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SMRP BOK Guided Study	Experienced maintenance and reliability professionals who want to attain the CMRP designation.	Review SMRP's Five Pillars of Knowledge. The guided study is an intensive review of each pillar's components designed for organizations looking to further develop their team through CMRP certification.	Sep 19-21, 2017 (CHS)	4 consecutive days Exam on day 4	Contact us for pricing

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Uptime® Elements™

A Reliability Framework and Asset Management System™

Reliabilityweb.com's Asset Management Timeline

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Editorial
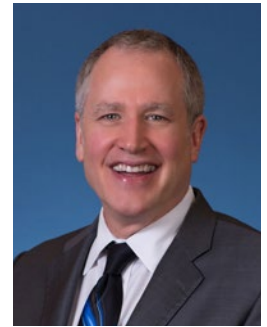
Reliability and Maintenance
NEED TO BREAK UP

Most of you know that I work in inquiries, and two of them are:

What is reliability?
Where does reliability come from?

Pondering them recently, I realized that I may be guilty of creating some of the confusion I often encounter as I travel and meet asset managers and reliability leaders.

I have been using the terms maintenance AND reliability in the same sentence. Many years ago, I dropped the use of "AND" to state it simply as maintenance reliability, as if they were one word. And unfortunately, it caught on.

My original intention was to use the term as an indicator of how reliable your maintenance was. But…I have had a major transformation, and now I am firmly in the camp that RELIABILITY should probably get a divorce from MAINTENANCE.

It is as if they both (Mr. Reliability and Ms. Maintenance) attended the company Christmas party, got drunk, ended up with each other and then stayed together and never parted. Now they are stuck with each other, and it is bringing each of them down.

Granted, the effects of unreliability almost always ends up with the maintenance department, so it is understandable that laypeople would think that must be where reliability comes from.

Reliability is a lot of things, and one of them is NOT maintenance. Maintenance is the upkeep of property or equipment. Reliability may require maintenance; however, they are two different things.

Why not Operations and Reliability?

Why not Engineering and Reliability?

Why not Purchasing and Reliability?

Why not Human Resources and Reliability?

Why not Management and Reliability?

These all sound like better relationships to me. Besides that, each of these stakeholders can enable reliability or disable reliability in ways that are beyond the influence of maintenance.

Reliability is confusing enough on its own. It gets even more confusing when you fail to create a distinction between maintenance and reliability or combine the topics as if they are one.

Reliability is NOT a maintenance initiative any more than safety is.

You cannot maintain your way to reliability, nor can you maintain your way to safety.
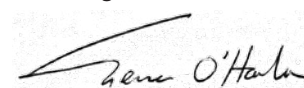
Safety is, first and foremost, a culture and set of behaviors by everyone in the organization. People are taught to "think safety," and then management demands strong adherence to the organization's safety framework.

Reliability is, first and foremost, a culture and set of behaviors by everyone in the organization. We use Uptime® Elements™ Reliability Framework and Asset Management System™ to teach cross-functional stakeholders to "speak reliability" in the sense of a language and to "think reliability" in terms of behaviors. Most of the successful organizations we work with have a strong executive sponsor who models reliability. The executive sponsor encourages and empowers the frontline workforce to create a culture of reliability and leadership that also improves safety and sustainability.

To support a more sustainable effort, the revised Uptime® Elements™ Reliability Framework (see page 18) now includes the Asset Management knowledge domain to align the technical activities to the business processes via policy, strategy and plan that meets the intention of ISO55001: 2014 Asset Management – Management Systems – Requirements.

Please enjoy another issue of Uptime® Magazine. Use what you discover in these pages as a change agent – then share your story with us in a future issue or at one of our conferences. I want to hear how you are making a dent in the universe.

Warm regards,

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

RAIL RELIABILITY AND ASSET MANAGEMENT ROUNDTABLE

Reliabilityweb.com hosted the Rail Reliability and Asset Management Roundtable on March 14th-15th in New York City, New York.

During the meeting, a few topics were shown to be urgent:

1. The new transit asset management requirements create the need for compliance but also the opportunity for improved levels of service at lower costs.
2. Smart connected transit assets and the IoT are creating new possibilities for transit.
3. Asset information configuration matters.
4. There is an urgent need to create a culture of reliability and leadership.

In attendance were representatives from:

Amtrak • Argo • Bay Area Rapid Transit • Bentley Systems
Crossrail Ltd (UK) • CSX Transportation • Interloc • LIRR
Metro Trains Melbourne • Metrolink • MetroNorth • MTA • Network Rail
New Jersey Transit • NY Subway • Parsons Brinckerhoff/WSP
Port Authority of New York and New Jersey
Siemens Mobility • WMATA

To support this continued conversation, interested parties are encouraged to attend the Transit Asset Management and Reliability Forum taking place at IMC-2017 on December 11th-15th, 2017. **For more information, visit: www.imc-2017.com.**

ISO/TC251 Asset Management – Management System Meeting Held in Brisbane, Australia

Reliabilityweb.com® is committed to discovering and delivering approaches to advance asset management and reliability. CEO, Terrence O'Hanlon, has been involved with the development of the ISO55000 series of Asset Management – Management Systems standards since the creation of the ISO Technical Committee 251. Mr. O'Hanlon participated in the ISO/TC251 meeting hosted in Brisbane, Australia on March 27th-31st as a delegate for Working Group 6 that created a revised version of ISO55002.

Maura Abad, Global Relationship Leader at Reliabilityweb.com, is the Chairperson for Servicio Ecuatoriano de Normalizaión (INEN) Technical Advisory Group and the Head of Delegation to ISO/TC251 for Ecuador. Additionally, Ms. Abad is working on creating the Spanish translation for the ISO55000 series of standards.

La Red CONFIABILIDAD

Reliabilityweb.com held training and networking events for asset managers and reliability leaders in Monterrey, Mexico and Lima, Peru in the past 60 days.

"The appetite for advancing reliability and asset management in Latin America is at an all-time high," states Reliabilityweb.com CEO, Terrence O'Hanlon. "These reliability leaders understand that they are working on a world stage and competing with world-class organizations from around the world, and they are facing the challenges head-on."

More events are planned for Mexico, Chile and Puerto Rico in 2017. For more information, visit: **http://reliability.international**

Accenture Opens New Innovation Center

Uptime Magazine was thrilled to be a part of the grand opening of Accenture's Innovation Center located in Houston, Texas on February 22nd, 2017. The first of ten new hubs in the United States, the innovation center is designed to assist clients through the use of technology, including artificial intelligence, drones and virtual reality, to drive business decisions and high performance. When clients have an idea or a concept they want to explore, they spend time in the liquid studio, where they have the ability to try the various technologies and turn a concept into a prototype. This is a place for businesses to discover solutions that are specific to their needs.

For more information, visit: www.accenture.com

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Created by Ramesh Gulati
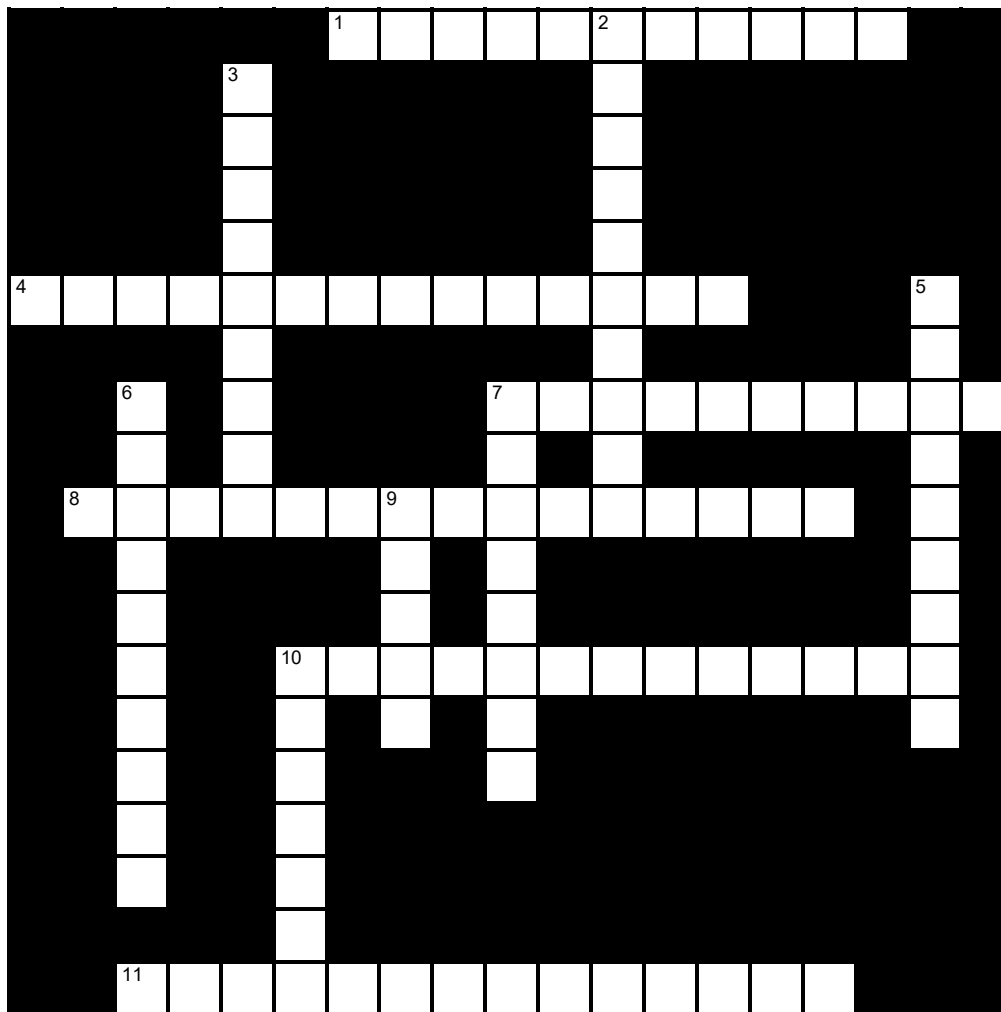
ACROSS

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

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

DOWN

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

THE EVOLUTION OF

PERFORMANCE

MEASUREMENT

G. Lance Jakob

I n the current environment of ever-increasing demands to deliver exceptional results with limited resources, leaders are placing greater emphasis on performance measurement. Performance measurement is defined as *the process of analyzing information to determine the progress toward a desired outcome for a given organization*.

You have the incredible fortune of experiencing firsthand a transformational crossroads in this field; it's a front row seat to the fascinating evolution of performance measurement.

In 2016, Gartner, a U.S. information technology research and advisory firm, recognized this evolutionary shift in performance measurement by separating its archetypal business intelligence (BI) market segment into two distinct categories: traditional BI platforms and modern BI platforms.

According to Gartner, "The BI platform category is undergoing the biggest transformation it has ever seen as spending has come to a screeching halt in traditional BI platform investments."

Those organizations with the capacity to embrace the newest generation of performance measurement can **leverage the principles as a catalyst to accelerate their performance beyond their competition**. Sadly, organizations that haven't recognized the shift will be left behind.

Interestingly, this isn't the first major shift modern performance measurement has experienced.

ORIGINS – MEASUREMENT 1.0

To explore the origin of modern performance measurement, one must travel back to the early 20th century. This early type of analysis was characterized by accounting-centric measures, mostly because that was the only meaningful data available at the time. These measures were generally considered a supplement to financial and accounting results, and showed high-level financial trends to give users a general idea of the success and trajectory of historical organizational performance.

Unfortunately, the underlying data became available only after the books were closed at the end of the accounting period. This meant the measures provided limited value since they were, by and large, lagging indicators for which organizations had little direct control.

Let's call this phase of results evaluation *Measurement 1.0*. The age of *Measurement 1.0* continued for several decades, with only minor advancements. Meaningful data from which performance information was derived was generally found in onerous account ledgers.

In the 1920s, DuPont made an incremental advancement when it began measuring return on equity (ROE), broken down into three primary subcomponents that ultimately became known as The DuPont Analysis (or The DuPont Identity).

In the late 1930s, Saint-Gobain, a French glass, insulation and building materials manufacturer, began supplementing its balance sheets and income statements with narrative-based statistics, which accompanied financial data to provide additional context for those interpreting the results. The goal was to standardize the measurements across the diverse enterprise and then distribute the measurement results to provide new insights into performance that had never been visible before.

In the mid-20th century, General Electric initiated a series of performance measurements that included results outside of the existing realm of the general ledger. Much of the results were largely subjective, but it was an important step that communicated to the market that success is not measured solely by short-term, financial values.

Finally, in the 1970s, General Motors began measuring non-financial performance measures tied to production and operations.

One major flaw in *Measurement 1.0* was what scholars refer to as the strategy to execution gap. The strategy to execution gap is the philosophy that, while companies spend countless resources on developing sophisticated organizational strategies, those strategies are meaningless without clearly aligned processes to properly execute the strategy.

Measurement 1.0 seems so far behind us, yet a 2011 study from *Forbes* magazine found that while "82 percent of Fortune 500 CEOs feel their organization did an effective job of strategic planning, only 14 percent of the same CEOs indicated their organization did an effective job of implementing the strategy."

As organizations began branching away from accounting measures, evidence-based decisions were still rare. Instead, "gut feeling" continued to drive organizational direction. Organizational dogma – the unwillingness of an organization to change course, even when presented with empirical evidence to the contrary – is the enemy of continuous improvement. Geocentrism seems naïve in retrospect, but prior to the 16th century, nearly the entire human race believed the sun revolved around the earth. This belief existed despite heliocentric models being introduced by Aristarchus of Samos over 1,800 years prior to the Copernican Revolution.

Even in modern times, Jeffrey Pfeffer and Robert Sutton, authors of *Hard Facts, Dangerous Half-Truths and Total Nonsense*, point out that key business decisions "are frequently based on hope or fear, what others seem to be doing, what senior leaders have done and believe has worked in the past and their dearly held ideologies – in short, on lots of things other than the facts."

Organizational dogma – the unwillingness of an organization to change course, even when presented with empirical evidence to the contrary – is the enemy of continuous improvement.

MEASUREMENT 2.0

SECOND GENERATION –

The second generation of performance measurement, *Measurement 2.0*, is characterized by a major influx of data.

Businesses found themselves asking the question: What can we do with all this data? Internal IT departments held the belief that traditional BI tools were the panacea that would solve the data-rich, information-poor dilemma.

Measurement 2.0 was data and technology driven, and implementations were almost exclusively owned by IT departments. Unfortunately, IT departments typically lack the intimate knowledge of the business to deliver what is truly needed to drive informed business decisions.

> ❝ What can we do
> with all this data? ❞

Requirements analysis was also run by IT departments, which generally took months to complete and years to begin delivering value. This paradigm created a rigid environment unable to pivot with the changing demands of the business; by the time IT delivered its answers, the questions had often changed.

Some enterprising companies addressed the inherent development delays by marketing key performance indicators (KPI) catalogs with the promise of delivering thousands of off-the-shelf measurements to their customers. Sadly, these solutions falsely assumed the performance measurement needs of all organizations were homogenous.

No two organizations are alike; they all have varied strategies and face unique challenges. Moreover, the data collected in support of the key business processes are never the same. For these reasons, leaders quickly abandoned the one-size-fits-all solutions.

Since *Measurement 2.0* focused on data and technology, this generation also experienced the proliferation of bloated BI support organizations just to maintain the cumbersome tools. Further, the BI tools placed the burden of *pulling* information from BI systems on the business users. Business users lacked the technical understanding to interact with the complex systems, thus placing further reliance on the already overburdened IT support groups. This environment ultimately prevented businesses from fully embracing BI tools as had been expected.

A lack of consistent, credible, trustworthy data also played a large role in poor BI adoption rates. Specifically, business groups placed blame on IT for not delivering usable information, while IT argued the business wasn't collecting consistent, usable data.

Finally, leadership recognized that the data delivered through BI initiatives frequently fostered the wrong behaviors. *Measurement 2.0* users were often more focused on "chasing their numbers" rather than addressing improvements in the underlying processes. As with *Measurement 1.0*, this is a definite side effect of the strategy to execution gap.

Sports Authority was a great example of a *Measurement 2.0* organization. With more than 450 stores throughout the country and a sophisticated business intelligence investment, Sports Authority collected nearly 114 million customer records and 25 million e-mail addresses. Unfortunately, it was unable to leverage that information to help in executing its strategy and avoid complete liquidation of its stores. The data collected contained enormous potential, so much so that Dick's Sporting Goods recently purchased the data, along with other intellectual property, for $15 million.

MEASUREMENT 3.0

EVOLUTION –

Measurement 3.0 is the current generation of performance measurement. It's characterized by a transformative focus on objective-driven performance management.

Objective-driven performance management is the foundation for operational excellence. It's a process-centric approach that aligns the execution of key processes to strategic goals by measuring and improving what matters most to an organization.

In her latest publication, *Prove It!*, Stacey Barr points out that: "Performance measures are supposed to be the evidence that convinces us we've achieved, or at least are making progress in the right direction, toward our goals. But most of what is measured in organizations doesn't do this. We measure the easy stuff, where data is readily available. We measure the traditional stuff, what we've always measured. We measure the obvious stuff, the resources we use, the effort we put in, and the widgets we produce. We measure the popular stuff, the measures that everyone in our industry seems to be measuring."

Measurement 3.0 keeps ownership and the configuration of performance measurement in the hands of the business, those with the most intimate understanding of the strategies and processes being measured. Such a decentralized, self-service paradigm is integral to meeting the ever-changing demands of the business by removing the restrictions and bottlenecks historically imposed by internal IT departments. Agility and flexibility are innate tenets in *Measurement 3.0*.

Objective-driven performance management also incorporates unambiguous performance goals so everyone maintains a consistent definition of good performance and unacceptable performance. Predefined response plans are typically associated with performance goals. The philosophy states that if you know all the variables that go into the measurement and you know how each variable can affect the direction of the measurement, then you should also have a reasonable idea of the steps you should take to get back on track if performance results are outside the acceptable tolerances. Response plans clarify accountability and establish a direct action framework when performance targets are missed.

Measurement 3.0 also includes the capability to visualize the corollary effect of business initiatives. This equips business leaders with a rational basis for selecting which improvements provide the greatest value to the organization. It also validates whether the outcomes of a particular initiative match the expectations as defined *prior* to their implementation.

Southern Power Company, the wholesale energy subsidiary of perennial Fortune 200 luminary Southern Company, is an industry leader in *Measurement 3.0*. Southern Power understands that while it operates with an admirably high degree of efficiency, there is always opportunity for improvement. One example is the active approach the company takes to empirically measure the effect of strategic initiatives on corollary performance results.

Timing risk is the potential negative consequence associated with making decisions later than would be ideal, often as a result of aggregation and publication delays in traditional business intelligence tech-

niques. *Measurement 3.0* reduces timing risk by delivering information with which to make better decisions to the right people at the right time. Rather than relying on users to navigate a series of static dashboards, users are provided exception-based notifications when performance falls outside of acceptable levels. Information is pushed directly to users, allowing them to focus on the most important aspects of their job rather than navigating BI reports.

Another major shift of *Measurement 3.0* is the injection of trust in the results through the concept of data confidence. Data confidence, which measures the adherence to a defined process, should not be confused with data quality. Data quality defines the volume of records that can be evaluated for a given measure (i.e., the number of records that contain the minimum data elements necessary to derive a measure). Conversely, data confidence measures the volume of records that can demonstrate the process was consistently and accurately followed.

While data quality risk is controlled through data governance techniques, data confidence risk is managed through process controls. Data confidence reinforces the idea that if processes are not consistently followed, users will view any resultant performance measurements with a high degree of skepticism and are less likely to fully commit to decisions based on the results. In his seminal publication, *Transforming Performance Measurement*, Dean Spitzer argues, "Trust is an essential ingredient of effective measurement. … If people don't trust the measurement system, they are likely to view it as an enemy."

Finally, *Measurement 3.0* is characterized by the eschewal of the one-size-fits-all mentality. Leaders have realized that what works for one organization will not necessarily work for them. Measures must be tightly aligned to the organizational objectives and to the structured processes that support those objectives.

Throughout each discrete process, key data elements are being captured. All of these elements contribute to the individuality of the measurement. Any attempt to wedge the data into a rigid model dilutes the applicability of the results.

The inherent flaw in the reliance of a one-size-fits-all structure can be demonstrated through the story behind the "myth of average." Gilbert Daniels was a first lieutenant in the United States Air Force and a recent Harvard graduate. Daniels was stationed at Wright-Patterson Air Force Base in Dayton, Ohio, in the 1950s when he began studying cockpit designs.

During this period, an alarmingly high number of accidents led to an investigation that determined the root cause was poorly fitting cockpits. Military aircraft were designed to fit an "average pilot," as determined from measurements taken on hundreds of pilots back in 1926. Leaders initially assumed the average size of pilots had changed. Daniels had a different hypothesis.

Daniels took measurements across 60 dimensions for more than 3,300 pilots. He then chose the 10 dimensions he thought were most crucial to proper cockpit fit and defined the average for each of the 10 dimensions as +/- 15 percent of the 50th percentile ranking. Finally,
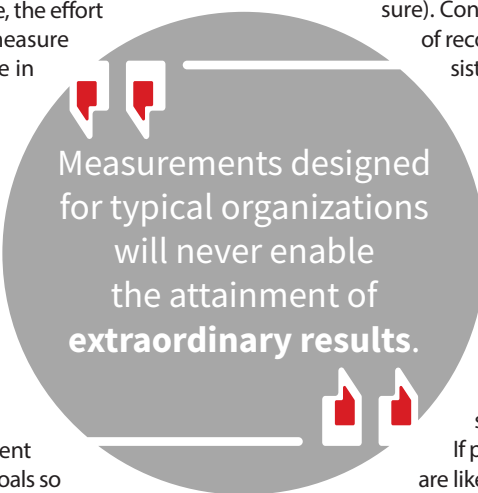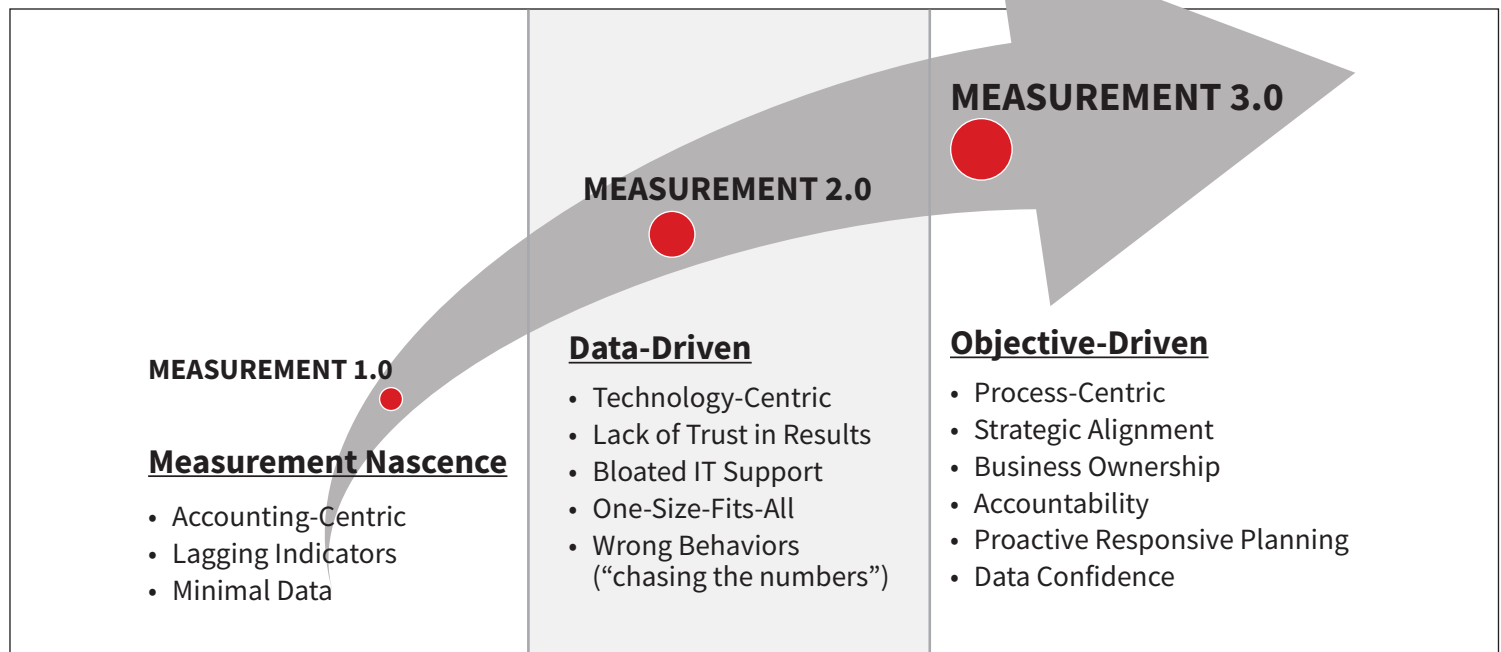
> Measurements designed for typical organizations will never enable the attainment of **extraordinary results**.

Figure 1: Performance measurement across the generations

MEASUREMENT 3.0

MEASUREMENT 2.0

MEASUREMENT 1.0

Measurement Nascence

- Accounting-Centric
- Lagging Indicators
- Minimal Data

Data-Driven

- Technology-Centric
- Lack of Trust in Results
- Bloated IT Support
- One-Size-Fits-All
- Wrong Behaviors ("chasing the numbers")

Objective-Driven

- Process-Centric
- Strategic Alignment
- Business Ownership
- Accountability
- Proactive Responsive Planning
- Data Confidence

Daniels determined how many of the 3,300 pilots fell into the "average" range on all 10 crucial size dimensions.

Surprisingly to almost everyone (other than Daniels), not a single pilot in the study fell into the average range on all 10 dimensions. ZERO! Daniels was able to demonstrate that **there is no such thing as "average."**

As a result of his findings, the United States Air Force began forcing manufacturers to provide adjustable cockpits across a variety of dimensions. More importantly, Daniels proved a one-size-fits-all cockpit design injected a myriad of unnecessary risks.

Flexibility of design allowed pilots to perform at their full potential. Likewise, *Measurement 3.0* champions expect flexibility of design in performance management systems to enable businesses to perform at their full potential. **Measurements designed for typical organizations will never enable the attainment of extraordinary results**.

CONCLUSION

Measurement 3.0 relies on the deliberate alignment of objectives with a structured methodology of performance measurement. **In business, nothing of consequence gets accomplished accidentally**.

While *Measurement 2.0* was focused on data and technology, *Measurement 3.0* is focused on value and engagement. The objective is not as much about predicting the future as it is about illuminating the current trends and identifying opportunities to change course or capitalize on exceptional performance.

In viewing the performance measurement framework in your organization, ask yourself these questions:

- Do you experience people in your organization more focused on "chasing their numbers" than improving their underlying business processes?

- Do you measure performance in some areas of your organization simply because you have the necessary data?

- Are you making decisions in your organization based on information some may view as untrustworthy?

If you answered *YES* to any of these questions, it likely your performance management philosophy is stuck in dogmatic concepts of the last century. **It's time to evolve**. It's time for *Measurement 3.0*.

> In business, nothing of consequence gets accomplished accidentally.
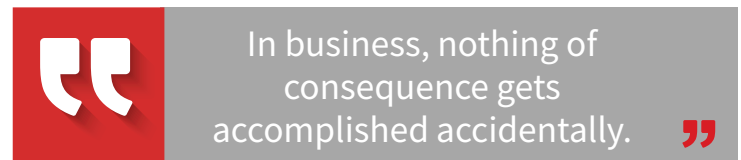
References

1. Hare, Jim; Woodward, Alys; and Sood, Bhavish. "Update: Gartner to Expand Its BI Platform Segmentation." February 18, 2016. https://www.gartner.com/doc/3215522/update-gartner-expand-bi-platform

2. Liesz, Thomas J., and Maranville, Steven J. "Ratio Analysis Featuring The DuPont Method." *Small Business Institute Journal* Vol 1 No 1, 2008: 17-34.

3. Brudan, Aurel. "Learning from Practice – A Brief History of Performance Measurement." *Performance Magazine*, August 7, 2010. http://www.performancemagazine.org/learning-from-practice-a-brief-history-of-performance-measurement/

4. Pezet, Anne. "The history of the French tableau de bord (1885-1975): evidence from the archives." Accounting Business and Financial History, Taylor & Francis, 2009, 19 (2), pp.103-125. https://halshs.archives-ouvertes.fr/halshs-00498670/document

5. Pfeffer, Jeffrey and Sutton, Robert I. *Hard Facts, Dangerous Half-Truths And Total Nonsense: Profiting From Evidence-Based Management*. Boston: Harvard Business Review Press, 2006.

6. Addady, Michal. "Dick's Just Paid $15 Million For Sports Authority's Name." *Fortune* magazine, June 30, 2016. http://fortune.com/2016/06/30/dicks-sports-authority/

7. Barr, Stacey. *Prove It! How to Create a High-Performance Culture and Measurable Success*. Milton, Queensland: Wiley, 2017.

8. Spitzer, Dean R. *Transforming Performance Measurement: Rethinking the Way We Measure and Drive Organizational Success*. New York: AMACOM, 2007.

9. Rose, Todd. *The End of Average: How We Succeed in a World That Values Sameness*. San Francisco: HarperOne, 2016.

10. Daniels, Gilbert S. and Meyers Jr., H. C. *Anthropometry of Male Basic Trainees*. Wright Air Development Center, Air Research and Development Command, United States Air Force, July 1953. http://noblestatman.com/uploads/6/6/7/3/66731677/cockpit.gilbert.report.pdf

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Asset management is the science of making the right decisions and optimizing the delivery of value.

Introducing Asset Management

Is asset management (AM) a new buzzword or a "flavor of the month" management initiative? AM is becoming a frequently used term in the industry around the world. It is a term being used more frequently by engineers, designers, facility planners and regulators, as well.

Unfortunately, the term is developing the initial symptoms of becoming a buzzword. This tendency is dangerous in several respects. First, asset owners and managers may view it as something new and, therefore, a potentially costly additional task they may be required to perform. Secondly, and perhaps more importantly, the concept loses cogency and impact as a buzzword. It becomes just another annoying fad that will hopefully go away. Neither could be further from the truth. AM is neither something new nor, hopefully, a temporary fad. It's a reality, a real value adder if done right. Asset management is the science of making the right decisions and optimizing the delivery of value.

Also, it has been noted that the majority of companies who used to be in the equipment maintenance and reliability field now have become asset management companies or have added AM in their name. If you search asset management, you get over 101,000,000 hits, with 90 percent of those sites related to financial companies or finance related service providers.

So, what's asset management? Why are so many ignorant about AM and, at the same time, why are some vigorously trying to join the AM bandwagon?

This article will help you understand asset and asset management and how it can be a value adder.

AM is not something new and there are tangible benefits to be realized, both short- and long-term, by the adoption of a coordinated AM strategy.

Asset, as defined in the online BusinessDictionary, is something valuable that an entity owns, benefits from, or has use of, in generating income. It could be physical, such as cash, machinery, inventory, land and buildings. *The Uptime® Elements™ Dictionary for Reliability Leaders and Asset Managers* de-

Figure 1: Performance versus value based

Ramesh Gulati and Lynn Moran

10 RIGHTS

1 R — Specify
2 R — Design
3 R — Source
4 R — Build/Fabricate
5 R — Install/Commission
6 R — Operate
7 R — Maintain
8 R — Improve/Modify
9 R — Dispose/Decommission
10 R — Manage

Figure 2: 10 rights of asset management

fines an asset as "an item with a potential value that an organization owns and has a use for to create value and has the responsibility to take care of it. The value could be tangible or intangible, financial or non-financial." The asset management standard ISO55000 established by the International Organization for Standardization (ISO) defines an asset as "a thing, item, or entity that has potential or actual value to an organization."

The Institute of Asset Management (IAM) states that asset management involves the balancing of costs, opportunities and risks against the desired performance of assets to achieve the organizational objectives. This balancing might need to be considered over different time frames. AM enables the application of analytical approaches toward managing an asset over the different stages of its lifecycle. A common objective is to minimize the whole life cost of assets, but there may be other critical factors, such as risk or business continuity, to be considered in this decision-making.

Performance vs. Value-Based Strategy

In the past, the maintenance strategy has been to manage equipment (assets). You perform preventive maintenance (PM) on assets to reduce failures or get them repaired quickly when they break. Also, you try to use condition-based maintenance (CBM) wherever it's feasible. The goal in this strategy is to ensure that equipment keeps performing. Some call this a "performance" based strategy. You keep fixing equipment at whatever it costs to ensure it keeps producing products or provides services. In reality, this is challenging and may be expensive.

If your maintenance reliability tribe gets involved early in the machine (asset) development, meaning the asset acquisition phase, they could provide valuable input in writing specifications and support design to ensure assets are designed from a reliability, availability, maintainability, safety and sustainability (RAMS[2]) perspective. They could also get involved in the asset build, installation and commissioning phases. Operators and maintainers need to be engaged and appropriately trained before assets become operational. They need to know how to operate or maintain assets properly (i.e., in the right manner) and have a good understanding of what not to do to damage or misuse the asset when being operated.

Studies have indicated that over 40 percent of asset failures are caused by operational errors/omissions. A good understanding of how asset functions can reduce these types of failures to a minimum is necessary. The important thing is to create a culture of asset ownership. With this concept, the operator becomes the "owner" of the machine/asset he or she is operating. This creates a different mindset, caring for the equipment as if they own it. Equipment is maintained from a lifecycle cost perspective. This concept or strategy of managing equipment is called asset management (AM).

> Studies have indicated that over 40 percent of asset failures are caused by operational errors/omissions.

Asset management is a systematic process of deploying, operating, maintaining, upgrading and disposing of assets in a cost-effective manner. ISO55000 defines AM as "coordinated activities of an organization to realize value from assets." This is a value-based strategy. It means you try to do the right things to assets from concept to disposal so you get more value out of them during their lifespan. You design, build, operate, maintain, etc., them right so they cost less during their whole life. Whereas in old strategies, you did things on an asset based on performance at whatever it cost, mostly during O&M phase. Operators may have abused an asset to produce more to meet production requirements, or you may have experienced more failures from poor design, bad installation, etc.

To implement a good asset management strategy on assets, you should deploy a 10-point plan called 10 Rights of Asset Management as shown in Figure 2. This 10-point plan includes:

①	**Specify It Right** – provide the right requirements and specifications;
②	**Design It Right** – design it with RAMS[2] to minimize failures and O&M costs;
③	**Source It Right** – purchase best value components and equipment (assets);
④	**Build It Right** – fabricate and assemble the asset with quality workmanship;
⑤	**Install/Commission It Right** – install with precision quality;
⑥	**Operate It Right** – operate with care and safety within its design limits;
⑦	**Maintain It Right** – perform the right maintenance;
⑧	**Improve It Right** – apply the right tools and practices to improve;
⑨	**Dispose of/Decommission It Right** – dispose of it in an environmentally safe manner;
⑩	**Manage It Right** – ensure the right skill and talent available at every role to do all 10 Rights right.

But, you must not only recognize the right things to do; you must daily: encourage, educate, remind and embrace these 10 rights and be on the lookout for efforts where they have not been considered and be the champion in the use of AM science.

Benefits

Implementation of the 10 Rights of Asset Management ensures a robust AM process that results in:

• Low/minimum failures and high reliability;
• High uptime and availability;
• Low injury rates and safe operation;
• Process repeatability;
• Lower overall lifecycle cost of ownership;
• High morale;
• Very satisfied stakeholders.

AM is not a buzzword or fad. The implementation of the 10 Rights of Asset Management will help to improve a company's bottom line. They will also support and put the company in compliance with the ISO55001 standard. The 10 Rights of Asset Management process will engage the stakeholders and workforce, encourage teamwork and become a value creator by making or supporting the right decisions.

References

1. Gulati, Ramesh and O'Hanlon, Terrence. *10 Rights of Asset Management: Achieve Reliability, Asset Performance and Operational Excellence*. Fort Myers: Reliabilityweb.com, April 2017.
2. Davies, Rhys and Humphrey, Danielle. *ISO55000 Asset Management – A Biography*. Fort Myers: Reliabilityweb.com, December 2016.
3. Gulati, Ramesh. *Uptime® Elements™ Dictionary for Reliability Leaders and Asset Managers*, Second Edition. Fort Myers: Reliabilityweb.com, March 2017.
4. Gulati, Ramesh. *Maintenance and Reliability Best Practices*, Second Edition. New York: Industrial Press, August 2012.
5. The Institute of Asset Management (IAM), https://theiam.org/
6. The International Organization for Standardization (ISO), https://www.iso.org/home.html

Ramesh Gulati, CRL, CMRP, CRE, is an Asset Management and Reliability Specialist at Jacobs - Asset Management Group in Tullahoma, TN. Ramesh is a world-renowned leader in the maintenance, reliability, and asset management field and the author of more than four books, including "Maintenance & Reliability Best Practices."

Lynn Moran, CMRP, is the Asset Management & Reliability Specialist at Jacobs Technology. Lynn has 38 years of experience in facility operations & maintenance and project management. Her technical expertise includes understanding facility operations and all phases of asset management from cradle to grave with an emphasis on using industry best practices.

DO YOU SPEAK RELIABILITY?

Terrence O'Hanlon

Part of the mission at Reliabilityweb.com® is to discover and deliver approaches to make reliability leaders and asset managers safer and more successful. I am blessed to be able to meet some of the best reliability leaders and asset managers in the world as I travel to learn (discover) and teach (deliver). There is nothing more satisfying than seeing someone presenting their journey based on the use of the Uptime® Elements™ framework.

Since December 2013, over 1,300 Reliability Leaders have been certified by the Association of Asset Management Professionals[1]. The team at Reliabilityweb.com has trained over 10,000 people around the world who use the Uptime Elements framework to guide their reliability journey on a more informal basis. At its simplest level, the Uptime Elements framework is a language that aligns stakeholders across the organization.

All things that can be mastered begin with the acquisition of a specialized language that contains words, concepts and ideas. An example would be a doctor in medical training who begins by studying the specialized words, phrases and concepts related to the practice of medicine. The same is true for reliability.

Organizations that begin their journey with some effort to install the Uptime Elements framework as a specialized language create alignment from day one and avoid the pitfalls that result from a lack of precision in language and a lack of distinction for ideas and concepts.

At a level above language, the Uptime Elements framework is a system designed to embed a culture of reliability across the enterprise through an engaged and empowered team that ranges from the executive suite to the frontline workforce.

RELIABILITY LEADERS DISCOVER FOR THEMSELVES

There are some fantastic leadership books and courses available from the masters, including Stephen Covey, John Maxwell and others. These books and courses tend to focus on traits and techniques that, even when mastered, do not create leaders.

Leadership cannot be taught in a classroom, so at one of its highest levels, the Uptime Elements framework is a leadership system designed to allow you to discover for yourself what it is to be a Reliability Leader™.

Being a Reliability Leader is defined as someone who can realize a future that was not going to happen anyway.

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[1] Association of Asset Management Professionals CRL List http://www.maintenance.org

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RELIABILITY LEADERSHIP IS BUILT ON FOUR FUNDAMENTALS:

Integrity – Do what you say you will do.

Authenticity – Be who you say you are.

Responsibility – Be accountable/take a stand for reliability and asset management.

Aim – Work for a purpose bigger than one's self.

These leadership fundamentals focus on creating a culture of reliability and when combined with the technical activities of Reliability Engineering for Maintenance, Asset Condition Management and Work Execution Management result in an effective reliability strategy.

WHY REVISE THE UPTIME ELEMENTS FRAMEWORK?

There were numerous drivers to revise the Uptime Elements framework, including:

1. Three years of experience applying the Uptime Elements framework have taught the Reliabilityweb.com® team some valuable lessons we wanted to share.

2. Many organizations that adopted the Uptime Elements framework are expressing interest in using ISO55000 as a managing system to advance asset management.

3. Current European and Australian approaches to asset management are designed for public infrastructure and can be heavy-handed, confusing and bureaucratic, making them hard to implement in lean North American organizations.

4. There is a distinct lack of diversity of ideas related to asset management and reliability. It was time to expand the gene pool of ideas and concepts.

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

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WHAT'S NEW?

The space allotted for this article does not permit me to dive into full details around the revisions, however, this brief overview should provide a clear glimpse.

Reliability Strategy Development (RSD)

Continuing to refine the concepts expressed in the *Reliability-Centered Maintenance Project Managers Guide*[2], a new element, Reliability Strategy Development (RSD), is formed that combines various approaches for developing reliability strategies based on failure modes. A new matrix that details the value and outcomes for each of the seven questions of SAE-JA1011 compliant RCM supports educated choices when selecting methodologies. The former elements of Reliability-Centered Maintenance (RCM), Failure Modes and Effects Analysis (FMEA) and PM Optimization (PMO) are combined in this new element.

Reliability-Centered Design (RCD)

One of the powerful inquiries from the Uptime Elements is: "Where does reliability come from?"

One of the answers is design.

This new element begins the discussion and the journey toward the aspect of ensuring reliability from the beginning.

Fluid Analysis (FA)

The element was formed by advancing the body of knowledge on Oil Analysis, encouraged by users of the Uptime Elements framework who use synthetic lubricants and test fluids like fuel and coolant.

The Reliability Journey (RJ)

The RJ element replaces and expands *The Reliability Leadership Travel Guide* and describes the true nature of what it looks like to be on the reliability journey.

The Asset Management Knowledge Domain

This is the most significant addition, with nine new Uptime Elements to complete the framework by connecting the technical activities to leadership and aligning them with the business process (see Figure 1).

The new Asset Management knowledge domain is fully aligned with the intent of ISO55000. It is designed to provide a path for companies who are on a reliability journey to conduct that journey in the context of asset management.

BODY OF KNOWLEDGE

More significant changes were made to the Uptime Elements Body of Knowledge based on feedback and the requirements of the revisions.
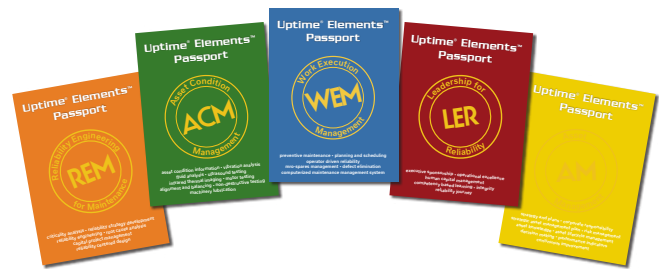
Uptime Elements Passport Series has moved from the 29 individual passport booklets to five Uptime Elements knowledge domain books to make reading easier and to enhance the open book Certified Reliability Leader™ Exam.

COMPLETE BODY OF KNOWLEDGE
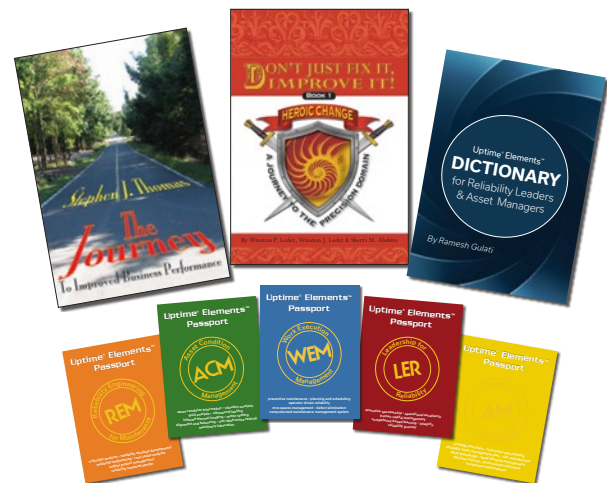
The Journey to Improved Business Performance by Steve Thomas (ISBN: 978-0-9832258-9-8), featuring all the concepts taught in the author's first two books, *Successfully Managing Change in Organizations* and *Improving Maintenance & Reliability Through Cultural Change*. The book is written in a way that readers can quickly apply the knowledge gained.

Don't Just Fix It, Improve It! by Winston P. Ledet, Winston J. Ledet and Sherri M. Abshire (ISBN: 978-0-9825163-1-7), an easy read because it is told

[2] http://reliabilityweb.com/articles/entry/reliability_centered_maintenance_project_managers_guide

as a story and is a good reminder of why you can't just focus on maintenance planning and scheduling. The really good performers eliminate the defects before they ever turn into work orders. Small problems are seldom left to turn into big failures and big problems rarely happen. The authors hit the nail on the head when they demonstrate through the story that improvement efforts that simply focus on driving the right maintenance work practices bog the organization down with too much work and seldom succeed. Only after building in the defect elimination culture and reducing the defects coming into the system can the organization achieve the best practices benchmarks. The small problems don't clog the computerized maintenance management system (CMMS) and the work processes can focus on the big issues. Small problems are taken care of immediately at the source.

***Uptime Elements Dictionary for Reliability Leaders and Asset Managers*** by Ramesh Gulati (ISBN: 978-1-941872-63-5), which represents a significant step toward improving the knowledge of and communications between cross functional stakeholders who need to speak one language of reliability. The compilation reflects a virtual explosion of commonly practiced concepts, ideas, methodologies and various approaches to advance reliability asset management.

UPTIME ELEMENTS BONUS POSTERS
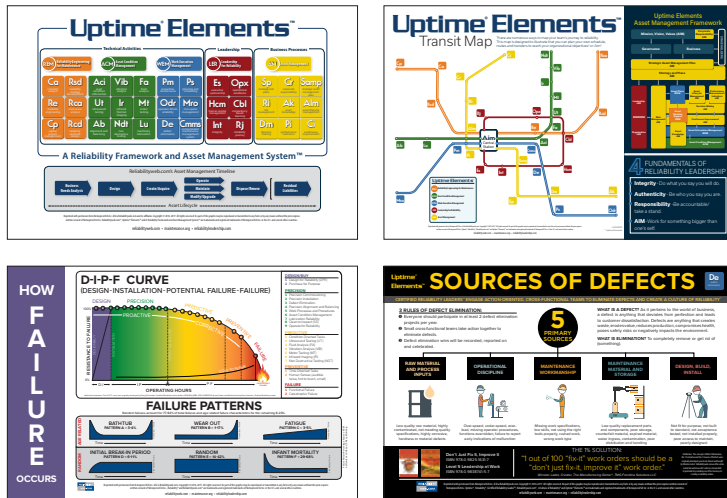
Uptime Elements Passport Series - Includes the Uptime Elements Chart.

Complete Body of Knowledge - Includes all four posters.

PDF Download: reliabilityweb.com/steal-these-graphics

Request flat posters: mrostore@mro-zone.com

To order a laminated set: reliabilityweb.com/bookstore

SUMMARY

Change is never easy. However, the team at Reliabilityweb.com feels these revisions increase the value and potential for those who choose the Uptime Elements as a strategy and road map.

We learn from you as you advance reliability and asset management in one big, virtuous circle. Keep working, learning, sharing and communicating so we can work together to discover and deliver approaches to enhance safety and success.

"At its simplest level, the Uptime Elements framework is a language that aligns stakeholders across the organization."

GETTING STARTED

There are many ways to get started on your journey with the Uptime Elements Reliability Framework and Asset Management System.

Self-Paced Study Methods

1 **Uptime Elements Body of Knowledge**

Read the Uptime Elements Body of Knowledge. Estimated time investment is 15-30 minutes per day for 60 days.
http://www.mro-zone.com

2 **Uptime Academy Online Learning Management System**

Self-paced study includes text and video lessons plus a short quiz for each element. Estimated time investment is 15-30 minutes per day for 60 days.
https://uptime.academy

Courses and Workshops

1 **Instructor-Led Training Public Courses**

The most comprehensive training is the four-day Uptime Elements Advanced Workshop held at the Reliability Leadership Institute five to six times per year.
Next Workshop May 15th-19th
www.reliabilityleadership.com

The Uptime Elements Advanced Workshops are also held at The RELIABILITY Conference and at IMC-2017 The 32nd International Maintenance Conference. The schedule is aligned to ensure students can attend the conference's general sessions, keynotes, social events and expo.
www.reliabilityconference.com
www.imc-2017.com

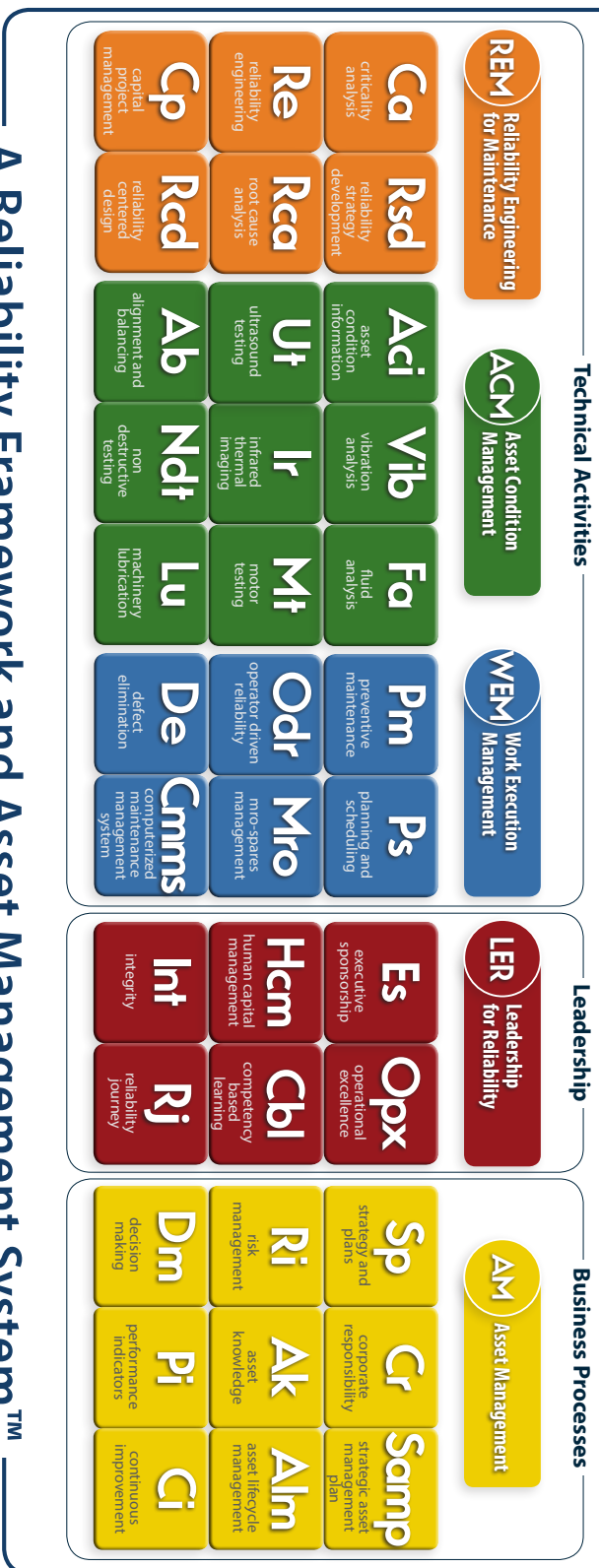**2** **Instructor-Led Training Private Courses**

Uptime Elements workshops are available at your site in a private setting optimized for your team and objectives. Call 239-333-2500 for details and pricing.
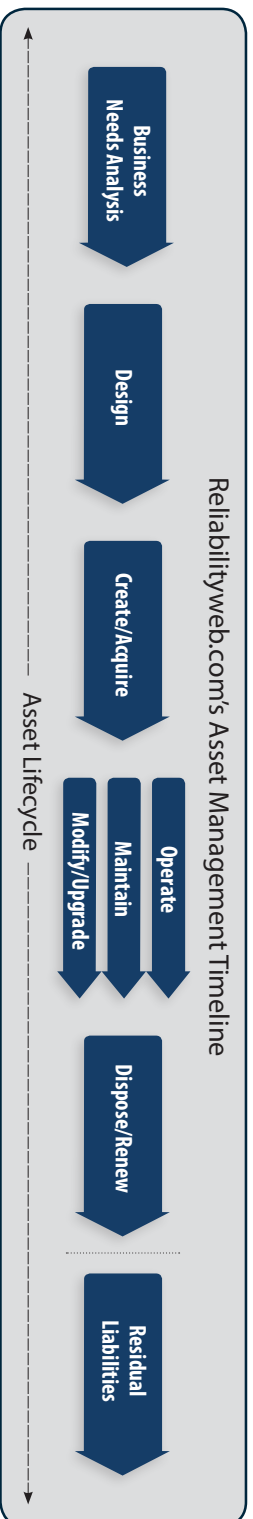
3 **Uptime Elements Awareness Workshop**

Reliabilityweb.com supports a number of one- to two-day Uptime Elements Awareness Workshops around the world. **www.maintenance.org**

Uptime Elements®™

A Reliability Framework and Asset Management System™

Technical Activities

REM — Reliability Engineering for Maintenance

Ca	Rsd	Re	Rca	Cp	Rcd
criticality analysis	reliability strategy development	reliability engineering	root cause analysis	capital project management	reliability centered design

ACM — Asset Condition Management

Aci	Vib	Ut	Ir	Ab	Ndt
asset condition information	vibration analysis	ultrasound testing	infrared thermal imaging	alignment and balancing	non destructive testing

Fa	Mt	Lu
fluid analysis	motor testing	machinery lubrication

WEM — Work Execution Management

Pm	Odr	De
preventive maintenance	operator driven reliability	defect elimination

Ps	Mro	Cmms
planning and scheduling	mro-spares management	computerized maintenance management system

Leadership

LER — Leadership for Reliability

Es	Hcm	Int
executive sponsorship	human capital management	integrity

Opx	Cbl	Rj
operational excellence	competency based learning	reliability journey

Business Processes

AM — Asset Management

Sp	Ri	Dm
strategy and plans	risk management	decision making

Cr	Ak	Pi
corporate responsibility	asset knowledge	performance indicators

Samp	Alm	Ci
strategic asset management plan	asset lifecycle management	continuous improvement

Reliabilityweb.com's Asset Management Timeline

Asset Lifecycle

- Business Needs Analysis
- Design
- Create/Acquire
- Operate
- Maintain
- Modify/Upgrade
- Dispose/Renew
- Residual Liabilities

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Uptime Elements™
Transit Map

Uptime Elements
Asset Management Framework

STAKEHOLDERS

Mission, Vision, Values (AIM)

Governance

Business

Corporate Responsibility AM

Strategic Asset Management Plan AM

Strategy and Plans AM

Performance Measurement/ Indicators AM

Decision Making AM

Asset Lifecycle Management AM

Continuous Improvement AM

Asset Information Management WEM

Asset Condition Management ACM

Asset Plans WEM

Asset Decision Support REM

Asset Knowledge AM

Risk Management AM

Leadership LER

Organization LER

FUNDAMENTALS OF RELIABILITY LEADERSHIP

Integrity - Do what you say you will do.

Authenticity - Be who you say you are.

Responsibility - Be accountable/ take a stand.

AIM - Work for something bigger than one's self.

There are numerous ways to map your team's journey to reliability. This map is designed to illustrate that you can plan your own schedule, routes and transfers to reach your organizational objectives[1] or Aim[2].

Aim Central Station

Rca, Rcd, Ak, Odr, Cbl, Hcm, Vib, Mt, Ut, Fa, Ndt, Ir, Dm, Ps, Opx, Re, Aci, De, Cmms, Scmp, Sp, Gi, Int, Rj, Es, Ri, Alm, Pi, Cr, Pm, Ca, Rsd, Lu, Cp, Ab, Mro

Uptime Elements
- REM Reliability Engineering for Maintenance
- ACM Asset Condition Management
- WEM Work Execution Management
- LER Leadership for Reliability
- AM Asset Management

[1] ISO55000
[2] Uptime Elements

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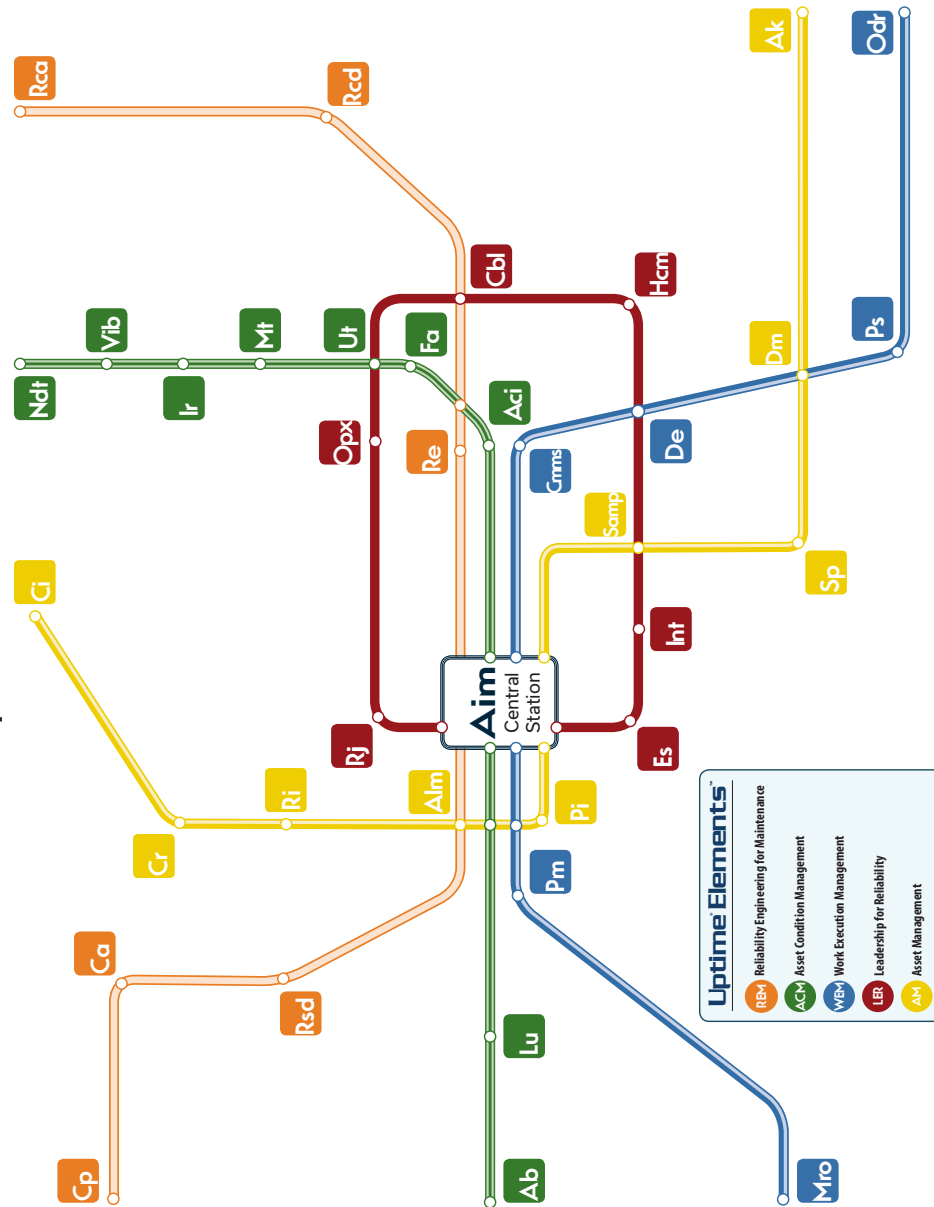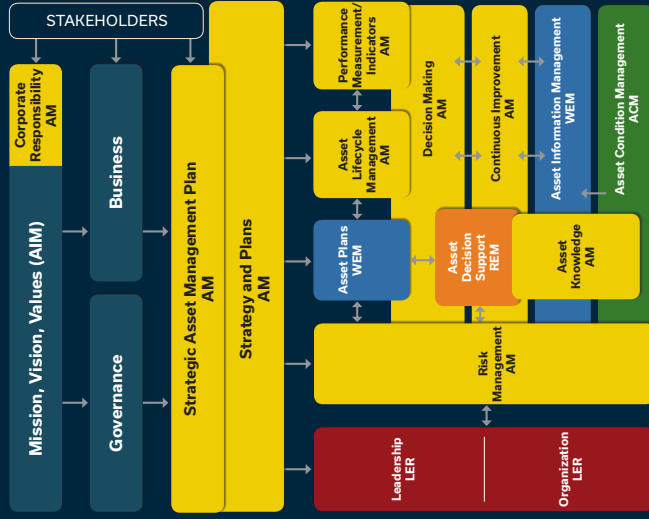**PDF Download:** reliabilityweb.com/steal-these-graphics

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Uptime Elements®™

SOURCES OF DEFECTS

CERTIFIED RELIABILITY LEADERS™ ENGAGE ACTION-ORIENTED, CROSS-FUNCTIONAL TEAMS TO ELIMINATE DEFECTS AND CREATE A CULTURE OF RELIABILITY®

De defect elimination

3 RULES OF DEFECT ELIMINATION:

❶ Everyone should participate in at least 2 defect elimination projects per year.

❷ Small cross-functional teams take action together to eliminate defects.

❸ Defect elimination wins will be recorded, reported on and celebrated.

WHAT IS A DEFECT? As it pertains to the world of business, a defect is anything that deviates from perfection and leads to customer dissatisfaction. Defects are anything that creates waste, erodes value, reduces production, compromises health, poses safety risks or negatively impacts the environment.
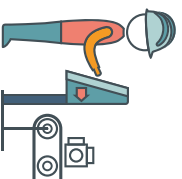
WHAT IS ELIMINATION? To completely remove or get rid of (something).

5 PRIMARY SOURCES

RAW MATERIAL AND PROCESS INPUTS

Low quality raw material, highly contaminated, not meeting quality specifications, highly corrosive, hardness or material defects
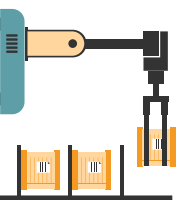
OPERATIONAL DISCIPLINE

Over-speed, under-speed, over-load, missing operator procedures, functions overridden, failure to report early indications of malfunction

MAINTENANCE WORKMANSHIP

Missing work specifications, low skills, not using the right tools properly, rushed work, wrong work type

MAINTENANCE MATERIAL AND STORAGE

Low quality replacement parts and components, poor storage, counterfeit material, expired material, water ingress, contamination, poor distribution and handling

DESIGN, BUILD, INSTALL

Not fit for purpose, not built to standard, not acceptance tested, not installed properly, poor access to maintain, poorly designed

THE 1% SOLUTION:

"1 out of 100 "fix-it" work orders should be a "don't just fix-it, improve it" work order."

Winston Ledet, Creator, The Manufacturing Game®, TMG Frontline Solutions LLC

HOW FAILURE OCCURS

D-I-P-F CURVE
(DESIGN - INSTALLATION - POTENTIAL FAILURE - FAILURE)

RESISTANCE TO FAILURE

100%

0%

DESIGN/BUY

DESIGN

PRECISION

PROACTIVE

INSTALLATION

POTENTIAL FAILURE

PREDICTIVE

CORRECTIVE

PREVENTIVE

FAILURE

CATASTROPHIC FAILURE

COST TO REPAIR

OPERATING HOURS

D-I

I-P

P-F

Attribution/Inspiration: The D-I-P-F curve was originally developed by Doug Plucknette, Certified Reliability Leader, Author, RCM Blitz (ISBN 978-0-98387416-4) and further modified/evolved by Brian Helnsius, Certified Reliability Leader

DESIGN/BUY
1 Design for Reliability (DFR)
2 Purchase for Purpose

PRECISION
1 Precision Commissioning
2 Precision Installation
3 Defect Elimination
4 Precision Alignment and Balancing
5 Work Processes and Procedures
6 Asset Condition Management
7 Lubrication Reliability
8 Clean to Inspect (5S)
9 Operate for Reliability

PREDICTIVE
1 Condition Directed Tasks
2 Ultrasound Testing (UT)
3 Fluid Analysis (FA)
4 Vibration Analysis (VIB)
5 Motor Testing (MT)
6 Infrared Imaging (IR)
7 Non Destructive Testing (NDT)

PREVENTIVE
1 Time-Directed Tasks
2 Human Senses (audible noise, hot to touch, smell)

FAILURE
1 Functional Failure
2 Catastrophic Failure

FAILURE PATTERNS

Random failures account for 77-92% of total failures and age related failure characteristics for the remaining 8-23%.

AGE RELATED

BATHTUB
PATTERN A = 3-4%
Probability of Failure
Time

WEAR OUT
PATTERN B = 1-17%
Probability of Failure
Time

FATIGUE
PATTERN C = 3-5%
Probability of Failure
Time

RANDOM

INITIAL BREAK-IN PERIOD
PATTERN D = 6-11%
Probability of Failure
Time

RANDOM
PATTERN E = 14-42%
Probability of Failure
Time

INFANT MORTALITY
PATTERN F = 29-68%
Probability of Failure
Time

Failure Pattern Percentage Sources: RCM by Nowlan and Heap, US Navy, Bromberg

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Complete Body of Knowledge - Includes all four posters.

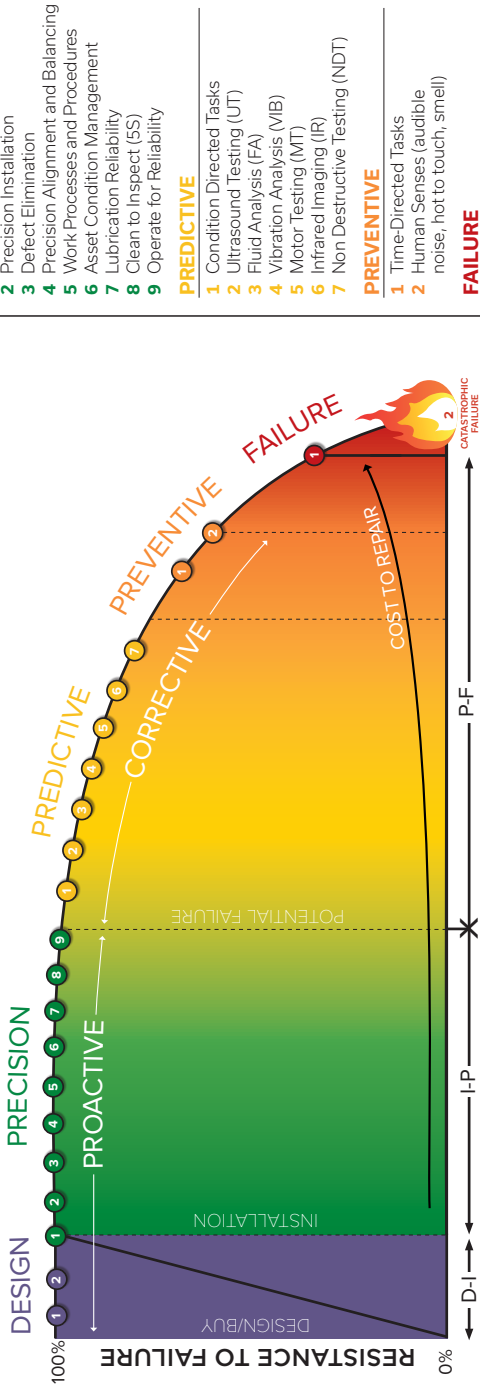**PDF Download:** reliabilityweb.com/steal-these-graphics

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PUSHING IIoT PREDICTIVE MAINTENANCE FORWARD:

TWO CHALLENGES TO OVERCOME

Amnon Shenfeld

There's no doubt the Internet of Things (IoT) is moving quickly to the front lines of industrial maintenance reliability and asset management. Communication between machines and human technicians, enabled by wireless technology and connected devices, is fueling a shift from preventative to predictive maintenance. But while the Industrial Internet of Things (IIoT) groundwork has been laid, and it's projected to be a $151 billion market by 2020, the revolution is still young.

Gartner's special report, "Hype Cycle for Emerging Technologies," points out that all new trends follow a similar growth pattern, and IIoT is no exception. While there's a lot of excitement about the potential to apply data-driven algorithms to large data streams from industrial assets, IIoT is heading into the trough of disillusionment. Two major challenges must be overcome to push IIoT predictive maintenance technologies up the slope of enlightenment and spark mainstream adoption and success.
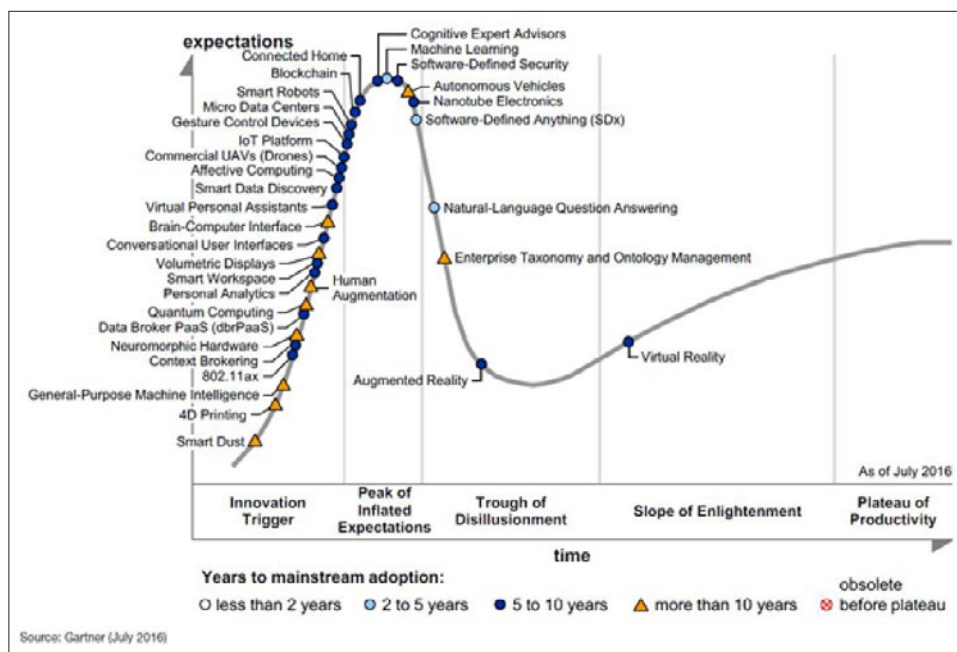

Figure 1: Hype cycle for emerging technologies

CHALLENGE 1:
Poor Data Quality

Big data went through its own hype cycle, but is now more firmly grounded in the realization that merely collecting large amounts of data is insufficient to achieve meaningful insights. For IIoT predictive maintenance, the data challenges are twofold. Firstly, it's difficult to obtain high quality, labeled data from industrial machines to begin with. Secondly, it's even more challenging to then apply that data to provide human engineers and technicians with relevant and actionable condition-based maintenance insights.

Gathering large volumes of raw, unlabeled data is relatively easy, but when attempting to build learning algorithms for IIoT predictive maintenance platforms, the algorithm is only as good as the quality of data labeling (i.e., assigning each piece of data a useful tag or label that makes it somehow informative and useful). Building databases of high quality, labeled data is a much more technologically challenging and time-consuming endeavor.

For example, industrial machine engineers and technicians have used vibration testing and analysis for condition-based maintenance for ages. Vibration sensors, meters and related technologies have evolved and are now more advanced and affordable than ever before. However, an ongoing challenge with collecting large volumes of vibration data over time is that the data alone often isn't enough to achieve deeper insights beyond the trivial, "it's vibrating too much, I don't know why without visiting this machine." (Could be a loose part, a worn part, or something not aligned correctly.)

CHALLENGE 2:
Fragmented Technologies and Human Operations

Because industrial maintenance software platforms, sensors and operations are currently highly fragmented, it's a challenge to fuse sensor data (e.g., signals based on vibration, temperature, power consumption, etc.) with actual events or maintenance activities that humans carry out on machines.

Many existing condition-based maintenance solutions, such as vibration analysis via a handheld device, require sampling and diagnostics by human technicians going from machine to machine. These contact-based methods can fall victim to producing biased, one-sided results depending on the location of the sensor and the experience of the technician, and aren't constantly monitoring and sending alerts in real time. Other non-handheld sensors with "smart" monitoring capabilities require complex integrations, training and retrofitting of old industrial assets.

IIoT is helping to change this, but so far in the hype phase, IIoT predictive maintenance solutions have mainly consisted of software to analyze data collected from sensors designed and manufactured by third parties. In many cases, users and implementers of such software solutions don't control the sensors or the data origins. Therefore, they are very exposed to garbage in, garbage out scenarios where false-positive alerts rule and maintenance teams eventually ignore valuable alerts as they are trained to distrust the outputs of

such systems. Industrial machine data will only be as good as its worst sensor and it's impossible to identify which sensors are good and which are bad if they are not properly controlled, installed, or built in tandem with the software that's processing the data inputs.

Reliability monitoring software also needs to be highly reliable. The challenge is to bridge the gap between human maintenance engineers, sensors and enterprise resource planning and monitoring software, especially when working within harsh industrial/manufacturing environments, such as steel plants or oil rigs, or with equipment spread across remote locations, such as energy generating turbines.

> " The **challenge is to bridge the gap** between human maintenance engineers, sensors and enterprise resource planning and monitoring software "

Additionally, airborne acoustics will help address the first challenge. Allowing a human to hear how a machine sounded at a specific moment in time will make it easier to label the data and speed up the herculean task of building high quality, labeled databases. This is analogous to how the CAPTCHA™ program works. Anyone who has ever bought concert or sports tickets online knows what CAPTCHA™ is. It's that form during checkout where you're asked to type some displayed words in order to verify you're human and prevent spam and abuse by automated bots. It works because humans can read text like the ones in Figure 2, while computer programs currently cannot.

What you probably don't know is that all the human input that goes into verifying all these words is, at the same time, being used to help digitize or translate books, newspapers and other texts that are too illegible to be scanned by computers. In both cases, leveraging human input helps facilitate ordinarily massive and laborious projects.

SOLUTIONS

Much of the data quality challenges will be addressed by new, deep learning algorithms that mimic the learning faculties of the human brain and can be used to build more accurate predictive models. These deep learning models will be able to apply insights from previously labeled data to new, unlabeled data so both predictive and prescriptive analyses will become even more accurate over time. It's only with optimal predictive models that any array of connected hardware devices can provide maximum return on investment (ROI) and benefit for decreasing human errors, reducing downtime and increasing average production.

To overcome the challenge of fragmented technologies and operations, maintenance engineers and technicians will need to start relying on classic signal outputs, such as vibration, temperature, power consumption, etc., as well as new smart sensors, such as deep learning, powered, airborne acoustics. Such sensor inputs will increasingly play a larger role in IIoT predictive maintenance. Engineers and technicians have, of course, always diagnosed machine problems simply by listening to them. However, humans can't be physically next to every machine at all times during operation and also have a hard time filtering out other noise interference present in harsh industrial environments.

While vibrations are technically a form of acoustics, airborne acoustic monitoring allows maintenance engineers and technicians to listen to equipment and tap into the intuitive human capacity of sound-based diagnosis (looking at a vibration readout graph doesn't trigger the same intuition regarding the machine's actual problem). It also represents sensor fusion, as a machine working under different loads in different conditions will sound differently. Using signals like acoustics, which are intuitively meaningful to maintenance experts, will be a big step in bridging the gap, with a symbiotic relationship between the IIoT hardware, software and humans.

> " As industrial manufacturing and production become more automated, there will be an increased need in the future for predictive maintenance technology "

THE FUTURE

Today, there's a rising global demand for industrial automation systems as companies work to optimize operational efficiencies. As industrial manufacturing and production become more automated, there will be an increased need in the future for predictive maintenance technology – both hardware and software – that helps keep equipment running at optimal performance and identifies problems in real time before machine failure interrupts production and causes costly unplanned downtime and replacement of damaged parts.

IIoT and deep learning will play a big role in the advancement of predictive analytics and overcoming these two major challenges of data quality and the gap between humans and machines. IIoT and deep learning also will be critical to help get passed the upcoming phase of disillusionment and create more mainstream adoption of IIoT predictive maintenance solutions.

Figure 2: Example of a CAPTCHA™ program

Amnon Shenfeld is founder and CEO of 3DSignals, a company developing a disruptive predictive maintenance IoT system that uses deep learning algorithms to analyze the airborne sounds of machines and predict malfunctions. Before 3DSignals, Amnon was the VP R&D of a computer vision company, Eyesight Technologies, and prior to that, held several R&D roles for global corporations and research laboratories. *www.3dsig.com*

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MOTOR REPAIR DECISIONS

Jeff Guy

Figure 1: SGL 5 stator after reconditioning

The Central Arizona Project (CAP) operates and maintains 109 motor/pump units in 15 pumping plants scattered across 336 miles of aqueduct. These units are indispensable to CAP's mission of delivering Colorado River water to the people and farms of central Arizona.

CAP motors vary in size from 700 hp to 60,000 hp. Most were installed in the early- to mid-1980s and 25 percent of them have not been overhauled for at least 20 years. Given their criticality and age, CAP maintains an active motor condition monitoring program, including power factor tests, online partial discharge measurements and motor circuit evaluations.

One of CAP's motors, a 5,200 hp Salt-Gila Unit 5 (SGL 5) synchronous motor manufactured in 1984, had some very high power factor results and increasing partial discharge activity. Because these tests are indicative of stator winding insulation deterioration, CAP scheduled a service outage for SGL 5 to evaluate and address the situation.

In December 2015, the SGL 5 was disassembled and shipped to an outside motor shop to perform a complete electrical evaluation. Just before Christmas, the shop recommended that CAP rewind the SGL 5 stator at a cost of around $225,000.

This posed a problem for CAP management because its board of directors had just approved the 2016 budget, which did not include funds for a rewind. Based on past practices after similar test results, the CAP maintenance staff had budgeted only $30,000 for SGL 5, the projected cost of reconditioning the stator.

So, management was faced with a tough decision: go back to the board of directors and ask for more money before the new budget period had even begun, or proceed with reconditioning as budgeted even though the outside contractor recommended rewinding? To assist in that decision, management posed these questions to its operations and maintenance personnel:

- If CAP reconditioned SGL 5, rather than rewinding, and the unit were to fail as CAP entered its peak summer pumping season, would we still be able to make all scheduled customer deliveries?
- How do the latest test readings on SGL 5 compare to past readings on that unit and to other similar units across the CAP system?

Operations responded that CAP could still meet its scheduled deliveries even if it were to lose SGL 5 in the summer of 2016. That gave management some flexibility in deciding what to do with the unit.

Interestingly, the second question posed more of a challenge. Although CAP had been collecting motor test data for at least a decade, there was no easy way to compare that data across units and time. But CAP's reliability engineers responded by compiling all motor test results into a central database and developing a system for ranking the condition of all 109 motors. The data and ranking system showed that SGL 5 was in better condition than was previously thought. Although some power factor measurements were very poor, they did not necessarily indicate the need to rewind the stator. The partial discharge measurements were also less concerning, as the ranking system indicated the condition was only moderately deteriorated. Also, the partial discharge test results were significantly higher for all 10 of CAP's motors

> CAP's reliability engineers responded by compiling all motor test results into a central database and developing a system for ranking the condition of all 109 motors.

Figure 2: SGL 5 rotor
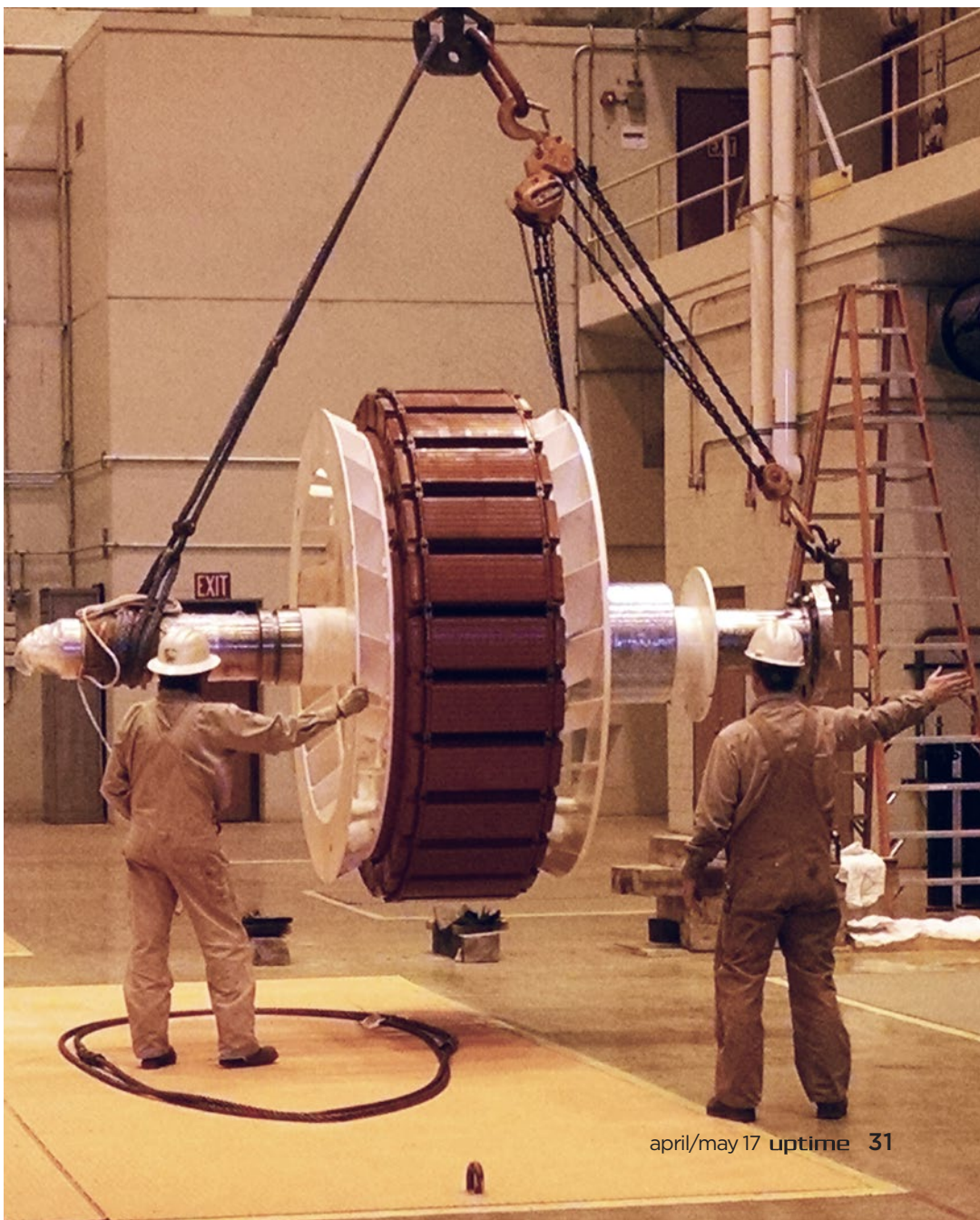
compared to its other motors, leading management to conclude that the ranking method may need to be adjusted for that group.

With this information in hand, management made the decision to proceed with reconditioning SGL 5 as originally planned and budgeted, but directed the maintenance staff to test and monitor the unit after the repairs were completed to evaluate their effectiveness. In this way, CAP would use SGL 5 as a test bed to inform future decisions for the rest of its aging motor fleet. If the reconditioning was successful, CAP might be able to prolong the useful life of other motors at a relatively low cost; if not, then CAP would need to begin budgeting for more costly rewinds in the near future.

So how did the reconditioning of SGL 5 turn out? The power factor readings showed dramatic improvement over 2015 levels after the unit was reconditioned. Partial discharge is being trended before reaching a definitive conclusion.

In Figures 3-5, the background color gradations approximate the rating criteria developed based on the engineering database, with green indicating "like new," blue "aged," yellow "degraded" and red "failing." The "failing" ranking means that CAP believes it has reached the "P" point in the P-F interval.

Two different power factor measurements are performed on each stator winding, a grounded specimen test (GST) and an ungrounded specimen test (UST). The GST power factor assesses the insulation between the winding and ground (i.e., the core). This is the majority of the insulation in the motor and a failure would likely require major repair or a complete rewind. The UST power factor assesses the insulation between phases, which is primarily the end winding. The GST power factor is the best indicator of overall insulation condition. For SGL 5, the GST readings were good even before reconditioning. Following repair, the GST reading was about one percent, better than it had been in a decade.

The UST power factor trend for SGL 5 was considerably worse than the GST results and had been high for the last five years. These are the results that really drove the decision to recondition the motor.

The latest power factor measurements after reconditioning were better than they were 10 years ago. A few were actually slightly negative, which is not unusual and is caused by the semi-conductive paint used to minimize the voltage stress at the point where the coil exits the core slot.

Partial discharge is a measure of electrical discharges in the stator winding, indicating voids in the insulation. The manufacturer of the test
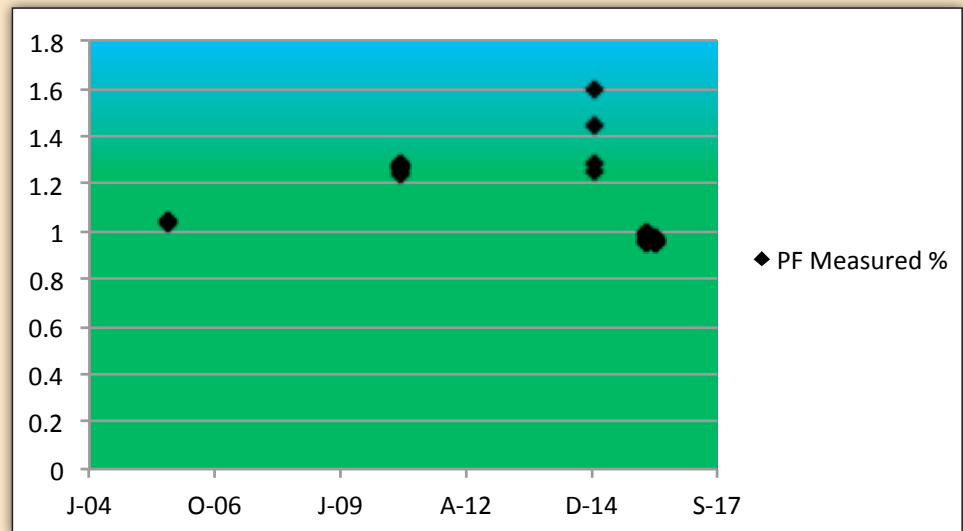

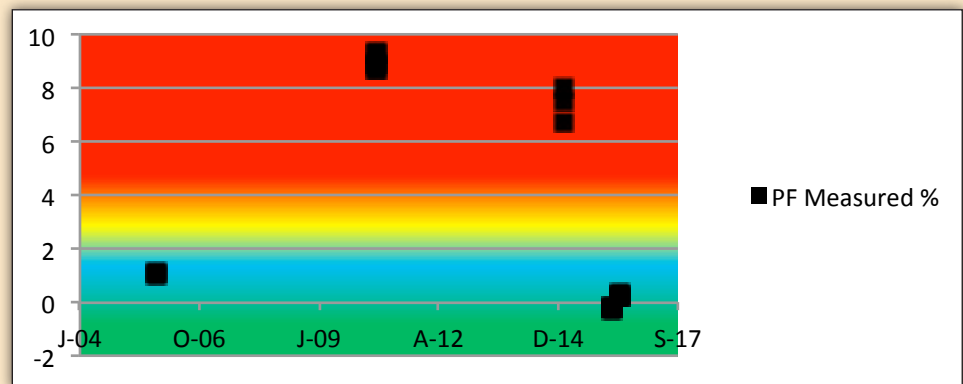**Figure 3:** Salt-Gila Unit 5 GST power factor
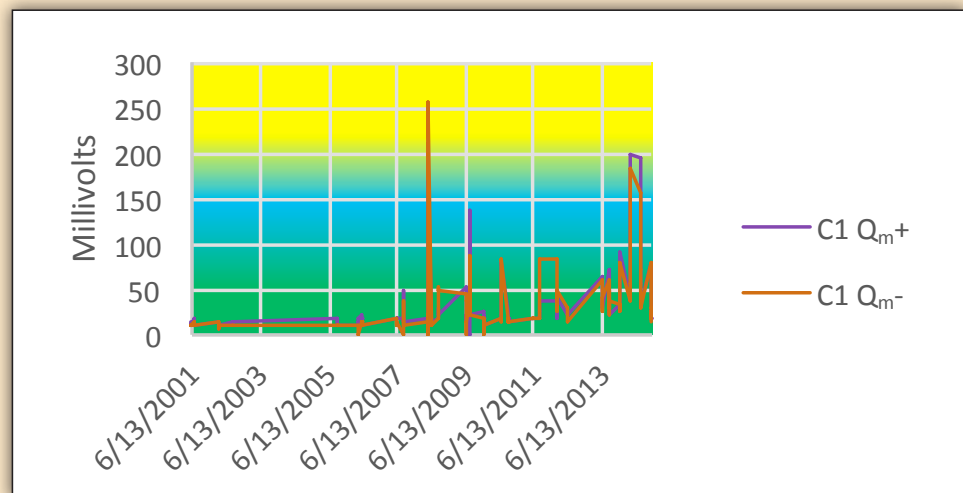

Figure 4: Salt-Gila Unit 5 UST power factor

Figure 5: Salt-Gila Unit 5 partial discharge Q_m trend

> ## « The intent is to understand what the problems are and develop and execute an appropriate plan to correct those problems. »

equipment CAP uses, recommends using the Q_m value as the first criterion for evaluating the insulation condition. Q_m refers to the highest magnitude discharges that occur with a frequency of at least 10 per second. The blue/yellow boundary is where at least 75 percent of all similar voltage motors in the manufacturer's database have Q_m readings below that value. The trend is slowly increasing and has a few flier points, but overall the condition is good.

The reason for measuring power factor and partial discharge on motors is to gain information on the condition of the insulation. When the measurements indicate problems are developing, the intent is to understand what the problems are and develop and execute an appropriate plan to correct those problems.

In this case, CAP had clear indications of a developing problem with SGL 5. Alternatives were evaluated, taking into account operational risk, and a plan was developed and executed. So far, measurements taken after the work was completed show that it was highly successful in mitigating the problem.

CAP is continuing to monitor the unit with semiannual testing to validate the results.

Jeff Guy has worked as an electrical engineer at Central Arizona Project (CAP) for over 30 years. Jeff has been a reliability engineer since the group was formed in 2013. Prior to that, he was a maintenance engineer.
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ANALYZING
REPAIRABLE SYSTEM FAILURES DATA

Ziad Ali Al-Zahrani

Many reliability engineers throughout history have had concerns with the reliability of the repairable system. Several researchers have presented a few calculation or estimation techniques to achieve repairable system reliability. This article explains the mean cumulative function (MCF) as a powerful and easy technique to estimate and monitor repairable system reliability.
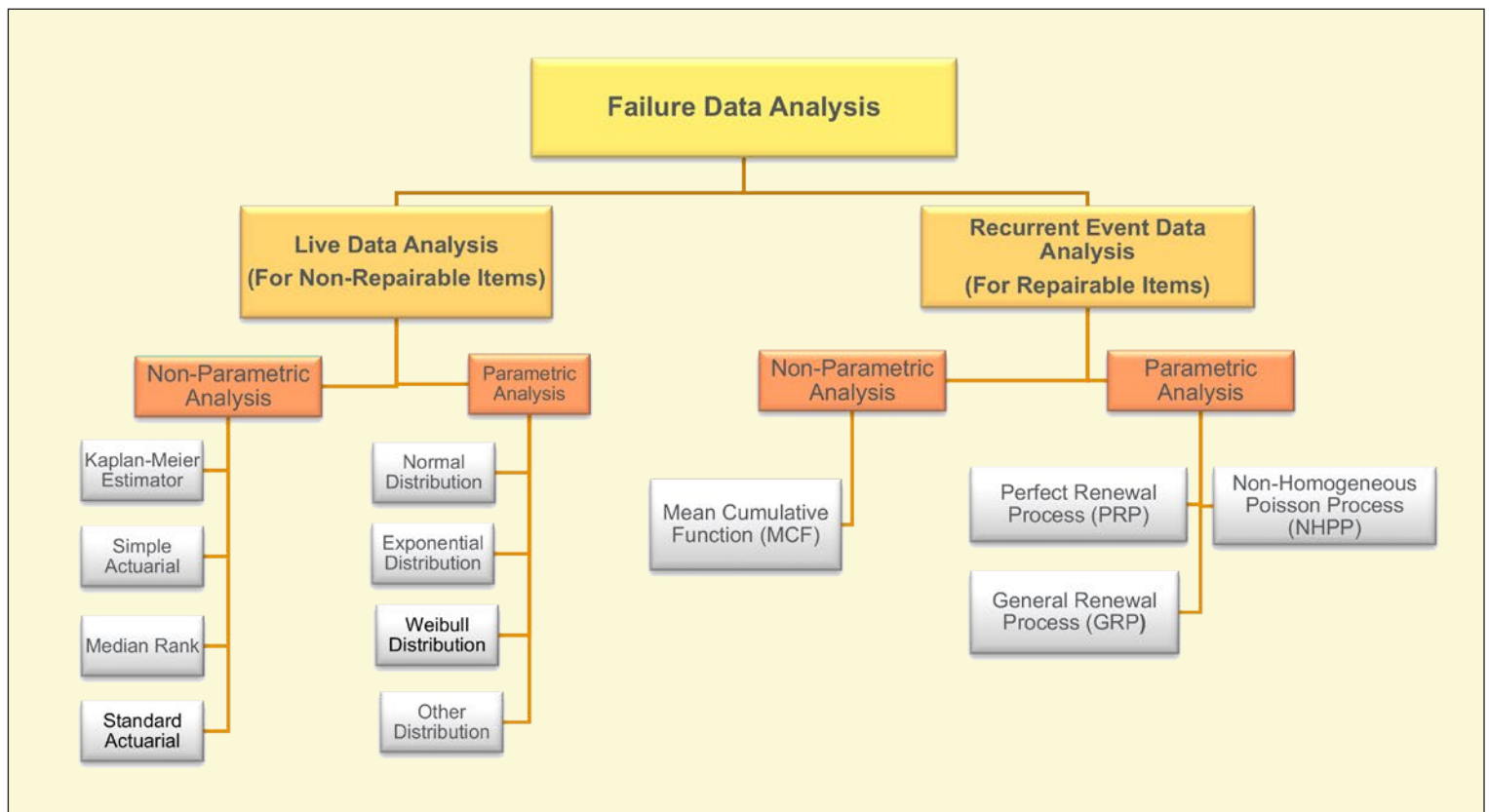

Figure1: Commonly used techniques for reliability measurements

When assessing reliability, it is important to make the distinction between non-repairable components and repairable systems. Figure 1 summarizes the commonly used techniques for reliability measurements for both repairable systems and non-repairable items.

Parametric methods require a high degree of statistical knowledge and the ability to solve complex equations and verify distributional assumptions. These equations cannot be solved analytically and require an iterative procedure or special software. Parametric approaches are computationally intensive and not intuitive to the average person. Special solution techniques are required, along with the ability to justify distributional assumptions, which is rarely done.

Mean Cumulative Function

Given a set of failure times for a repairable system, the simplest graph that can be constructed is a cumulative plot. This plots the number of failures versus the age of the system. A cumulative plot can be constructed for all failures, outages, system failures due to specific failure modes, etc. Likewise, a cumulative plot can be constructed for just one machine, all machines, or for a group of machines in a population. The average of several cumulative plots is called mean cumulative function.

Recurrence Rate vs Age

Since the MCF is the cumulative average number of failures versus time, one can take the slope of the MCF curve to obtain a rate of occurrence of events as a function of time. This slope is called the recurrence rate to avoid confusion with terms like failure rate.

The recurrence rate can be calculated by a simple numerical differentiation procedure that estimates the slope of the curve numerically. This can be easily implemented in a spreadsheet using the slope (Y1:Yn; X1:Xn) function, where MCF is the Y axis and time is the X axis. One can take five or seven adjacent points and calculate the slope of that section of the curve by a simple ruler method and plot the slope value at the midpoint. The rate tends to amplify sharp changes in curvature in the MCF. If the MCF rises quickly, it can be seen by a sharp spike in the recurrence rate. Similarly, if the MCF is linear, the recurrence rate is a flat line. When the recurrence rate is a constant, the data follows a homogeneous Poisson process (HPP), allowing for the use of metrics, such as mean time between failures (MTBF), to describe the reliability of the population.

MCF Extensions

All parametric methods apply primarily to "counts" data. That is, they provide an estimate of the expected number of events as they are generalizations of counting processes. However, the MCF is far more flexible than just counts data. It can be used in availability analysis by accumulating average downtime instead of just average number of outage events. MCFs can be used to track service cost per machine in the form of mean cumulative cost function. They also can be used to track any continuous cumulative history in addition to counts, such as energy output from plants, amount of radiation dosage in astronauts, etc.

Example:

Consider a plant's failures cost data due to different causes. A, B and C are available and remain so for a period of one year, as depicted in Table 1.

A cumulative failures cost plot can be constructed based on the data available in Table 1. Figure 2 shows the overall cumulative failures cost, as

Table 1: Assumption of Plant Production Loss Cost Data Due to Different Causes A, B and C

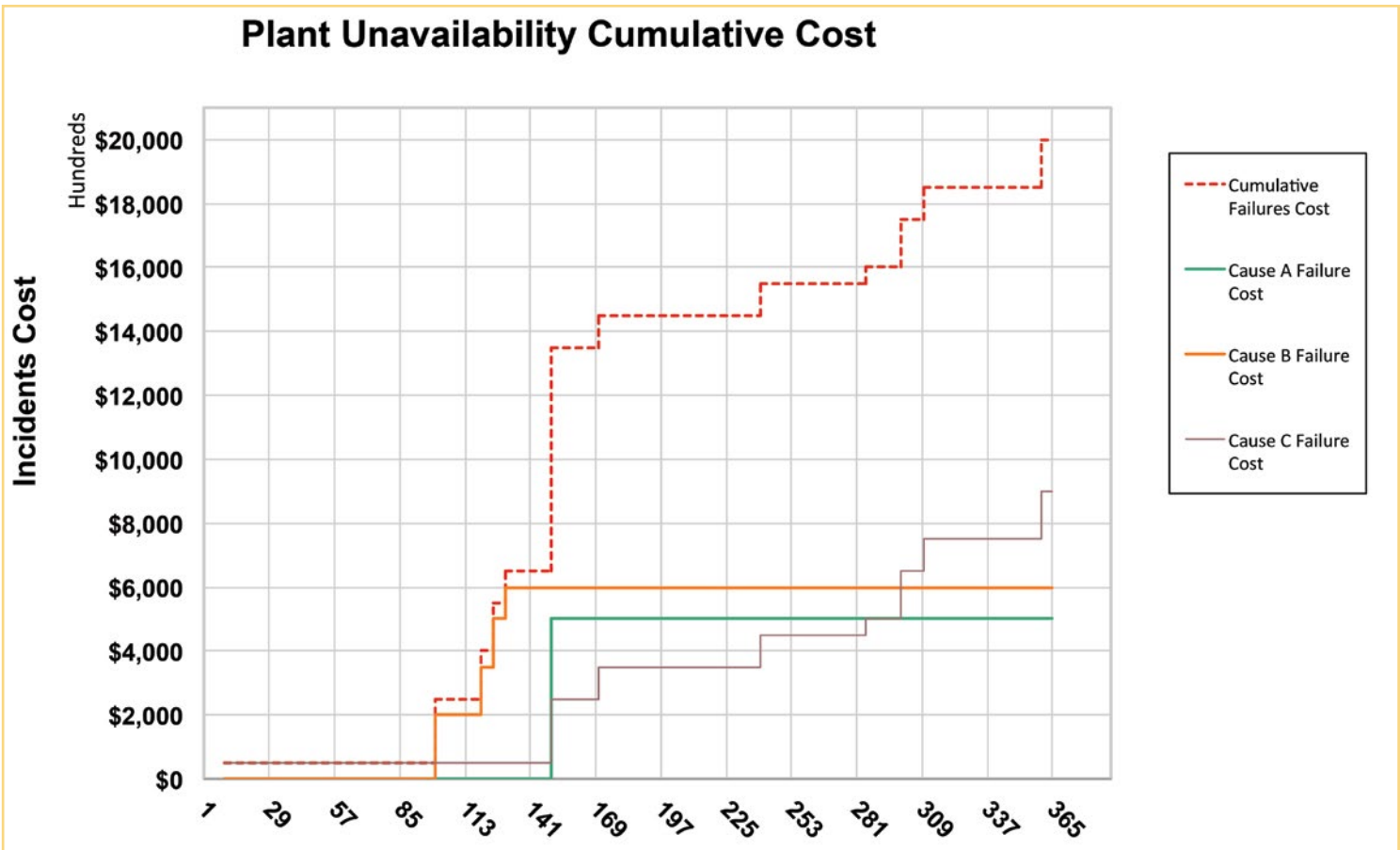| Day	Cumulative No. of Failures	Cumulative Failures Cost	Cause A Failure Cost	Cause B Failure Cost	Cause C Failure Cost
10	1	50,000	0	0	50,000
100	2	50,000	0	0	50,000
120	3	250,000	0	200,000	50,000
125	4	400,000	0	350,000	50,000
130	5	550,000	0	500,000	50,000
150	6	650,000	0	600,000	50,000
170	7	1,350,000	500,000	600,000	250,000
240	8	1,450,000	500,000	600,000	350,000
285	9	1,550,000	500,000	600,000	450,000
300	10	1,600,000	500,000	600,000	500,000
310	11	1,750,000	500,000	600,000	650,000
360	12	1,850,000	500,000	600,000	750,000

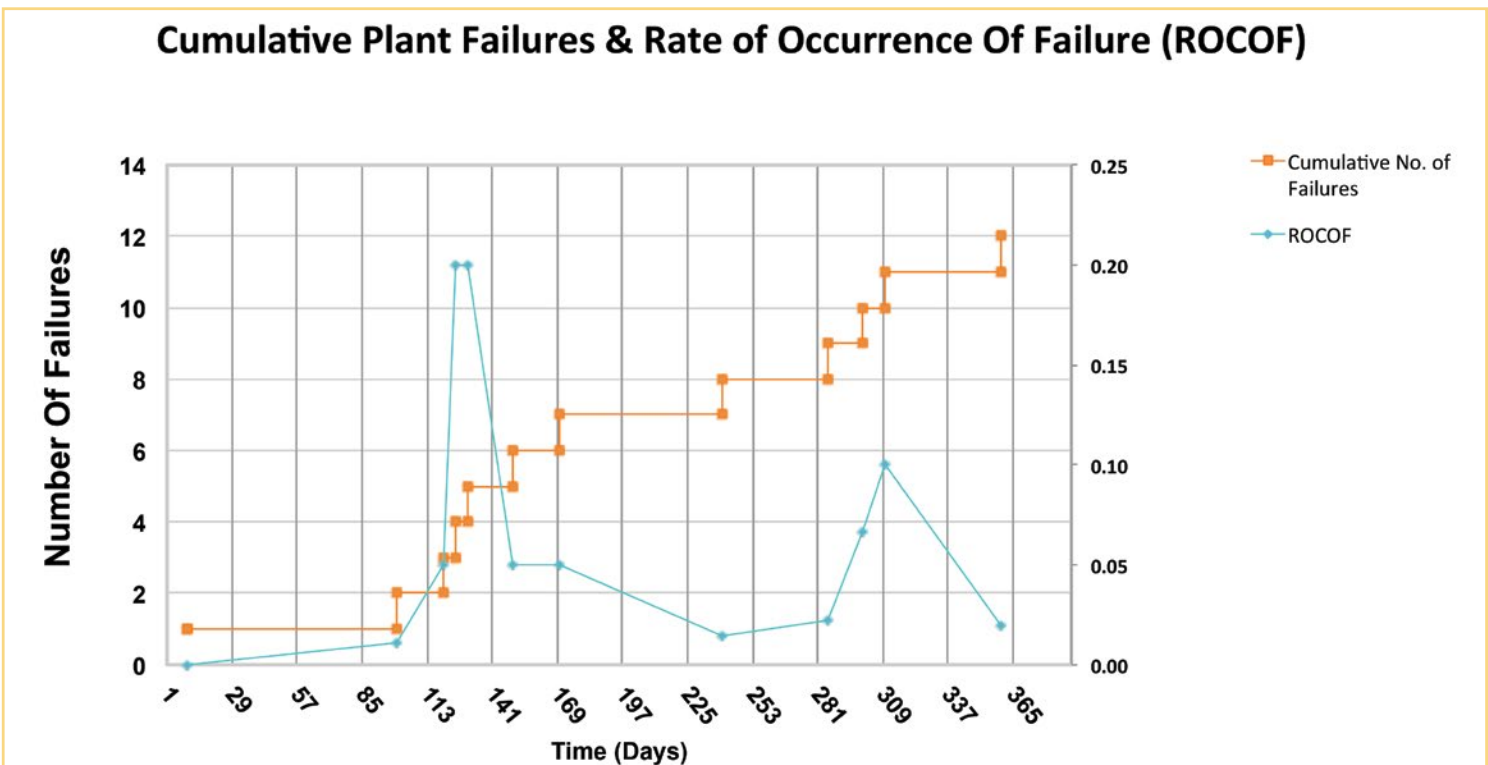**Figure 2:** Plant A failure causes cumulative cost plot

Figure 3: Plant A cumulative plant failures and rate of occurrence of failure (ROCOF)
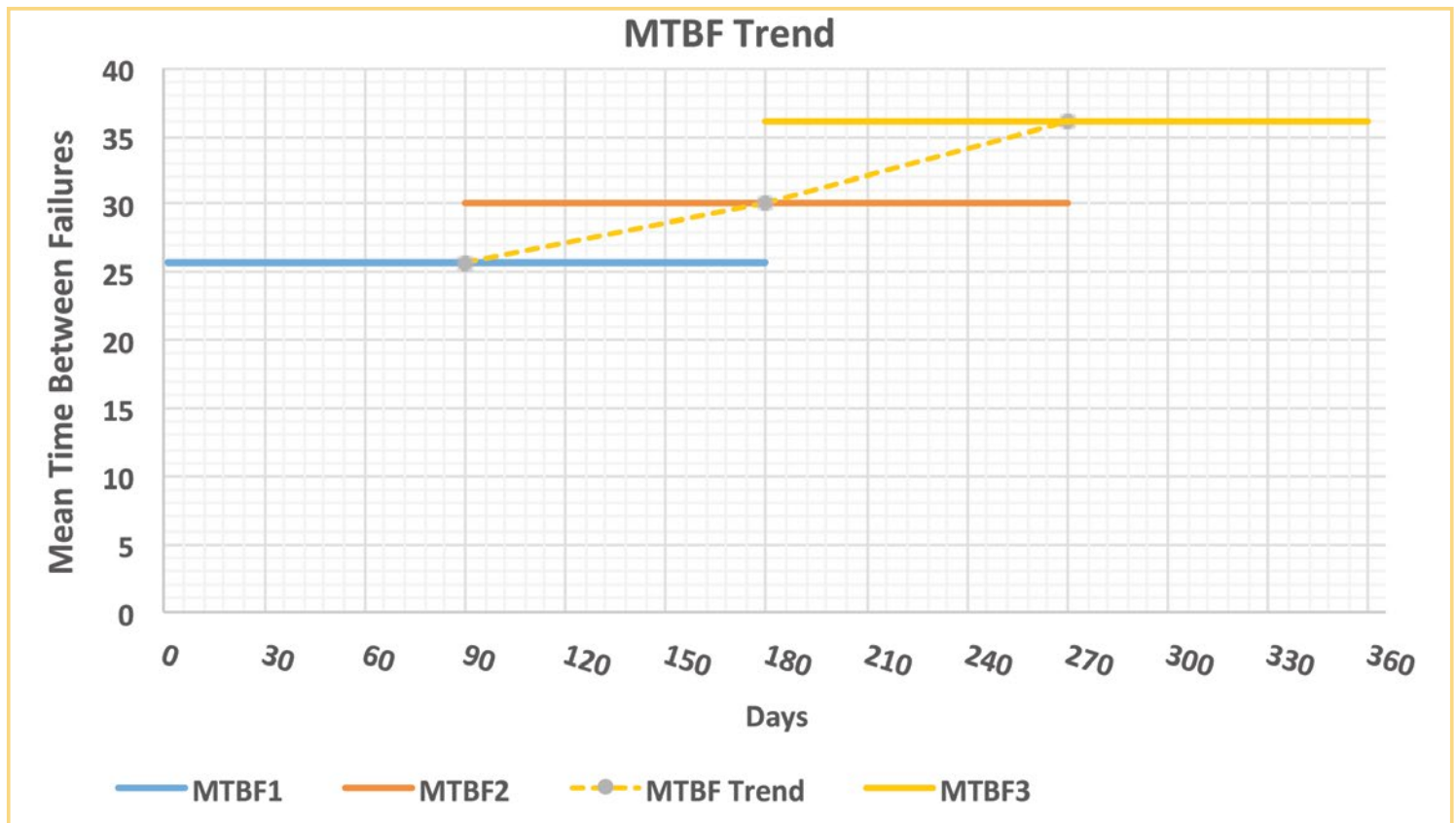
Figure 4: A 180 day time span MTBF trend with a 60 day shift

well as each cause contribution in the cost. Figure 3 shows the cumulative failures and rate of occurrence of failure (ROCOF). It is important to observe these two observations from Figures 2 and 3:

1. The cumulative cost plot in Figure 2 shows the failures cost spiked on day number 141 due to one failure related to Cause A, which did not add any failures cost after that. Cause B added failures cost in the period from day number 90 to 120 and stopped adding any cost thereafter. Cause C, on the other hand, started adding failures cost after day number 140 and kept adding cost thereafter periodically.

   It can be concluded that Cause A was a major cost failure and shall be investigated to prevent the recurrence. However, it did not happen again throughout the year, which may mean that Cause A was resolved already. Cause B stopped adding any failure cost and seems to be stable, so there's no need to worry about it. But, Cause C is still bleeding and keeps adding failure costs, which need to be investigated and stopped.

2. The cumulative failures plot in Figure 3 rises quickly in the period from 100 days to 150 days, which can be seen by a sharp spike in the recurrence rate (ROCOF) plotted in the same figure. This means system reliability degraded quickly in that period and needs to be investigated. After that, system reliability improves in the period from 150 days to 240 days, which is reflected by a decreasing ROCOF. System reliability degraded again from 240 days to 310 days and finally improved thereafter. Figure 3 gives a clear, instant trend of system reliability.

By using Figure 2, one can direct the focus and efforts to the area where more cost impact is coming from, while using Figure 3 will give a clear instant trend of system reliability.

The two observations may not be obtained using other analysis techniques. For example, growth analysis will indicate only the final status of sys-

tem reliability as improving, but will not show the previous reliability changes. Another example is trending the periodic MTBF (Figure 4), showing a trending up system with no indication of system reliability degrading periods. A production Weibull plot will estimate the process reliability and estimate the cost of unreliability, but will not show the system reliability trend, nor each cause failure cost.

CONCLUSION

The analysis of repairable systems does not have to be difficult. A simple graphical technique can provide excellent estimates of the expected number of failures without resorting to solving complex equations or justifying distributional assumption.

The demonstrated example shows the advantages of using MCF and ROCOF over other methodologies to monitor production line reliability. Advantages include, but are not limited to, simplicity, timely reflecting actual system relatability and flexibility because their extensions can be constructed versus downtime, cost, etc. These advantages are not offered by other analysis methods.

REFERENCES

1. Trindade, David and Nathan, Swami. "Statistical Analysis of Field Data for Repairable Systems." http://www.trindade.com/2006RM-035_draft.pdf

Ziad Ali Al-Zahrani, *CMRP, is a Senior Reliability Improvement Engineer and is trained by Meridium for advanced reliability analytics. His nearly 10 years of experience covers engineering design, procurement, construction, and operating and maintenance of electrical power systems in petrochemical plants. He has a strong background in reliability improvement methodologies and measurements techniques.*

Scott Keough

Be a Better Buyer with

Closed Loop MRO Purchasing

You can tell a lot about a maintenance organization by observing how it purchases and consumes repair parts. Reactive organizations only seem to have time to "keep it running." They don't have time to shop for the best deals. Instead, they send the same noncompetitive purchase orders to the same vendors and take whatever pricing they get. And their receiving dock looks like a major courier service depot – full of emergency shipments. Cycle counts are mysteriously high because received parts aren't always checked into inventory. Or, cycle counts are mysteriously low because parts are not always checked out of inventory and/or are lost to theft.

Many of these organizations have solid maintenance, repair and operations (MRO) policies that dictate that they:

• Pre-negotiate prices for high volume parts;
• Obtain multiple quotes for high priced parts;
• Check inventory levels frequently to avoid both outages and overstocking;
• Check parts into and out of inventory to guard against shrinkage.

The policies include workflows showing smooth information handoffs between the maintenance, purchasing and accounts payable departments. It all works well on paper, but reality is far messier and more difficult.

These organizations may have a solid computerized maintenance management system (CMMS) or enterprise asset management (EAM) system. But these systems often don't close the loop on MRO purchases. Many CMMS/EAM users are forced to use manual purchasing processes to overcome this shortcoming.

If this describes your organization, welcome to the majority – the majority with a suboptimal MRO purchasing process and a system that doesn't support closed loop MRO purchasing.

What Is Closed Loop MRO Purchasing?

A closed loop MRO purchasing system automatically checks the CMMS/EAM at least daily to determine which parts are below their reorder point. When parts are found, the system automatically alerts the purchasing team that they need to make a purchase. When an order for the items is placed, the system automatically updates the quantity on order information in the CMMS/EAM. And when the parts are received, the system automatically decrements the quantity on order and increments the quantity on hand. This is all done automatically without the maintenance staff having to log into their CMMS/EAM to run reports or manually update information.

A closed loop MRO purchasing system automatically **checks the CMMS/EAM at least daily** to determine which parts are below their reorder point.

Closed loop MRO purchasing leads to multiple benefits:

• Fewer parts outages that result in higher uptime and more reliable assets and equipment;
• Fewer emergency shipments, resulting in lower shipping costs;
• Lower inventory levels, resulting in both lower depreciation expense and working capital utilization;
• Lower purchase prices, resulting in a lower overall maintenance spend;
• Lots of time saved and more accurate inventory information through the elimination of tedious, manual work.

It all sounds good. Who wouldn't want that? But how do you get there? You need two key components: a CMMS/EAM system and a procurement management system. If you are reading this article, you probably already have a CMMS/EAM. What you need is a procurement management system with several key features to enable closed loop MRO purchasing and make the most of it.

Integration Capability

Integration capability is the single most important feature. Your procurement management system must be able to integrate easily with your CMMS/EAM. The systems must be able to work together to realize the benefits described in the previous section. Look for a procurement management system that has a well-defined application programming interface (API). Ideally, it should be a web service API so communication with your CMMS/EAM can be in real time. This enables better parts inventory management and ensures timely and accurate inventory updates. Why should you care about this? How often do you have to overnight a part to ensure continued operations because you didn't have it on hand? Did you pay a premium for the part? Was the shipping expensive?

Without closed loop MRO purchasing, it's easy to blow through reorder points. People get busy. They check inventory levels too infrequently. Required pur-

chases languish and go unordered. To address this, reorder points may be set higher than they should be, or staff members maintain their own personal parts stashes just in case. This excess inventory drives up parts expense, sucks up more working capital and increases depreciation expense.

Has anyone in your organization ever cut a purchase order, but failed to update the CMMS/EAM quantity on order information? Then, another team member sees that the part is below the reorder point but has not been ordered yet. So that person places another order.

Has anyone in your organization ever received a shipment and decided to update the inventory in the CMMS/EAM later, only to forget to do so? Or, is it just too much of a hassle to update the inventory information so staff members don't bother doing so?

Whatever the reasons, when purchasing doesn't integrate with your CMMS/EAM, it is significantly more difficult to manage your parts inventory.

Look for a procurement management system that has integration capability that allows it to:

• Automatically check inventory multiple times a day;
• Automatically notify the purchasing team when you need to reorder parts;
• Automatically update the quantity on order and quantity on hand information.

While integration capability is the most important feature of a procurement management system, it is not the only critical one. You'll want several other capabilities in your procurement management system.

Proactive Pricing Analytics

The best procurement management systems enable you to get the best price for expensive, low volume items, high volume commodity items and everything in between. You probably have some parts that you can get from only one supplier. In that case, you are a price taker, with little to no negotiating leverage. But, the majority of your parts can be sourced from many different suppliers. Your procurement management system should help you keep these suppliers competitive by checking prices on every part in every quote for every order.

Look for a procurement management system that automatically compares the price you receive today to the price you paid in the past for the same or equivalent parts. Are prices going up? By how much? Can your supplier do anything about price increases or is it out of the supplier's control? Look for a procurement management system that puts historical pricing information all in one place and enables you to establish price thresholds with automatic alerts to help you identify savings opportunities.

One key point: You should not have to run reports to get this information and then manually compare historical prices to the quotes you receive. Do you have time to do this? No, you don't and you should not have to track down the pric-

ing information. The information should find you when you need it.

Being able to compare the prices on a single quote to previous prices paid is great. But, you need more than that.

Intuitive Quote Comparison

If you want to get the best prices, you have to shop around to find the best deals. That sounds great in theory, but have you ever tried to compare quotes from multiple vendors for a single purchase? It's a hassle.

Do you print all the quotes out and do the thrilling stare and compare, hoping to catch any errors in the quotes? Did they quote open bearings when you asked for sealed ones? Did they quote one item when you asked for seven? Did they quote free on board (FOB) origin when you asked for FOB destination? Did they include taxes and shipping? Because you know they'll include those on the invoice, even if they weren't on the quote.

Or, do you custom build a spreadsheet and then copy and paste or enter manually product and price information into it? Did you get those comparison formulas right?

Do you have time to do this? No, you don't.

Instead, look for a procurement management system that can analyze multiple quotes automatically, highlighting discrepancies between the request for quotation (RFQ) you sent and the quotes you received, whether with the actual parts or in the terms and conditions. This should be a visual comparison so you can quickly and easily see any potential problems.

Bonus points for a system that shows you a price spread analysis – the difference between the highest and lowest cost for each part in both dollars and percent. This tells you where you have room to negotiate with your vendors.

Also, if you have pre-negotiated pricing for specific parts, your procurement management
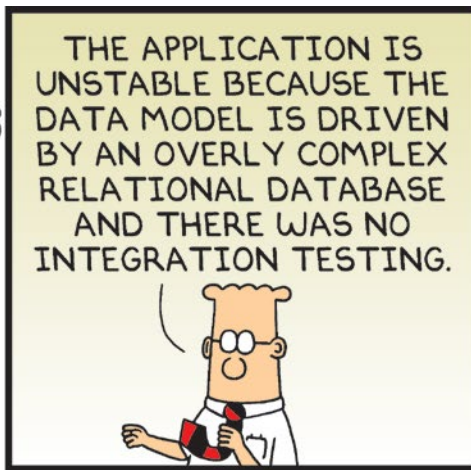
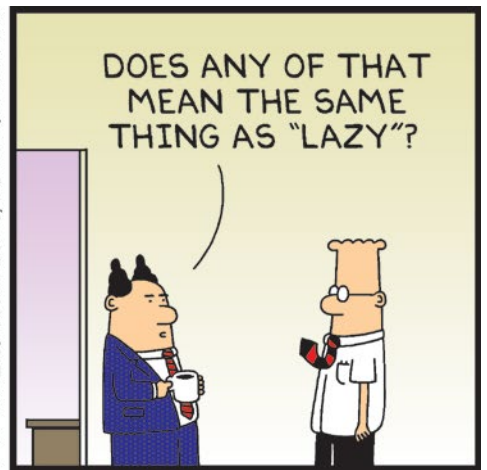> **Integration capability is the single most important feature.**

system should alert you if your vendor's price exceeds the agreed upon pricing.

Price Benchmarking

Comparing pricing across multiple quotes is great, but you also want to benchmark that pricing to other vendors. Do they have better pricing? How would you know? Do you ever spot-check your vendors' prices with supplier websites? Do you open multiple web browsers and search for each part? This is tedious and time consuming. Do you have time to do this? No, you don't.

Your procurement management system should do it for you for every part on every quote. Even if you don't purchase from these sources, you can use this information to negotiate better pricing. Doing so will allow you to cut your parts' cost, in some cases, dramatically.

Quick Implementation

Once you find the right procurement management system and make the decision to implement it, the deployment has to go quickly and smoothly to spare your team as much anguish as

possible and allow them to focus on their day jobs. You can't wait six months or a year to get up and running. With that in mind, look for a software as a service (SaaS) solution. Otherwise, you will have to buy, manage and maintain additional hardware and software. SaaS solutions also make it much easier to bring multiple locations online quickly.

Implementation shouldn't require numerous, highly paid consultants for data import, custom configuration and integration. If it does, you'll see your up-front expenses grow two to three times before you even touch the system.

Procurement Management Partner

So far, this article covered the importance of specific closed loop MRO purchasing functionality and key features you should look for in your procurement management system. It's also worth considering what kind of vendor you want to work with.

Maintenance organizations can be an afterthought when compared to operations. They often operate with limited resources. Some procurement management vendors require you to take on a huge software implementation, man-

age a bunch of customizations and dramatically revamp the way you work.

Do you have time to do this? No, you don't.

With that in mind, look for a procurement management partner who is nimble enough to make changes, add functionality, integrate with other systems and provide the support and attention you need to get up and running. You want a partner that uses an agile software development methodology. Otherwise, you will have to wait for months or quarters to get any changes you need made to the system.

These characteristics are hard to come by in large software companies. Enterprise resource planning (ERP) platforms are notoriously big, inflexible and expensive. Even larger midsized software companies have lost close touch with their clients.

Have you ever called a software vendor to ask for new functionality and been told they'll add it to their list of things they'll get to eventually? How often has your request fallen on deaf ears? How much money/hassle has that cost you while you wait? If you are successful in catching someone's attention, do you get exactly what you want? How many compromises are you asked to make due to

Conclusion

This article has given you a few things to keep in mind when considering your closed loop MRO purchasing options. Look for a system/partner that:

- Integrates quickly and easily with your CMMS/EAM;
- Automatically detects parts that need to be ordered and alerts your purchasing department;
- Automatically updates inventory information;
- Provides data-driven historic and comparative price analytics that will enable you to negotiate the best prices for all the parts you buy;
- Is nimble enough to make changes, add functionality and provide the kind of support and attention your business needs.

If you can implement a system like that, you will be able to drive your parts expense, depreciation expense and working capital utilization down while maximizing your uptime.

software architecture constraints or other customers asking for similar, but not the same functionality? When do you actually get to see the functionality? In a year?

The big, and even medium-sized, companies who boast of all the resources they can bring to bear to ensure your success won't talk about their brittle legacy software code or the bureaucracy and the many other priorities that get in between you and those resources. Look for a partner who wants to collaborate with you and wants you to help shape their product road map.

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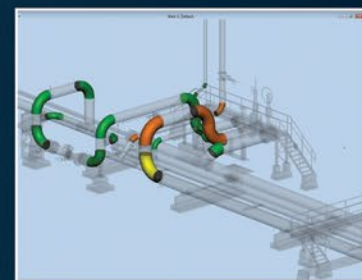
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Asset Management

in the Era of the
Internet of Things

Andrea Ceiner

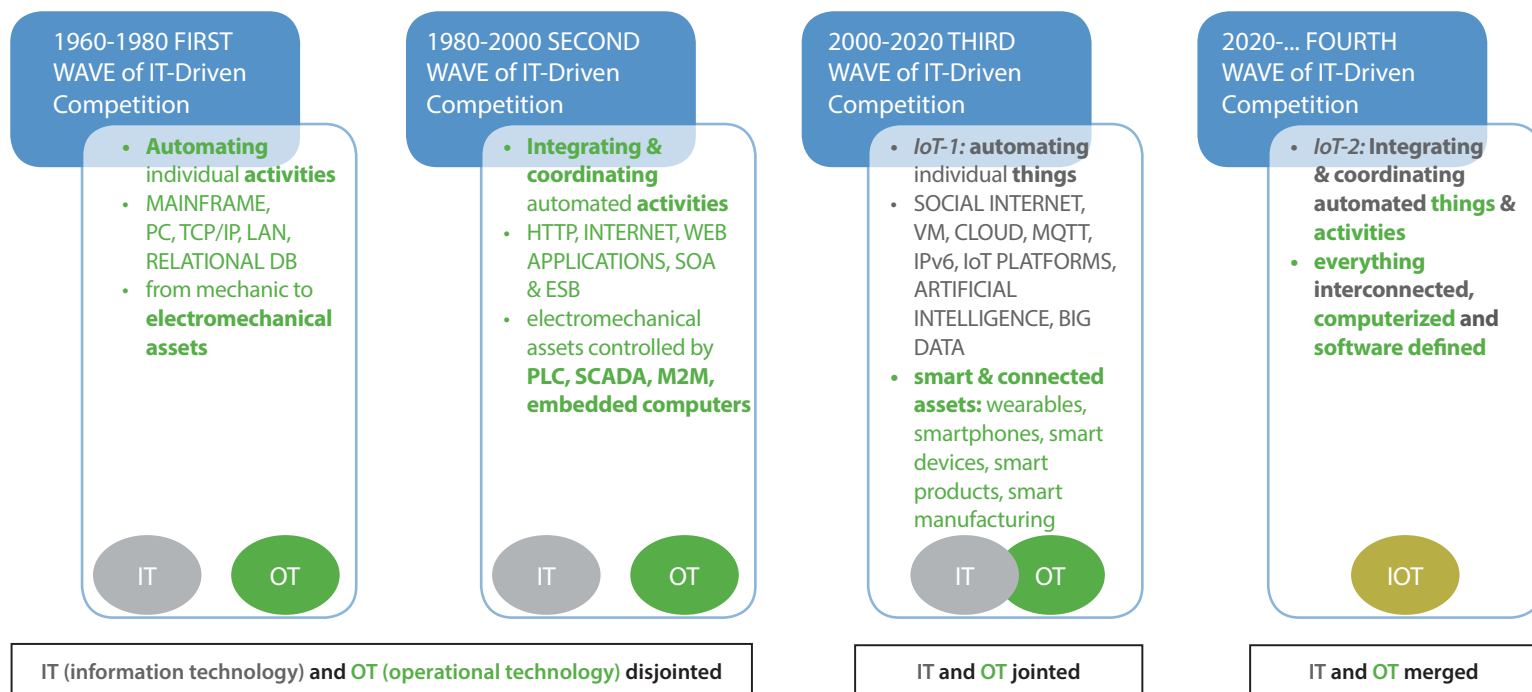| 1960-1980 FIRST WAVE of IT-Driven Competition	1980-2000 SECOND WAVE of IT-Driven Competition	2000-2020 THIRD WAVE of IT-Driven Competition	2020-... FOURTH WAVE of IT-Driven Competition
• **Automating** individual **activities** • MAINFRAME, PC, TCP/IP, LAN, RELATIONAL DB • from mechanic to **electromechanical assets**	• **Integrating & coordinating** automated **activities** • HTTP, INTERNET, WEB APPLICATIONS, SOA & ESB • electromechanical assets controlled by **PLC, SCADA, M2M, embedded computers**	• *IoT-1:* **automating** individual **things** • SOCIAL INTERNET, VM, CLOUD, MQTT, IPv6, IoT PLATFORMS, ARTIFICIAL INTELLIGENCE, BIG DATA • **smart & connected assets:** wearables, smartphones, smart devices, smart products, smart manufacturing	• *IoT-2:* **Integrating & coordinating** automated **things & activities** • **everything interconnected, computerized and software defined**
IT OT	IT OT	IT OT	IOT
IT (information technology) and OT (operational technology) disjointed		IT and OT jointed	IT and OT merged

Figure 1: The four waves of IT-driven competition

Before addressing the way asset management changes in the Internet of Things (IoT) era, it is worth summarizing what has happened since information technology (IT) became one of the main forces influencing the global economy and the competition.

Figure 1 shows the historical IT waves that changed the competition. Each wave represented a big move in many businesses, asset management included. Every wave required new skills, techniques and technologies to manage a new kind of asset.

It was in the second wave when a European leader in multivendor clinical engineering services designed a new enterprise software application supporting asset management. The company's core business is all about the management of medical devices in the hospital environment, a particular kind of asset management.

The main tasks were grouped by the following services portfolio:

- Inventory and localization;
- Preventive maintenance (i.e., scheduling and executing a pre-defined checklist);
- Corrective maintenance, on call, with on premise repair, spare parts replacement (MRO);
- Safety and security checks, following predefined protocols;
- Replacement (e.g., obsolescence, unavailability of spare parts, unsupported by original design manufacturer (ODM), failure before maintenance too short).

The IT system was a multi-tenant web application, replicated with the single-tenant local servers spread throughout the network of hospitals served by the company. This architecture permitted the company's technicians to work in a collaborative manner: technicians inside the hospitals performing equipment tests and measurements, and experts of regulations and senior technicians and engineers assessing remotely the results and defining the operative protocols and procedures to be shared.

This architecture was uncommon in that market niche. Most, if not all, competitors had a single-tenant local server, installed on premise at each hospital, with no replication or sharing of data. The fact that the company had all data replicated and shared gave it two competitive advantages:

A. It was able to leverage the remote collaboration and knowledge sharing among technicians in different countries about different medical devices, which meant giving its customers a good quality for a nice price;
B. It was able to be very precise in bid quotations, thanks to its big and historical database (one million devices, with all economical and technical data).

Unfortunately, all the data was manually inserted by the company's IT team during working hours. If, instead, the company was in the third wave utilizing IoT, more than 60 percent of that costly quantity of data input would have been replaced by an automatic computerized process, from the medical device down to the shared database, until the backlog of the single technician, permitting the company to deliver even better service with less people.

> " IoT is more of a business model revolution rather than a technological revolution.

Table 1 – IoT Impact on Clinical Engineering Services		
Service	**Second Wave (pre-IoT)**	**Third Wave (IoT-1)**
Inventory and Localization	Manual	IoT driven: Automatic
Preventive Maintenance	IT aided	IoT driven: Predictive
Corrective Maintenance	IT aided	IoT driven: Over-the-air maintenance plus machine learning and cognitive computing suggesting intervention
Safety and Security Checks	IT aided	IoT driven: Over-the-air telemetrics and image detection plus machine learning and cognitive computing recalculating risks and reprofiling
Replacement	IT aided	IoT driven: Automatically calculated

But, this is not the only benefit of IoT. It is interesting to see how IoT impacts that business. Table 1 presents a summary of the differences between the pre-IoT era (second wave) and today (third wave).

Here's a deeper look at how it all changes with IoT.

- **Inventory and Localization**: In the second wave, the company had people who went from ward to ward and room to room throughout the entire hospital, assessing and recording on paper the medical devices. During this phase, the company collected identification data (e.g., serial number, label and other identifications), classification by type of device (e.g., defibrillator by ODM and by model), localization (e.g., building, department, floor, room) and state of the device (e.g., needs reconditioning, to be replaced, or good like new). Once the "tour" of the hospital was done, all the paper was copied into the web application to be electronically recorded, cleaned up, normalized and enriched by other information.

In the third wave, this process could be automatic. The devices' identification information is either on hardware or firmware, or also inside the embedded software, kept up-to-date in a secure manner by the ODM or service provider via over-the-air provisioning and authentication cloud services. The location could be set and determined by more than one modality, such as radio-frequency identification (RFID) tags, Bluetooth® dongles, Wi-Fi position, global positioning system (GPS) or cellular positioning, or a manual setting triggered by an alarm triggered by an accelerometer, etc. The device could autonomously publish the data to authorized subscribers (e.g., an asset management software application) via message queuing telemetry transport (MQTT) protocol over secure sockets layer (SSL), or any other secure transmission protocol. Classification and state assessment could be done through low-cost augmented reality techniques, using a webcam or smartphone in combination with image processing for device picture matching.

- **Preventive Maintenance**: The company would go from preventive toward predictive. Today, the metrics published continuously by the devices are a valuable source of information. They can be processed by standard normalization paths services in the Cloud that prepare the data to feed properly to the machine's learning and cognitive computing algorithms. Statisticians analyze the output and share the results with R&D engineers, after-sale service managers and marketing managers. When a cloud service can predict a device failure 24 hours in advance with 99.8 percent precision (as evident recently in a real case), this information can be used by:

    - the end user to call for help before the break occurs;
    - technical assistance to avoid an intervention covered by warranty and to discover fraud;
    - a backlog optimizer service for the support engineers, with automatic opening of tickets with self-documenting capabilities;
    - the device itself, setting its own failure based maintenance (FBM) indicator and shutting down with an alarm notification to avoid clinical risks and costs.

- **Corrective Maintenance**: Connecting a device to cloud services and to the apps and web applications used by the maintenance service means performing a lot of tasks over the air, without the need to be physically in front of the device. You can have precise diagnostics and know exactly what the device's state was before and at the time of failure. The same data can feed the machine learning algorithms, which bind that failure with the intervention procedures that best fit with it. You can connect via MQTT or virtual private network (VPN) with the remote device in alarm and change its settings, reboot and update the firmware, operative system, embedded middleware and software applica-

" The Internet of Things will change the asset management market, led by those companies that will design their business models as IoT-driven.

tions. You can have a senior engineer remotely guiding a lower skilled technician in real time by use of augmented reality. This way, you save the time and cost of moving skilled engineers here and there, and you can also design a new technical support organization and skills map.

- **Safety and Security**: The device could autonomously publish its events, metrics and all relevant data for safety and security checks to authorized subscribers (e.g., a risk assessment software application running in the Cloud) via MQTT protocol over SSL or any other secure transmission protocol. The full process could be computerized, requesting human intervention only at the end of the process for reading and reviewing the final report to the customer. Visual parameters could be quickly detected through low-cost augmented reality techniques using a webcam or smartphone in combination with image processing for device picture matching, avoiding moving skilled people on premise. Also, the use of machine learning and cognitive computing can have a huge impact on how clinical risks related to the use of medical devices are profiled and detected.

- **Replacement**: As a consequence of the radical impact of IoT on the complete lifetime of a medical device, the replacement date is calculated with precision based on the data collected all along its lifetime (e.g., real usage, events log, settings, state log).

- **New Revenue Streams:** IoT is more of a business model revolution rather than a technological revolution. From the technical point of view, it is a fast evolution and commoditization of IT and OT converging over the Internet protocol and available as a service at a low price. All that informatics encapsulated in easy to use services available in the Cloud opens the door to new business models as never before. One example is selling data to ODMs. Dynamic maintenance predictive paths, real use information and real objective data about warranty claims (anti-fraud detection) have a real monetary value for ODMs. Short-term, it cuts the warranty costs of their medical devices and permits the R&D and marketing staff to design new models fit for real use, which means selling more for a long time. Additionally, ODMs themselves could design their own service-oriented business model, moving from selling a product one-off toward selling a recurrent service forever.

Conclusion

The Internet of Things will change the asset management market, led by those companies that will design their business models as IoT-driven. To succeed, they will have to create an ecosystem of clients, partners and suppliers because IoT can only succeed by leveraging an ecosystem. No company, regardless of its size, can do it all by itself.

There are more than 360 IoT platforms and over 100 protocols available today, with an impressive concentration of venture capital in start-ups having IoT in their goals. You need to partner with a local company that has the expertise and skills to help you make the right choices for your business and helps you in designing your IoT solutions.

Andrea Ceiner is the Group Product Marketing Manager M2M/IoT at Tempestive S.r.l. Andrea has been working in the IT and Software industry since 1991 and began his professional career with Euris Group as a software developer and project manager. *www.tempestive.com*

A JOURNEY TOWARD

WIRELESS ASSET CONDITION MONITORING

JBILI Abdenour

"In maintenance, you must always begin from the beginning, but don't forget to set your ultimate goal. Otherwise, you will just waste your time and energy, and lose your right path."
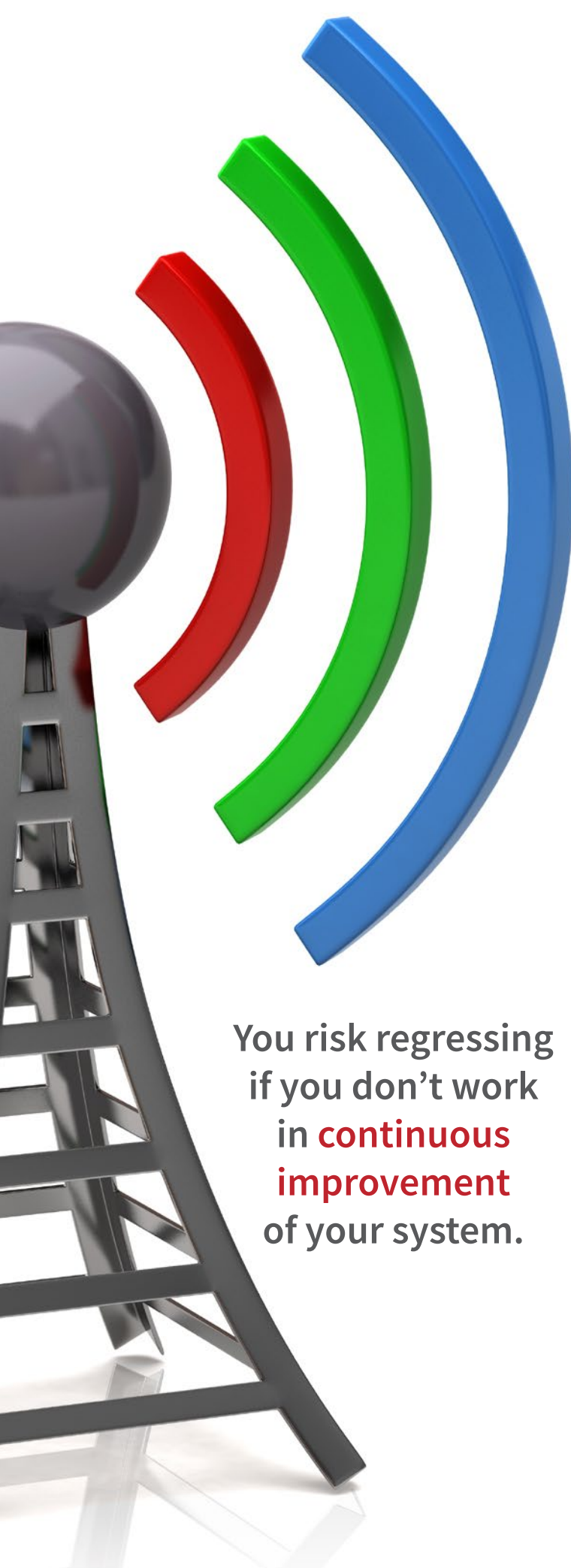
> ## "Don't begin with purchasing new devices to enhance the ACM; think first of the right organization and workforce competence and skills to use contently what you will buy."

I n maintenance, a big challenge is how to put different concepts and theories into practice, especially when you must also change the mind-set of your workforce and introduce a new way of thinking.

At OCP Group, the world's leading producer of phosphate rock and phosphoric acid, and a global fertilizer leader serving the agricultural industry, several obstacles surfaced while trying to change its operating point of view in maintenance.

The journey began in 2007 with a mission to conduct systematic overhauls and preventive maintenance based on frequencies and durations. Condition-based maintenance (CBM) was not fully developed at that time and was considered as a luxury, not a necessity. Moreover, people did not really trust the results of CBM.

In 2008, maintenance engineers in the Maroc Chimie plant received basic training in vibration analysis. From this, they began to understand the benefit of vibration analysis to predict and fix future failures before breakdown. It was really a shift in the company's philosophy of maintenance and really magical to see how basic vibration training can make a huge impact when it is used.

The big question was how to enlist all Maroc Chimie workers to embrace and engage in this new concept. How do you lead a smooth change in maintenance, and even in production, and be more persuasive? The first step was to learn and deeply master all asset condition monitoring (ACM) techniques and methods, especially vibration and infrared temperature measurements, buy and use the right devices, and show and publish results to others.

The first achievement was when a maintenance engineer managed to balance a big blower in a fertilizer plant, which runs with 45 mm/s (0,147 ft/s) in vibration to 2mm/s. Back then, it was an impossible problem to solve in the maintenance workforce's eyes. One worker remarked: "I know that we can balance blowers, but not this one! How did you do it?" It was then that the maintenance engineer realized the problem was deeper than just exploring new technologies or applying conditional maintenance in the plant. The limitation was in each maintenance worker's brain and beliefs, which shackle and stop each of them from seeking and exploring new solutions.

To break this barrier, plant maintenance workers needed to gain more confidence in themselves. To become more confident, you have to increase your competence. Competence comes naturally with experience, or with high-level training and practicing. That is why, in 2009, the OCP Safi plant initiated a big effort for ISO certification on vibration and thermography. All Maroc Chimie inspectors were certified ISO level two in those fields. They became proud and more confident in their analysis and interpretations. Then, other maintenance personnel showed more respect and esteem to inspectors and accepted their recommendations.

The first version of the CBM program was in the form of an inspection calendar containing all tasks and frequencies. Inspectors had to check the frequencies from the calendar and do the inspection rounds, then initiate a work order in the computerized maintenance management system (CMMS) if the vibration or temperature exceeded the limit value.

At the end of each week, inspectors would send an overview report of all anomalies detected within the week, with the number of each work order and the investigation or remedy status. Those reports allow the plant to have a reliable database of all previous problems to improve future maintenance strategies.

In 2010, in order to be more professional and share inspector expertise, each work order generated by the inspector was accompanied by an "Anomaly Flash" report, scientifically describing the physical phenomenon in more detail. This document was the last link to complete the chain of the plant's inspection process and respond clearly to maintenance personnel's needs and requests.
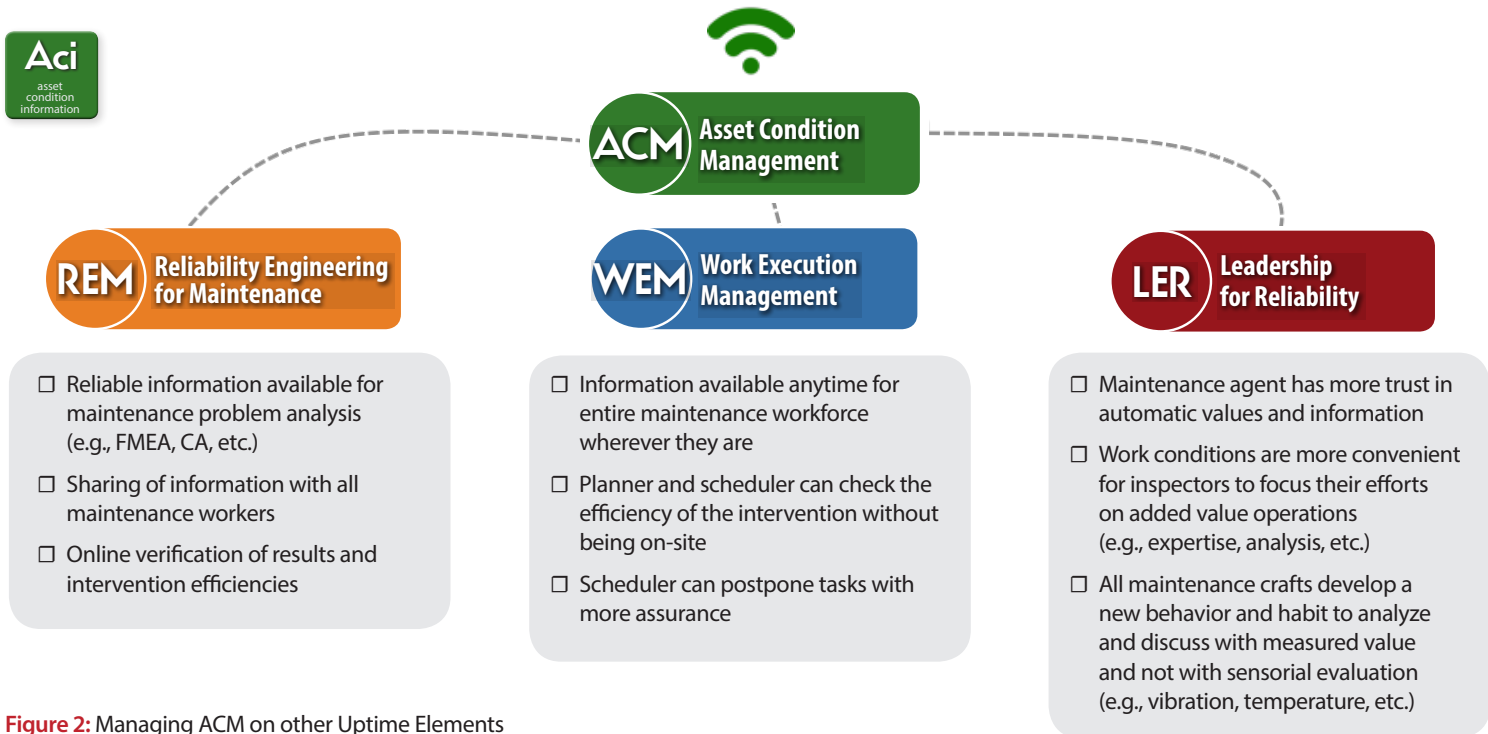
You risk regressing if you don't work in **continuous improvement** of your system.

Figure 2: Managing ACM on other Uptime Elements

REM — Reliability Engineering for Maintenance
- ☐ Reliable information available for maintenance problem analysis (e.g., FMEA, CA, etc.)
- ☐ Sharing of information with all maintenance workers
- ☐ Online verification of results and intervention efficiencies

WEM — Work Execution Management
- ☐ Information available anytime for entire maintenance workforce wherever they are
- ☐ Planner and scheduler can check the efficiency of the intervention without being on-site
- ☐ Scheduler can postpone tasks with more assurance

LER — Leadership for Reliability
- ☐ Maintenance agent has more trust in automatic values and information
- ☐ Work conditions are more convenient for inspectors to focus their efforts on added value operations (e.g., expertise, analysis, etc.)
- ☐ All maintenance crafts develop a new behavior and habit to analyze and discuss with measured value and not with sensorial evaluation (e.g., vibration, temperature, etc.)

To better utilize its CMMS, since 2012, all inspectors' calendars have been configured in the CMMS system and all measurement values were integrated and stored inside. With business intelligent software, the company can generate all graphs and follow measured value tendencies and trends.

As is the case for all disciplines, when you feel that you master something, be aware! You risk regressing if you don't work in continuous improvement of your system. It is not something that is "NICE TO HAVE" to make your system living; you must improve or just think deeply in all your maintenance activities to maintain and drive your progress. In the case of Maroc Chimie, new gaps began to appear:

- Retirement of experienced inspectors;
- No respect of the maintenance calendar (e.g., vacation periods, difficulty to access in some equipment at the top of the elevator, breakdown in measurement devices, etc.);
- Disinterest of inspectors in periodic measurements (task without added value), especially when they feel more competent.

In dealing with this situation, the company explored several questions: How can new technologies help us overcome all the previous constraints? How can we make our system less dependent on humans without losing their advantages? After extensive research, the company found the appropriate solution in a wireless system. The concept of this solution is summarized in Figure 1.

It consists of wireless sensors that send periodic measurements of vibration and temperature through multiple relays to the gateway. All this information is recorded on the server and can 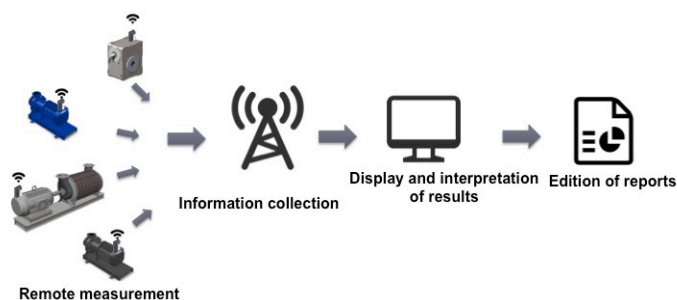be displayed and analyzed on the system's website. You can also add the spectrum of acceleration, velocity and temporal signal if you want to enhance your analysis.

With this solution, any qualified and experienced inspector can analyze values and share reports. This activity can be outsourced, depending on the company's maintenance strategy. According to the available number of wireless sensors, you can begin with critical equipment and expand it to others; you also can change the position of the sensors if the criticality of equipment changes. Maroc Chimie outsources this activity to a company that handles the maintenance of all systems and interpretation of results. The plant receives a "daily flash," which includes the situation of the network and all measured alarms, and a more detailed weekly report with spectrum analysis, efficiency of previous interventions, etc.

Now, the plant is working on a link between this solution and the CMMS to automatically generate a work order if the value exceeds its limit. The calculation of mean time between failures (MTBF) and mean time to repair (MTTR) also can be done automatically using this solution to follow or confirm the reliability of the plant's equipment (e.g., if the value of vibration is approximate to 0 mm/s, the equipment is at a standstill). The plant just needs to work on a combination of values and information in the wireless software to have the right information.

What's next? How to make all ACM elements wireless. The plant is now working with several subcontractors and suppliers to develop this aspect. It will test a new wireless oil analysis in a turbine tank. It is also working on intelligent lubrication with wireless sensors, which would automatically add oil or grease if the temperature is high.

The impact of this new way of managing ACM on other Uptime® Elements™ is summarized in Figure 2. The creation of a reliability section and a laboratory of maintenance in the plant facilitates the interaction between wireless systems and other maintenance activities.

Figure 1: Wireless measurement and interpretation

JBILI Abdenour, CMRP, is a manager of maintenance methods at OCP Group. Jbili is leading asset condition monitoring improvements at the OCP Safi chemical site. Mr. Abdenour is also certified ISO 18436 level 2 on vibration and has advanced notions in inspection and all NDC techniques. www.ocpgroup.ma

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IMPLEMENTING A
PROFESSIONAL DEVELOPMENT PROGRAM

Kenny Foley

If you're looking for a way to strengthen internal and external customer relationships, provide prospects with a forum to familiarize themselves with your expertise, and add value to your industry, consider implementing a professional development program. Not a product training program, although that can be a separate, related component, but a professional development program whereby you share current and emerging industry knowledge that helps participants be more successful on the job.

If this sounds overwhelming, consider different ways you could focus your efforts: provide specialized training that addresses specific individual or group skill gaps; train new hires and transfers on specific operating procedures and standards as they join the department; or keep an existing workforce updated on new industry trends.

In-house reliability professionals can also consider creating professional development programs for their internal customers, particularly for situations where close collaboration is required. These departmental presentations can help others in the organization understand current policies and processes, why they're important, and the roles and responsibilities of the personnel involved. An added benefit is the potential for improvement that comes about when everyone has greater awareness, understanding and credibility.

Here are some tips to keep in mind to ensure an effective professional development program.

Start Small

Master one topic and delivery platform, then evaluate customer and prospect responses to the offering, participant engagement and subsequent financial return. Evaluate others who offer the same kind of training that you're considering. What gaps remain?

Test your topic with small groups at trade shows, lunch and learns, and association events. Ask for detailed feedback and follow up with participants weeks or months after to see if your training truly made a difference.

Use this opportunity to develop an accompanying resource guide. Start with a handout and augment it as you gain more experience and refine your training. For example, you could have a manual for a three-day program that is over an inch thick and a manual for a one to two day session that is 43 pages long. Each manual should be developed to serve as a longtime reference guide that reinforces the training and knowledge.

If you don't charge a fee for your professional development program, make sure your financials include income from business resulting from attendees. You may not always be able to attribute the additional business directly to the training, however, you can confidently attribute a percentage.

Focus on the Content

Spend the necessary resources to create a curriculum that can't be replicated through YouTube™ and a few good books. Identify an instructor or two who has significant and current real-world experience and can link the classroom subject matter with his/her practical experience. Look within your company for would-be instructors who have expertise and deep experience. You probably have people already on staff who can fill this role and simply need a little practice time to hone their onstage presence. The testing process mentioned previously is a good time to train this talent and prepare them for the high stakes presentations.

Make sure the content stays current with continual updates. The overall flow and themes may remain the same, but you want to make sure you have examples that are weeks/months old, not years.

Fight the urge to focus on company products or services. It's tempting to tout your latest and greatest, however, it's also the best way to erode credibility and your chances of continuing a relationship with the participants.

Mine Existing Custom Programs for Scalable Ideas

Look at presentations you're currently putting together for customers and prospects. Can these be made customer-agnostic and turned

into a training class? Or could you put several different presentations together for a longer class?

What questions are your customers and prospects asking about the industry? What concerns do they have about developments in your product category? Are there some questions or topics that come up repeatedly? Or is there a need that they have that could also fit other companies? Track these for a few weeks or months to identify trends, then use these trends to drive your next steps.

This strategy was recently used to create a digital training program for an international soft drink company. The company needed a digital vehicle that allowed it to deliver a skills-based assessment to its reliability professionals. Once the project was completed, the digital training program was used as a template for other customers. The process of developing and completing the project also revealed potential bottlenecks, as well as opportunities for expansion and additional customization.

Expand Deliberately – Begin With the End in Mind

As you look to expand, consider building out multiple ways to deliver the same topic. Assuming you've already mastered presenting in person, evaluate how you could incorporate a webinar, either live or recorded. Experiment with posting snippets of a webinar or recorded presentation on your website or LinkedIn® page. You can also record the entire presentation and make it available to attendees as a refresher. This works best if the training is for a specific purpose and won't be valuable to others. You don't want your videos to replace your involvement in the process.

Turn sections of your presentation into blogs that can be serialized on your website or an association or trade media publication, or incorporated into an e-mail campaign to customers and prospects. This keeps your company's brand and its availability as a professional development resource in front of people who are looking for the guidance you offer.

Offer current customers a presentation of your core topic with specific ideas on how you could add custom content to address their current or future needs. Use this as an opportunity to visit their offices (if you haven't) or invite them to yours (if they haven't).

Capitalize on the Human Nature of Networking

If you're hosting participants from multiple organizations, deliberately mix the groups so individuals expand their network during the learning process. This elevates their experience and helps them learn from one another.

Separate preexisting groups that already know one another through seat assignments for presentations and meals, provide everyone with a name tag and use table tent cards to reinforce the individual's and organization's name. Use class participation to encourage the exchange of best practices. Allow participants to exchange contact information themselves; you'll want to respect their ability to select whom they prefer to interact with beyond the training experience.

Whether your intent is to influence internal or external customers or prospects, a professional development or training program of any scale provides a replicable tool you can scale for your needs and that of your audience.

"An added benefit is the potential for improvement that comes about when everyone has greater awareness, understanding and credibility."

Kenny Foley *leads the technical response team at Hydrotex, a national manufacturer and distributor of high performance lubrication and fuel improver solutions. He is also a leader of Hydrotex's Lubrication University, the company's professional development organization and manages the company's Principles of Lubrication Certification program, which ensures Hydrotex consultants are trained to present to customers and prospects. He is a Certified Lubrication Specialist through STLE. www.hydrotexlube.com*

NORMALIZATION OF DEVIANCE AND THE PERCEPTION OF

DEFECTS

Joel Levitt

Ever walk into a room, look around and conclude that all is well. But then, someone picks up papers, a briefcase, or some other object from the floor, right where you were about to walk. You hadn't seen it. Your vision is fine, so how could you have missed it? It makes you wonder how many other little things you missed in other places, too.

There is a mind-set needed to see little things. Sure, there are those who rebel against those compulsive people who want everything just so. But as it turns out, when everything is just so, the scene is easier to take in and see if there are any insidious defects that could cause real problems. Factories are like that, too. If the plant is just so, it is easier to separate out the problems from the background.

There is something even deeper at play. How can anyone walk by a defect right there, day in and day out and in their face, and do nothing?

There is a mind-set needed to **see little things**.

Humans are masterful at separating out the signal from the noise. If the background stays the same, then the signal (defect) fades and eventually disappears.

An article in a NASA publication explored the normalization of deviance. It describes it as a cognitive (i.e., wired into the brain) process that when a scene doesn't change, we stop seeing the details. The article cited the space shuttle Challenger tragedy to this phenomenon. In the maintenance reliability world, it would be a temporary repair that after a few days, stops looking temporary. In fact, it stops being visually present entirely. If anyone asked you if there are any temporary repairs, you might answer, "I'm sure there are some," but you might not remember the one right in front of you.

Rather, you will be reminded of something if it actively intrudes into your conscience. Think of a factory defect that makes scrap and it is your job to clean it up. Since you are actively involved, the defect fades into the background much more slowly. It still fades, but more slowly, so it can be recalled into consciousness much more quickly. Many of the exercises used to identify activities that add value are designed to highlight defects that might have been forgotten.

Defect elimination is the royal road to reliability and institutional integrity. Some defects have been around for a while and stop being seen or per-

How can anyone walk by a defect right there, day in and day out and in their face, and do nothing?

ceived. For a manager who does not work with the equipment and, therefore, doesn't get confronted by the consequences of the defects, the defects he or she sees would blend into the background. For the workers, however, the defects would have more persistence since they are confronted by them and have to mitigate them.

There are probably people in your life that seem to be universally better at spotting defects than you. Whereas you might normalize crumbs on the dining room table after 10 minutes, other people might keep seeing them. Of course, it can be attributed to laziness, but you can always plead normalization of deviance and only a little laziness!

When it comes to the perception of defects, the conclusion is twofold. If you want to attack defects, don't rely on managers because they cannot see the problem as well. Rather, recruit people into leadership roles that are detail oriented because they are just plain better at seeing defects.

Finally, these invisible defects are in the way of a smooth running institution. They are also responsible for many things, from small breakdowns to major catastrophes.


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

Be sure to look for future cartoons from Tom in upcoming issues, and don't miss his Keynote at The RELIABILITY Conference where he uses cartoons, case studies, and his marketing career to tell a story visually. It is sure to be both humorous and insightful!

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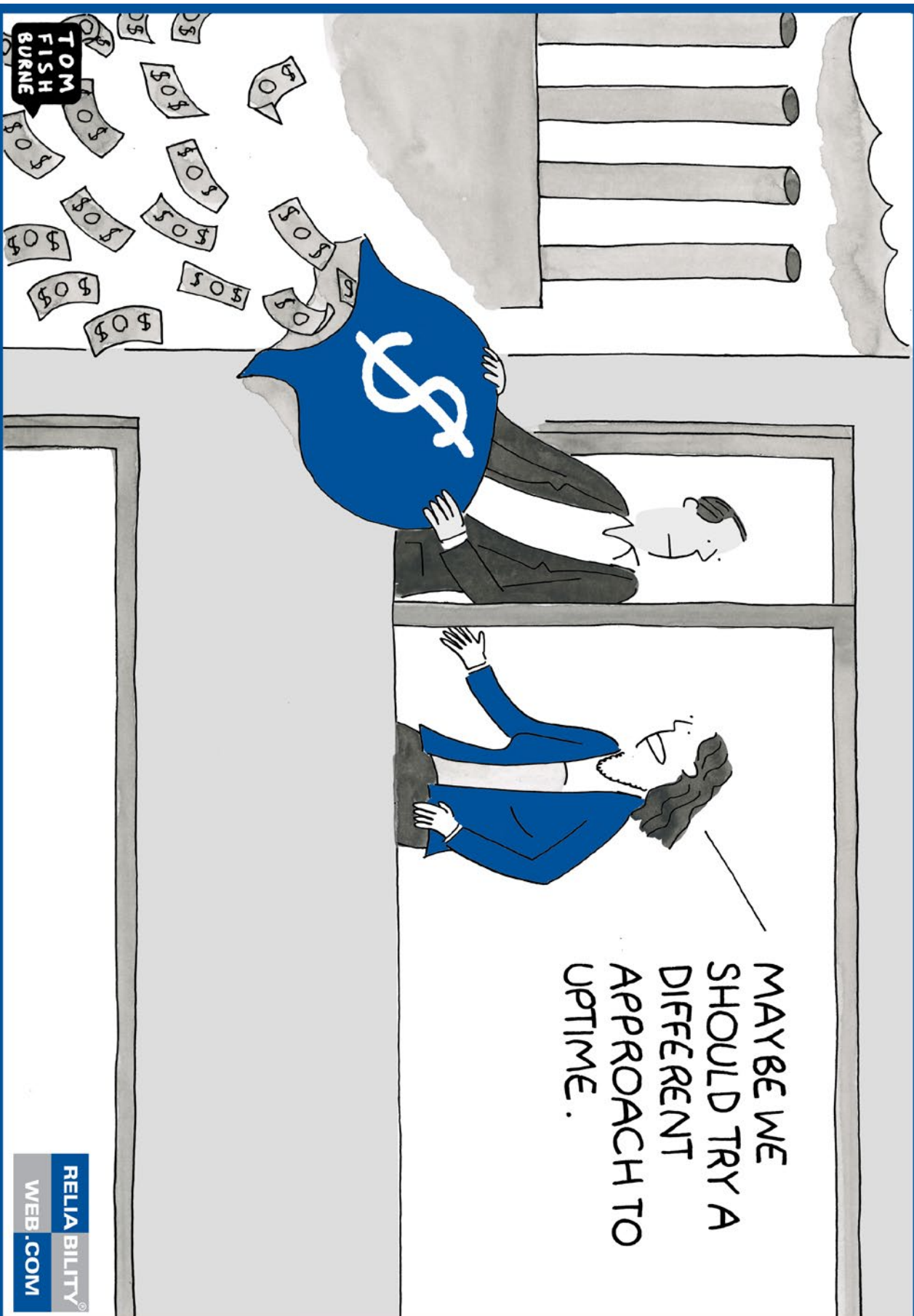
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❹ AIM
Work for something bigger than one's self

WORK WITH SOMEONE YOU TRUST

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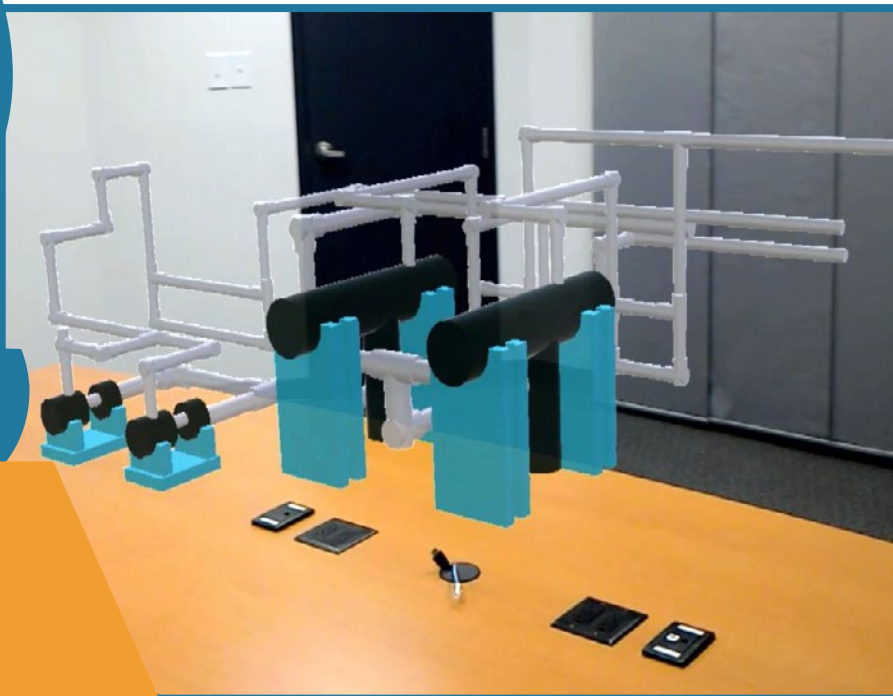
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Augmented reality is a touchstone of any film that is set in the future. The character stands in front of multiple holographic screens, able to access any information he or she wants with the flick of a wrist.

Uptime® magazine recently met with Stéphane Côté, Fellow and Research Director in Bentley Systems' Applied Research Group. Côté's work explores the potential of augmented reality in the context of infrastructure engineering. Last spring, he and his team experimented with Microsoft® HoloLens™, an augmented reality device that will shape how all of us will work going forward. Côté talked with us about the HoloLens itself, the benefits of implementing it, and much more.

Now, what was once something that only could be seen in the movies is reality.
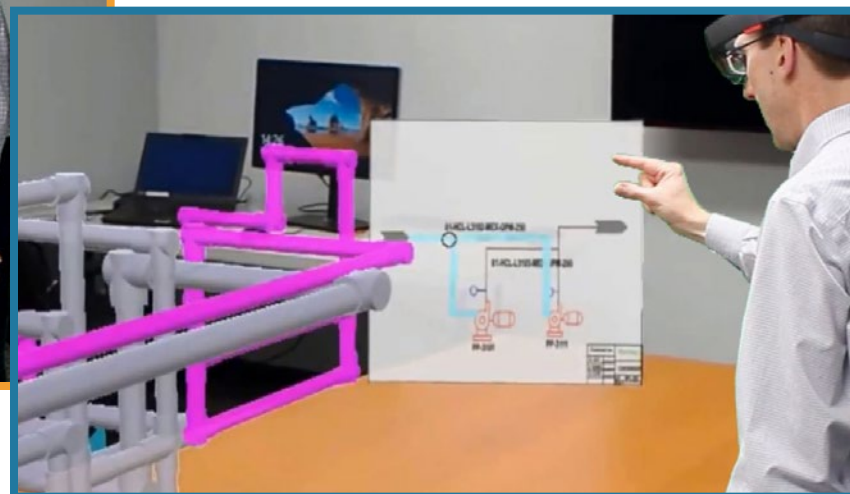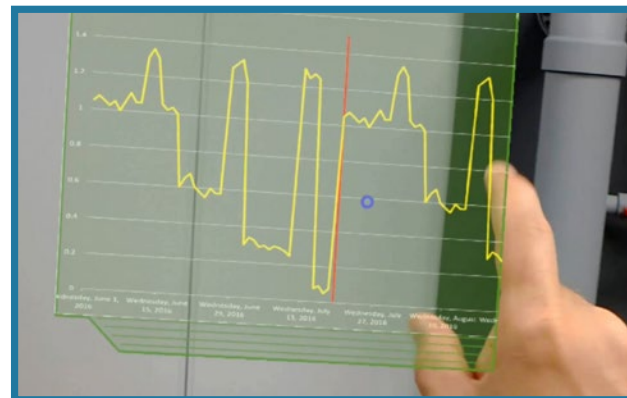
Q: A lot of our audience has never used anything like this before. Can you give us a little background of what the Microsoft HoloLens is and how it works?

A: What the HoloLens can do, essentially, is take the data you want to view and put it in context. I have difficulty remembering people's names, so the perfect augmented reality application I would like to have is one where I put on my HoloLens and when I see you, your name would appear next to your head. This is one example. Another example is when I go to the grocery store and put a can of food in my cart. How do I know it is good for me? The HoloLens could display extra information related to nutrition, whether people liked it on Facebook® and those sorts of things. Two weeks ago, I was visiting my stepparents and had to do some work in the basement that included destroying an old window and laying out bricks to close the space. I've never laid out bricks, so I looked on the Web to learn how to do it. Then, I had to remember the information. I went downstairs and, based on my reconstruction of the video, I laid out bricks. But the augmented reality system would put it all in front of you and show you how to do something, like lay out bricks. It is just there in context, in 3D, exactly where the work has to take place. That's what makes it so convenient. And, that's what this whole idea of augmented reality is all about. You can display things at their appropriate place.

Q: What are the types of benefits that we're going to see, especially in the manufacturing industry and day-to-day operations?

A: Anytime you need to access information, like the specifications of a device, how to do this type of operation, who is the last one that changed that part, that information is stored with a reference to that object. So, you see a pump and it's broken. And you ask, "Has it been fixed several times?"

Using augmented reality, you would just click on it with your finger and all this information would appear in the form of a menu. You could have access to the specifications of that device, the number of times it's been repaired, the company that installed it, the company that built it and the new models that are available. All that would be next to it. You wouldn't have to search anymore or browse documents.

Let me explain it another way. Say you have a certain type of maintenance done in your plant every month. It's always the same guy who does it. Well, one day, he is out sick. No one else knows how to do it, so how can you proceed? Well, one possibility is you send someone with an augmented reality system that gives instructions on how to perform the maintenance. It might say, "I know where you are because I can sense your location. Turn this handle left." And it's very clear. There's an arrow that displays around the handle. You follow the steps and at the end, you've done something you've never done before. Now, you might need some help in the process. For example, the system says open the handle, but it doesn't open. You can call someone and that person remotely sees what you're seeing. And, that person can annotate what you're seeing. In the case of our example, this person might say, "Okay, you're using this handle. There is a screw there." The individual can illustrate this by putting an arrow next to it, so you can see what the person is showing you. Augmented reality would dramatically facilitate collaboration.

Augmented reality also can be used in unexpected situations. Let's say a pipe bursts or an instrument breaks. You can't program a HoloLens to tell you how to proceed because you don't know how to proceed. There's no written procedure for fixing that. How do you solve that? Instead of using the HoloLens as a teacher or guide, you use it as an assistant. You are in front of the device that's broken and you ask, "What's the problem?" The system will be programmed to tell you, "The problem is that instrument doesn't seem to work anymore." So, you have to make a decision. You say, "Could you show me the historical

values measured by that device?" The system would show you in front of your eyes the graphs of the variations of pressure and then you can browse through that. This could make a huge difference in terms of efficiency.

Q: As I hear about this technology, I think, "Why wouldn't you want to use this?" It seems so practical and easy, and it eliminates a lot of human error and unnecessary steps. But, is there any resistance to using augmented reality from the current workforce? Or have many in the industry embraced it?

A: The only negative comment I've heard is, "Okay, that's interesting, but that's not the way we do things currently." I think one can easily overcome that problem. The augmentation program can be adapted to existing procedures. And, employees can be educated to the new system. It's not like 20 years ago when computers were still a new thing. I saw how people reacted to the HoloLens. You see, in the center, you have a small dot. That's your mouse pointer. Now, you must click by doing this. They instantly got the idea in a few seconds. Augmented reality offers a user interface that is very natural to use.

Q: It almost sounds as if somebody is exposed to it; as they try it, they can see it. It's not a hard technology to understand. It's just adapting it, like you said, adopting it into their process.

A: Exactly, and I'll give you an example. The main difficulty of augmented reality is tracking. That is, measuring the position of the tablet or the HoloLens. And it's extremely important because that's how we display things at the right place. Let's say on this table you want to display a virtual pot of flowers. If it was a true object, as you walk around the table, you would expect this pot of flowers to stay in the same place. That's how real objects behave. But, if you don't do a good job of tracking, this pot of flowers will move around. And then you'd say, "That's not a real one because it moves strangely." What's so nice about the HoloLens is that the tracking aspect has been mastered in a nearly perfect way. If you put a hologram in the middle of the room or even in the middle of the air, you leave it there and walk around. It behaves as if it were staying there, stable, not moving. It behaves like the physical world. If the augmentation is done well, then people will automatically see these augmentations as normal and they will interact with them as if they were interacting with the real object by taking them and moving them around. It is as if augmented reality is just an extension of reality. It's very easy to master. You don't even need to learn to use a map.

Q: That's really interesting. Where do you see this technology going? I mean, it's so complete at this point, but what are the possibilities with this technology?

A: It's just beginning. I was viewing a nine minute movie produced four years ago. It's called "Sight." It is a futuristic movie, where Sight is an augmented reality system running on your contact lenses. You see virtual objects, real objects, information, names of people. It's perfect. And then the lady says during a conversation, "The other day, my Sight crashed." And the guy in front of her, who is the developer of Sight, says, "No, Sight never crashes." "Yeah," she says, "I'm positive my Sight crashed. I was running in the park and it just stopped working. I couldn't see anything. I was afraid." Of course, she could see the physical world. She just could not see the augmentations that she was used to seeing with the physical world, like the proximity of a shop, someone suspicious approaching, information about her current e-mails, or all that stuff that would be normal in your everyday life. She was afraid because those were no longer visible. We might become as dependent on augmented reality as
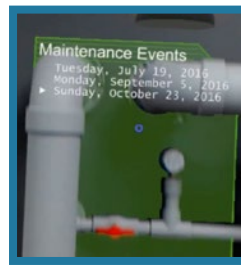
we are today with electric power. We feel we can't do anything if there's no power.

Q: That's an impressive statement—a future you can visualize.

A: What I've often heard is that in the future, forgetting your augmented reality device at home would be as bad as it is today when you forget your smartphone. It would be integrated into our lives.

Q: There's a component that was discussed about the voice-based virtual assistant. Can you explain that a little bit?

A: A worker on-site is typically carrying or using tools. That worker's hands must be free to do work. There are two ways to interact with augmented reality technology, either by voice or by hand. With your hands, there are only a limited number of gestures you can make and it becomes tiring in the end. So, the voice-enabled technology might be a good choice. Let's say you're being taught by a human about how to do something. This person explains, you can ask questions and it's very natural. That's what we're trying to do in our demo, simulate someone who is trying to help you.

Q: It's just like talking to the machine itself and getting those answers.

A: Exactly.

Q: This has been very interesting. Is there anything else you would like to add?

A: There are two things. First, this technology, like any other technology, has good and bad aspects. But, if this technology helps you learn faster, become a better person and better understand how to live with other people, then it's good for us. So, it's a good idea to start right away and think of ways this technology can help us become better. Secondly, whether we want it or not, whether we think this technology is good or not, it is going to happen and become an integral part of our lives. I believe everything in the future will be augmented everywhere by everyone. These augmentations will give us superpowers – it is like the next step of human evolution.

Maintenance ➤ TIPS

A Lubrication Condition or a Mechanical Condition?

When monitoring your bearing lubrication with ultrasound, it is important to watch for very high values in your condition indicators (total RMS and peak values). After applying grease, both values should decrease proportionately. This is a sign the bearing was under-lubricated. If the total RMS value lowers, and the peak value stays relatively the same, then the bearing has a mechanical condition that is generating impacts.

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PDCA Cycle
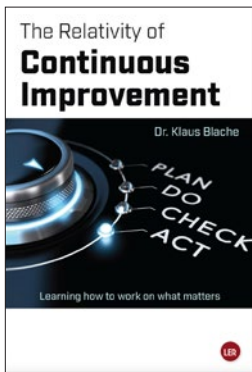
The power of PDCA is its simplicity and cumulative improvement possibilities by continually repeating the cycle, done either by the same team or other teams.

PLAN: Start with the expected results in mind. Establish the objectives and processes required to attain the expected results.

DO: Implement the new process. Start small at first to test the new idea.

CHECK: Measure the new process relative to the expected results.

ACT: Analyze the differences and root causes by comparing current best practice versus new ideas to understand specific opportunities. Each cause should be the beginning of another PDCA, resulting in further improvement.

Dr. Klaus Blache • The Relativity of Continuous Improvement
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7 Steps to Performing RCM Analysis

1. Develop operational objectives
2. Identify functions
3. Identify functional failures
4. Determine failure modes & effects
5. Identify equipment and systems with poor reliability history
6. Develop task recommendations
7. Identify "reliability issues" and one-time improvement opportunities

To read a full case study utilizing this approach, visit: http://pinnacleart.com/increasing-profitability-through-a-comprehensive-risk-based-reliability-improvement-project/

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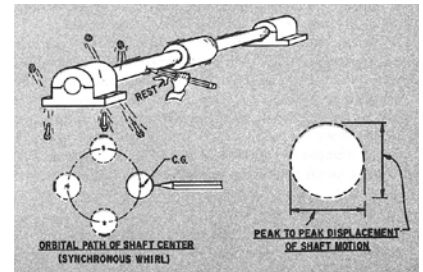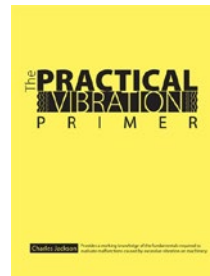## The Pencil Method of Balancing

Figure - You can balance with a pencil if you have slow speeds, large deflections, and a steady hand.

Many craftspeople and engineers have tried to balance a machine using a pencil to mark the shaft. Given a slow speed, large deflections, a steady hand and some nerve, this could have been successful (see Figure). A weight is simply added opposite the point of shaft deflection or pencil mark on the shaft.

This book will present an accurate electronic approach to the pencil method of balancing. Electronically, an orbit path of the shaft can be generated. Also, electromechanically, a phase reference mark can be produced to show where the shaft is at a particular time. The author's experience is confined to machines with hydrodynamic bearings.

Charles Jackson • The Practical Vibration Primer
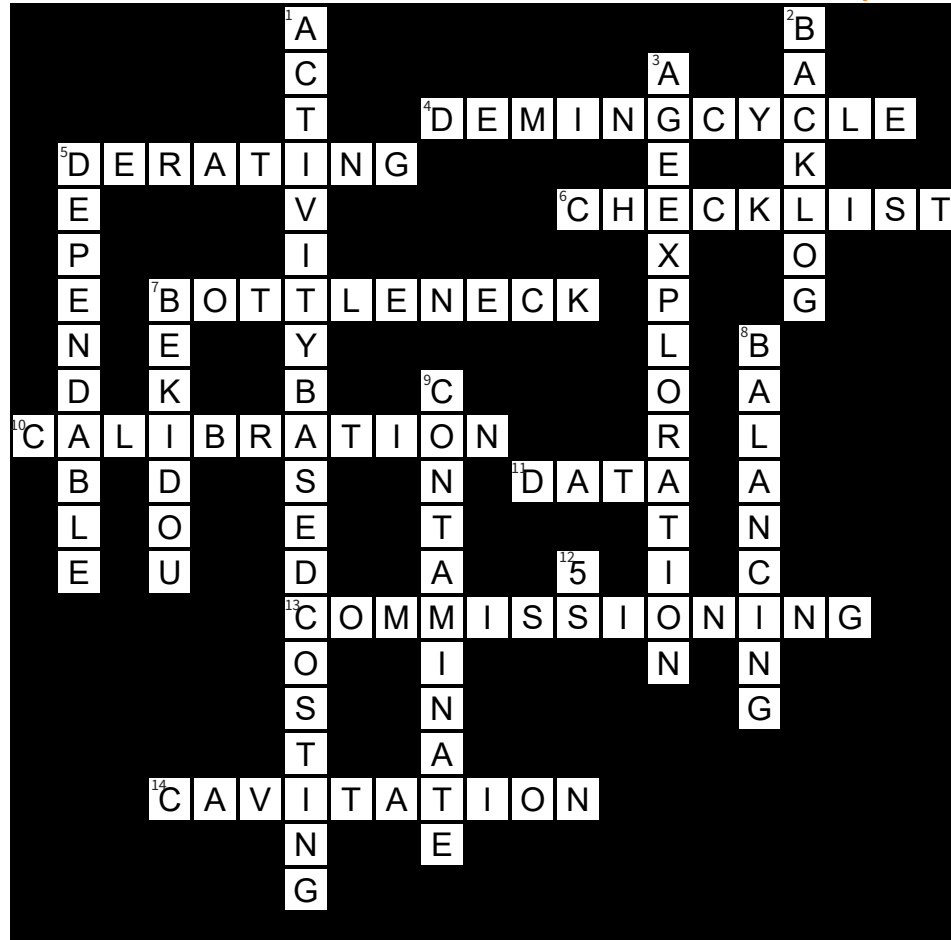**www.reliabilityweb.com/bookstore**

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ANSWERS FEB/MAR ISSUE

Crossword Puzzle

Crossword grid (answers):

- 1 Down: ACTIVITYDEPENDED (ACTIVITY / DEPENDED)
- 2 Down: BACKLOG
- 3 Down: AGEEXPLORATING
- 4 Across: DEMINGCYCLE
- 5 Across: DERATING
- 5 Down: DEPENDABLE
- 6 Across: CHECKLIST
- 7 Across: BOTTLENECK
- 7 Down: BEKKSED
- 8 Down: BALANCING
- 9 Down: CONTAMINATE
- 10 Across: CALIBRATION
- 11 Across: DATA
- 12 Down: 5S
- 13 Across: COMMISSIONING
- 14 Across: CAVITATION

ACROSS

4. A continuous improvement cycle consisting of plan-do-check-act is known as

5. Using an item in a way that applies stresses that are below the recommended stress values

6. A structured, pre-prepared form for collecting, recording and analyzing data as work progresses

7. Any resource (asset/system) whose capacity is less than the demand placed on it, or which controls the maximum rate of production of resources ahead or behind in the process stream

10. A comparison of a measurement of a system of unverified accuracy to a measurement of a system of known accuracy to detect any variation from true value

11. A piece of information, in raw or unorganized form, used as a basis for reasoning, discussion, calculations, further processing and communication

13. A process by which equipment or a facility is tested to verify that it functions in accordance with its design objectives or specifications

14. A phenomenon that occurs when the absolute pressure in a pump intake line is reduced below the vapor pressure of the liquid

DOWN

1. A method that allows an organization to determine the actual cost associated with each product/component, process, or service produced based on actual resources consumed

2. All work waiting to be done

3. An iterative process used to optimize preventive maintenance (PM) intervals

5. Trustworthy, something you can depend on

7. A Japanese word for Output Optimization

8. Adjusting the distribution of mass in a rotating element to reduce vibratory forces generated by imbalance

9. Any foreign or unwanted substance that can have a negative effect on system operation or reliability

12. A Japanese workplace organization technique to reduce wastage of resources and space while increasing operational efficiency

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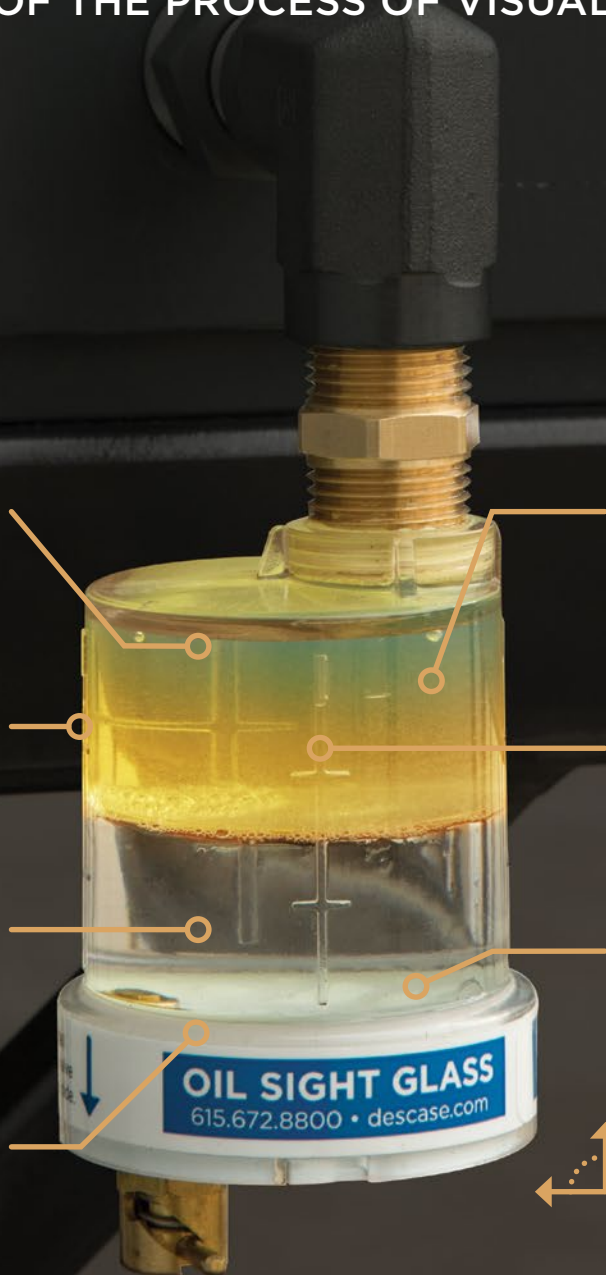
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