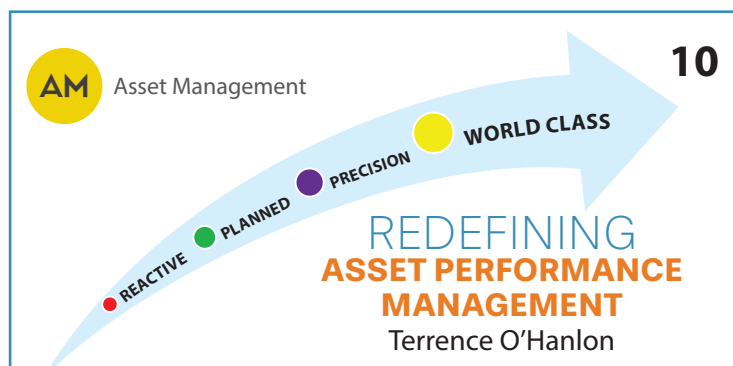
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aug/sept 2019



**uptime**  
for reliability leaders and  
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Can you find the hidden Uptime  
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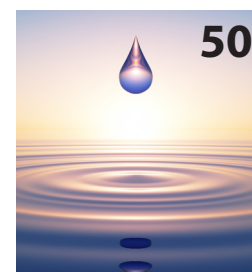
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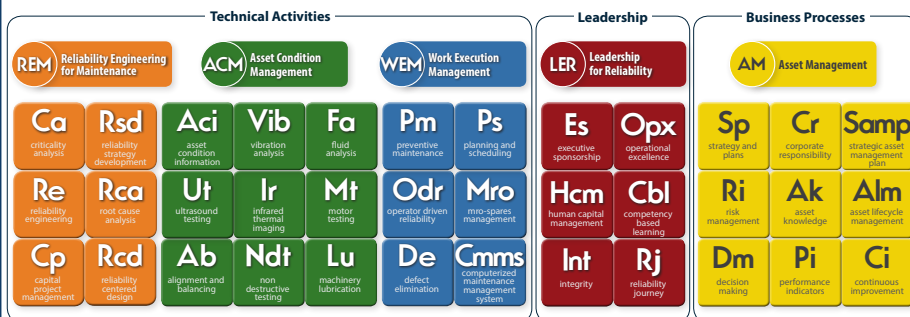


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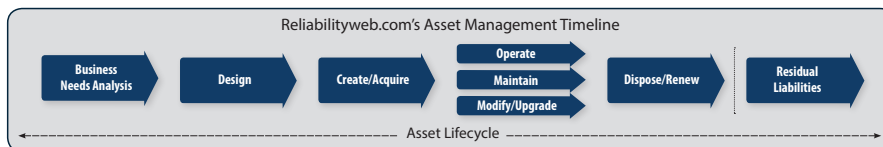
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## Uptime® Elements



### A Reliability Framework and Asset Management System™



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## DINNER WITH R. BUCKMINSTER FULLER

**PUBLISHER'S NOTE:** When I write, I occasionally dip into the realm of fiction/fantasy as a storytelling method. I request that the reader suspend disbelief, learn and enjoy. It was 50 years ago that one of my main influencers, Buckminster (Bucky) Fuller, wrote "Operating Manual for Spaceship Earth" [ISBN: 8601400798959], so I am taking the liberty to create a story that takes place at dinner just after Bucky completed a 5-day Certified Reliability Leader workshop. For Bucky's side of the dinner conversation, I am using exact quotes so that his ideas remain intact – word for word. I hope there is something for each of us to learn from Bucky and from each other 50 years later. I will post this conversation to my LinkedIn page at [linkedin.com/in/reliabilityweb](https://www.linkedin.com/in/reliabilityweb) and invite you to add to the conversation there.

**TERRENCE:** Bucky, now that you are a Certified Reliability Leader, you must recognize your work as a major influence of mine.

**BUCKY:** I just invent, then wait until man comes around to needing what I've invented. I look for what needs to be done. After all, that's how the universe designs itself.

**TERRENCE:** One of the reasons why safety has progressed is because as an industry, we collectively took a stand to advance safety performance. Although we are not at zero incidents, industry has made progress. For some reason, the will to take a stand for reliability is not as common. Many of the mid-level managers we meet are no longer willing to adopt new ideas or learn the new context of reliability.

**BUCKY:** What usually happens in the educational process is that the faculties are dulled, overloaded, stuffed and paralyzed so that by the time most people are mature, they have lost their innate capabilities. Everyone is born a genius, but the process of living de-geniuses them.

**TERRENCE:** One of the challenges with advancing reliability and asset management is that the benefits are seldom connected in real time. They are almost always delayed and delivered at some time in the future of the asset's lifecycle.

**BUCKY:** There is nothing in a caterpillar that tells you it's going to be a butterfly.

**TERRENCE:** Almost six years after the introduction of the Uptime® Elements A Reliability Framework and Asset Management System™, one of the main Leadership for Reliability Elements we observe related to performance is Integrity. Without integrity, reliability simply does not work.

**BUCKY:** Integrity is the essence of everything successful.

*"Don't fight forces, use them. You never change something by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."*

**TERRENCE:** We also discover many organizations attempting to "maintain their way to reliability" by trying to advance reliability through the maintenance department. Our work has led us to discover that reliability is much more analogous to safety, with the goal to achieve an empowered and engaged cross-functional approach in the context of reliability for everyone – with no one left behind. It has to be reliability for everyone or reliability for no one.

**BUCKY:** We are not going to be able to operate our Spaceship Earth successfully nor for much longer unless we see it as a whole spaceship and our fate as common. It has to be everybody or nobody.

**TERRENCE:** It is difficult for organizations as there seems to be no shortage of cross-functional expertise and desire, however, because asset systems and operating context are unique, there is no 'master' operating manual for most organizations, so they make it up as they go. The techniques, processes and technology for creating reliability strategy are available, however, they are not generally well understood or implemented on a dynamic basis. With the launch of ISO55001 Asset management – Management systems – Requirements, some organizations are beginning to create an 'operating manual' by creating strategic asset management plans (SAMP) and asset management plans (AMP).

**BUCKY:** We are called to be architects of the future, not its victims. Now there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it.

**TERRENCE:** I like to say that Reliability Leaders look for what's needed, and then they supply it. People and organizations have been struggling to advance reliability and asset management for the past 50 years, so we created the Uptime Elements A Reliability Framework and Asset Management System to address the technical, process and cultural aspects of the journey from a holistic view.

**BUCKY:** A designer is an emerging synthesis of artist, inventor, mechanic, objective economist and evolutionary strategist. When I am working on a problem, I never think about beauty but when I have finished, if the solution is not beautiful, I know it is wrong.

**TERRENCE:** There are people and organizations that are vested in maintaining the status quo and do not want to see the change we are driving to advance reliability and asset management using the Uptime Elements A Reliability Framework and Asset Management System.

**BUCKY:** Don't fight forces, use them. You never change something by fighting the existing reality. To change something, build a new model that makes the existing model obsolete.

**TERRENCE:** Thank you Bucky, your ideas wake me up and make me think. I am certain they will stand the test of time. Congratulations on sitting for the Certified Reliability Leader exam. I look forward to learning more from you as the caterpillar turns into a butterfly.

**BUCKY:** All of humanity now has the option to "make it" successfully and sustainably, by virtue of having our minds, discovering principles and being able to employ these principles to do more with less.

**Take a stand for Reliability and be a Reliability Leader!**

Terrence O'Hanlon, CMRP  
[About.me/reliability](https://about.me/reliability)  
CEO and Publisher  
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# IN THE NEWS

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## Tom Peters Announced as IMC-2019 Keynote

Reliabilityweb.com® has announced that Tom Peters, one of today's foremost management thinkers, will give a keynote address at the 34<sup>th</sup> International Maintenance Conference (IMC-2019), held on Marco Island, Florida, December 9-12, 2019. Following his keynote, he will participate in additional events, including a panel discussion and audience Q&A, an executive meet & greet and a podcast.

Tom Peters, who has been described as the "Red Bull of management thinkers," is one of the world's foremost management gurus. In 1982, Tom Peters co-authored (with Bob Waterman) *In Search of Excellence: Lessons from America's Best-Run Companies*, and introduced business to the notion of excellence as a state of mind. *In Search of Excellence* has been widely hailed as one of the most influential business books of all time.

For more information: [www.imc-2019.com](http://www.imc-2019.com)



## First Diversity in Reliability and Asset Management HACKATHON

The Association of Asset Management Professionals (AMP) is excited to announce the first Diversity in Reliability and Asset Management Hackathon taking place December 6-7, 2019, at the Reliability Leadership Institute in Fort Myers, Florida. This weekend project is for reliability and asset management enthusiasts who want to create new approaches, technology, applications and ideas to build and promote greater diversity in the reliability and asset management community. The material will be provided to the community under Creative Commons (open source) license at no cost.

### SCHEDULE OVERVIEW:

#### Friday, December 6 • 3:00pm

- Opening presentations and overview
- Team selection and breakout - The main work of the diversity hackathon begins. Teams work for several hours, some may even pull an all-nighter.

#### Saturday, December 7 • 3:00pm

- Team presentations and demonstrations
- Evaluation and judging of presentations
- Awards and prizes

**BRING YOUR TEAM!** There is no cost to participate; however, advance registration is required and space is limited. To get more details on signing up or supporting this exciting event, email: [crm@reliabilityweb.com](mailto:crm@reliabilityweb.com)



CRL Workshop, Mississauga, Ontario, Canada



Bentley's Going Digital, London, England



Windrock User Group Conference, New Orleans, Louisiana



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Greg Bentley



# DIGITAL TWINS to Advance Reliability and Asset Management

One of the organizations that has been a huge long-term source of awe, inspiration and new paradigms for me is Bentley Systems, Incorporated, led by Greg Bentley, CEO. Greg joined his brothers at Bentley Systems in 1991. Keith A. Bentley and Barry J. Bentley founded Bentley Systems in 1984.

Bentley Systems is an American-based software development company that develops software and services for the design, construction, and operation and reliability of infrastructure. The company's software serves the building, plant, civil and geospatial markets in the areas of architecture, engineering, construction (AEC) and operations. Its software products are used to design, engineer, build, and operate and maintain large constructed assets, such as roadways, railways, bridges, buildings, industrial plants, power plants and utility networks. The company reinvests 20 percent of its revenues in research and design (R&D).

Greg Bentley has led the creation of a team of some of the best and brightest subject matter experts, technical leaders and visionary relationship managers in infrastructure asset information.

Greg recently stated, "Bentley Systems opens up the dark data, the digital alignment, the change synchronization from the reality, the voracity of the engineering information and the integrity. Because if it's going to be a twin, it has to continually change, as does a construction project or an infrastructure asset. But, we want to be enabling everyone to take advantage of that..."

"Opening up to that dark data is the sea change that will enable us to be thinking differently about how our work in construction and project delivery leads to smart enterprises and connected plants. This creates opportunities for engineers in improving the throughput and functionality of what's designed in projects and the value delivered in operation."

## **Analytics and Machine Learning – Nothing Wasted**

Imagine all asset information in a connected data environment, in any available view, from every phase of the asset's lifecycle, available for decision support, modeling and performance analysis. In other words, begin asset performance and value delivery on the day the idea for the asset is born.

At its core, Bentley Systems is a software development company that supports the professional needs of those responsible for creating and managing the world's infrastructure assets, including roadways, bridges, airports,



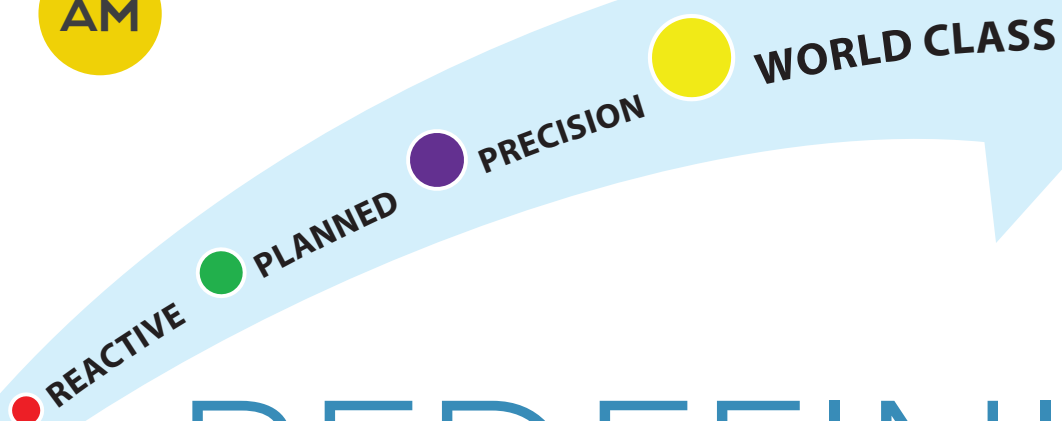
skyscrapers, industrial and power plants, as well as utility networks. Bentley delivers solutions for the entire lifecycle of the infrastructure asset, tailored to the needs of the various professions – the engineers, architects, planners, contractors, fabricators, IT managers, operators and maintenance engineers – who will work on and work with that asset over its lifetime.

The team at Bentley Systems views infrastructure asset management holistically and creates technology to support commonly used frameworks, like ISO55001 Asset management — Management systems — Requirements and Uptime® Elements A Reliability Framework and Asset Management System™.

The team at Bentley understands that a successful infrastructure is needed for a successful world. They are leading digitalization for advancing reliability and asset management in real and pragmatic ways. We look forward to the future they are creating under the leadership of their CEO, Greg Bentley.

Terrence O'Hanlon  
CEO/Publisher  
Reliabilityweb.com  
Uptime Magazine





# REDEFINING ASSET PERFORMANCE MANAGEMENT

Terrence O'Hanlon

**PUBLISHER'S NOTE:** I have spent close to 40 years learning and inquiring about various approaches to advance reliability and asset management. Although I have made a few of my own contributions, I treasure the contributions that come from others. In fact, the business I lead is optimized to provide opportunities for big contributors and small contributors alike. It includes book publishing, magazine and website publishing, conference presentations, training workshops, roundtable discussions, keynote addresses, white papers, research reports, project guides, videos, podcasts, webinars, and all other forms of modern communication. I get great satisfaction providing a stage and platform for people to express their work, especially when it can be used to make the people we serve safer and more successful by advancing reliability and asset management.

The objective for this article is to redefine Asset Performance Management (APM) and its maturity levels in a way that I propose will make more sense to the asset owner's stakeholders, the technology company stakeholders and, hopefully, some the analysts who originally defined APM themselves.

## The World According to Reliability

If you work for an asset intensive organization and your role involves ensuring value from assets, you are unlikely to organize the world by software applications as software marketing professionals or software analysts'

do in order to describe these applications and functions to chief information officers, IT leaders or other chief officers.

As a reliability leader, you begin with a theory of reliability, which, in simple terms, is about a failure-free operation. Leading businesses and mission focused organizations also include a theory of asset management, which, in simple terms, is coordinating activities across the functional roles in the organization and across the asset's lifecycle and across the enterprise to ensure value is delivered from the assets. A reliability and asset management strategy will usually include a comprehensive collection of technically valid and economically feasible maintenance tasks, including condition-directed tasks, time-directed tasks, failure finding tasks and run to failure decisions packaged as a preventive maintenance program.

“...There is a high probability that laying hands on or invading the boundary of a perfectly good working asset will create what is known as infant mortality or a worse new or worse repaired condition”



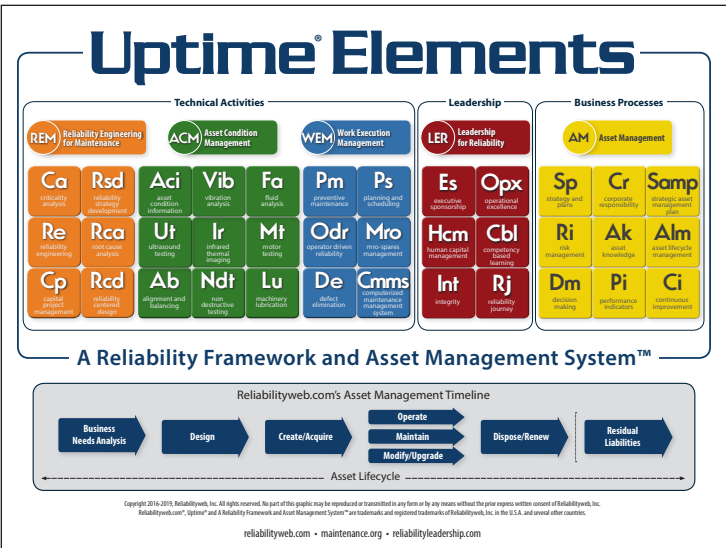
**Preventive maintenance** explained simply is asset servicing (e.g., repair, renew, replace) and inspection that is part of your plan and strategy. In other words, you know you are going to do it.

**Corrective maintenance** explained simply is asset servicing (e.g., repair, renew, replace) that surprises you – it is not part of your plan or strategy. In other words, it is an asset failure you did not have covered by a reliability strategy or there is a flaw in the reliability strategy you had for it.

It would be great if all assets were maintenance free and failure free, but that is an aspiration one may need to wait for Industry 5.0 to deliver as, to my knowledge, it is not an objective for Industry 4.0.

In the interim, most industrial organizations use maintenance work management applications, such as computerized maintenance management systems (CMMS) or enterprise asset management (EAM), to manage their preventive maintenance program and the corrective work management program created from reliability strategy development or other sources. These applications create work orders, store equipment maintenance history (e.g., schedules, failures, repairs, inspection results, material and parts usage, root causes, job plans, bill of materials, observations and notes, other data) and asset data.

You need a basic understanding of two reliability concepts in order to gain insight into how asset performance management works in a holistic system or reliability framework, as shown in Figure 1. One is reliability strategy development using the failure patterns. The other is asset condition management.



**Figure 1: Uptime Elements A Reliability Framework and Asset Management System**

### Reliability Strategy Development

As previously stated, asset intensive organizations use CMMS/EAM applications to manage preventive maintenance programs created from reliability strategy development or other sources. As renowned fiction writer, William Shakespeare stated, “Ay, there’s the rub!”

According to the Uptime® Elements – A Reliability Framework and Asset Management System™ body of knowledge, reliability strategy development uses tools like, reliability-centered maintenance (RCM), preventive maintenance optimization (PMO), and failure mode and effects analysis (FMEA)/failure mode, effects and criticality analysis (FMECA), to identify failure modes/failure mechanisms and failure causes, then applies a technical sound and economically feasible maintenance task to eliminate the functional failure.

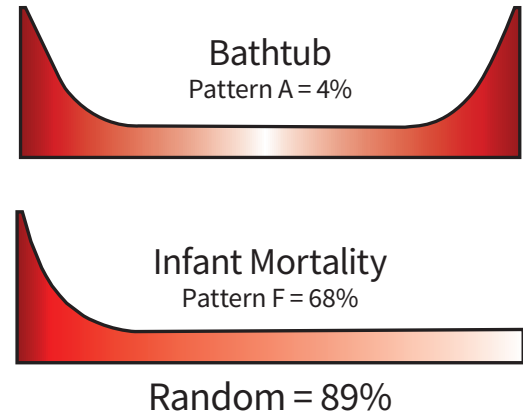
But, what about the other sources? Typically, the other sources for maintenance tasks are:

1. Original equipment manufacturers (OEM);
2. “We’ve always done it that way!”
3. Universal knee-jerk reaction to last data point management PM;
4. “No one knows why we do this one.”

Although it is possible that some of these maintenance tasks are adding value and contributing to reliability, it is more likely they are not. They may actually be causing your assets harm.

Only maintenance tasks that are technically validated should be performed since there is a high probability that laying hands on or invading the boundary of a perfectly good working asset will create what is known as infant mortality or a worse new or worse repaired condition, as shown in Figure 2.

### What is the risk of performing intrusive, time directed tasks?



There is a high probability that laying hands on or invading the boundary of a perfectly good working asset will create what is known as infant mortality, or “worse new” “worse repaired” condition

**Figure 2: Risk of performing intrusive, time directed tasks**

Maintenance tasks should be based on technically and economically effective responses to failure modes that can defeat the function of an asset or system. Since most failure patterns are random (i.e., not related to time), the most appropriate maintenance task decisions will usually be condition directed tasks or no maintenance task at all as a run to failure decision. Run to failure decisions must be integrated into any preventive maintenance program because many of your assets and systems do not justify time directed or condition directed preventive tasks. For example, a standard light bulb runs to failure, an employee reports it, and a replacement is scheduled.

Assets require some sort of intervention in the form of maintenance because of excessive age (usually less than five percent) or basic wear and tear (less than 12 percent). You may be able to make an argument, depending on the type of assets your organization operates, that basic wear and tear could extend to 23 percent (see failure patterns in Figure 3), but you rarely see it extend much higher. Aging assets arguments are handled on a case-by-case basis, depending on your organization's appetite for capital investment.

That still leaves a gaping 75 percent of asset failures caused by the asset not getting all the care it needs to run perfectly. Some reasons for those failures include:

- The defects preventing value and causing failure could have been created in the design stage of the asset's life and without redesign is not something maintenance is going to improve.





- The defects preventing value and causing failure could have been created in the build or asset creation phase.
- The defects preventing value and causing failure could have been created in the commissioning or installation phase.
- The defects preventing value and causing failure could be caused by raw material input or process inputs.
- The defects preventing value and causing failure could be caused by operational discipline issues.
- The defects preventing value and causing failure could be caused by maintenance workmanship.
- The defects preventing value and causing failure could be caused by maintenance material.
- The defects preventing value and causing failure could be caused by raw material input or process inputs.
- The defects preventing value and causing failure could be caused by data deficiency or poor information management.
- The defects preventing value and causing failure could be caused by senior management policy.

As an asset owner, you want your assets to deliver the organizational objectives (i.e., value) and you want to remove as much uncertainty (i.e., risk) as needed to do so. It's about having the ability to manage asset performance (i.e., APM) by automating condition monitoring, inspection results, operating data and other observations and conditions, setting rules, possibly adding machine learning (ML) and artificial intelligence (AI), and feeding the results and requested follow-up actions to the work management system (CMMS/EAM). The feedback loop then monitors the effectiveness and efficiency of the task to optimize future task decisions.

## Asset Condition Management

Asset condition management (ACM) involves measuring and monitoring equipment condition, system trends and operational performance using selected operating parameters and techniques to forecast the potential for future failures and permit timely maintenance in advance of these failures.

Modern condition monitoring technology provides information that can be confidently used to operate at maximum capacity and efficiency for a given load or throughput, as well as to scope and schedule emergent/secondary maintenance tasks based on asset condition. This monitoring capability also contributes to reliability and safety by ensuring that impending potential failures are identified and corrected at an early stage, minimizing both cost and the potential for catastrophic failure.

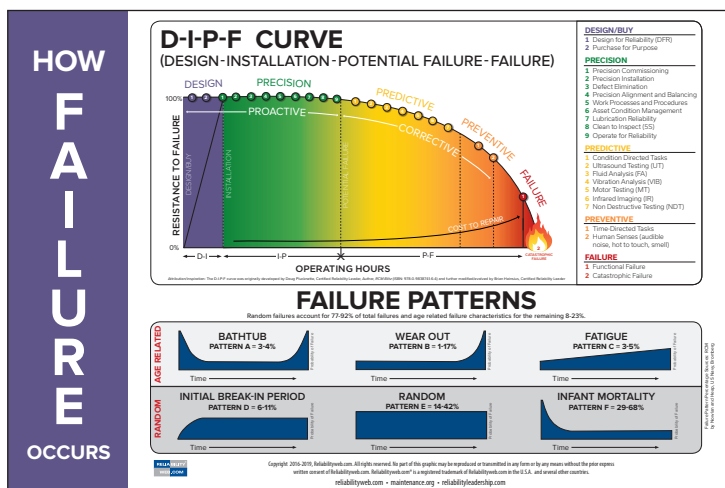


Figure 3: The D-I-P-F curve and failure patterns

ACM often provides maintenance personnel with the ability to assess the operating condition of equipment at any time and permit the monitoring of progressive deterioration of components without the necessity for their physical inspection through intrusive inspection.

Condition monitoring provides useful information to diagnose and correct problems early in the aging or failure sequence. This permits maintenance to be planned and scheduled with minimal impact on plant operation.

ACM is generally nonintrusive and does not interfere with equipment control functions or instrumentation.

## The Gravity Trap of the Maintenance Maturity Domains

Conventional best practices wisdom promoted by traditional old-school maintenance experts guide you from the reactive domain to the preventive maintenance or planned maintenance domain. From there, they guide you to the predictive maintenance domain, then the reliability-centered maintenance domain and finally the newly minted Internet of Things-enabled prescriptive maintenance domain.

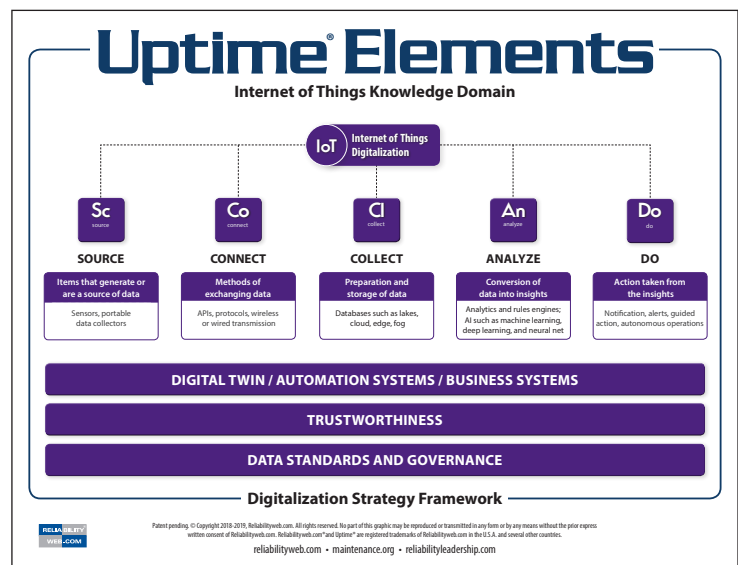


Figure 4: Uptime Elements Internet of Things Knowledge Domain

If reliability and asset performance are your objectives, here's the bad news: The best practices for maintenance do not work. In fact, they never did! The planned maintenance domain is not stable.

The Terrence O'Hanlon's Laws state:

- You cannot maintain your way to reliability and asset performance.
- You cannot preventive maintenance your way to reliability and asset performance.
- You cannot predictive maintenance your way to reliability and asset performance.
- You cannot reliability-centered maintenance your way to reliability and asset performance.
- You cannot prescriptive maintenance your way to reliability and asset performance.

The maturity journey to reliability and asset management is one of people/culture, practices/processes and technologies and will likely stretch across several domains.



**Table 1: Uptime Elements Asset Performance Management Maturity Matrix**

Domain	Blended Reactive and Proactive	Planned Maintenance Domain	Competent & Directionally Oriented	High Reliability Leadership Organization
Maturity	Innocent	Developing	Optimizing	Excellent
	REACTIVE	PLANNED	PRECISION	WORLD CLASS
<b>Outcomes</b>	High Cost, Low Output, Excessive Unplanned Work, Safety Challenge, Energy Waste, Low Quality, Turnover, Low Moral, Silo Mentality, Low Engagement	Workflow Control, Discipline, Planning System, Scheduling System, Spare Parts Management, Staffing Resource	Executive Sponsorship Aligned Goals, Cross-Functional Teams Aware with Desire, Knowledge-Building, Practice Fields, Communication, Policy/Strategy, Asset Information Management	Persistent Leadership, Lower Cost, Higher Output (\$), Safer, Energy Sustainability, Engagement, Retention, Recruiting, Recognition, Reinforcement, Celebration, Sharing
<b>Behavior Traits</b>	Responsive Work	Planned Work	Cross-Functional Organizational Discipline Toward Reliability and Asset Performance	Leadership-Centered Learning Organization, including Shared Vision, Personal Mastery, Mental Models, Team Learning and System Thinking
<b>Top Management</b>	Unaware of the Nature of Reliability Journey	Delegates Reliability and Asset Performance Leadership	Executive Sponsor Removes Obstacles	Highly Visible and Vocal, Leading Change by Words and Actions, Actively Involved and Visible
<b>Frameworks Adopted</b>	None	Various Models Used Individually in Disconnected Fashion	Uptime Elements, Certified Reliability Leader, Certified Maintenance Manager	Uptime Elements, Certified Reliability Leader, Certified Maintenance Manager, Asset Management Leader, Lubrication Leader Badge, ISO55000, ISO14224
<b>Reliability Leadership</b>	Only Managers Are Empowered as Leaders	A Mix of Informal Approaches to Reliability Leadership	Individuals Taking a Stand as Reliability Leaders to Work with Integrity, Authenticity, Responsibility and Toward an Aim Bigger Than One's Self	Everyone Is Empowered as a Reliability Leader and Works with Integrity, Authenticity, Responsibility and Toward an Aim Bigger Than One's Self
<b>Reliability</b>	Fix It After It Fails	Fix It Before It Fails	Improve It to Reduce Failure Effects and Consequences, Seek Opportunities to Remove Work from the System	Design Out Failure Modes and Defects Optimize Current Work
<b>Reliability Strategy for Maintenance Tasks</b>	Based on Original Equipment Manufacturer Recommendations and Past Experience ("That's the way we have always done it.")	Based on Experience of Peer Workforce and Combined with Original Equipment Manufacturer Recommendations and Past Experience ("That's the way we have always done it.")	Based on Formal Failure Mode and Criticality/Risk Analysis (RCM/FMEA/PMO)	Dynamic Technology Enabled Reliability Strategy Management Application Connected to Work Execution Management System (CMMS/EAM)
<b>Asset Care</b>	Asset Care Request Through Formal Work Request, Low Feedback	Asset Care Activities Directed by Management	Assets Get All the Care They Need to Run Perfectly	Team Is Empowered to Prioritize Asset Care Targets
<b>Precision</b>	Low Precision Work with No Progress Toward Improving	Mixed Precision Work with Little Progress Toward Improving	Standard and Improving Skills in the Workforce	Standard and Highly Skilled Workforce
<b>Feedback Loops</b>	The Asset Condition Directs the Work	Anticipation of Failure Tells You What to Work On	Elimination of Failure and Defects Tells You What to Work On	Defects and Failure Modes Designed Out Of Assets Based on Failure Knowledge
<b>Technology</b>	Basic Work Management	Enterprise Asset Management, Asset Condition Monitoring	Enterprise Asset Management, Asset Performance Management, Asset Condition Management	Digital Twin, Configuration Management, IoT Platform, AI/ML Whole Asset Lifecycle Information Management, Enterprise Asset Management, Asset Performance Management, Asset Investment Management, AR/VR/MR, BIM
<b>People/Culture</b>	Not Engaged, Silo Work Teams	Intense Effort, Hard Work, Get It Done	Empowered, Engaged, Cross-Functional	Synergy, Leadership, One Team: Us
<b>Competency Based Learning</b>	Ad Hoc Training When Time Permits	Skills-Based Classroom Training	Mix of Competency-Based Learning and Skills-Based Training and Dedicated Practice Fields	Partnered Collaboration with Human Capital Management to Create Required Competencies in the Workforce
<b>Performance Management</b>	Disconnected Metrics	Lagging Indicators	Leading & Lagging Indicators	Aligned and Cascaded Organizational Objectives and Metrics
<b>Asset Management</b>	Focused on Asset Restoration, Renewal, or Repair Tasks	Focused on Asset Condition Inspection and Servicing Tasks	Focused on Asset Condition Inspection and Servicing Task Based on Business Rules	Robust Managing System with Asset Management Policy, Strategy and Plan (by Asset Class)



**Table 2: Five Disciplines of a High Reliability Organization**

	Innocent	Developing	Competent	Excellent
Shared Vision Set for the Aim or Organizational Objectives				
Personal Mastery of Uptime Elements and Supporting Frameworks (i.e., ISO55000)				
Mental Models That Enable Collaboration Are Installed and Spoken About				
Team Learning Is Happening Together Toward the Policies, Strategies and Plans and Required Competencies Based On Roles and Responsibilities				
System Thinking About Reliability as Simply “The Way We Do Business”				



The *maintenance* concept has become so mistakenly entwined with *reliability* that the two terms are often used as synonyms. No CEO wants more maintenance – think “high maintenance.” All CEOs want failure-free operations – think “high reliability. Which would you rather be?”

The planned domain is not a stable domain because without a high reliability culture, it is likely that everyone across the organization is adding defects into the system faster than the maintenance and inspection system can remove them. Set the next destination for the precision domain and realize that parts of your strategy and maturity will stretch across multiple domains.

As a reliability leader, your role is to point the way to **world class** and set the ultimate destination to being a “learning organization” that has flexibility

“The maturity journey to reliability and asset management is one of people/culture, practices/processes and technologies”

through the use of a framework for future reliability and asset management challenges.

Encourage yourself to learn more about ISO55000/55001/55002, Managing System for Asset Management, Uptime Elements – A Reliability Framework and Asset Management System and Uptime Elements Digitalization Strategy Framework to lead the way toward creating a cross-functional, engaged and empowered team of reliability leaders across your enterprise who stand for delivering a safe, sustainable, failure-free value toward organizational objectives from assets.

Today, there are numerous technology providers that offer platforms for asset performance management fueling EAM. Begin your advance with a strategic view toward the people side of the journey, which is usually the most significant and difficult, the process side of the journey and the technology side of the journey.

A dynamic linkage and feedback loops between reliability strategy management, asset condition management and EAM will fuel asset performance and delivery of organizational objectives in a safe and sustainable fashion.



**Terrence O'Hanlon** is CEO and Publisher of *Reliabilityweb.com* and *Uptime Magazine*. Terrence is an asset management leader specializing in reliability and operational excellence and is a popular keynote presenter with the ability to deliver awareness about the business advantages of asset management to top management. [www.reliabilityweb.com](http://www.reliabilityweb.com)



A wide-angle photograph of a wooden pier with metal railings extending into the water of Marina Bay Sands in Singapore. The skyline of Singapore, including the Marina Bay Sands hotel, is visible in the background under a clear blue sky.A large, stylized blue logo consisting of the letters 'Y' and 'I' formed by geometric shapes.

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Figure 1: Southern Gardens



# Moving Down a Reliability Continuum in Pursuit of Excellence

Jim Sullivan



# Southern Gardens Mission: Continuously improve and become the low-cost supplier of high quality citrus products to our customers, while maximizing returns to our shareholders.

**S**outhern Gardens has embarked on a journey in pursuit of achieving excellence in reliability. The key is perseverance because the road is often bumpy. Continuous improvement moves you down the continuum, so when you think you are at the end, you realize there is always room for improvement.

## Overview of Southern Gardens

Southern Gardens (SG) is a bulk processor of not from concentrate (NFC) orange juice located in Clewiston, Florida. Its official grand opening was January 20, 1994. Over the course of 25 years, the orange juice industry has gone through some significant changes. In the 1990s and 2000s, the industry experienced record crops, causing SG to process 24/7 during the fruit season. Diseases and competition have affected the industry to the point where SG now processes 24/5. It is important in agriculture to process consistently while building a reliability program. Plenty of storage space allows SG to ship product to the brands and private label year round.

## Building a Foundation

SG's first two seasons focused fully on commissioning the plant and training the employees. Equipment maintenance received very little attention. Lubrication was nonexistent and less technicians were needed during the off-season. After the second season, SG hired a new vice president.

The change in leadership exposed employees to a new series of buzzwords and acronyms used to change and mold the culture. Total productive maintenance (TPM), collaboration, self-directed work teams and the five star philosophy were the concepts employees began to learn. The new VP's vision for maintenance was to move down a continuum. Self-directed work teams were a key component to help with this strategy.

SG developed a mission statement that 25 years later has remained unchanged. It states: "Continuously improve and become the low-cost supplier of high quality citrus products to our customers, while maximizing returns to our shareholders."

Early on, at the written request of a technician, technicians were assigned to specific pieces of equipment. Ultimately, that led to assigning the technicians to a production team, reporting to the operations team leader. This started out as a good idea and led to immediate improvement in equipment uptime. As the uptime improved, the focus for the technicians changed to improvement projects. At that time in the continuum, SG did not understand that the primary responsibility of the maintenance department is to maintain equipment reliability.

During those early years, SG had not formulated a definitive plan. It was determined to start with the basics, including lubricating equipment, hiring maintenance planners, hiring various consultants, using a computerized maintenance management system (CMMS) and developing metrics.

## Gaining Ground

As you move down a continuum, there will be times when you level out. An event occurs to trigger a resurgence in your efforts. In 2001, two significant events occurred that reenergized SG's efforts and continue to shape its pursuit of maintenance excellence. First, SG submitted and received ISO certification for its food quality process. ISO certification is significant because it enforces the importance of having defined and documented processes. The

other event was establishing a maintenance guru, commonly referred to as a reliability champion.

The next several years, employees attended maintenance management training, conferences and benchmarking learning about maintenance best practices and moving from reactionary to proactive maintenance. In order to continue to move down the continuum with the goal of improving cost, the reliability champion successfully convinced senior management to make four changes to SG's strategy. They were:

1. Centralize maintenance under a maintenance manager;
2. Hire a reliability engineer (always a difficult request when adding head count);
3. Make capital planning/implementation part of the reliability champion's responsibility to control maintenance costs;
4. Assign reliability its own star in the five star philosophy. This philosophy was a basis for SG's culture. Moving down the maintenance continuum is cultural change.

Immediately, a collaborative change of design process was developed for all project work, capital and expense. This process, once modified, became part of the asset management program and helps maintenance control spending. Project overruns often "hit" the maintenance expense budget. SG also hired a reliability engineer, who immediately started working on equipment criticality, further development of the preventive maintenance (PM) program, development of lubrication routes and improving the root cause analysis program.

## Building a Process

Once again, SG lost momentum and needed another significant event to ignite its efforts. This happened in 2006 with the implementation of a fully integrated enterprise resource planning (ERP) system. This was impactful

2006-2007	# of PMs	% of PMs	Planned Man-Hour Change Per Month	Cost at \$30/Hour
Non-Value Added	45	1.56%	68.625	\$2,058.75
Frequency Decreased	359	12.46%	228.34	\$6,850.20
Frequency Increased	45	1.56%	-41.5	(\$1,245.00)
No Modifications	2432	84.42%	0	\$0.00
Total	2881	100%	255.465	\$7,663.95

2017-2018	# of PMs	% of PMs	Planned Man-Hour Change Per Month	Cost at \$30/Hour
Non-Value Added	0	0.00%	0.0	\$0.00
Frequency Decreased	47	4.10%	36.1	\$1,080.30
Frequency Increased	0	0.00%	0.0	\$0.00
No Modifications	1099	95.90%	0.0	\$0.00
Total	1146	100%	36.1	\$1,080.30

Figure 2: Preventive maintenance optimization (PMO)



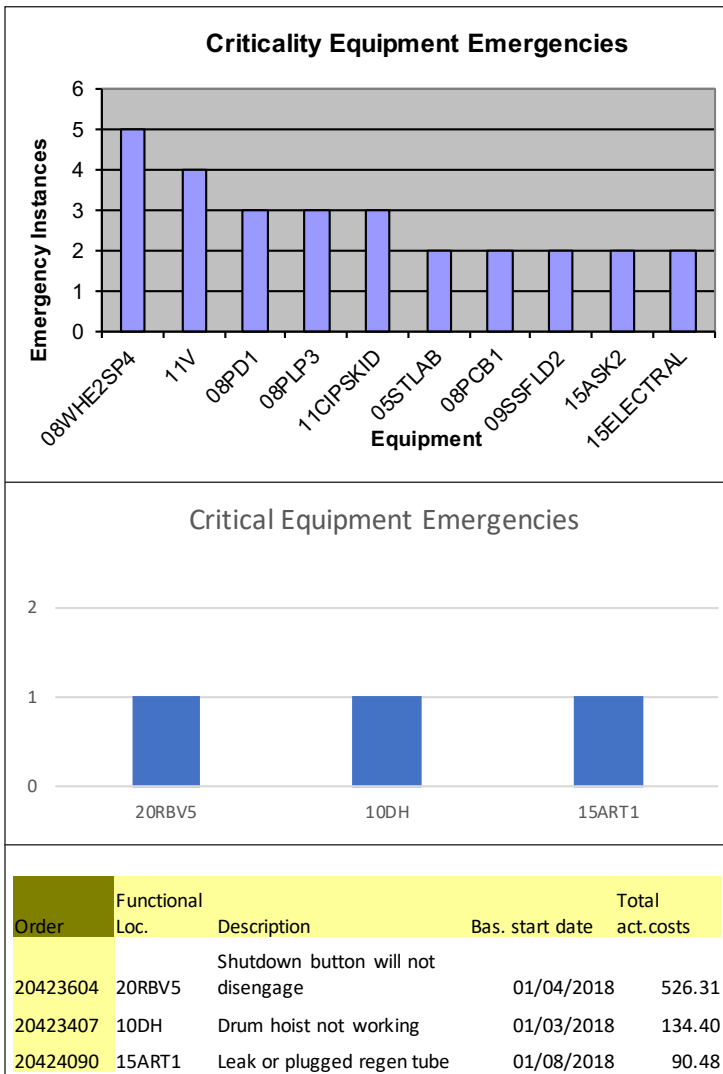


Figure 3: RCA – critical equipment emergencies

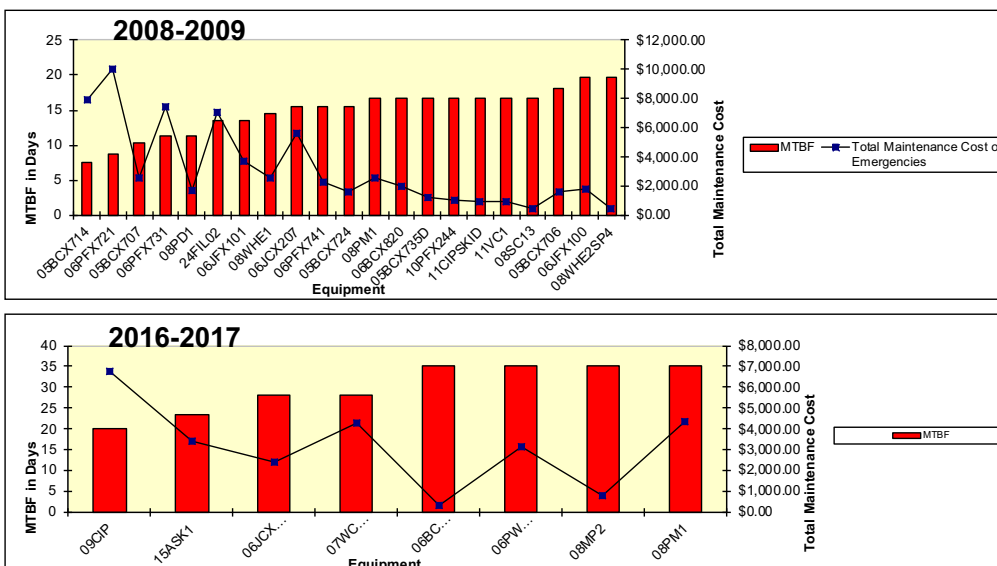


Figure 4: RCA – equipment emergency MTBF vs maintenance cost

since the software company's consultant helped SG map out its three main maintenance processes: work management, reliability engineering, and maintenance, repair and operations (MRO). This was the aha moment when it was decided that reliability excellence was SG's new goal. Programs and steering committees often need names, so SG's is REAL, which stands for reliability excellence and leadership. A success program needs leadership.

In work management, SG focused on developing and documenting processes for metrics; a joint maintenance/operations meeting; improvements to planning and scheduling; planners' responsibilities in order to remove them from emergencies; and maintenance supervision. For MRO, besides developing processes around kitting, metrics and other best practices, SG renovated the parts warehouse. For the reliability section, SG developed a preventive maintenance optimization (PMO) program and a condition-based maintenance program, including predictive maintenance (PdM). It also improved root cause analysis (RCA), which included the development of RCA triggers and the formation of RCA teams. (In 2015, SG was awarded the Uptime Award for Best Asset Condition Management Program.)

SG continued to make progress decreasing costs and improving reliability. It also continued to add and/or improve its processes. A significant improvement altered the management of change (MOC) process. The company now uses the MOC process for all projects (capital and expense). The cost benefits for having such a program should not be underestimated. This process also helps with external auditors, insurance companies and regulatory agencies. The revised process focuses on collaboration, communication, commitment and consensus for all projects across all stakeholders. (In 2017, SG received the Uptime Award for Best Asset Management Program.)

## Building Momentum

A successful project needs the cooperation of the entire organization. You especially need buy-in from operations. From 2011 to 2015, SG chose to develop an operations/maintenance partnership agreement. This led to an operator driven reliability (ODR) program, developed by operations. The company promoted a new vice president from within who understood the benefit of maintenance meetings. To have a successful program, it is just as important to have an executive sponsor as it is to have a maintenance champion. SG also incorporated utilities under the maintenance umbrella, developed a strategic asset management plan (SAMP) and started using vending machines for operational and safety supplies to realize cost savings.

Recently, SG started using a data historian for capturing data from its programmable logic controllers (PLCs) to help troubleshoot and diagnose upset conditions. In addition, the facility changed its approach to off-season rebuilds. The old philosophy was to rebuild everything during the rebuild. This is very expensive. Now with a proactive reliability program, SG can perform inspections on all the equipment. It rebuilds only what is necessary.

“Always challenge the status quo and embrace change”



## BEFORE OPTIMIZATION



Figure 5: MRO before and after optimization

## AFTER OPTIMIZATION



### Results and Lessons Learned

1. Throughout the process, even when small steps were made, SG continued to reduce maintenance costs.
2. The facility significantly reduced technician and summer help head count.
3. SG realized improved equipment reliability and uptime.
4. Electrical and welding contractors were eliminated by performing the work internally. This saved costs, improved knowledge and gained buy-in due to the success of projects.
5. Collaboration (i.e., no person is smarter than a group) and involvement of all the stakeholders in the development of any process is extremely important.
6. Leadership and executive sponsorship is equally important.
7. As failures were eliminated, the facility needed to change its triggers by grouping equipment for RCAs.
8. In 2018, Uptime® magazine and Reliabilityweb.com recognized SG as having the Best Overall Program.

Where does SG go from here? The reliability champion will continue the facility's pursuit to excellence and continue to find ways to reduce costs while improving equipment reliability. One item the reliability champion has already started working on and has a lot of passion for is the digital transformation and the Internet of Things (IoT).

### Summary

Organizations moving down the reliability continuum in pursuit of excellence should keep these tips in mind:

- Always challenge the status quo and embrace change. Ask: "Is there a better way?"
- You need a defined plan, but be flexible. The plan is not set in stone.
- You need a defined and documented process.
- Vision without implementation is just a dream.

**One final thought: Drink plenty of NFC orange juice!**



### UPTIME AWARD WINNER:

2015 Best Asset Condition Management Program  
2017 Best Asset Management Program  
2018 Best Overall Program



**Jim Sullivan** is Engineering and Maintenance Facility Leader at Southern Gardens Citrus Processing. Jim is a trained CPMM and has received a variety of training from institutions, such as Dale Carnegie, American Management Association, Maintenance Solutions and Clemons University. [www.ussugar.com/citrus](http://www.ussugar.com/citrus)





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# HOW THE QUEST FOR BETTER PUMPS CAME TO (ALMOST) NOTHING



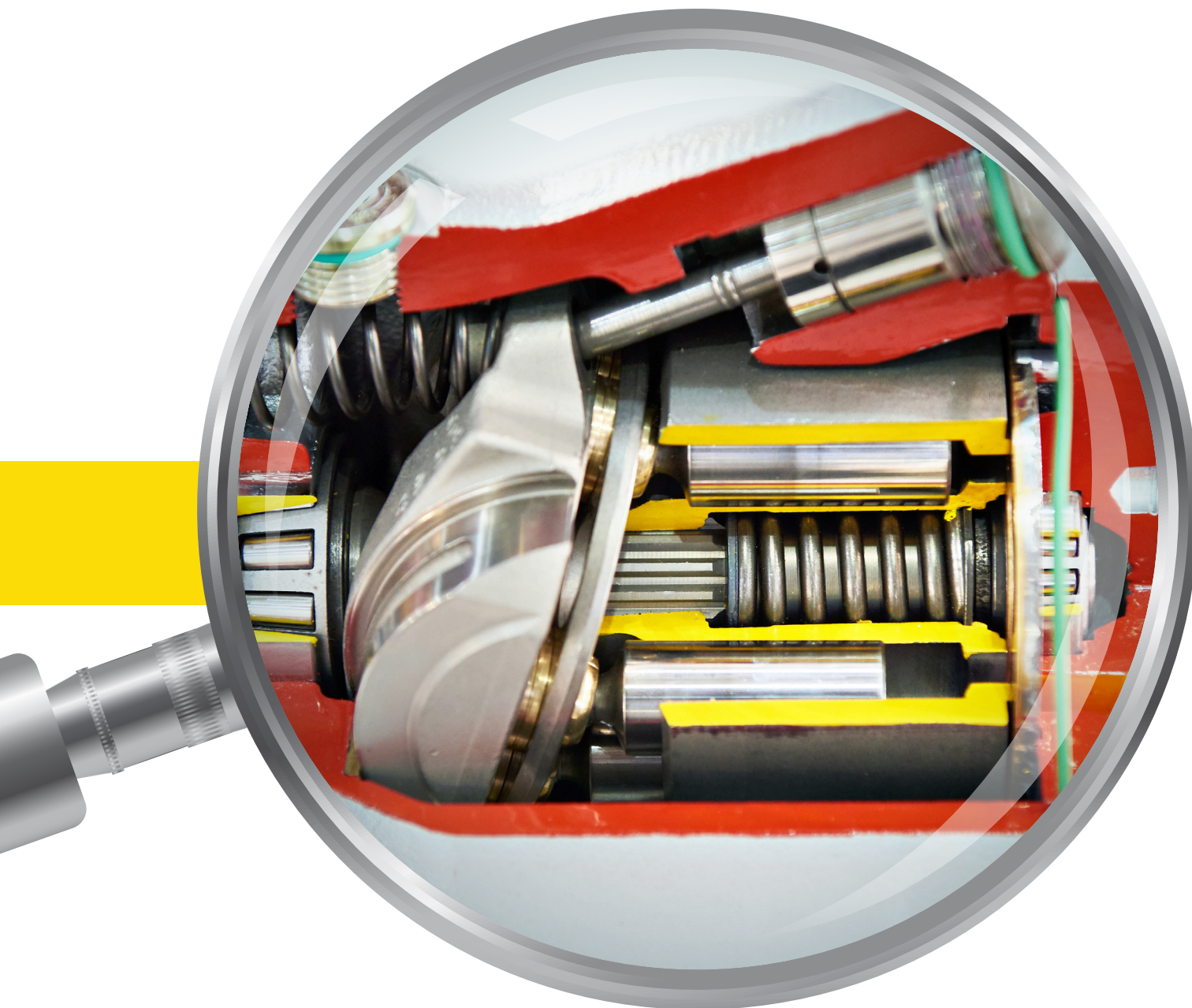
Heinz P. Bloch

Part 1 in the June/July 2019 *Uptime* issue closed with the experience-based statement that failure risk can escalate by certain specification practices, including some contained in API 610. Without going into the many possible reasons for bearing life reductions, the quest for better bearings in upgraded process pumps elicits several observations that should be considered when preparing a modern pump specification.

- Deep-groove, Conrad-type ball bearings with loose internal clearance (C3) are more tolerant of off-design pump operation than bearings with normal internal clearance. With few exceptions, this clearance should be specified for pump bearings.
- In centrifugal pumps that occasionally see temperature excursions, destruction of the cage may be experienced. Phenolic cages are generally limited to operation below 100°C or 212°F. They tend to become brittle at both high and excessively low temperatures. New cage materials, such as Polyamide 66, provide a marginally higher temperature limit and excellent lubricity at somewhat higher operating temperatures.

- All plastic cage material must be avoided in equipment where vibration data acquisition and analysis are used as the predominant predictive maintenance approaches. Cage deformation and wear-related distress will not show up in the overwhelming majority of vibration data acquisition and detection instruments (e.g., sensors) used by maintenance reliability engineering workforces.
- The relative temperature sensitivity of both thermosetting (i.e., phenolic) and thermoplastic (i.e., polyamide) cages makes it impractical to entrust shaft mounting via heat dilation to anyone other than a select few conscientious and highly experienced repair shops.
- Metallic cages are the least temperature-sensitive. Deterioration of metallic cages will generally show up in vibration spectra displaying vibration amplitude versus vibration frequency. Therefore, rolling element bearings with metallic cages (e.g., brass, steel) became the preferred repair, replacement and/or retrofit component. But, brass cages are prone to smearing and, notwithstanding that API 610 advocates their use, may not be the preferred choice of well-informed reliability professionals.





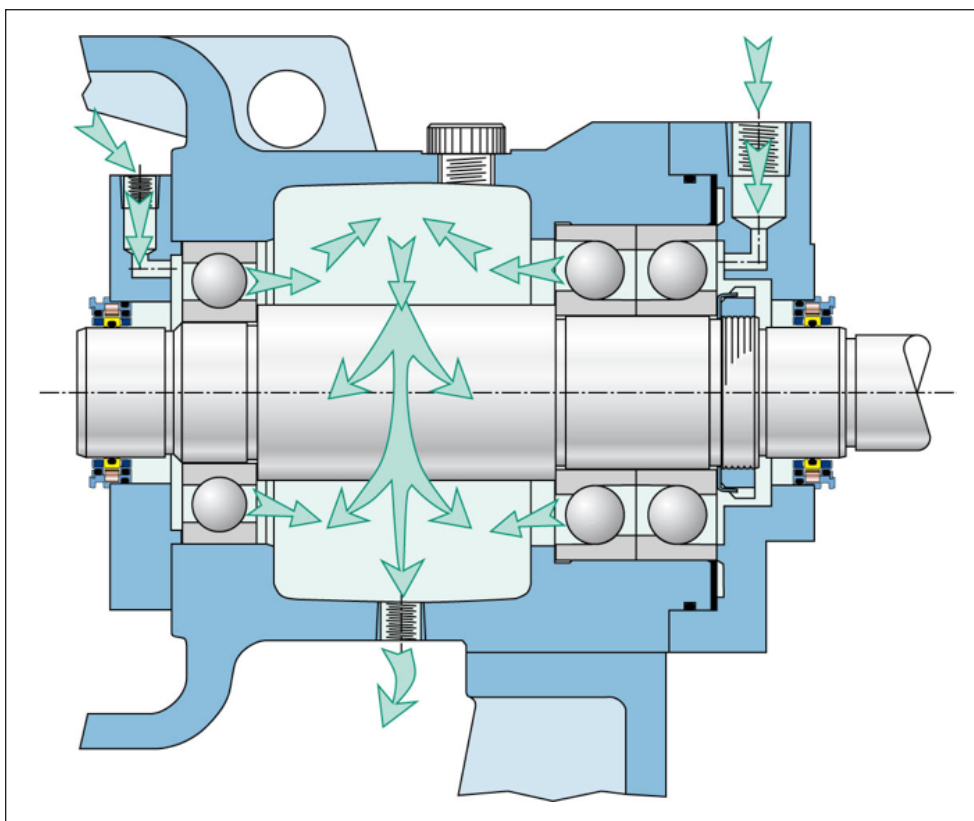
- Years ago, the API 610 requirement to utilize duplex 40° angular contact/angle thrust bearings was prompted by the desire to obtain maximum load capacity from a given size bearing. Similarly, the requirement of installing these bearings back-to-back with only a light or zero axial preload was aimed at reducing axial shuttling of rotors to prevent brinelling of contact surfaces (i.e., raceways) and ball skidding. One bearing company had shown that, for the same load, 40° angular contact bearings generate less heat than thrust bearings with lower contact angles.<sup>1</sup> However, preloading adds to the heat load and using an interference fit between shaft and inner ring may compound the problem. Unless lubricant application methods take this into account, bearing life and reliability may be curtailed.
- Double or single row filling notch bearings are considerably more vulnerable in pump thrust applications than other bearing types and should not be used.<sup>2</sup>
- Ball bearings are sensitive to shaft misalignment and must be properly mounted to eliminate this mode of failure. Misalignment must be no greater than .001" per inch of shaft diameter. Bearings operating in a misaligned condition are subject to failure, regardless of cage type.

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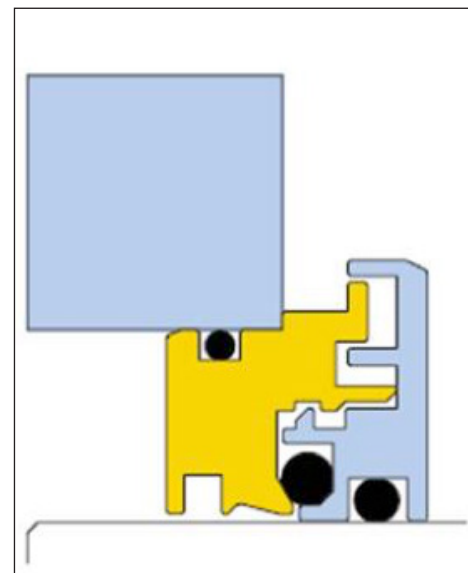
...Pump life extensions and component improvements can come from better specifications, more careful engineering and better dissemination or presentation of relevant data

.....





**Figure 1:** UMD pump bearing housing showing various bearing-related features



**Figure 2:** State-of-the-art bearing housing protector seal with a dynamic O-ring  
(Source: AESSEAL Inc., Rotherham, UK and Rockford, TN)

As mentioned at the outset in Part 1, pump life extensions and component improvements can come from better specifications, more careful engineering and better dissemination or presentation of relevant data. It is in these areas where closer cooperation between user, contractor, pump manufacturer and component suppliers (e.g., bearings, seals, couplings) could prove highly advantageous to all parties.

The upgraded medium duty (UMD) bearing housing shown in Figure 1 incorporates the various bearing-related features that have been discussed in the years since 1979, including:

- A deep-groove, Conrad-type, loose fitting radial bearing;
- A set of duplex angular contact (40°), but lightly preloaded, back-to-back mounted thrust bearings;
- A vent port that remains plugged for pure (i.e., dry sump) oil mist lubricated bearings;
- Bearing housing end covers made to serve as directed oil mist reclassifier fittings or, in certain upgraded pump bearing housings to be built in the future, as oil delivery jets;
- A set of advanced bearing housing protector seals (see Figure 2).

### A Retired Pump Distributor Joins the Conversation

A pump distributor, who had just retired, decided to attend a well-known pump conference just one more time. His observations tied in with a tutorial on better pumps and seals for hydrofluoric acid (HF) services. His candor was truly refreshing. Here are his sentiments, with a few names changed in his directly quoted narrative. He wrote:

"Your visit to the Vendor X booth last Wednesday was a real treat for me. I very much enjoyed visiting with you and was interested in your work concerning optimized lubrication of pump power ends.

"With absolutely no intention of 'blowing smoke' as my pump industry career winds down, I have little to gain by foolish or deceptive talk; now, I just say what I mean. I would like to say how much I have admired your efforts to improve the operating performance of rotating machinery used in the energy industry. I watched (from a distance) as you attempted to improve the reliability of ANSI B73 pumps.

"During the years that you worked on pump specification upgrades, which led to the proposed UMD pump classification, I was the regional representative for both Vendor X and a centrifugal pump company.

"I became a strong supporter of the UMD classification and sold several UMD pumps. As you of course recall, you collaborated freely with the vice president of the centrifugal pump company.

"My favorite UMD sale was to a southwestern refinery. As I remember, it was a fairly big pump, possibly a 4 x 6 medium process duty pump with a mechanical seal. It was made of 100 percent Monel metal, which is needed for concentrated hydrofluoric acid (HF) service.

"The pump ran for more than three years completely trouble free, at which time a small leak developed at the mechanical seal. The year was 1991 and with unforgivable lack of forethought, compounded by four or



five erroneous assumptions, the lead maintenance man, with about 10 assistants standing by, began to remove the back cover without blocking in the pump and draining the residual HF. As I recall, the cover had 16 bolts.

"In what might be called a machine's final attempt to avoid disaster, and thanks to its well-engineered O-ring placement, the pump did not immediately leak HF. By now, 13 cover bolts had been removed to speed up replacement of the pull-out assembly or to make a quick repair. When one of the last three cover bolts was loosened, a torrent of HF poured out. Two mechanics died painful deaths and five men were badly burned. The owner of the refinery was sued. Until the full details were discovered, the pump company and I were threatened with legal action. Comments such as: 'The pump didn't even meet API 610' were frequently heard. After the dust (and the HF) settled, the refinery acknowledged full responsibility. The pump company and I, the seller, never even heard from the trial lawyers. The pump, although UMD and not API 610, was fully exonerated and many of its design features complimented. I still think the HF disaster was unfairly used to discourage use of the UMD specification.

"Well, that's my story and I'm sticking to it, as the saying goes. Pioneers like you are up against the big boys and their vested interest of selling junk, since they make a good living doing so. I sometimes think a few honest engineers are just tilting at windmills, as the Don Quixote expression goes, as they go up against 'Big Money' looking to maintain their cash flow.

"Best wishes in your campaign to improve power end lubrication. From the very little that I know about lubrication, you have the facts on your side and the big pump manufacturers have the money (and lawyers) on theirs. I wish you well, my friend."

The president of the company previously identified as "Vendor X" promised to get his engineers involved in looking at the cost of developing a par-

ticularly promising pump lubricant application method. To date, there are no progress updates. He made an offer to provide cost versus benefit information in tutorial format at the next conference; it was met with lukewarm approval by the reviewers who evidently have their own agendas. So, rather than trying to teach the unteachable, it's more desirable to discuss superior lubrication methods with innovative user-professionals. There is no gain in continuing with futile efforts to convince vendors to build better pumps or pumps that fail less frequently. Instead, the goal is to publish upgraded topics and highlight cost justified opportunities in publications and materials that will potentially reach receptive audiences.

And that's where the story ends. Were it not for enjoying the centrifugal pump's decades of success, those involved could look back at years of tilting at windmills. Not even Don Quixote spent that much time on a task!

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*Optimized Equipment Lubrication, Oil Mist Technology, and Storage Preservation Best Practices* by Heinz Bloch is scheduled to be released Fall of 2019 by Reliabilityweb.com Publishing.



**Heinz P. Bloch** has had long-term assignments as Exxon Chemical's Regional Machinery Specialist for the United States. He has authored or coauthored over 730 publications, among them 21 comprehensive books on practical machinery management, failure analysis, failure avoidance, compressors, steam turbines, pumps, oil mist lubrication and optimized lubrication for industry.

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# Failure to Launch

Ray Miciek

## Why IoT Projects Fail to Get Started

The May 2019 The RELIABILITY Conference™ saw a significant increase in the number of sessions and vendors that included the Internet of Things (IoT), Industry 4.0, or digitization topics/themes. The IoT related content has been on a steady rise for the past couple of years, with no sign of slowing down as evidenced by the agendas for the MaximoWorld 2019 and IMC-2019 conferences in August and December 2019, respectively. Of course, if you are in the business of maintenance reliability, this subject prevalence is nothing new to you.

What is surprising came from a discussion among industry professionals at The RELIABILITY Conference. They observed that despite all the hype about IoT, there is not a commensurate amount of hype regarding companies that are actually doing something. That's not to say there aren't some great examples of companies using IoT to improve operations and reliability. But those who were part of the discussion couldn't help but ask: "Why are there not more?" Vendors and companies talk about the "vision" of IoT within the industry, but a lot less of them seem to be putting that vision into practice.

It's sort of like that 2006 movie, *Failure to Launch*. It centers on Matthew McConaughey, whose 35-year-old character, Tripp, still lives at home with his parents, played by Terry Bradshaw and Kathy Bates. Despite their best efforts, they cannot get Tripp to move out, who, by the way, believes his parents love

having him there. Tripp knows he probably should leave, but it's pretty good where he is. It is a goofy rom-com that is fun to watch and relatable if you have a recent graduate who has come back home to live.

So, how is this movie relevant to an organization's IoT strategy? Over the past couple of years, a great number of companies have been exploring the value that IoT solutions can provide. There have been numerous conferences and user groups where this value is presented. Yet, despite knowing the benefits that it can bring them, organizations stay the course. They are suffering from a *failure to launch* in one of two areas:

“ Vendors and companies talk about the “vision” of IoT within the industry, but a lot less of them seem to be putting that vision into practice ”



## Failure to *start* a project or pilot Or Failure to *expand* beyond a pilot.

Back to the discussion at The RELIABILITY Conference, the participants came to some conclusions about each of these two areas.

### FAILURE TO START A PROJECT OR PILOT

This can be traced back to one of five broad reasons:

1. **IT Arrogance** – That may be too strong of a word, but it does seem to creep into nearly the start of every IoT conversation. Typically, it manifests itself in one of two comments. The first one is: “We are already doing IoT.” In many ways, this is true, especially in a regulated environment, such as a utility or oil&gas company. They have been monitoring assets forever with huge control rooms and the like and it is effective, meaning they do catch the big failures. But, what do they do with the rest of the data? Or, how do they manage the thousands of other unmonitored assets? The second comment is: “We have all the data we need.” This also may be true as they have created data lakes and have databases associated with all their pop-up applications. But again, what are they doing with it and how hard is it to use all that data?
2. **An IoT Project Is Too Complicated and Would Take Too Long** – For sure, a perception exists that is associated with past integrations into Supervisory Control and Data Acquisition (SCADA) systems or Manufacturing Execution Systems (MES). However, this reason is no longer true with the new set of technologies available. Certain IoT solutions can be up and running in a matter of weeks, not months.
3. **No Dedicated Budget** – A common reason is: “We did not plan for this in our maintenance, equipment, reliability budget, so I have no money.” It’s an interesting reason, given that they will spend money elsewhere to shore up gaps they may have, say a labor shortage or an equipment replacement. Yet, the right project can eliminate a lot of the problem areas that are costing much more than what an IoT project would cost.
4. **Only Operations/Maintenance Will Benefit** – This is an age-old problem of maintenance and reliability being seen only as a cost center.
5. **Focus on Immediate Concerns** – Maintenance will always be under the gun. The mind-set at companies will always be if the product gets out the door and the machines keep running, that is good enough, with little regard to the impact on culture or employees. Or, there is the thinking that organizations have enough on their plate keeping a plant running without starting a new project.

### FAILURE TO EXPAND BEYOND A PILOT

Let’s say a company decides to move to pilot stage. What is keeping it from moving into production? There are several reasons:

- **Technology Looking for a Problem; IT Led vs. Business Led** – This is a real issue. Often, the pilot will start with some edict that states: “We need to do IoT.” This often will fall on IT – they have innovative people and maybe, with the help of a creative vendor, create a can’t miss solution. The IT folks go to the operations people and let them know they are implementing this IoT solution that will be great. Turns out no one ever talks to the line of business to see if this solves a problem worth solving.

A recent survey conducted at the Internet of Things World Forum seems to support this theory. It reveals that 35 percent of IT staff view an IoT project a success, while only 15 percent of business decisions makers shared the same

view. If the business decision makers do not think a project is a success, they won’t fund it or dedicate resources to rolling it out.

- **No Plan for Rollout** – There seems to be a mind-set of applying IoT project to a singular issue, but no plans to take it further if it is successful. A small approach is fine, but if you choose a solution that is too limited, then the project will not go any further.
- **Little Focus on the Value** – A project that showcases technology, but has no real return, has no future. There has to be some value in it for the business, be it cost savings, labor optimization or some other concrete benefit.

Knowing the challenges and roadblocks can help you kick-start an IoT project and/or move it past pilot into a full production rollout and expansion to other areas. Here are six strategies to help ensure success:

1. **Get Executive Support** – Get the highest level person in your organization who is willing to listen and has ties to upper management. Buy-in to your vision is critical in getting started, both from a personnel resource and dollar commitment.
2. **Start Simply, Execute Relentlessly** – Choose a use case that is simple, has value and can be a quick win. Then, focus 100 percent of your attention on doing that well. Success with a simple project will build management buy-in, whereas a grandiose vision that is difficult and problematic will kill any momentum, regardless of the potential value.
3. **Focus on the Outcome vs. Technology** – Know what problem you are trying to solve. What is the use case? What does it mean to the organization to solve the problem? The technology will be there – that is the more straightforward part of a project. Solving a known problem will get people on board because, most likely, it is a problem that people have been pointing out for a long time. The aforementioned survey also revealed that 54 percent of successful IoT projects cite strong collaboration between IT and business.
4. **Focus on the People** – Yes, IoT is a terrific solution to many things. But in the end, you still need people to make it work, whether it is defining the right use case, analyzing the data, or acting on the data. Focus on making the people it touches better.
5. **Failure Is Okay** – The right solution allows you to test multiple use cases quickly. One may not work, which is fine. Set up a plan so you can simply and easily attempt the next use case.
6. **Don’t Go It Alone** – IoT solutions can be broad and encompass large swaths of technology. Most likely, your organization does not have all the skill sets you need to be successful. Leverage partners that can close those gaps to ensure your best chance of success.

Back to the movie, Tripp’s parents call in Paula, an expert in the field, to assist in getting him to move out. Ultimately, Paula, played by Sarah Jessica Parker, working with Tripp’s parents, apply the aforementioned six strategies to move to a successful conclusion where the parents have the house all to themselves. Although your IoT projects may not always have such tidy endings, by understanding the challenges you face and employing the right tactics, you can avoid a *failure to launch*.



**Ray Miciek** has been the driving force behind Aquitas Solutions’ increased success in the Enterprise Asset Management (EAM) market and is responsible for the execution of the company’s sales and go-to-market strategies. Ray has over two decades of asset and service management experience.  
[www.aquitas-solutions.com](http://www.aquitas-solutions.com)



# 85%

## OF RCM RECOMMENDED IMPROVEMENTS ARE NEVER IMPLEMENTED:

# Is There a Better Solution?

———— Nick Jize and Matt Boehne ————

It is disappointing when reliability-centered maintenance (RCM) studies are performed on a critical system, yet weeks roll on and then years go by without implementing the needed changes into the computerized maintenance management system (CMMS). The RCM team inevitably gets too busy with the day-to-day challenges and time just slips by.

In fact, an industry survey of more than 250 companies conducted by Reliabilityweb.com reveals a remarkable concern: Over 85 percent of the recommendations from RCM analyses are never implemented. Aside from the short-term waste of corporate resources, this often drives program abandonment, as it reinforces buy-in resistance from both management and supporting staff. This is, after all, an understandable and predictable reaction since negative return on investment (ROI) is a fatal condition. This result can only be avoided by ensuring that the recommended RCM tasks are consistently entered into the CMMS immediately after the conclusion of the analysis, thus avoiding the inevitable day-to-day distractions. Recognizing this issue, the RCM and CMMS experts at JMS Software and Banetti teamed up to create the critical dynamic integration between RCM and CMMS. This integration eliminates dependency on manual intervention, thereby ensuring this critical step is never missed.



Figure 1: The vision of the Reliability Partners (Copyright 2019, Banetti Inc)



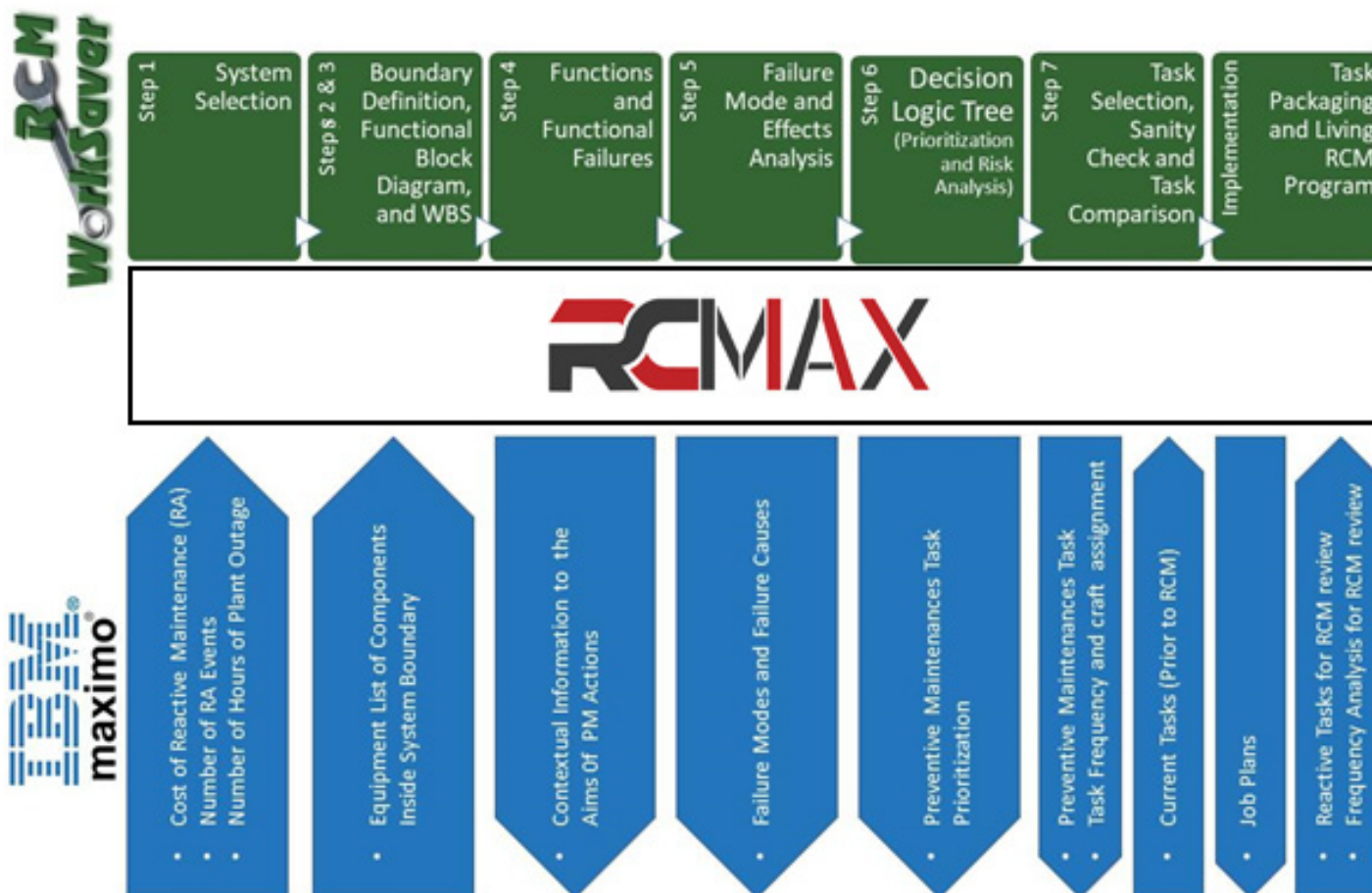


Figure 2: Dynamic integration of RCM software with Maximo

This venture took flight in January 2019, during a gathering sponsored by Reliabilityweb.com of the Reliability Partners®, a group of 14 industry leading reliability organizations. These carefully selected organizations jointly resolved to enhance the business effectiveness and sustainability of reliability and asset management. The combined vision of the Reliability Partners is to advance the industry toward: **Zero Accidents, Zero Downtime, Zero Waste.**

It was during this meeting that the companies realized that by collaborating to make the transition between the one company's RCM software and IBM® Maximo seamless, they could bring tremendous value to their clients. Shortly after this meeting, the respective teams from each company began collaborating to bring their vision into reality. The two teams continued to meet, discuss and study the impact of streamlining the process. Through their efforts, both parties developed a high level of confidence that this would ultimately drive a higher success rate in RCM programs, thus reducing the 85 percent implementation failure rate. Since January, their ongoing efforts are demonstrating additional benefits of this collaboration through a "Living RCM Program." The implementation of a dynamic living program, established through a continuous feedback loop with Maximo, can improve upon the initial RCM-based preventive maintenance (PM) strategies established through CMMS measured reliability feedback.

This vision guided the creation of a system in which the RCM software guides in the selection of the optimal mixture of PMs based on system functions and mitigation of failure modes that result in functional failures. These PMs are then fed into Maximo with the reasoning for these selections provided via a dynamic integration. Feedback into the RCM software on PM selections is then returned using real-time asset performance data via the integration. Figure 2 illustrates how this dynamic integration functions.

“...To make the transition between the one company's RCM software and IBM® Maximo seamless, they could bring tremendous value to their clients”

ed via a dynamic integration. Feedback into the RCM software on PM selections is then returned using real-time asset performance data via the integration. Figure 2 illustrates how this dynamic integration functions.

At the start of an RCM process, a system must be selected for analysis. For this selection to yield the greatest benefit, an inquiry of which systems have the greatest number of reactive maintenance events and hours of unplanned downtime must be completed. These systems are the proven points of concern, having the largest negative impact on overall plant performance, downtime, reliability and, ultimately, profitability. In order to address this, the integration allows for the utilization of a Pareto chart to focus on these problem assets. This enables organizations to focus their efforts on the highest value systems to analyze. Once a system is selected, the component assets of that system are pushed to the RCM

software. This allows for a functional review, as well as a failure mode and effects analysis (FMEA) and the selection of tasks to mitigate the failure modes. These tasks are then routed back to Maximo to generate new, optimized job plans for this system. Additionally, the FMEA data from RCM also provides



**Figure 3:** An example of Maximo FMECA

Maximo with the appropriate problem codes and remedies for each of the assets.

The second phase of this collaboration is the expansion of the integration to inform the maintainers why the PM action is required. Having this type of information available within Maximo enables the maintainers to record direct feedback about the effectiveness and frequency of the tasks.

## “Can the collaboration achieve the ideal state of 100 percent implementation of RCM results?”

An advanced element of this collaboration is a feedback loop that allows RCM analysts to evaluate the effectiveness of the implemented RCM recommendations. The before and after metrics of the system's performance, such as mean time between failures (MTBF), mean time to repair (MTTR), cost analysis and downtime analysis, can be reexamined as required. In the event of a downtime event in an RCM analyzed system, the integration will flag the event for review. RCM analysts can then carefully evaluate the event to discover gaps in strategy, like an unanticipated failure mode or a miscalculation on task frequency, and develop an appropriate mitigation strategy. Within Maximo, there is a parallel evaluation to determine if the RCM derived tasks were performed as planned and recommended, as well as if the PM included accurate and sufficient data to drive proper execution of these tasks.

Both JMS Software and Banetti are committed to this dynamic integration solution as a contribution to the foundational goals of the Reliability

Partners and the overall reliability community, as well as to add value to their customers who use Maximo as their EAM/CMMS platform. The team is moving forward with a focus on the Reliability Partners' target of zero accidents, zero downtime and zero waste.

Integrating RCM and CMMS into one seamless integration is a monumental step in the right direction toward significantly improving the implementation rate of RCM programs. Can the collaboration achieve the ideal state of 100 percent implementation of RCM results – a 566 percent improvement over where companies are today? While there is no telling what the future holds, the Reliability Partners are united in their commitment to the goal... are you?



**Nick Jize**, CRL, is the co-founder of JMS Software, a company that produces RCM software solutions. Nick has a background in RCM and predictive maintenance leadership with over 30 years of experience helping customers improve their reliability programs. He has a master's degree in Engineering. [www.jmssoft.com](http://www.jmssoft.com)



**Matt Boehne**, CRL, is CEO of Banetti and an asset management industry leader with over 25 years in results-oriented implementations of the IBM Maximo CMMS platform for global customers in regulated industries. Matt's passion to see organizations reap more value from their CMMS led him and Banetti to the Reliability Partners, forging relationships that have led to numerous reliability integrations and add-ons to the IBM Maximo suite. [www.banetti.com](http://www.banetti.com)





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Jason Apps

# **AUGMENTED DECISION-MAKING: When Data Replaces Experience**



It's a fascinating time to be working in the asset management space. Rapid developments in both information technology (IT) and operational technology (OT) systems are paving the way for a new future.

**O**n their desktops, laptops, tablets and mobile phones, people have the power to open applications and use data to perform complex analysis and reporting, record transactions, and store knowledge. This new standard continues to evolve at a rapid rate, converging toward a limited set of key platforms.

The evolution of OT is meteoric. Today, a proliferation of connected devices can monitor asset condition and performance, along with operational conditions. The information captured from these devices enables operational optimization. It can also prevent unplanned downtime through early detection of impending failures, allowing corrective actions to be planned.

While advances in both IT and OT are leading to incremental advancements in the management of physical assets, the step change will come with the convergence of IT and OT. The opportunity is to automate decision-making and decision implementation, with the first step being augmented decision-making.

## “The opportunity is to automate decision-making and decision implementation”

### The Shift from Experience to Data

Augmented decision-making becomes real when the OT ecosystem delivers enough of the right data to the IT systems so the latter can present a recommendation on a course of action. Once this ideal state is reached, data drives decision-making, rather than a combination of data and experience.

It's likely that human interaction will be required for some time to come to ensure the correct data is fed into the OT systems.

The current maturity of OT systems has proven prognostic capability. That means it has the ability to predict what's going to happen given the current data set. For example, if you detect increased vibration under normal operating conditions, it's likely some component of the asset is degrading. Based on the trend, you could predict out the likely time frame to failure.

It's a great start. But, you need to improve on the diagnostics, meaning, what is the cause of the degradation? While you might be able to derive some options by detailed analysis of the vibration spectrum, there are still several causes that may show the same peaks.

Currently, the diagnostic capability of OT systems is supported by having subject matter experts identify causes by the patterns in historical data sets. This provides a starting point for machine learning to establish appropriate models.

However, this is vastly inefficient since it really needs to be done for each individual implementation and can be extremely complex for multivariant monitoring systems.

### Support from Subject Matter Experts

It is important to recognize that the OT and IT systems' role is to make decisions with support from qualified people who feed in causal data at the time of events. This builds the models over time, but also allows you to immediately begin making decisions based on data, not experience. Input from the subject matter experts supports the systems with causal information, but you're not making decisions solely based on their experience.

It is equally important to place emphasis on the capture of cause codes. Many organizations have tried and failed to collect meaningful data. This may be attributed to such reasons as:

1. System limitations on the coding structures available;
2. Poor codes implemented, for example, cause and damage codes mixed together;
3. The data was never used and not mandated, so it stopped being a focal point for closing out a work order.

In too many cases, organizations just gave up. For example, one large mining company decided not to include cause codes in its enterprise asset management (EAM) system blueprint because “no one enters them anyway.” That's akin to not providing safety glasses because no one wants to use them! Tolerating data without causal information is not negotiable if you are going to move into the digital age and remain competitive.

For OT and IT systems to really generate a step change in operations and arrive at greater asset reliability, you need to support them with the correct data so that decisions are automated and accurate. That's why key causal data should be a focal point in all organizations right now.

## “Tolerating data without causal information is not negotiable if you are going to move into the digital age and remain competitive”



*Jason Apps is the CEO of ARMS Reliability, a leading global provider of asset management solutions to some of the world's largest resource, power and utility companies. Jason has over 20 years of experience in reliability and maintenance engineering. [www.armsreliability.com](http://www.armsreliability.com)*





# RELIABILITYWEB.COM WORKSHOPS

## CERTIFIED RELIABILITY LEADER WORKSHOP

This advanced workshop is designed to teach the knowing/learning part of the Uptime® Elements - A Reliability Framework and Asset Management System™ and lead students to discover for themselves what it is to "BE" a reliability leader and to exercise reliability leadership as natural self-expression.



## CERTIFIED MAINTENANCE MANAGER WORKSHOP

The Certified Maintenance Manager™ (CMM) workshop creates maintenance leaders who are also maintenance managers. Designed to provide the skills required to optimize asset value, the CMM class and certification covers the processes, enablers and business needs of maintenance management.\*

\* Applicable to anyone in maintenance.



## MODELS FOR OPERATIONAL EXCELLENCE

Ron Moore, author of *Making Common Sense Common Practice* and *What Tool? When?*, and Jeff Smith, Senior Reliability Leader, Reliabilityweb.com, are collaborating to deliver this three-day workshop based on maximizing industrial business performance through superior practices that allow an organization to prosper in an increasingly competitive world.



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December 9-12

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■ **IMC-2019 (CO-LOCATED)**

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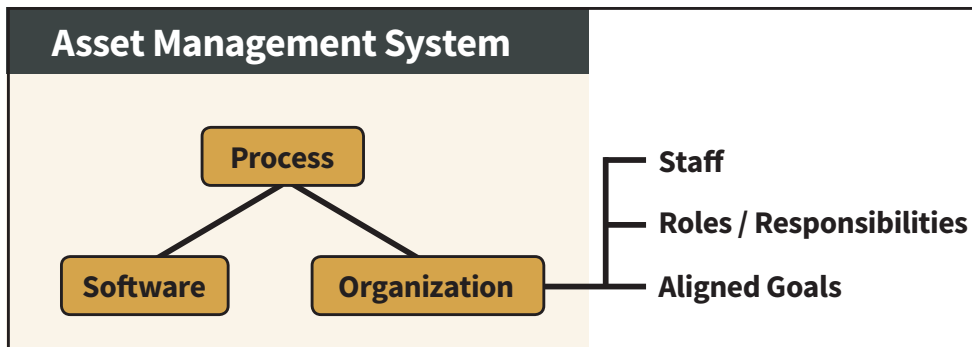


# DEMANDING EXCELLENCE

from Your Asset Management System

John Reeve





- How do you verify that your **preventive maintenance/condition-based technology program** is set up correctly?
- How do you create a **living program** in support of failure mode refinement?

If you can't make data-based decisions by leveraging failure data in your CMMS, then what are you doing?

### You Can't Install Reliability

**Reliability** is the probability that a system will perform satisfactorily for a given period of time under stated conditions.

**Reliability Engineering** is a subdiscipline of systems engineering that emphasizes dependability in the lifecycle management of a product. Dependability, or reliability, describes the ability of a system or component to function under stated conditions for a specified period of time.

Asset reliability does not magically improve when a CMMS goes live. The software may be best of breed, but it is the culture of the organization that drives excellence. Quite often, leadership does not clearly define the endgame or provide a long-range plan to get there. Or, the implementation team does not involve reliability leaders in defining the output essential to measuring performance. Once the CMMS is operational, there also needs to be a strategy for optimization and sustainment other than vendor recommended software upgrades.

Organizations that aggressively pursue operational excellence have the best opportunity for enhanced profitability. They also realize value provided from a purpose-built computerized maintenance management system (CMMS), precisely configured to extract knowledge and manage by exception. However, the CMMS is only as good as the surrounding process and roles. Hence, a comprehensive plan is needed that encompasses the entire asset management system to enhance reliability, workforce productivity and job safety.

### What Is a Purpose-Built System?

Very few organizations know what they want, even after their CMMS goes live. A good implementer blends software knowledge with industry best practices. The implementer also trains

the core team to seek continuous improvement through benchmarking activities. As a result, leadership may not know exactly what they want, but they are designing the CMMS with the end goals in mind. Using the Uptime® Elements as a framework for reliability, empowered by a configurable CMMS, leadership can set their own pace and build as they go.

### The Reliability Journey

The Uptime Elements provide a critical relationship between the CMMS database and reliability engineering. It is this relationship, however, that is oftentimes underdeveloped. In order to pursue the shortest path to value, a clear road map is needed that addresses the hard subjects, like:

- How do you reduce **reactive maintenance**?
- How do you extract **bad actors**?
- How do you implement **defect elimination**?

The ideal asset management system is one that is **based in reliability**. And a **CMMS**, if properly set up, will facilitate data-based decision making.



Every task in a reliability program should be aimed at

### Reliability Journey

1. Prevention of a **failure mode**,
2. Discovery of a **potential failure mode**, or
3. Meeting a regulation or legal requirement



Best-in-class organizations configure their CMMS to support these objectives.



## Where Are the Roadblocks?

- An executive level policy that does not encourage employees to attend off-site venues to broaden knowledge in asset management
- Reliability engineer who is really a maintenance engineer
- No formation of a core team to integrate software functionality with asset management best practices; unclear business rules; no benchmarking activities
- No CMMS utilization plan that states how the product should be used to add value to the organization; this plan would identify the shortest path to value
- A working level that sees the asset management system as a people tracking system
- No business analyst to regularly interview the working level to identify process flaws, lack of training and declining morale
- No planner/scheduler to improve workforce productivity and backlog reduction

## There Is No Guidebook for Utilization and Optimization

### 4 Ways to Implement

When implementing a CMMS, management has three options:

- Replicate existing legacy system processes;
- Rely on software vendor suggested processes;
- Perform some combination.

There could be a fourth option: Combining industry best practices and advanced processes. This combined approach assumes the consultant has knowledge to share regarding best practices. But, regardless of the path cho-

sen, without a clear understanding of output requirements and analytical report design, you may not even be capturing the right data from day one. Therefore, the individual or group who has the authority to define the intended usage of the CMMS should determine the long-term success of this system.

### Underutilization of CMMS Places Organization at a Disadvantage

Software by itself will not succeed in a poorly aligned culture. After all, the CMMS is just one of 36 elements in the Uptime Elements framework. However, the CMMS is often underutilized, misused and even misunderstood. The software vendor will not be able to provide an industry specific process map, therefore, it is up to the asset stakeholders and core team to build this map.

### Advanced Processes Deliver Greatest ROI

Most implementers will implement the CMMS using basic processes since this is the quickest and cheapest way to reach the go live milestone. Basic processes, such as creating and completing work orders, are easily understood, but advanced processes, such as chronic failure analysis, backlog management and future scheduling, are frequently not pursued. A CMMS, unlike other software programs, only achieves greatness when surrounding processes are optimized and decision-making tools are enabled. Admittedly, these advanced processes are more complex and take more time to implement, but they enable decision makers to maximize value.

### The Goal of Operational Excellence Must Come from Within

The first step toward operational excellence is to establish an awareness and understanding

within the executive team. The executive sponsor should have training in asset management strategy. More importantly, the *concept of advanced processes* should be defined and linked to the return on assets (ROA). In a perfect scenario, the CMMS implementation contract would be worded to identify both short-term and long-term goals. Either way, the onus is on the sponsors and reliability leaders to clearly communicate strategies for success.

## Investigating the Sub-Elements of a CMMS

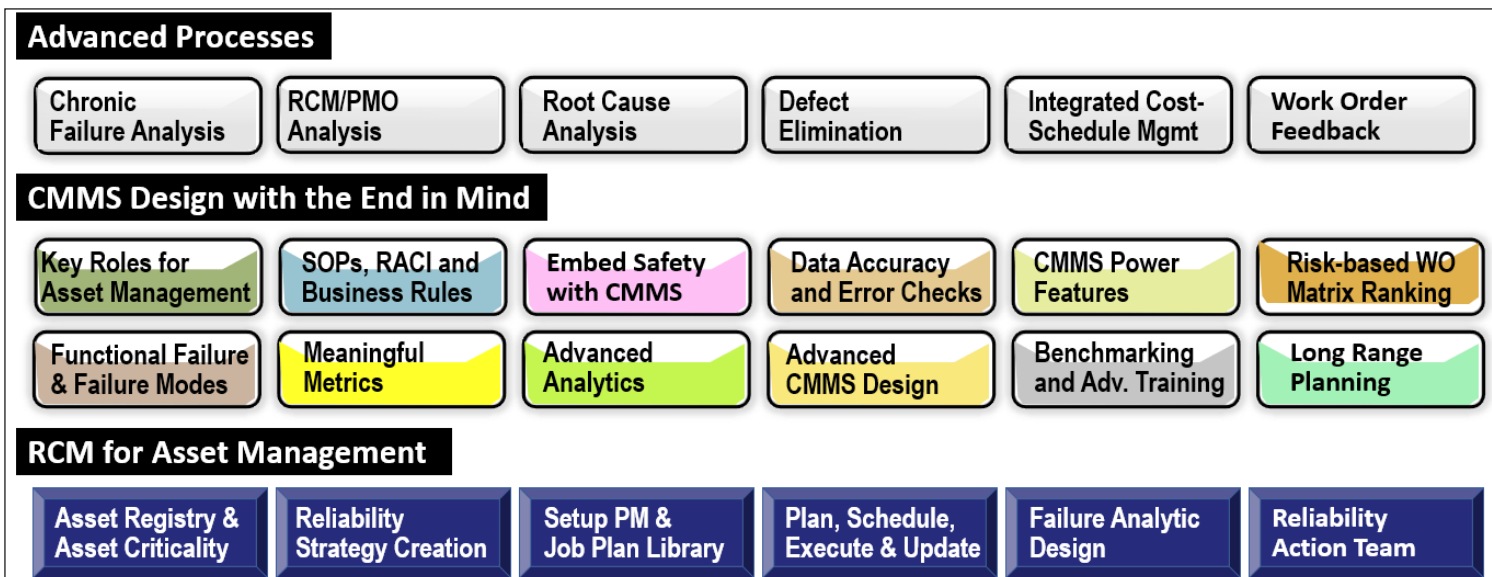
Every CMMS has user applications. Examples include work orders, assets, locations, inventory and purchasing. But rather than focus on product navigation, let's look at the things that really matter, such as process and roles.

### Advanced Processes

Root cause analysis (RCA) might be done once or twice a month. An RCA also might have trigger points that mandate performance. However, it is the smaller, recurring failures that cause 40 to 60 percent of maintenance costs, so they deserve greater attention. If reliability leaders want to stop the problem at the origin, then defect elimination should be pursued. The combination of these techniques, plus work order (WO) feedback, helps ensure the right work is being done by the right staff at the right time.

### CMMS Design with the End in Mind

Too many implementers focus only on the software. This means they perform rudimentary setup per the product training manual, load data and train staff. But, if the implementers were to involve the reliability engineers, they might get an





“...The concept of advanced processes should be defined and linked to the return on assets (ROA)”

entirely different emphasis. Reliability engineers benefit the most from failure data that is properly captured to support reliability engineering. They would start with a failure analytic design that enables the reliability team to drill down on failure modes once the bad actors are defined. In some cases, these new output requirements require configuration of the input screens to provide the right data, such as a validated failure mode.

#### RCM for Asset Management

Setting up reliability-centered maintenance (RCM) for asset management can be illustrated with six primary blocks. The asset registry must be populated with criticality that is risk based. Using this criticality, the best method for strategy creation, for example RCM analysis or preventive

maintenance (PM) optimization, can be determined. In some cases, the original equipment manufacturer (OEM) guidelines are used or simply, peer-to-peer recommendations. These strategies are then converted to PM servicing activities or condition-based technology (CBT) routes. Work can then be properly planned, scheduled and executed. Using a failure analytic, bad actors can be presented to the reliability action team for analysis and action.

#### Stretch Goals Are Ideal

Best in class organizations continually seek new ideas and technologies in support of their goals. Some improvement initiatives can take a while to implement. And, every organization has the right to use the CMMS in the manner it sees fit. But, leadership should not assume there is a guaranteed benefit from poorly implemented systems. Therefore, if an organization wishes to pursue the highest levels of asset management,

#### Continuous Improvement

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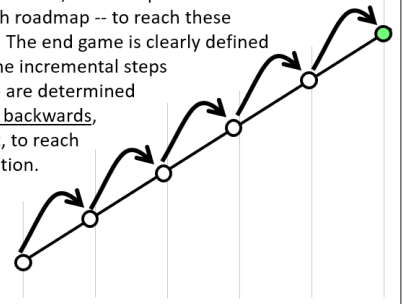
##### Model 1

This is mostly an informal process whereby staff comes into work each day, and as individuals, seeks to find ways to continually improve. The amount of efficiency gain from day to day however may vary. Plus it is up to the individual to determine **area of emphasis** and the amount of **effort to be applied**.



##### Model 2

This is a more structured approach to improvement whereby the focus is on **objectives for the organization**. Plus, leadership has defined **stretch goals** -- with roadmap -- to reach these objectives. The end game is clearly defined and then the incremental steps (and dates) are determined by **working backwards**, right to left, to reach the destination.





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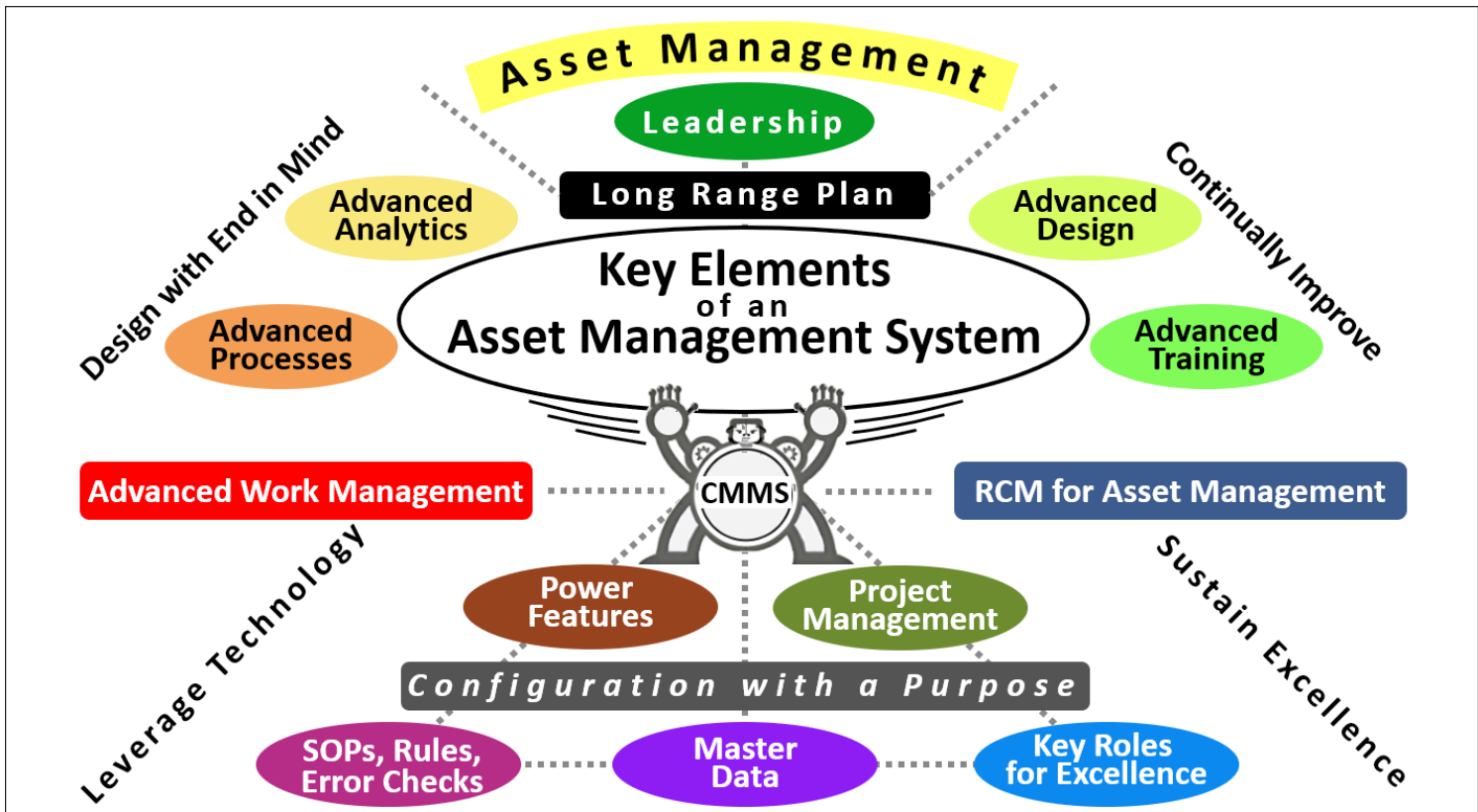


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it needs to configure the software and surrounding processes, including stretch goals, to maximize value.

If leadership leaves it up to individuals to pursue continuous improvement, the opportunity for greater results may be missed. If stretch goals are used, there is a greater chance of success through awareness. You may not always make these stretch goals, but if they are not established, you absolutely will not. The other benefit of this strategy is that by defining the endgame or target goal(s), you can then, as a group, sit down and lay out the

logical steps to get there. This becomes the road map, with a timeline.

### Key Elements of an Asset Management System

In summary, there are many elements of an asset management system. The CMMS should be purpose-built to manage by exception and improve ROA. Leadership should be informed and goals aligned. But remember, it is the advanced processes that provide the biggest bang for the buck.

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“...Leadership may not know exactly what they want, but they are designing the CMMS with the end goals in mind



**John Reeve, CRL**, is Senior Business Consultant at EDI. John was the second consultant hired by the company that invented Maximo and has focused on Maximo software and asset management system design for the last 20 years. His combined knowledge in both project management and asset management make him unique in the consulting field. [www.edatai.com](http://www.edatai.com)

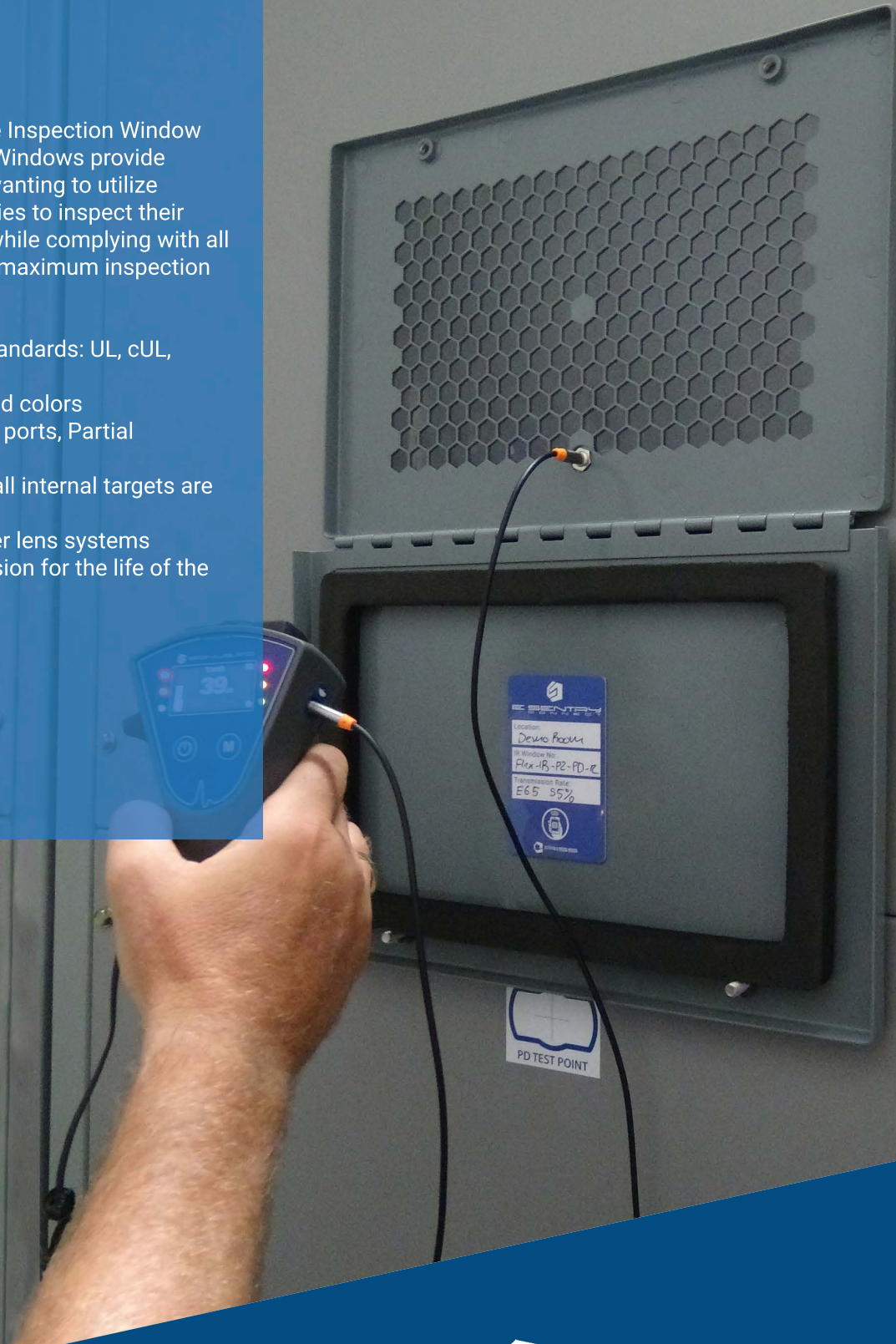


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# THE HIDDEN FRONT LINE OF CYBERATTACKS: INDUSTRIAL CONTROL SYSTEMS

Juan F. Villarreal

## Connected and Defenseless

It's a quiet December afternoon in 2015. In the Ivano-Frankivsk region of Western Ukraine, workers are preparing to finish their day and make their way home into a cold night. Inside the Prykarpattiaoblenergo control center, which

distributes power to the region's residents, operators are nearing the end of their shift. Suddenly, an unprecedented series of cyberattacks takes place as they watch in amazement. The attacks eventually knock out parts of Ukraine's electric grid, thus cutting the power to nearly a quarter of a million residences.

The attacks, directed at three regional electric distribution companies, demonstrate prowess in several complex hacking techniques. These include spear-phishing to obtain fake credentials, exploiting vulnerabilities in software applications, such as office productivity programs, and deploying BlackEnergy 3 malware to infiltrate the utilities' networks.

The perpetrators were able to obtain login credentials to the utilities' virtual private networks, allowing access via the Internet to manipulate supervisory control and data acquisition (SCADA) servers. With this access and using BlackEnergy malware, the attackers cut off power to substations and changed passwords. Locked out of their computers, utility staff members watched the substations go offline one by one.

The attackers didn't stop there, however. They also struck two other power distribution centers at the same time, nearly doubling the number of substations taken offline and leaving more than 230,000 residents in the dark. And, as if that wasn't enough, they also disabled backup power supplies to two of the three distribution centers, leaving operators themselves stumbling in the dark.

Unfortunately, these types of events are becoming more commonplace. The Ukraine suffered another similar attack to its electric grid in December 2016. On December 2017, the safety shutdown system for an industrial plant in Saudi Arabia was penetrated by the Triton malware,



Figure 1



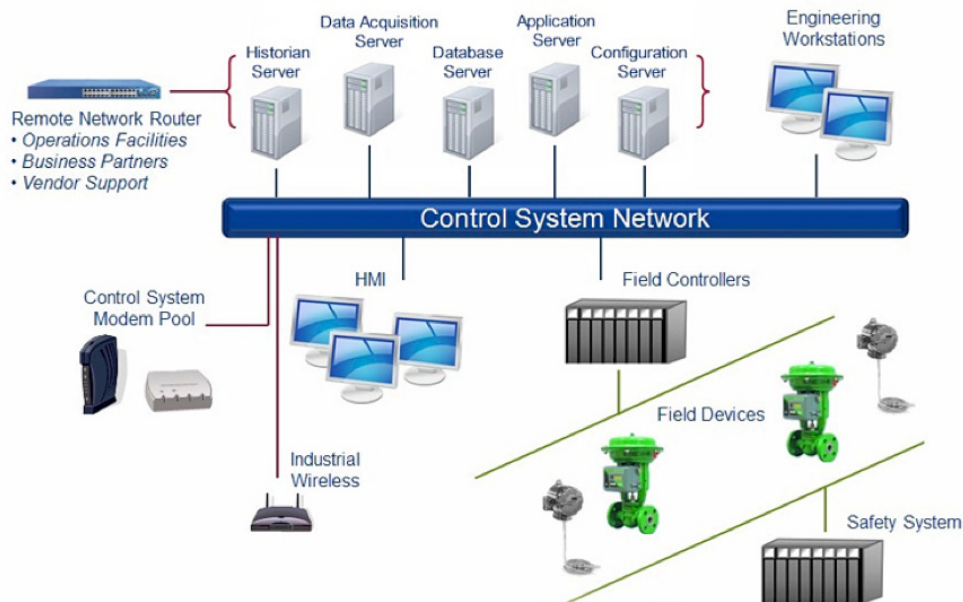


Figure 2: ICS architecture

causing a process shutdown. This malware is built to interact with certain safety instrumented system (SIS) controllers commonly used in nuclear power plants.

### Powerful, Yet Powerless

Most cyber threats involve identity theft — massive data breaches of personal information and alarming fraud scams that contribute to the mistaken sharing of personal data. Cyber threats such as these are collectively focused on information technology (IT) systems. These systems include personal computers and devices, bank accounts or private health data, or company databases and e-mail servers.

As serious as these IT threats are, more serious and less heard about consequences for people and the environment are stealth attacks like the one in the Ukraine. These types of attacks focus on industrial control systems (ICS). The perpetrators come from a variety of places. They could be adversarial national governments, industrial spies, or terrorists.

ICSs are the many unseen but important cogs in the world that control critical infrastructure. They control the electric grid. They measure

the level of water at hydroelectric dams. They keep trains running and planes in the air. Most critically, they keep us safe. Collectively, ICSs make up operational technology (OT) systems.

The term ICS refers to a broad set of control systems, including SCADA, distributed control systems (DCS) and safety instrumented systems (SIS). ICSs control and monitor systems that are used to make, monitor and move products. These systems have three types of components:

- Field devices, such as sensors, valves and switches;
- Field controllers, like programmable logic controllers (PLC), safety systems and remote terminal units (RTU);
- Human machine interfaces (HMI), such as engineering workstations.

Figure 2 shows a typical ICS architecture and its key components.

## ICS Trends and Vulnerabilities

While the low cost of sensors and the ease of connectivity has encouraged industrial facilities to add more sensors and controls to improve efficiency and reliability, this convergence of IT and OT systems has increased the risk of cyber threats and opens new surfaces of attack that need to be protected. For example, IT professionals are now monitoring processes from their PCs and handheld devices under the control of ICSs, thereby opening up a new set of vulnerabilities not present when operational controls were physically disconnected from IT.

As a consequence of this rapidly expanding digitalization, many ICS users do not have an adequate accounting of all the sensors, controllers and other connected components that have been added. They may not have a firm grasp on how they are all connected to the network. A complete picture of this is called digital configuration management. Absent of digital configuration management, the asset owner does not know which systems need to be protected or what capabilities exist in each new digital device that is being used. This lack of understanding may contribute to a lack of adequate management of control/sensor software upgrades and patches. These upgrades usually contain fixes for new or existing vulnerabilities to cyberattacks.

In addition, most digital or mechanical equipment suppliers are requiring online, real-time monitoring of their control systems for warranty purposes. The remote access required by the suppliers opens another window of attack through the IT systems of the equipment supplier.

### Protect and Defend

The good news is the call for a more robust cyber defense of ICSs has been heard. Most critical infrastructure asset owners have adopted the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) Framework for

“ ICSs are the many unseen but important cogs in the world that control critical infrastructure ”

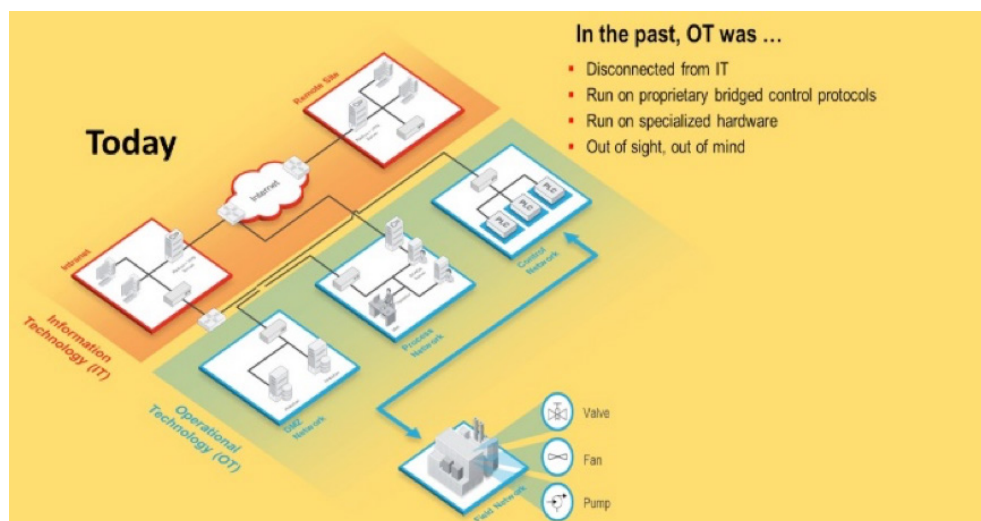


Figure 3





Improving Critical Infrastructure Cybersecurity. This framework defines five essential program activities:

- **Identify:** Develop the *organizational understanding* to manage security risks to systems, assets, data and capabilities.
- **Protect:** Develop and implement the *appropriate safeguards* to ensure delivery of critical infrastructure services.
- **Detect:** Develop and implement appropriate *activities to identify the occurrence* of a security event.
- **Respond:** Develop and implement the *appropriate activities to take action* regarding a detected security event.
- **Recover:** Develop and implement the *appropriate activities to maintain plans for resilience and to restore* any capabilities or services impaired due to a security event.

For example, some of the processes being applied to power generation assets under the *Protect* program are:

- Supply Chain Management – Implement a process to assure purchased equipment and services are compliant with industry regula-

tions and your organization's cybersecurity requirements.

- Digital Configuration Management – Know what digital equipment you have, how it is connected, and which capabilities are enabled or in use for each device.
- Secure Remote Access – Secure protocol for suppliers to access your network.
- Patch Management – Implement a process to make certain the right system and software updates are executed at the right time.
- Hardening of Cyber Assets – An example of hardening is unnecessary software being removed and default passwords changed to reduce the attack surface. Devices can be hardened to reduce their attack surface.

The electric generation industry has taken the NIST framework one step further and developed the North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP) standards for generation, transmission and distribution, as well as grid control centers.

### Enabling a Smooth Digital Journey

There is no doubt businesses will continue to digitalize operations by connecting processes and controls to networks. The threat of a cyberattack

may cause some business leaders to pause or slow down their digitization journey, but a well-crafted cybersecurity program following the NIST framework and addressing the aforementioned issues can enable progress, not inhibit it. With safeguards such as these in place, businesses can continue to take advantage of the latest technology for industrial control digitization and keep everyone out of harm's way.

### Resources

1. NIST Framework for Improving Critical Infrastructure Cybersecurity: <https://www.nist.gov/news-events/news/2018/04/nist-releases-version-11-its-popular-cybersecurity-framework>
2. NERC CIP Standards: <https://www.ferc.gov/industries/electric/indus-act/reliability/cybersecurity.asp>
3. Industrial Control Systems Basic Training: <https://ics-cert-training.inl.gov>



**Juan F. Villarreal** is the Managing Director at Villarreal Energy LLC. Juan is a technology-driven international operations and business development executive who has held leading roles in nuclear and fossil power generation and the oil and gas industries. [www.villarrealenergy.weebly.com](http://www.villarrealenergy.weebly.com)



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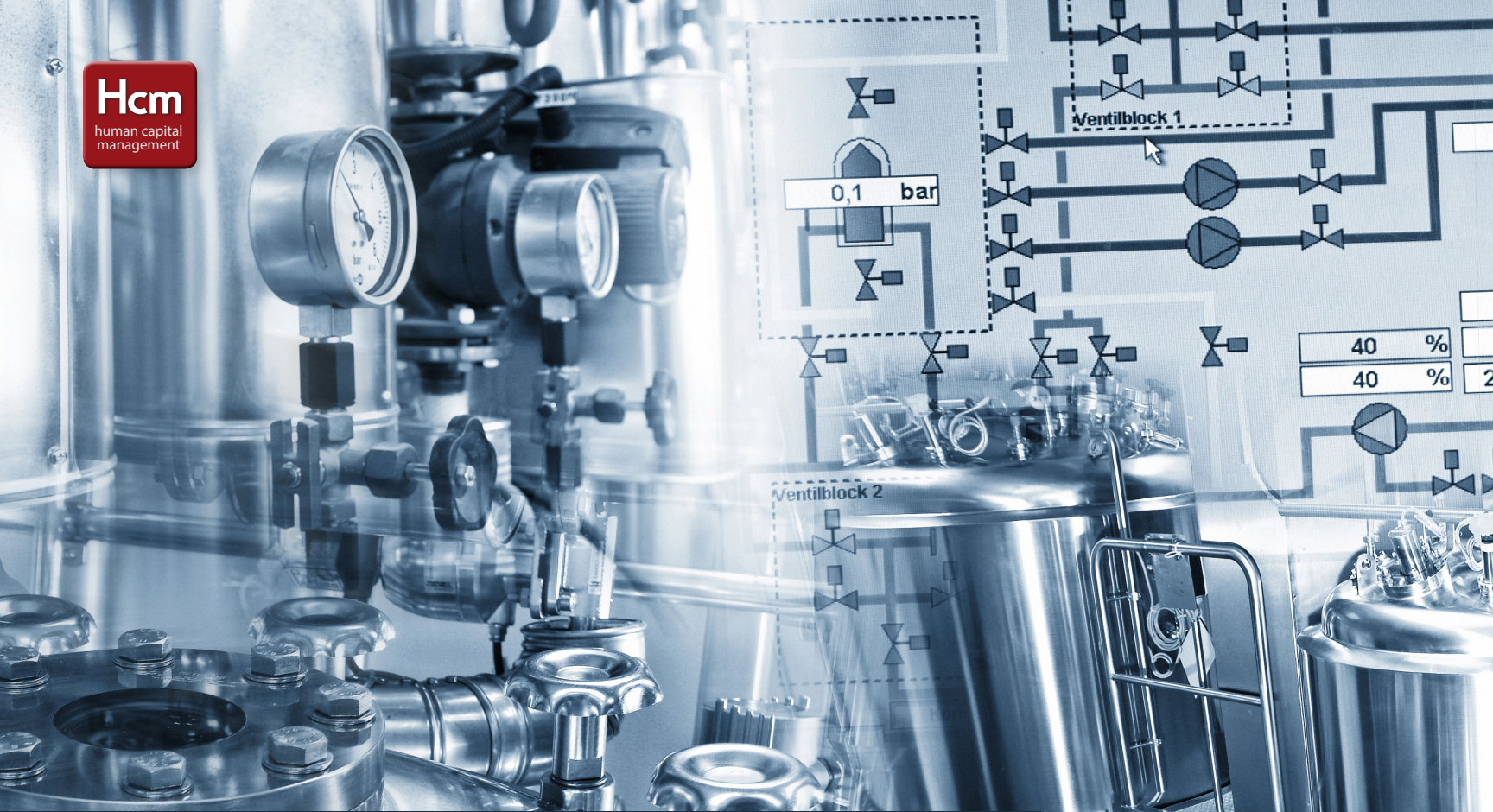
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# THE GREAT DISCONNECT:

Americans Don't Understand Modern Manufacturing and They Should


Keith Barr

Many Americans believe that American manufacturing is a relic of the past, a rusting abandoned profession where weary men and women drudge through the day performing a single task for hours on end.

**B**ut, experts on modern plant floor operations have seen first-hand how wrong that perception is. Modern manufacturing is a dynamic profession where tech savvy workers are actively engaged in complex problems, free to innovate solutions, and they are highly compensated. Yet, there is a shortage of workers.

To better understand why the misconceptions persist or who's to blame for the ongoing shortage of skilled manufacturing workers, a nationwide survey was initiated by Leading2Lean. Its purpose was to determine why what is being witnessed on the 21st century plant floor is so positive, yet so much of what is being heard about it is so negative.





# There is a shortage of skilled workers in a dynamic industry that's vital to the American economy

One of the ways to measure industry growth is through the number of available jobs. According to recent data from the Manufacturing Institute, in the next decade, approximately 3.5 million manufacturing jobs will need to be filled, yet 2 million of these jobs will go unfilled.<sup>1</sup>

Interestingly, 58 percent of Americans believe the number of manufacturing jobs is declining. This highlights the misconception that there are fewer jobs, when, in reality, there are millions that will go unfilled.

Another survey finds that only 55 percent of Americans agree that manufacturing jobs offer fulfilling careers and only 45 percent believe that manufacturing jobs are a good career option for younger workers. When many Americans think about manufacturing jobs, they don't think of jobs that are dynamic, collaborative, or rich with problem-solving and technological innovation. Instead, many imagine the jobs as being monotonous, repetitive and dull.

Those who work in modern plant floor operations see the intrigue, complexity and creativity in their work. But, the industry hasn't done a great job of sharing this with the rest of the world, particularly the younger generation. And it shows.

When looking at millennials, specifically those born between 1981 and 1998, only 49 percent believe manufacturing offers careers that are fulfilling. In comparison, 59 percent of baby boomers, born between 1946 and 1964, and 59 percent of Generation X, born between 1965 and 1980, think manufacturing offers fulfilling careers. This 10 percent gap could be the difference between a struggling labor force and a thriving one.

“ Modern manufacturing is a dynamic profession ”

Many young people are also unaware that manufacturing pays well. According to the U.S. Bureau of Labor Statistics, the average annual salary for manufacturing production and nonsupervisory employees in 2018 was \$44,595.20, or \$21.44 per hour.<sup>2</sup> That is almost three times the federal minimum wage, which is currently \$7.25 per hour.

For managerial roles, the pay is competitive with the tech industry, according to data from a global job and recruiting company. In 2018, the average base pay for a manufacturing supervisor was \$64,118.<sup>3</sup> For a manufacturing engineer, the average base pay was \$71,679.<sup>4</sup> For a director of manufacturing, the average base pay was \$146,412.<sup>5</sup> In addition to salary, manufacturing offers substantial benefits, such as insurance, paid leaves and bonuses, in comparison to other industries.<sup>6</sup>

Most Americans would be surprised that manufacturing offers such competitive pay and compensation. They would be shocked by the real nature of the work manufacturing employees perform. And, they would be floored by how modern, clean and advanced the factories really are.

Members of the manufacturing industry have an opportunity to shift how Americans view their industry by changing the narrative. They must become purveyors of relevant research, statistics and information. They must

Engine Insights was commissioned to conduct the nationwide survey at a 95 percent confidence level to address this great disconnect. Over 1,000 respondents who are representative of U.S. demographics took part in the survey.

The results are both surprising and revealing. Not only are the responses telling of Americans' attitudes toward manufacturing, but the generational differences between the responses are equally insightful.

When asked about the trajectory of the U.S. manufacturing industry, 70 percent of Americans said they believe American manufacturing is declining. In the eyes of most Americans, the industry is a far cry from thriving. But, data from outside sources suggest the industry is doing much better than what most people think. In fact, the industry is growing.



rise to the challenge and meet young people where they're at. Utilizing schools, universities, websites, scholarships and social media effectively and responsibly are all key here.

In truth, the future of the industry depends on the next generation. The industry is at risk as young people continue to select other career paths because they do not see manufacturing as being a viable, long-term career. They may think the industry is going to be taken over by robots, leaving no jobs for humans, as 54 percent of millennials indicated in the Engine Insights survey. These millennials believe robots, artificial intelligence (AI) and machines will replace all manufacturing jobs in the U.S., compared to 50 percent of Generation Xers and 47 percent of baby boomers. But, this isn't the case either. As seen with technology innovative auto manufacturers and other modern case studies, human creativity and problem-solving are essential for robots to be effective.

Americans do believe that manufacturing is important. In fact, 79 percent of respondents agree that manufacturing jobs are important to the American economy. Additionally, 75 percent believe having a strong manufacturing sector is important to help grow the U.S. economy. Unfortunately, they don't view the industry as offering adequate industry growth or viable career opportunities. The manufacturing industry can change this perception with the facts.

Let it sink in a bit. There is a shortage of skilled workers in a dynamic industry that's vital to the American economy. Manufacturing has a bad reputation, but the reputation is at odds with the facts.

So, there needs to be a change in perception. But, it's not going to be a single survey or a single company that is going to turn the industry's image around. Everyone connected to the industry needs to come together to promote the opportunities and importance of manufacturing. Major manufacturers, suppliers, regulators and executives need to constantly reinforce all that's good about their industry. Together, they can change the narrative.

It's time to show the world that manufacturing is growing, that the industry is driven by innovation and technology, and that great jobs are available today. If this is done, it will secure the future of the manufacturing industry for future generations.

To learn more about the survey, please visit:  
<https://www.l2l.com/leading2lean-manufacturing-index>

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**Keith Barr** is an experienced and informed authority on the challenges and changes currently impacting the manufacturing industry. Keith has worked in maintenance and logistics, CRM, IT Service Management, cloud-based solutions and product development with companies such as Ivanti, Echopass, Sento and Sykes.  
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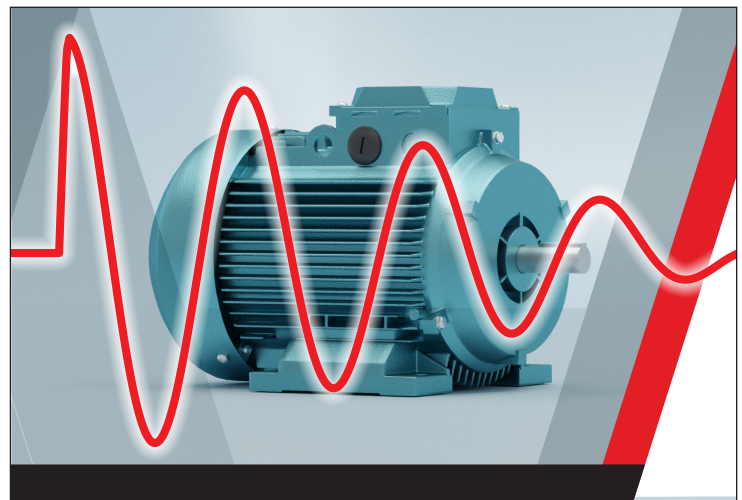
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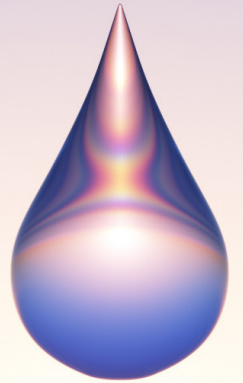
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# Perfecting the Water Industry:

Advanced Process Control Without a PhD



Aldo Ferrante



In any process automation & control industry, the most widely used control algorithm is proportional-integral-derivative (PID), according to National Instruments. PID control has been widely adopted throughout industrial control markets, dating back to the beginning of trying to optimize any process. What makes the PID algorithm/controller a fan favorite among engineers and operators is the algorithm's robust performance by nature under a breadth and range of operating conditions. Its popularity also can be attributed to its functional simplicity, enabling control engineers to shorten the learning curve on its mathematical application, all while operating the PID controller with confidence and efficiency.

The day has come when process engineers can optimize their control processes with out of the box, user-friendly machine learning (ML) technology as bolt on features to pre-existing PID controllers? To some, this may seem like a pie in the sky concept, but as computing power continues to increase, so will the realm of possibilities. Machine learning will rewrite the definition of how to properly control and tune a PID loop to drive efficiency in a process.

PID loop optimization and tuning will be able to process big data in minutes with machine learning web-driven tools and software packages aimed at detecting and predicting anomalies down to the equipment level before failures or unwarranted process variability overshoots. Just think of the standard software packages used today for visual programming language or to enhance the agility of your operation and add another layer of preconfigured, code free, advanced analytics and ML algorithms to augment their current offerings.

Predictive analytics, a subset of ML, is the key to both monitoring and analyzing vast amounts of asset sensor data and other variables not being factored into the equation today or collected during a multi-variate automation control processes. By adapting to the development of smart infrastructures end users can embrace ML technologies that are web based and simple to configure without having to hire resource intensive, data science or consultants.

### **SCADA Operator, Meet Your New Copilot: Predictive Analytics**

For supervisory control and data acquisition (SCADA) operators, these technologies will act as a real-time, 24-7 virtual operator. Future-proofed advanced process control solutions will collect sensor data for analysis on premises, eliminating the worry for security concerns in hosted cloud solutions and analysis. The key to closing the loop in successful deployments of predictive analytics solutions is pushing the intelligence generated in the Cloud down to the edge in real time. Without overloading the central processing unit (CPU) on programmable logic controllers (PLCs), sensors and controllers, these devices will have embedded, mapped out, advanced algorithms that serve as your extra horsepower and boots on the ground in detecting failures or real-time optimization of the current process at hand. This same copilot will learn, detect and classify patterns within your existing process, enabling operators/engineers adjust the setpoints for optimal control results when transferring that gained knowledge over a hierarchy of similar assets and processes. This concept or theory is known

as a digital twin and has been loosely thrown around by all the large industrial giants in the space without properly defining its real-life application or what it means in terms of improving the bottom line of business that drives revenue.

This process of collecting data and deploying edge machine intelligence is iterative. Think of it in parallel of how a newborn baby begins

to grow and mature as he or she eats, sleeps and repeats that cycle. Take this same concept and apply it to these levels of algorithms that only get more accurate and confident in their ability to make predictions and optimization decisions with more amounts of big data fed to it. Your co-pilot will create and deploy smart agents, which are advanced machine learning algorithms that proactively monitor vital areas in your process for early stage failures, quality issues, safety concerns and environmental events. What was traditionally performed using teams of aging subject matter experts (SMEs),

process control engineers and data analysts has now been digitalized into an extra set of virtual eyes and ears that never complains, gets sick, or throws in the towel when the going gets tough.

“ Machine learning will rewrite the definition of how to properly control and tune a PID loop to drive efficiency in a process ”

### **Advanced Process Control: The Technology of the Future Isn't Smoke and Mirrors**

Historical, present and future data, coupled with external or unforeseen variables, have yet to be utilized for PID loop optimization calculations until the advent of machine learning. Engineers have traditionally resorted to their own applied education, tuning controller inputs to the best of their ability in order to achieve optimal PID loop process calculations. Advanced process control incorporates both supervised and unsupervised learning capabilities, combining state-of-the-art machine learning technology with an operator's input for validation of the results. Eliminating the need for time-consuming data scientists' consensus, advanced process control will automatically set the conditions necessary to achieve a near perfect PID loop.

### **Adopt an Agnostic Approach to Collecting, Processing and Analyzing Big Data**

When it comes to implementing predictive analytic solutions for process automation industries, hybrid approaches, such as cloud computing, fog computing and edge computing, should be adopted according to how critically exposed your industrial control systems are. Utilities for example, need the ability to select modular, transparent systems that can scale with various third-party devices and databases, from float sensors and pressure transducers to existing work order management systems. These same solutions must also be able to handle millions of deployed algorithms in real time, with a hierarchy asset framework that mimics the historian infrastructure already running. Advanced process control should perform bulk industrial data collection that is both scalable and flexible for existing infrastructures. Engineering war rooms should be developing solutions centered on device and platform agnostic methodologies that are seamless with native integration toward critical industrial control systems (ICS) and able to handle current industrial protocols that transfer gained knowledge over similar plants and sites.



“ Big data is real and there is no denying that Internet of Things (IoT) applications will continue to surge exponentially ”

### Now's the Time to Disrupt the Process Control Industry Paradigm

Advanced process control solutions will enable legacy driven industries to accelerate their data collection and advanced analytics capabilities beyond what was once considered costly and resource intensive. Ideal PID loop tuning, automatically performed in real time, positions manufacturing companies and utilities to experience key competitive advantages across all areas of their organization. The value proposition behind AI IIoT technologies is its ability to:

- Decrease susceptibility to costly governmental penalties;
- Increase energy efficiency and improve public perception for conservation efforts;
- Accelerate return on investment (ROI) driven labor and organizational efficiencies;
- Decrease production waste and optimize raw material costs in overhead savings.

Big data is real and there is no denying that AI IIoT applications will continue to surge exponentially. Those who are able to manage these process optimization models, systems and applications will capture the biggest piece of the Industrial Internet of Things (IIoT)/advanced process control pie. To date, very few enterprise process optimization solutions can offer under one umbrella:

- Horizontal enterprise IoT management from the edge device to the cloud;
- Data collection supporting all industrial communication protocols;
- Connectors to industry-leading, real-time data historian applications;
- Simple, configuration-free, predictive analytics software to enable the deployment of production ready ML models tied to business outputs;
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**Aldo Ferrante** is the president and CEO of ITG Technologies. With more than 30 years of experience in automation and information technology industries, Aldo achieved great success in providing turnkey solutions to clients in the technology sector, including the manufacturing, transportation, and municipality industries. [www.sorbasoft.com](http://www.sorbasoft.com)



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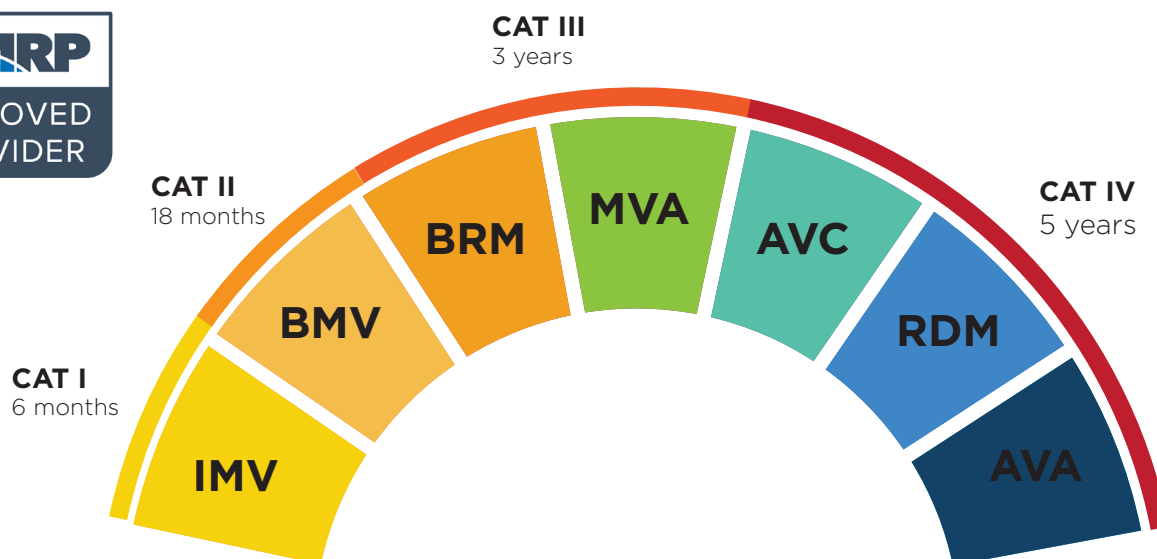
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# BAD ACTOR PROGRAM

Fahad Izhar Khan

“

...Based on the famous Pareto principle, which states that **80 percent** of the issues comes from **20 percent** of the causes

”

**R**eliability engineering is about predicting failures and providing ground for decision-making related to preventive maintenance optimization (PMO), lifecycle costing, spare parts forecasting, and reliability, availability and maintainability (RAM) modeling. Different tools are available to the reliability engineer for such levels of predictions. The benefit of these tools comes from proper planning and management plans to cope with future issues.

The industrial environment, due to the nature of work, has a large variation in the use of such tools. One end of the industry is welcoming Industry 4.0, which is based on data analytics and machine learning algorithms. At the other end is an asset management framework to integrate already present tools. The strategic plans and

objectives require the whole plant to be covered under one umbrella where different departments complement each other. The main purpose of the whole scheme is to prevent failures from happening. However, failures do happen and there is no guarantee you can stop failures 100 percent while remaining within appropriate budgetary constraints.

This reality check leads to the requirement of a program to deal with failure issues that exist in a plant even under the presence of reliability methodologies and strategies. Normally, it is called a bad actor program or performance killer. Both vary in nature, with one dealing with failures and the other with performance related issues. This article focuses on the development of a bad actor program and monitoring its effectiveness. However, the program can be applied similarly for performance killer.



## BAD ACTOR PROGRAM

A bad actor program is designed to identify the gaps present in an organization's current reliability strategies by analyzing unplanned failures based on the impact of each failure on maintenance cost and plant downtime. It is based on the famous Pareto principle, which states that 80 percent of the issues comes from 20 percent of the causes. By employing this principle, any organization can focus its attention on genuine and demanding issues related to plant maintenance and reliability, rather than overreacting on each failure.

The steps for a bad actor analysis are:

**STEP 1:** Define the scope of the plant-level analysis, either to consider the whole plant at a time or designated process areas of the plant individually for a selected time period.

**STEP 2:** Collect the work order history from the computerized maintenance management system (CMMS) for all assets.

**STEP 3:** Ensure the data in the work order consists of the equipment tag number, along with the order type, failure mode, cost of maintenance and associated downtime costs.

**STEP 4:** Use the collected data to prepare Pareto charts, so that equipment causing major failure costs ranks higher than others causing lower costs.

**STEP 5:** Select for further review the bad actors, which per the Pareto analysis would be the top 20 percent of assets.

**STEP 6:** Segregate the failure history of the selected assets for failure mode classification. Prepare the Pareto charts for failure modes existing in bad actors; the failure mode causing a frequent number of failures would rank higher than those causing fewer failures.

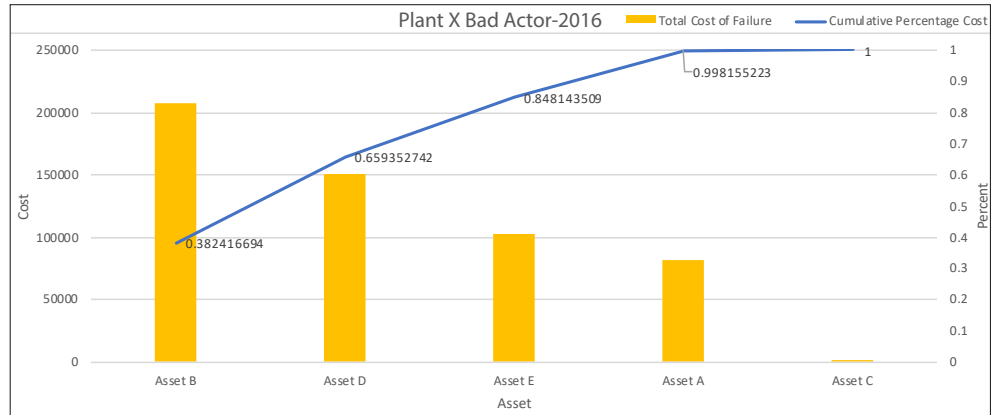
**STEP 7:** Compare these failure modes against those present in the methodologies database. If the failure mode already exists, the recommendation should be reviewed and revalidated either to change the frequency or assign a new task. It is also necessary to revalidate or revise the maintenance procedure for each task reviewed.

**STEP 8:** Review and revalidate the failure mode as per your root cause analysis (RCA) approach if the failure mode does not exist in the strategy database. Revalidating the new failure mode in RCA should result in determining a suitable task for that failure mode, such as a new preventive maintenance (PM) task or a redesign of the equipment part.

**STEP 9:** Examine the outcome of the bad actor analysis, which should consist of PM amendments, additional PM tasks, redesign tasks, or others.

**Table 1 – Ranking of Assets Based on Total Cost of Failure in Spreadsheet Format**

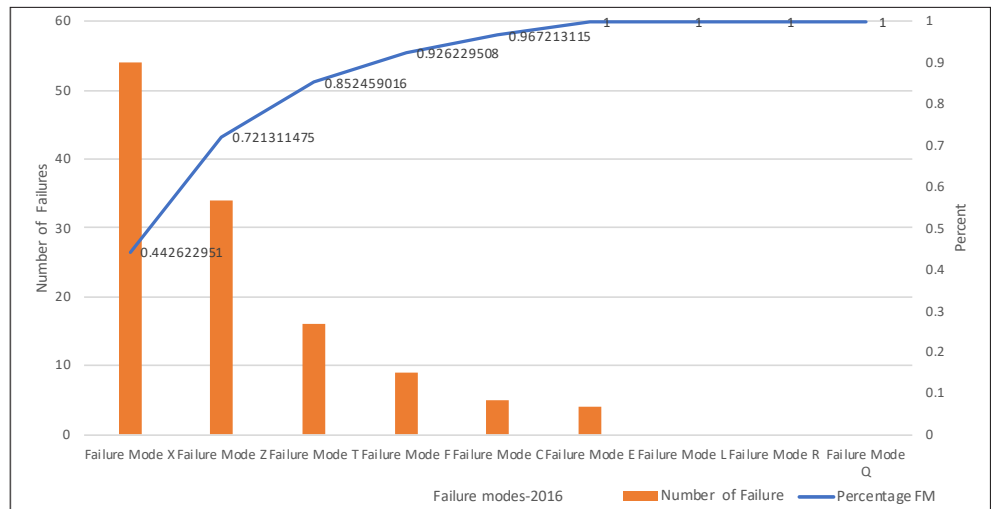
Year	Rank	Equipment	Number of Failures	Total Cost of Maintenance	Downtime (hr)	Cost of Downtime per hour	Downtime Cost	Total Cost of Failures	Cumulative Cost	Cumulative Percentage Cost
2016	1	Asset B	14	207297	0	100000	0	207297	207297	0.382416694
	2	Asset D	108	150119	0	100000	0	150119	357416	0.659352742
	3	Asset E	149	102338	228	100000	0	102338	459754	0.848143509
	4	Asset A	57	81317	227	100000	0	81317	541071	0.998155223
	5	Asset C	6	1000	0	100000	0	1000	542071	1



**Figure 1:** Graphical form of a Pareto analysis of an asset

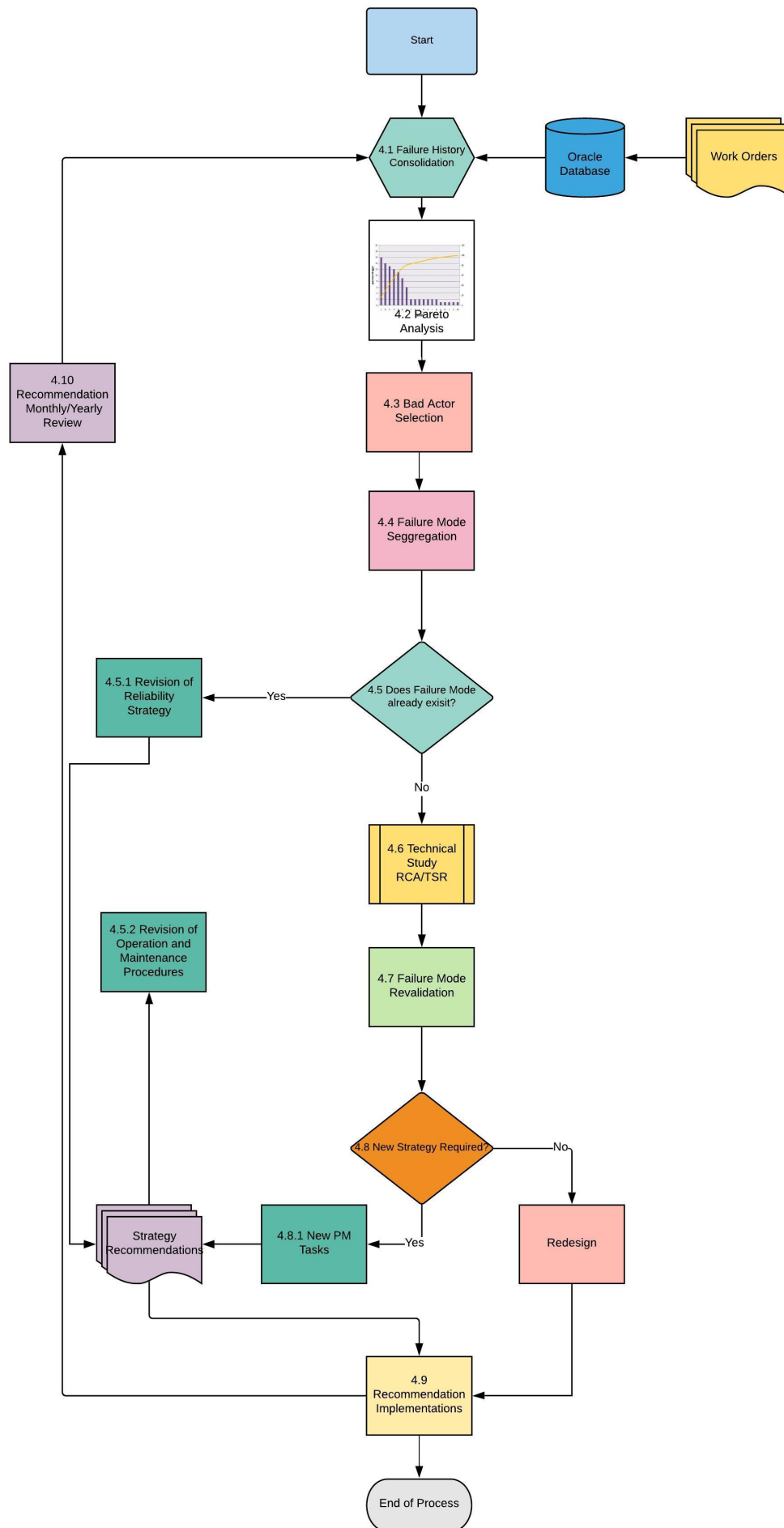
**Table 2 – Ranking of Failure Based on Total Number of Failures in Spreadsheet Format**

	Rank	Failure Modes	Number of Failures	Cumulative Failures	Percentage Failure Modes
2016	1	Failure Mode X	54	54	0.442622951
	2	Failure Mode Z	34	88	0.721311475
	3	Failure Mode T	16	104	0.852459016
	4	Failure Mode F	9	113	0.926229508
	5	Failure Mode C	5	118	0.967213115
	6	Failure Mode E	4	122	1
	7	Failure Mode L	0	122	1
	8	Failure Mode R	0	122	1
	9	Failure Mode Q	0	122	1



**Figure 2:** Graphical form of Pareto analysis of failure modes





**Figure 3:** Workflow of bad actor program





# The bad actor program is a continuously evolving tool based on data collection



## Performance Evaluation

The bad actor program is a continuously evolving tool based on data collection. The data can be analyzed on a monthly basis, however, it requires accumulation of monthly data. The best practice for evaluating the program is a yearly review to accommodate the time needed to implement the recommendations.

Unlike other reliability studies, a bad actor program does not possess any particular key performance indicator (KPI). However, the process can be analyzed qualitatively. This is based on a comparison of current bad actors with those from the past year.

- If the past year's recommendations were appropriate and executed properly as per standard operating procedures (SOPs), the bad actors should have moved off the bad actor list in the current bad actors analysis and replaced by others.
- It is also necessary to verify that the cost of failure for each previous bad actor in the current analysis is less than the cost of the previous year's analysis.
- There should be no repetition of similar failure modes in consequent years for each past year bad actor. This means that equipment is susceptible to failure from other failure modes than those reviewed in the past year, but should not fail dominantly by previous failure modes.

If any of these issues exist, then the program should inspect the quality of different items, including the:

- Failure modes entry in work orders;
- Maintenance cost and downtime hours entry in work orders;
- Maintenance execution and procedures;
- Spare parts quality;
- Recommendations quality.

Upon completion of the inspection, coordination with the respective department(s) is necessary for addressing the issues.

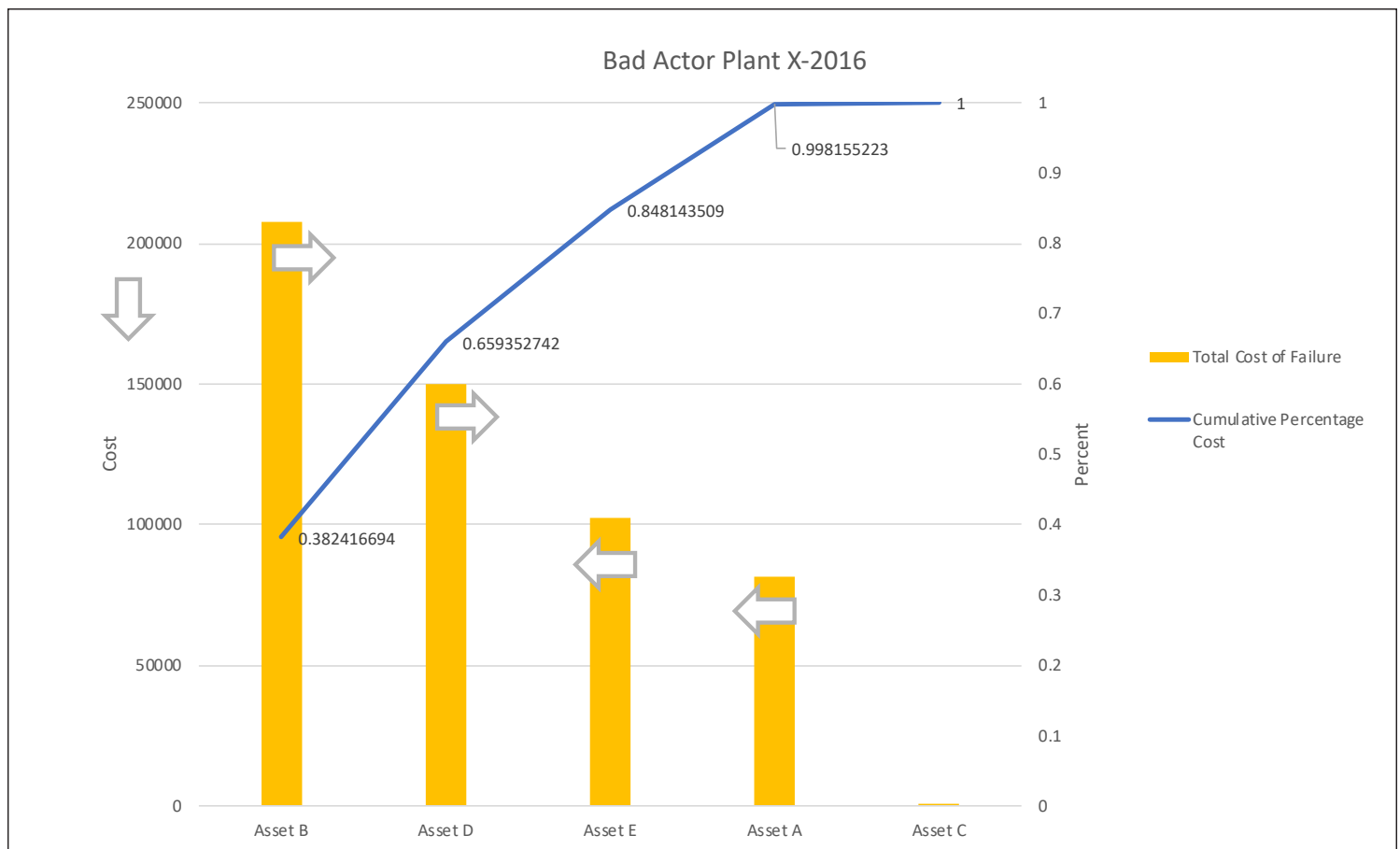
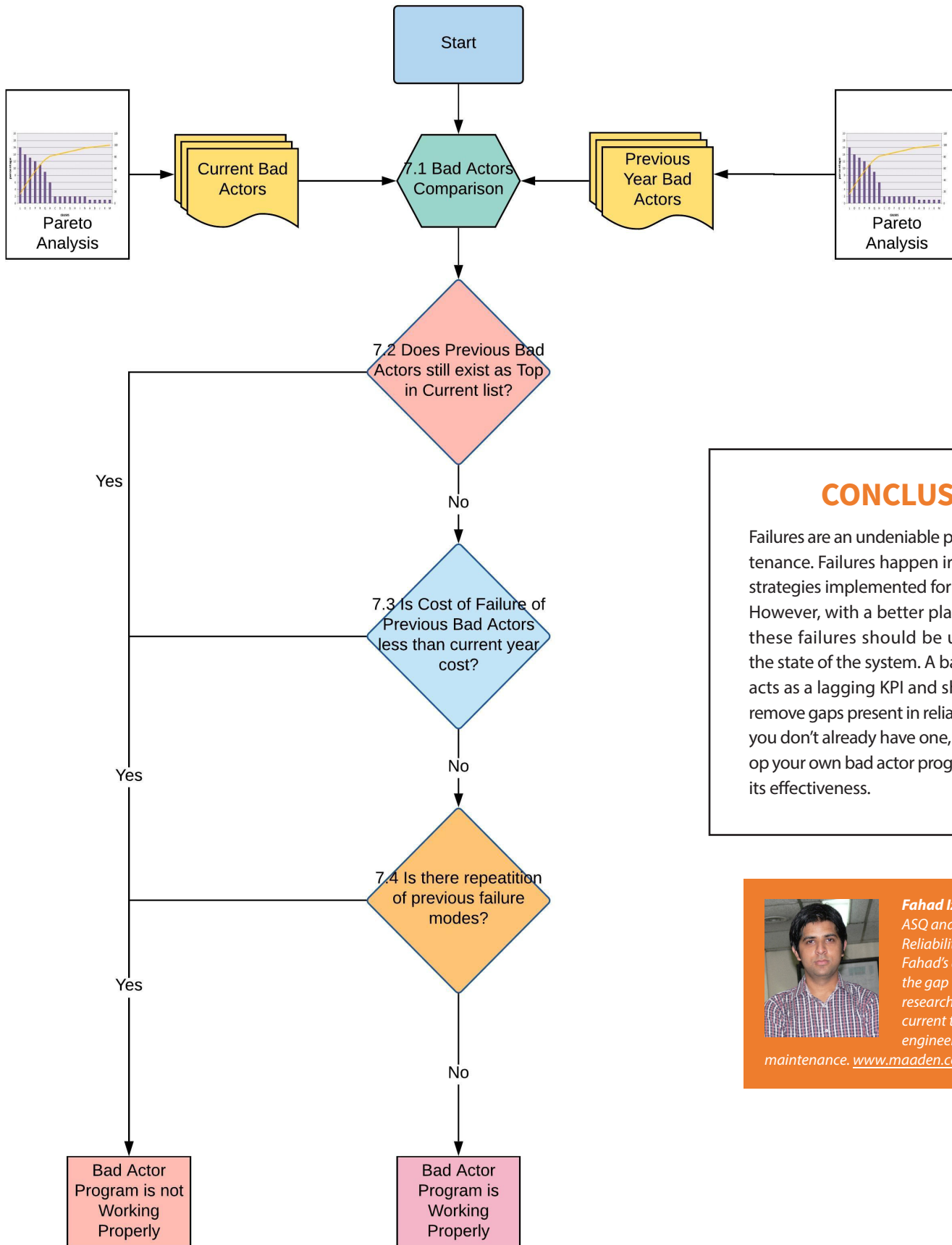


Figure 4: Illustration of bad actor performance





## CONCLUSION

Failures are an undeniable part of plant maintenance. Failures happen irrespective of the strategies implemented for their prevention. However, with a better planning approach, these failures should be used to improve the state of the system. A bad actor program acts as a lagging KPI and should be used to remove gaps present in reliability strategies. If you don't already have one, it's time to develop your own bad actor program and evaluate its effectiveness.



**Fahad Izhar Khan** is an ASQ and SMRP Certified Reliability Engineer. Fahad's aim is to bridge the gap in industry and research by using the current tools of reliability engineering in plant maintenance. [www.maden.com.sa](http://www.maden.com.sa)

Figure 5: Workflow of bad actor evaluation



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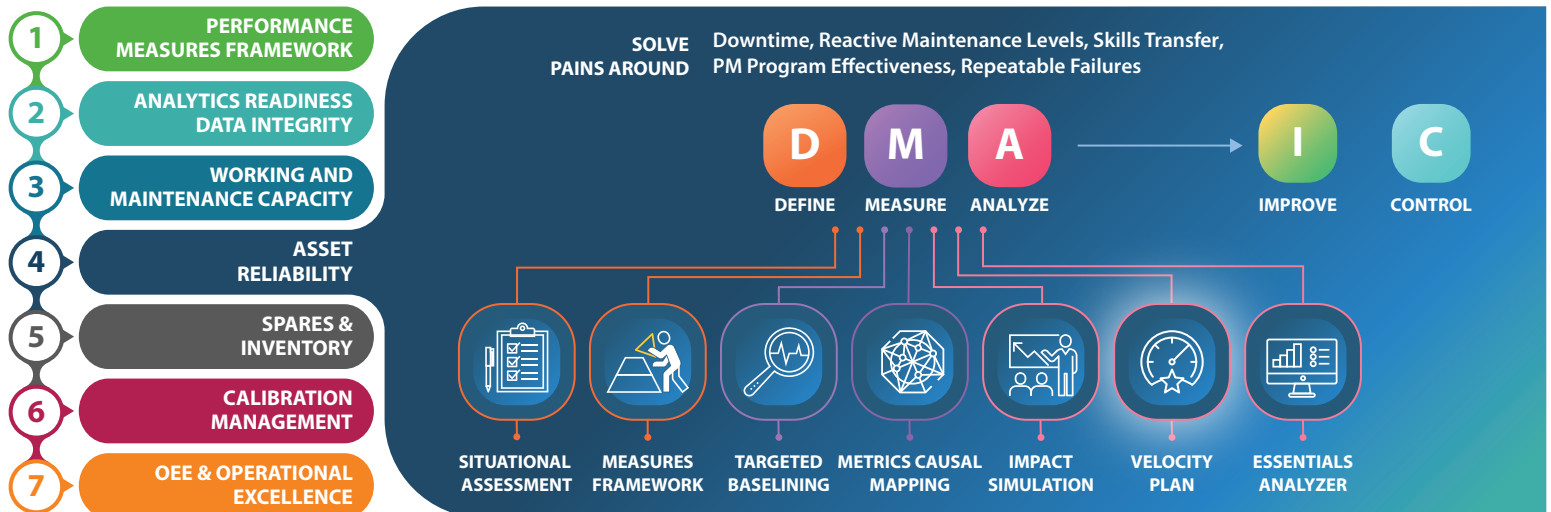


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## VILMA A. ROSADO


Asset Quality Lifecycle Sr. Engineer 2 • BioMarin Pharmaceutical, Inc. • Novato, California

A native of Lajas, Puerto Rico, Vilma Rosado joined the workforce as a process engineer in the electronics industry in 1998. Over the next 20 years, she has worked for the U.S. government, Hewlett-Packard, Johnson & Johnson and now as a Senior Manager level, individual contributor at BioMarin Pharmaceutical, Inc. Vilma is passionate about high performance teams and assets, and has a continuous commitment and interest in reliability engineering and asset management.

### How did you first get introduced into the field of life sciences?

 It began in 2005 when I was a senior manufacturing engineer for a high volume electronic contract manufacturer while working on my master's degree in pharmaceutical processes manufacturing engineering. As part of my graduate program, I took courses that introduced me to the basic theory of life sciences. At that same time, I was about to start my final project to complete graduation requirements, however, I had no hands-on experience in the life sciences industry. So, I decided it was the right time to look for a development opportunity within the life sciences industry and joined Ortho Biologics, a Johnson & Johnson company, as a maintenance supervisor in August 2005.

### How has this field changed since you began? Where do you see the future path of the life sciences field?

 It's been a long journey since then and I have witnessed how the industry has been evolving, emerging and positioning itself as the best option for patients taking the medicine of the future available in the present. Life sciences' future is bright, considering the new capabilities identified by many scientists around the world to treat not only well-known diseases, but rare diseases as well. Thanks to the evolution of this industry and the hard work of exceptional professionals, many patients can now receive treatment for conditions that 20 years ago were considered a death sentence. Today, these patients can enjoy a quality of



life that allows them to be independent, attend school, participate in outdoor activities and enjoy their families. That's what life is about and our roles as professionals are to help those who need it most and, at the same time, feel accomplished knowing our patients are happy.

## Q How is digitalization and the Internet of Things (IoT) affecting this area?

A Being a highly regulated industry, product quality and safety are our top priorities and risk management is crucial to this rapidly growing industry. Concurrently, it must be one that is agile, multi-product, smart and competitive. The introduction of emerging technologies, such as new digitalization capabilities and IoT, have come to support fulfillment of stringent risk management regulatory and business requirements, demonstrating higher levels of control. Specifically, they bring intelligence capabilities to assets so they can provide real-time and historian condition data and analytics capabilities, furnishing the ability to predict failures at an early stage that can be corrected before they become catastrophic and shut down operations.

## Q Are the ISO55000 asset management standards being considered in your work?

A Asset lifecycle management has been in the industry for a while and with the development and deployment of the ISO55000 standards, our strategies are looking to continuously improve and be fully aligned with those standards. In my current role within BioMarin Pharmaceutical's global quality organization, our asset quality lifecycle team is focused on providing sites with the internal global standards and business practices aligned to ISO55000 and other asset standards and regulations that support a high asset performance while looking after product quality. There is a change management process in progress instructing cross-functional organizational leaders, enhancing technical and leadership skills, and providing more visibility to the link between product quality and asset management standards.

## Q How is your company addressing the lack of diversity in this field?

A BioMarin Pharmaceutical is not only addressing the lack of diversity, but has also been an innovator in the way to do it. At both global and site levels, there are women leading asset management teams, initiatives and programs. If I look back to my years involved in asset management, many more women are currently showing interest in the area and demonstrating the competencies to continue influencing industry leaders to extend formal deployment of asset management programs.

## Q What advice do you have for young or female engineers that have an interest in this area?

A My major advice is to be brave; be determined; read; go to the field and learn; be hands-on; become a change agent no matter your level in the organization; do not hesitate to ask and promote discussion; be innovative; collaborate; and lead. There will be many challenges to overcome, particularly within the high level of the organization. Therefore, doing all of what I have just mentioned will help you get ready to lead the right discussions and influence towards reliability based informed decisions.

## Q What opportunities does the future hold for you in this field? Where do you see yourself in five years?

A First, I'm convinced there are many opportunities for all women interested in joining this engineering field. Every year, companies are more aware of the value we're able to create to the organization by ensuring the right things are being done from the beginning of the asset's lifecycle.

Considering my diverse experience of 21 years, I can easily see myself leading an engineering, reliability and maintenance organization at a senior management level. Having demonstrated leadership imperatives, such as Connect, Shape, Lead and Deliver, from lower responsibility levels up to managerial levels, creating site and global impacts through innovation and process-based transformation, and creating value by increasing efficiency and performance, I feel ready to continue contributing to my current quality organization and demonstrating my leadership by shaping asset lifecycle practices from a quality perspective while developing new competencies to continue escalating to higher responsibility roles.

## Q Do you have a mentor or someone you admire? What role has he/she played for you?

A I have an excellent mentor who has been supporting me shaping my career and identifying the next steps to take to continue escalating higher responsibility roles. She has been providing me with tools, guidance and direction to continuously improve my leadership and technical skills, increase my self-confidence, look for development and learn about new opportunities that enrich my career path while still allowing me to enjoy my roles.

## Q What are five words that describe you?

A Servant Leadership; Passionate; Collaborative; Determined; Sensible

## Q What is your favorite quote?

A "If you can't measure it, it doesn't exist." (Brené Brown).

## Q What books do you recommend? What's on your reading list?

A *10 Rights of Asset Management* by Ramesh Gulati and Terrence O'Hanlon; *Lead from Any Seat: 10 Ways to Get More Involved in Your Job, Make a Lasting Impact, and Advance Your Career Fast* by Andrei Anca; and *The Power of Positive Leadership* by Jon Gordon.



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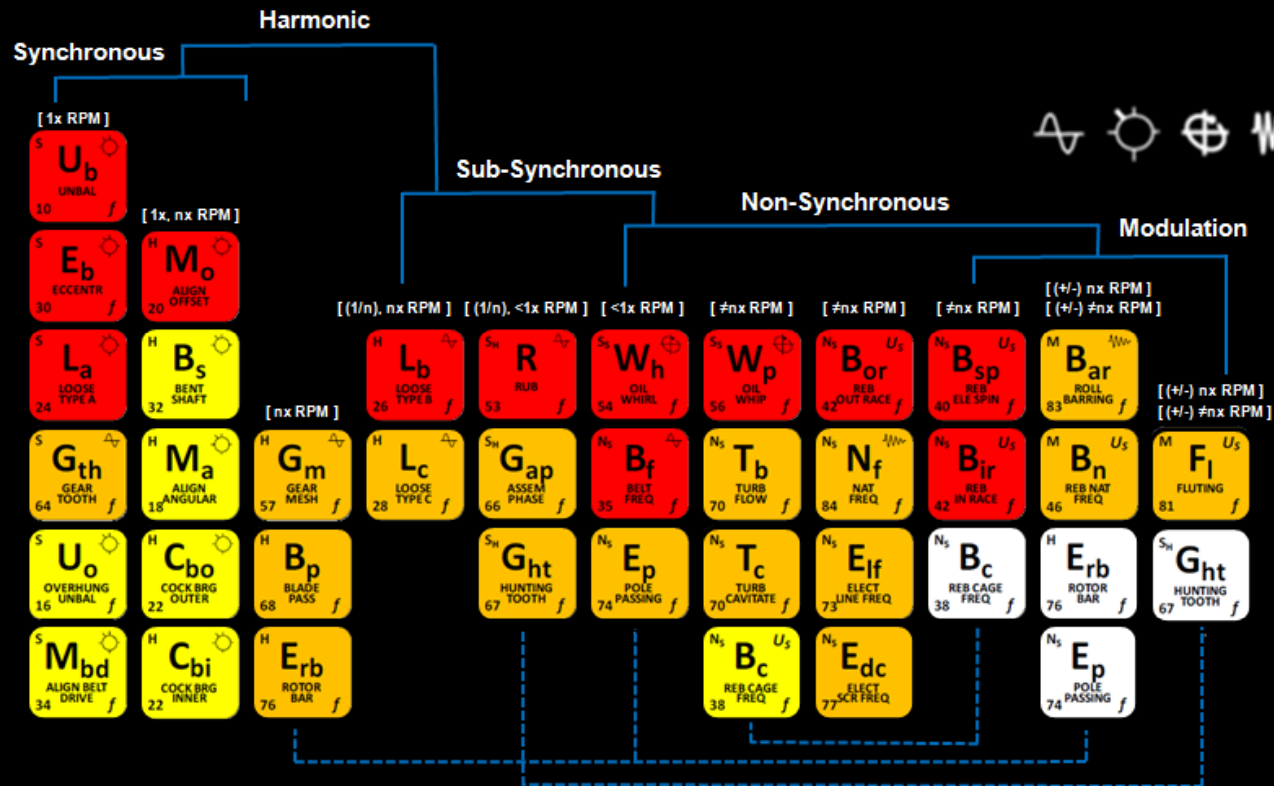
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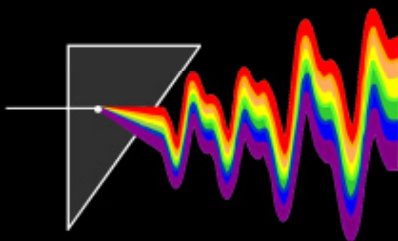


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