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for maintenance reliability and asset management professionals

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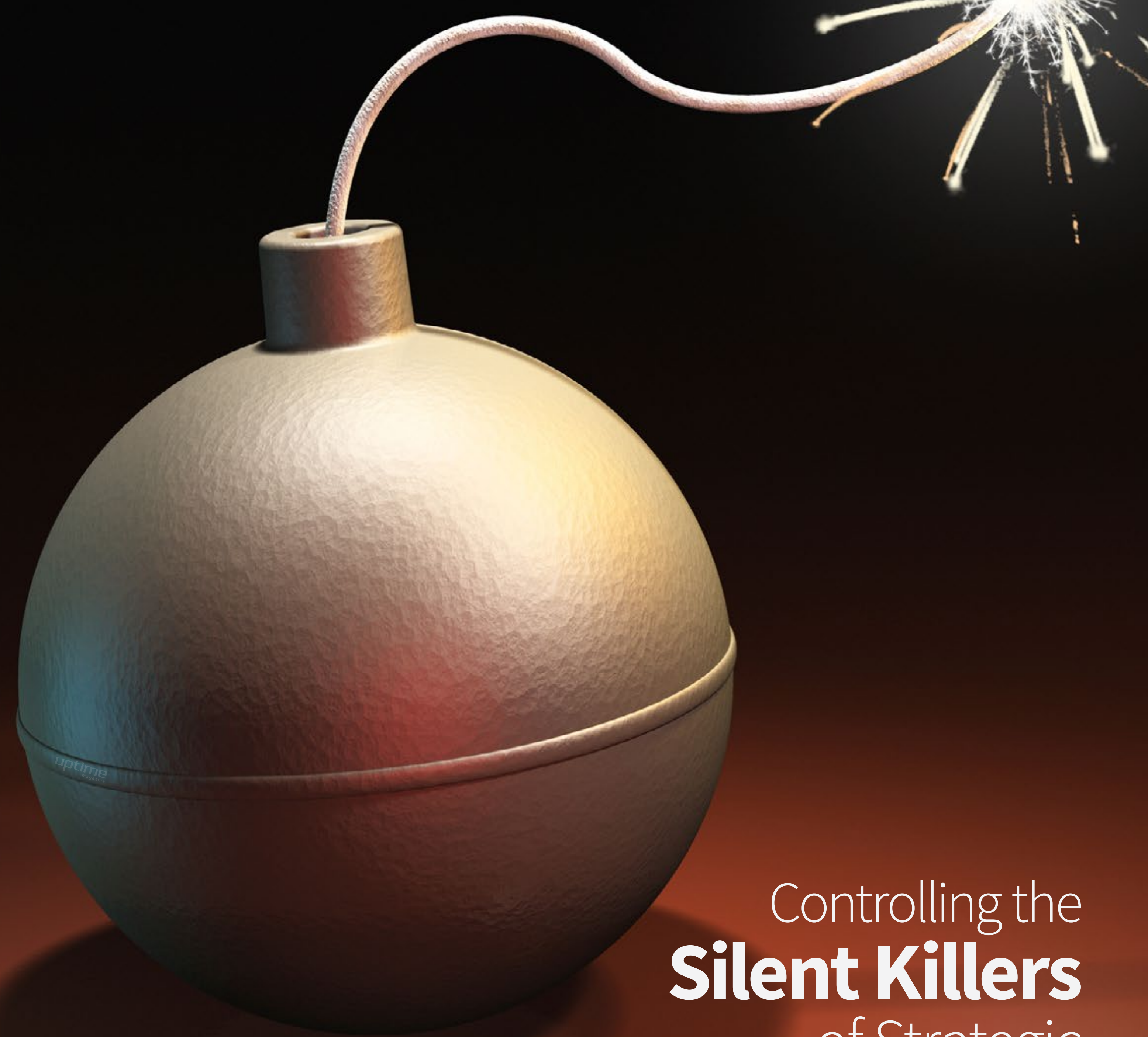

Controlling the **Silent Killers** of Strategic Asset Management

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april/may 2016

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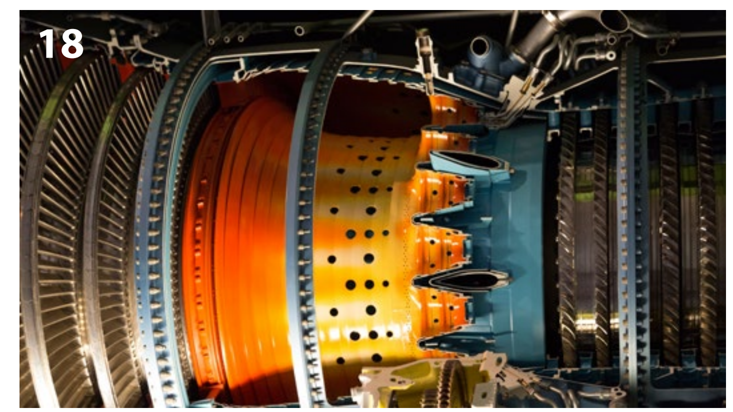

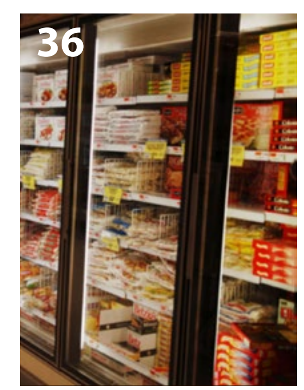

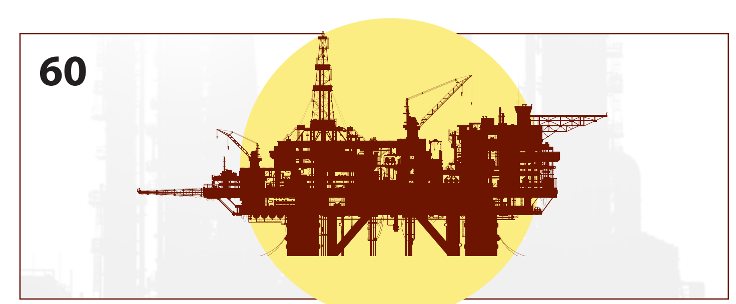

Elements

Editorial

The Defect Elimination Pandora's Box

We all know that planned maintenance is the key to reliability, right?

It must be because I still attend so many maintenance conferences where the bulk of the presentations are about refining planned maintenance in order to improve reliability and asset performance. I see so many software companies that focus on supporting and optimizing planned maintenance as the key to unlocking asset performance. I even see international training companies teaching the secrets of improved planned maintenance in order to learn reliability.

That must be the right path with so many people practicing it, creating software for it and teaching it.

> One of the primary lessons of defect elimination is to eliminate unplannable work, not manage it!

For those who follow my work, you probably know that I am a huge fan of Winston Ledet and the company he founded that created The Manufacturing Game.

I first heard Winston speak at an early RELIABILITY Conference where he presented the findings of a DuPont benchmark study. It explained the various levels of operating domains such as the regressive domain, the reactive domain, the planned domain and the improved precision domain. At the heart of progressing from one domain to the other was the handling of defects, with defect elimination being the primary behavior in the improved precision domain.

I was hooked and began to learn all I could. I became fascinated with the BP Lima case study. Today I am certain that there is still much more I can learn from the special team of people who were on hand for this incredible performance transformation.

Over the years, I have worked with Winston and his team on publishing two great books, *Don't Just Fix It, Improve It (978-0-9825163-1-7)* and *Level 5: Leadership at Work (978-0-9838741-5-7)*, and numerous conference presentations. I have sat through The Manufacturing Game several times and talked to hundreds of people who apply the real lessons on defect elimination.

And now I owe Winston and his team a huge apology. I was so taken with the positive effects I saw from defect elimination, I decided to add it as a foundational element of the Uptime Elements: A Reliability Framework for Asset Performance.

The Uptime Elements Framework is communicated often and used around the world by over 1,000 organizations. As a result, the importance and attention of each individual element has been amplified. What was once a comfortable niche of defect elimination has become more like McDefect Elimination approaches, like the way so many fast food restaurants turned a freshly cooked 100% beef patty from an old drive-in or diner into a grey, slushy substance that bears little resemblance to the original. *Fast? Yes. Easy? Yes. Defect elimination? No.* That is why I must apologize, for I feel semi-responsible for unleashing a monster of sorts.

Defect elimination is not about doing better planned maintenance. One of the primary lessons of defect elimination is to eliminate unplannable work, not manage it!

I am afraid that by adding defect elimination to the Uptime Elements, we have opened the defect elimination Pandora's Box with people using the term but not delivering the goods.

We are now working with Winston's daughter, Michelle Ledet Henley, to refine a defect elimination exercise to deliver the original defect elimination team concepts to a wider audience in a shorter time. In my opinion, Michelle is capable of taking defect elimination to an entirely new level, and we are encouraging her at every opportunity. We want to see more defect elimination books, too! (No pressure, Michelle–in your spare time!)

All I can do in the short space offered to me here is to warn you that if someone is offering defect elimination that has an objective of better planned maintenance, please pause.

Defect elimination removes unplannable work and defect elimination is a powerful tool to create a reliability culture.

Defect elimination is not about improving planned maintenance.

Warmest regards,

Terrence O'Hanlon

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Leadership for Reliability

RELIABILITY® IN THE NEWS

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Certified Reliability Leader Is on the Road

The Certified Reliability Leader training and exam has been on the road for the first quarter of 2016!

Events included:

- Las Vegas, NV - IBM
- Knoxville, TN - MARCON
- Marysville, OH - Honda North America
- Orlando, FL - ARC Conference
- Phoenix, AZ - Central Arizona Project
- Fort Myers, FL - Reliability Leadership Institute
- Philadelphia, PA - Penn State
- Lima, Peru - Duke Energy
- Alpharetta, GA - Siemens

WIRAM Women in Reliability and Asset Management

Women in Reliability and Asset Management (WIRAM) held their second meet-and-greet at OWAM Oracle in Phoenix, Arizona on March 2. The event was attended by many of the great female leaders in the industry.

The next meeting will take place at The RELIABILITY Conference, April 11 at 7pm, at South Point Hotel and Casino in Las Vegas, Nevada. For more information, visit:

www.maintenance.org/pages/wiram

The RELIABILITY Conference KEYNOTE

A special presentation will be given by Dr. Joyce Orsini, Fordham University Professor and author of *The Essential Deming: Leadership Principles from the Father of Quality*. Get a sneak peek and check out *Uptime* magazine's one-on-one interview with Dr. Orsini! **See Q&A on page 62.**

2016 Upcoming Certified Reliability Leader Events

CRL Workshop and Exam

April 7
Reliable Plant
Louisville, KY

April 11-15
The RELIABILITY Conference
Las Vegas, NV

May 9-13
Uptime Elements
Fort Myers, FL

June 20-24
Uptime Elements
Fort Myers, FL

September 12-16
Uptime Elements
Fort Myers, FL

October 10-14
Uptime Elements
Fort Myers, FL

December 12-16
IMC-2016
Bonita Springs, FL

Congratulations to the newest CERTIFIED RELIABILITY LEADERS!

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Bentley Canada, Inc.
Abel Assefa
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ARMS Reliability
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Pennsylvania State University

Maintenance TIPS

Struggling on Starting or Continuing Your Journey to Reliability?

Don't let circumstances and self-doubt stop you. Overcome self-doubt by:

1. Surrounding yourself with and spending time with people that support your efforts. You become the average of the people you surround yourself with.
2. Not making excuses
3. Becoming self-aware. You can learn anything.
4. Trusting your values
5. Stopping the need for constant approval or validation

Much of what inhibits you is based in your mind, driven by emotion. The journey of one thousand miles starts with a single step. Go make something happen.

Need help getting on the Journey to Reliability? Check out our award winning Maintenance and Reliability for Managers 4-part series at:

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How to Maximize Profits with Proper Machinery Alignment

It's a cruel reality, but in a business-minded world companies are concerned with only one topic: PROFIT. And there are two ways to go about maximizing profits: Either increase the number of sales or decrease the total costs.

One way to reduce costs is proper machinery alignment. Good alignment allows machines to run more efficiently, consuming less power and increasing output. Power loss (or power savings) is only a 'small piece of the saving pie.' However, it will always be significant. For instance, a 30 kilowatt per hour reduction in power consumption on a large compressor train at $0.06 per kwh can save you up to $15,768.00 in electricity per year.

Precision alignment pays by reducing operating cost, downtime costs, improving machine reliability, and increasing uptime and profits.

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68% of Pump Bearing Failures Are Caused by Lubrication Related Issues

Did you know that as many as 68% of pump bearing failures are caused by lubrication related issues that could be easily prevented by maintaining correct oil level?

Incorrect oil level is one of the most common causes of bearing failures in critical ANSI or API pumps. Oil level can be easily monitored using an oil sight glass, but standard flat sight glasses become stained over time making it difficult to accurately check the oil level. A 3-D sight glass that extends out, away from the machinery should be used. This window allows the oil level to be observed from any angle.

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How Deep Do You Have to Go with RCM Analysis?

RCM facilitators sometimes struggle with the concept of different levels of analysis. Let's look at it this way - you only need to analyse to the level of depth that will enable your analysis team to arrive at a decision that can manage that single failure mode. Just to make it a little more complicated it also depends on the criticality of the system being analyzed.

For example, analyzing the failure mode "printed circuit board fails" can be perfectly valid, as when that circuit board fails, it is simply replaced with a new one.

It could also be valid to analyze down to the level where an individual diode failure is identified. Perhaps this is part of a military system where mission failure could have catastrophic effects.

The thing to understand is that if you start analyzing every diode on a circuit board you will be analyzing for a very, very long time. If the end result of that diode failure is 10 minutes of downtime which does not lead to a loss of production, unacceptable safety or environmental risks, there is no need to analyze down to the component level when the result will be "replace the circuit board."

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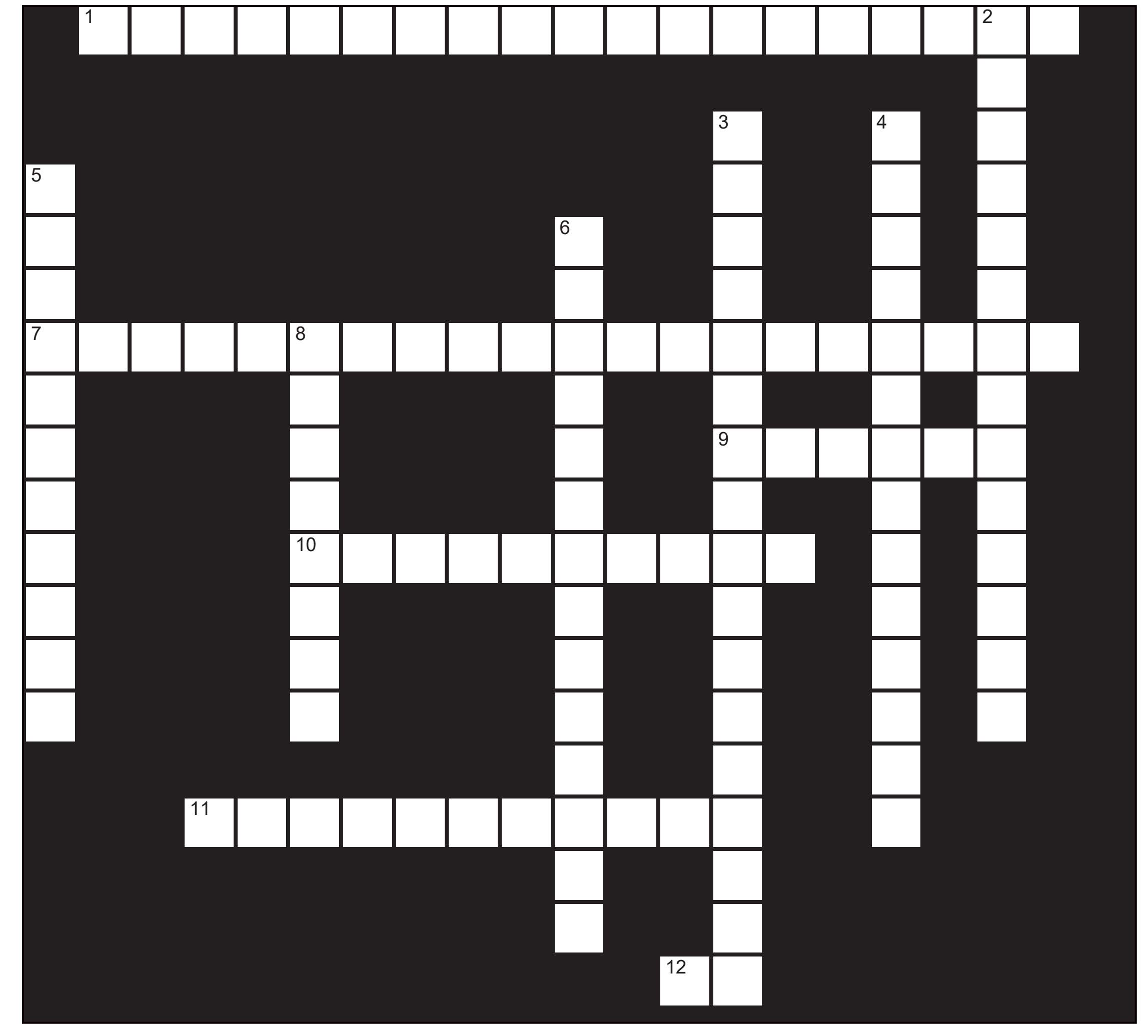
Crossword Puzzle

Created by Ramesh Gulati



ACROSS

1 Documented information that specifies the activities, resources and timescales required for assets to achieve management objectives

7 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

9 The inverse of downtime

10 A person or group of people who have the total responsibility for the operation and maintenance of asset(s), including capital improvements

11 A ranking of assets according to potential operational impact

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

DOWN

2 The fitness of an asset to perform its intended function effectively and efficiently without being degraded while protecting health, safety and the environment

3 A methodology that leads to the discovery of the basic cause of a problem

4 Stages or phases involved in the management of an asset during its life

5 A predictive technology used to determine the quality of the lubricant oil and/or condition of equipment being lubricated

6 Assets within the scope of the asset management system

8 A predictive technology that detects thermal energy emitted from an object and displays an image of temperature distribution

See page 64 for answers.

Controlling the SILENT KILLERS of Strategic Asset Management

by Grahame Fogel and Johann Stimie

This is the last installment of a two-part article that forms the basis of PhD research into the factors that prevent successful execution of asset management strategic initiatives.

Recognition among organizational stakeholders that asset management (AM) is important and requires an integrated and strategic focus is indeed a significant development. However, the mere fact that organizations have a strategic intent does not automatically lead to the achievement of strategic objectives. Asset management practitioners are faced with exactly the same strategy execution challenges as their counterparts in the rest of the business.

The ability of organizations to successfully execute their most important strategic intent is increasingly becoming a key differentiator. Part 1 of this article (*Uptime* December/January 2016) introduced the asset management strategy execution enforcement mechanism (AMSEEM), as shown in Figure 1, a practical mechanism that should become part of an organization's standard operating procedures and DNA.

Part 2 demonstrates the practical operationalization of each of these processes, with reference to an actual AMSEEM implementation within the context of a very large chemical processing plant.

The engineering manager at one of the world's largest precious metal concentrators was approached during June 2015. After AMSEEM's purpose was explained, he immediately expressed interest in using the mechanism.

In accordance with the research agreement between Stellenbosch University and the concentrator, the identities of the business units and critical stakeholders will not be revealed.

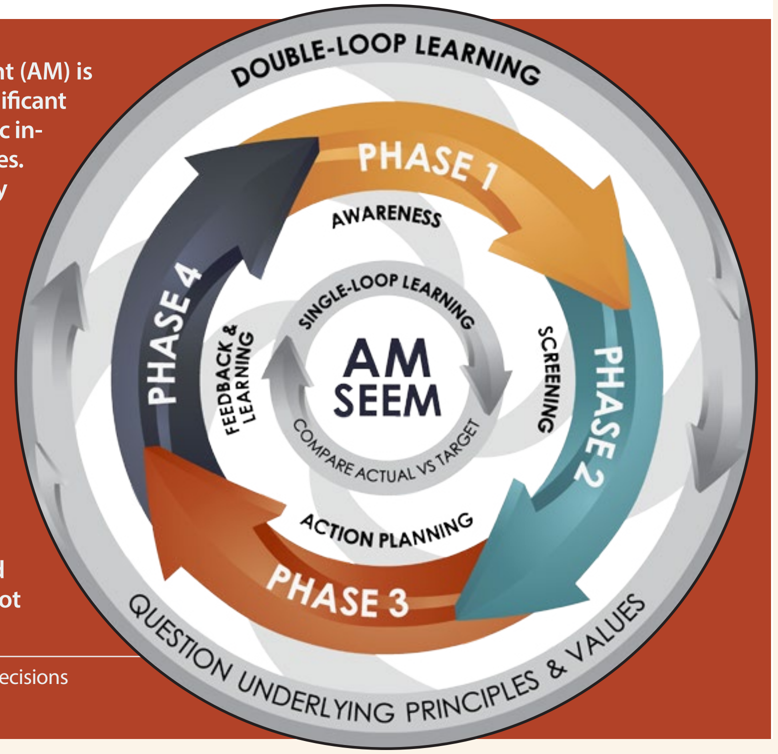


Figure 1: AMSEEM is a double-loop feedback system comprised of four iterative phases, four major decisions and several implementation processes or steps

PHASE 1

AWARENESS AND ACCEPTANCE

The concept of awareness has been used for hundreds of years by many contributors within a range of performance environments. But when it comes to asset management strategy execution failure (AMSEF), executives within organizations often deny its possibility and, even in those environments where progressive managers contemplate the possibility of AMSEF, very few mechanisms existed until now that could assist them in early identification of the presence of those factors that ultimately lead to AMSEF.

For organizations, some form of "catalyst for change" is normally required to spark them into action. In the case of an asset management organization, the catalyst for change may be a near miss, the failure of a critical piece of equipment, or a total catastrophe.

Operationalization of Phase 1: Awareness and Acceptance

The decision to initiate a risk identification and optimization process was already made by senior executives within the organization before embarking upon the intervention. The catalyst for change in this instance was a suboptimal AM performance and pressure from the central organizational structures.

AMSEEM recommends the completion of a number of action steps during Phase 1. The operationalization of each of these steps for the precious metal concentrator are:

STEP 1 – Constitute a Steering Committee

After consulting with the concentrator manager, the engineering manager and the plant manager, a steering committee was formed. The committee consisted of 18 members representing the most important asset management stakeholder groups: the maintenance manager and a selection of team supervisors, the production manager and a selection of key team supervisors, and a number of planners.

When composing the steering committee, great care was taken to ensure representation across functions and management levels.

STEP 2 – Evaluate Asset Management Strategy (AMS)

In light of the fact that a complete AM assessment took place prior to the operationalization of the AMSEEM, the AMS evaluation was not a requirement at the concentrator. However, regular references to the observations noted in the AM assessment report were made.

STEP 3 – Create a Statement of Direction (SoD)

Based on the observations made during the AM assessment, the steering committee formulated the following SOD:

"The concentrator accepts the reality that a number of factors prevent us from achieving our goals. We realize that far more value can be unlocked from our physical assets if our asset management strategy is well-defined and executed. We are committed to identifying these factors proactively, understand their impact on the organization and on each other, and are prepared to develop action plans to eradicate these factors or to minimize the possible effect they might have during the asset management strategy execution process."

STEP 4 – Introduction of the Generic AMSEEM

During a one-day workshop, the AMSEEM principles and objectives were explained in detail to the steering committee. All aspects and requirements were presented and contextualized.

STEP 5 – Agreement on the Terms of Engagement

The steering committee formulated these terms of engagement:

Mandate of the Steering Committee

The steering committee will have access to all information required to complete the screening phases. During the screening process, the steering committee may nominate representatives to gather information on its behalf. In the event any dispute arises regarding the sensitivity of any information, the matter will be referred back to the steering committee, which is authorized to access the information.

The screening team will have access to all relevant staff members and can set up meetings with them when required during the screening period.

Meeting Intervals

The steering committee will meet on a weekly basis during the screening period. Thereafter, the steering committee will meet either when reports are presented or decisions regarding progress or significant process changes need to be taken.

Delegation of Authority

The steering committee can delegate authority to relevant staff members or contractors to assist it during the course of the AMSEEM operationalization.

STEP 6 – Develop the AMSEEM Calendar

After agreement was reached regarding the research mandate and scope, a research project plan was developed. An abridged version of the agreed upon project plan is provided later in this article. However, presenting the detailed AMSEEM operationalization calendar falls outside the scope of this article.

STEP 7 – Develop a Stakeholder Communications Campaign

The steering committee considered the principles of internal marketing during the development of the communications campaign. The committee not only considered the themes it wanted to communicate, but also the stakeholder groups or market segments, as well as the use of the most appropriate communications media.

Impact and Effectiveness of the Process and Artifacts

Awareness in itself plays a critical role in prevention. During conversations with 14 of the 18 steering committee members, as well as e-mail correspondence entered into after the completion of the study, it was confirmed that awareness levels regarding the potential impact AMSEF could have on the sustainability of the concentrator increased significantly as a result of both the AM assessment and the AMSEEM operationalization.

Figure 2: Factors that cause AMSEF

PHASE 2

SCREENING AND DETECTION

Screening for AMSEF has three prerequisites:

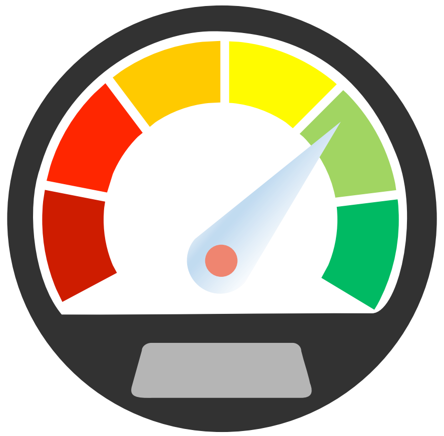
1. *Thorough understanding of the factors that cause AMSEF.* These factors are illustrated in Figure 2. The categorization of factors is not an attempt to illustrate possible causal relationships that might exist among the deadly defect factors (DDFs), but rather to assist users during the administration of the mechanism and enable improved communications and feedback regarding AMSEEM.
2. An instrument to screen for these factors. For the purpose of screening, a scorecard was developed to evaluate all causal factors in an integrated way. An example of a completed scorecard is presented in Table 1.
3. A reporting mechanism that AM practitioners can use to interpret and screen the results. A generic interpretation guideline is presented in Figure 3.

Table 1 – Completed AMSEEM Scorecard

Deadly Detect Factor	FW	TPC	IPS	MAS	PS	TFS	TFS%
Quality of Direction							
Strategy Formulation	20%	3.00	2	2	2	1.2	40%
Executors of Strategy	10%	1.50	4	3	2	0.9	60%
Quality of Design							
Organizational Design	15%	2.25	3	2	2	1.05	46%
Interdepartmental Relations	5%	0.75	4	3	2	0.45	60%
Management Control Systems	5%	0.75	3	2	2	0.35	46%
PAM Systems, Processes and Practices	20%	3.00	3	3	2	1.6	53%
Quality of Interpersonal Processes							
Communication	15%	2.25	3	2	2	1.05	46%
Change Management	2.5%	0.37	4	4	4	0.2	80%
Consensus and Priorities	2.5%	0.37	4	4	4	0.2	80%
Commitment	5%	0.75	3	3	3	0.45	60%
Totals	**100%**	**15**				**7.45%**	**49.6%**

PHASE 2 (Continued)

Figure 3: Interpretation guideline



01 0% - 50% Immediate action is required irrespective of the relative importance of the DDF.

02 51% -60% Immediate action is required if the DDF carries a weight of more than 15%. If the DDF carriers a weight of less than 15% the DDF should however still be closely monitored and is at all practical evaluated at least every three months.

03 61% - 70% No immediate action is required except if this is the lowest scoring DDF, and the organization has resources available. The DDF should however be closely monitored and evaluated at least every six to twelve months.

04 71% - 80% No immediate action is required. Should be evaluated on an annual basis.

05 81% - 90% No immediate action is required, and an indication of a very healthy state of affairs.

06 91% plus No immediate action is required, and an indication of a very healthy state of affairs. Should be used as a benchmark and the conditions contributing to the score should be evaluated, to ensure repeatability.

Operationalization of Phase 2: Screening and Detection

This section describes the implementation steps, as well as the artifacts, used during operationalization of Phase 2 of AMSEEM.

STEP 1 – Introduction and Contextualization of the Screening Scorecard

The generic screening scorecard was introduced to the steering committee. After deliberation and with full cognizance of the observations made during the AM assessment, the composition of the screening scorecard was finalized. The DDFs were weighted and the total possible contribution (TPC) of each factor calculated. It was agreed to utilize multivariate assessment criteria as part of the scorecard, with the steering committee deciding to use these three multivariate assessment topography (MAT) dimensions:

- **In place** – The availability and quality of strategies, policies, procedures and action plans;
- **Maturity** – Organizational awareness and understanding of available strategies, policies, procedures and action plans;
- **Performance** – The perception of key stakeholders regarding the extent to which goals and objectives are achieved.

In addition, it was agreed to use a five level Likert scale during the evaluation of various AMSEF causal factors. It was agreed that the five levels should have these descriptions:

1. Strongly disagree;
2. Disagree;
3. Neither agree nor disagree;
4. Agree;
5. Strongly agree.

STEP 2 – Data Gathering

During the AM assessment phase, the research team collected critical information. As the team applied the principles of triangulation, it was required to not only rely on information gathered during interviews and document evaluations, but to physically observe engineering and operational practices and processes. The observations were made during all shifts, including over weekends.

Inductive reasoning was followed in the analysis of the collected data. Attempts were made to discover key issues, recurrent issues, patterns and relationships through close scrutiny of the data. Data was analyzed and interpreted by means of inductive abstraction and generalization.

STEP 3 – Scorecard Completion and Score Calculation

In light of all available information, the steering committee completed the screening scorecard during a two-day workshop. The workshop was facilitated by the research team and all decisions were taken through consensus. The completed scorecard is presented in Table 1.

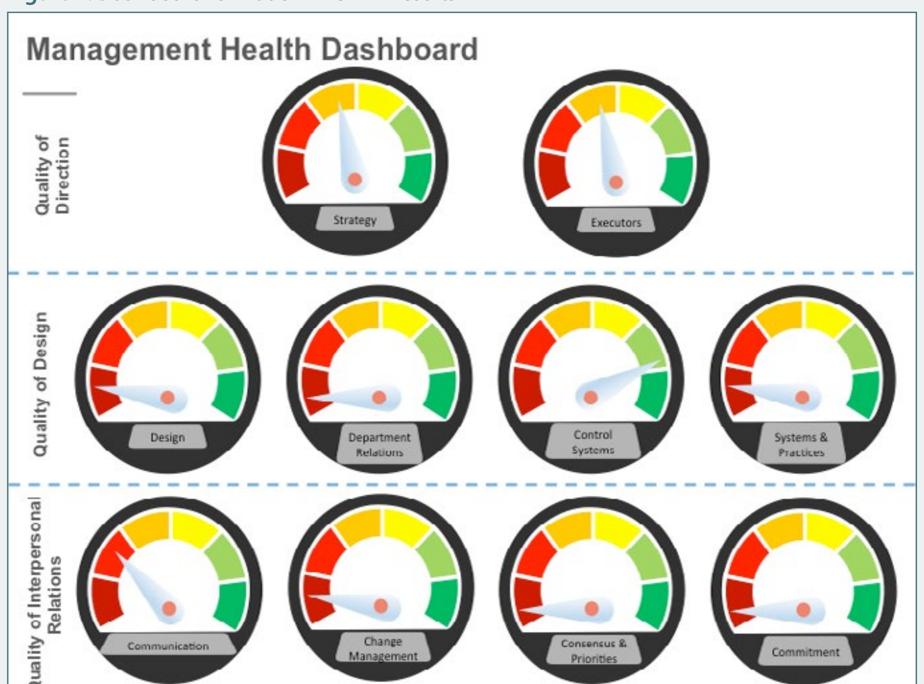
STEP 4: Interpret and Present the Results

After completion of the AMSEEM screening report, it was presented to various stakeholder groups. The aim of the feedback sessions was not only to provide feedback, but to extract information from stakeholders that was used during the development of action plans.

Focus group principles were applied to ensure optimal stakeholder participation. In addition, joint problem-solving was applied to ensure solutions for the presented problems were found in the most effective way. Thus, these sessions were treated as both an important group learning moment and an opportunity to tap into the tacit knowledge base that exists within the organization.

In an attempt to facilitate easier interpretation and communications, the results were also presented in a dashboard format, as illustrated in Figure 4. The generic interpretation guideline presented in Figure 3 was used during the interpretation of the results.

Figure 4: Dashboard format of AMSEEM results



PHASE 3

Action Planning

Phase 3 of AMSEEM is action planning. Based on the interpretation and recommendations made in the AMSEF DDF report, the organization had to develop and prioritize a number of action plans. A detailed presentation of these action plans falls outside the scope of this article. Suffice to note are the principles and guidelines the steering committee considered during the development of the action plans.

The Organization's Readiness to Change

AM practitioners need to understand and be cognizant of organizational stakeholders' readiness to change when action plans are being developed. Change readiness assessments identify possible barriers, enablers and risks, which, in turn, help identify where to focus change implementation activities and resources.

Stakeholder Demographics

AM practitioners should consider stakeholder demographics during the development of action plans. Stakeholder diversity often complicates action plan implementation, so practitioners should be aware of and consider this reality during the conception plans.

Action Plan Complexity

In line with observations regarding change readiness and stakeholder demographics, AM practitioners should also be cognizant of the importance of simplicity during the development of action plans. Highly complex plans have a far lower probability of being successfully implemented, especially within the context of a diverse group of stakeholders.

Quality of Interpersonal Relationships

Action plans have a far higher probability of succeeding if the relationship between managers and non-managers is sound. Unhealthy relationships are characterized by mistrust and suspicion, which complicates the implementation of action plans.

Change Management Campaign

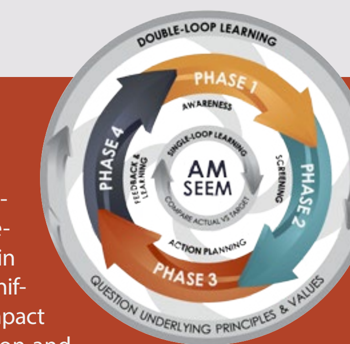
In line with observations regarding action plan complexity, an understanding and acceptance of the action plan's intention and purpose are critical prerequisites for effective organizational change to take place. Traditionally, organizations' communications efforts only create awareness, so AM practitioners should investigate and utilize appropriate and creative communication methods to ensure understanding and acceptance of the action plan's intentions.

PHASE 4

Learning and Feedback

The final, yet ongoing and iterative, phase of AMSEEM is learning and feedback. Although this phase is presented as the fourth step in a series of activities, it should not be construed as such. Feedback and learning is a continuous process and within the context of the contemporary organization, the AMSEEM steering committee of the concentrator was encouraged to be continuously vigilant in the identification of signs that might indicate or require not only a change of plans, but a fundamental rethink of the underlying objectives and principles.

Thus, AMSEEM embraces the principles of double-loop learning and dialogue. The process requires stakeholders to continuously engage in dialogue, not only on results being achieved or not, but on understanding the fundamental principles and values that lead to the formulation of the AMS in the first place. Only when an organization has acquired the discipline of double-loop learning and the skill to engage in continuous dialogue will effective strategy feedback and learning, and ultimately strategy execution, be possible.



CONCLUSION

The contribution and impact the mechanism made to ensure increased awareness of the factors causing AMSEF within the context of the concentrator was significant. Likewise, the contribution and impact the mechanism had on early detection and management of a possible AMSEF have clearly been confirmed. It would be impossible to express any validated opinion on the impact and effectiveness of action plans that were not fully implemented at the time of writing this article. The action planning process, however, was deployed in such a manner that stakeholder consensus and commitment were already confirmed during the formulation and prioritization of action plans. The action planning process in itself addressed a number of fundamental factors contributing to AMSEF, such as the lack of consensus, commitment and interdepartmental conflict.

Overall, the operationalization of AMSEEM made a significant contribution to the creation of a learning organization. AMSEEM is a logical tool, and when the steps described in this article are followed closely by practitioners, could contribute significantly to asset management strategy execution success.

Special Acknowledgement:

The authors wish to recognize Professor PJ Vlok, who formed the basis of the research referenced in this article. Professor Vlok is a mechanical engineer, with a PhD in Industrial Engineering and is the Director of Industrial Services at RDI Technologies and Adjunct Associate Professor at the University of Tennessee.

Grahame Fogel *is the Director of Gaussian Engineering and an Asset Management Consultant covering 25 years around the world. Mr. Fogel has been associated with many of the world's most recognized benchmark programs and was on the forefront for implementing PAS-55. He has a depth of experience in the power, pharmaceutical, mining and chemical process industries.* www.gauseng.com

Johann Stimie *has recently completed a PhD in Industrial Engineering at the University of Stellenbosch. Johann is an experienced strategy consultant and part of Gaussian Engineering. Johann has a specific interest in Strategy Control and Strategy Execution.* www.gauseng.com

RCM: On-Condition Task Interval Determination

by Gary West

***Author's Note:** While putting the finishing touches on this article, I happened upon Bill Berneski's Dec10/Jan11 Uptime article, "Deriving Task Periodicities within Reliability-Centered Maintenance." Mr. Berneski's article discussed mathematical formulae that could be used to compute intervals for scheduled restoration/discard, on-condition and failure finding tasks. The intent of this article is to strengthen the case for using a mathematical approach to derive the on-condition task interval for higher risk (or cost) failure modes. This mathematical method addresses the risk directly, by way of the reliability-centered maintenance (RCM) methodology, to assist organizations in meeting ISO310000 objectives for managing their assets.*

The highly structured RCM process is a proven approach for determining what must be done to any physical asset to ensure it continues to do what you want it to do in the present operating context. The first step of the task selection process starts by assessing the effects of the failure mode and classifying them into one of four broad categories of consequences. The next step identifies a proactive task that reduces the consequences of failure to the extent that it is technically feasible. The criteria used to judge whether an on-condition maintenance task is technically feasible are fairly consistent across the various compliant RCM processes. Specifically, RCM2™ uses the following yardsticks:

- It is possible to define a clear, potential failure condition.
- The P-F interval is reasonably consistent.
- It is practical to monitor the item at intervals less than the P-F interval.
- The net P-F interval is long enough to be of some use.

On-condition task intervals are based on the expected P-F interval. (See Section 7.7 in the book, *Reliability-Centered Maintenance II*, by John Moubray if you're having difficulty in determining a P-F interval in the absence of empirical data. Mr. Moubray suggests a "rational approach" method for estimating P-F intervals on the basis of judgment and experience.) In order to detect the potential failure before it becomes a functional failure, the task frequency must be less than the P-F interval. Conventional RCM wisdom suggests that it is usually sufficient to select a task interval equal to half of the P-F interval.

So the questions are:

What might represent an "unusual" situation when the one half P-F interval guidance does not apply?

Should the task periodicity be a smaller fraction of the P-F interval? And if so, how much smaller?

In addressing these questions, one can conclude that adjustments to the task interval should be based on these considerations:

- The actual failure may present a risk to the organization because of safety, environmental, or high operational consequences.
- The specific on-condition task may not identify the onset of failure with a sufficiently high degree of confidence because of some uncertainty or inconsistency with the inspection method.

The Naval Air Systems Command has an RCM program for its in-service aircraft and support equipment. Its *Guidelines for the Naval Aviation Reliability-Centered Maintenance Process*, NAVAIR 00-25-403 manual, states that on-condition task intervals for failure modes related to safety and the environment can be calculated using these two equations:

Equation (1) $I = P\text{-}F/n$

Where: I = inspection interval
P-F = potential failure interval
n = number of inspections in the P-F interval

Assigning an acceptable probability of failure to detect a potential failure yields a second equation that can be used to determine *n*.

Equation (2) $n = \ln(P_{acc})/\ln(1-\theta)$

Where: n = number of inspections in the P-F interval
θ = probability of detecting a potential failure with one occurrence of the proposed on-condition task, assuming the potential failure occurs
P_{acc} = acceptable probability of failure

The basis for using this method and deriving the equations are contained in NAVAIR 00-25-403, Appendix B. It would be a good idea to review the Appendix B, Section 1.2.1 explanation for the on-condition task interval determination methodology. SAE JA1011 states: "Any mathematical and statistical formulae that are used in the application of the process (especially those used to compute the intervals of any tasks) shall be logically supportable, and shall be available to and approved by the owner or user of the asset." Being able to explain the math goes a long way in obtaining owner buy-in of the methodology.

"This mathematical method addresses the risk directly, by way of the reliability-centered maintenance (RCM) methodology..."

Let's examine the NAVAIR equations to better understand how the variables P_{acc} and θ affect the outcome of the on-condition task interval determination by using the following example. Assume you have a structure that is held together with 12 bolts that, by design, are not visible to the operator of the asset during normal operations. If any four of the 12 bolts become completely disassembled, it is thought the structure will collapse, with the possibility of operator death or serious injury. Because of the way the structure is used, the RCM review team decides the P-F interval is two years from the time the first bolt starts to loosen. The asset owner has stated that P_{acc} (the acceptable probability the structure may collapse) in any given year will be assigned a value of 0.00001. (Note: An annual probability of failure of 0.00001 suggests that this failure mode is not reasonably expected to ever occur over a 50 year period.) The proposed on-condition task involves visually assessing if any one of the 12 bolts is loosening. Because identification of the potential failure is dependent on the inspector's judgment, θ will be assigned a value of 0.90 by the RCM review team. The 0.90 value should be considered reasonable for a technique based on the human senses. When you plug the variables into Equations (1) and (2), the resulting inspection interval (I) is 0.4 years.

Because the values assigned to variables used in this analysis (P_{acc}, θ) might be considered somewhat subjective, the group is interested in considering alternate scenarios to see if a reasonable inspection interval can be bounded. With the equations built into a spreadsheet, alternate scenarios are easy to evaluate.

- From the original scenario, increase the probability of detecting potential failure to 0.95 and the resulting inspection interval becomes approximately 0.5 years.
- From the original scenario, change the acceptable probability of failure to 0.0001 and the resulting inspection interval also becomes approximately 0.5 years.

Note that the original assumptions result in an on-condition task interval of one fifth of the P-F interval, not one half. It's also interesting to note that relaxing some of the assumptions, as was done with the alternate scenarios, didn't change the resulting task interval appreciably. Hopefully, this example sufficiently illustrates the point that failure to consider the implications of the functional failure risk and the capability of the inspection in detecting the

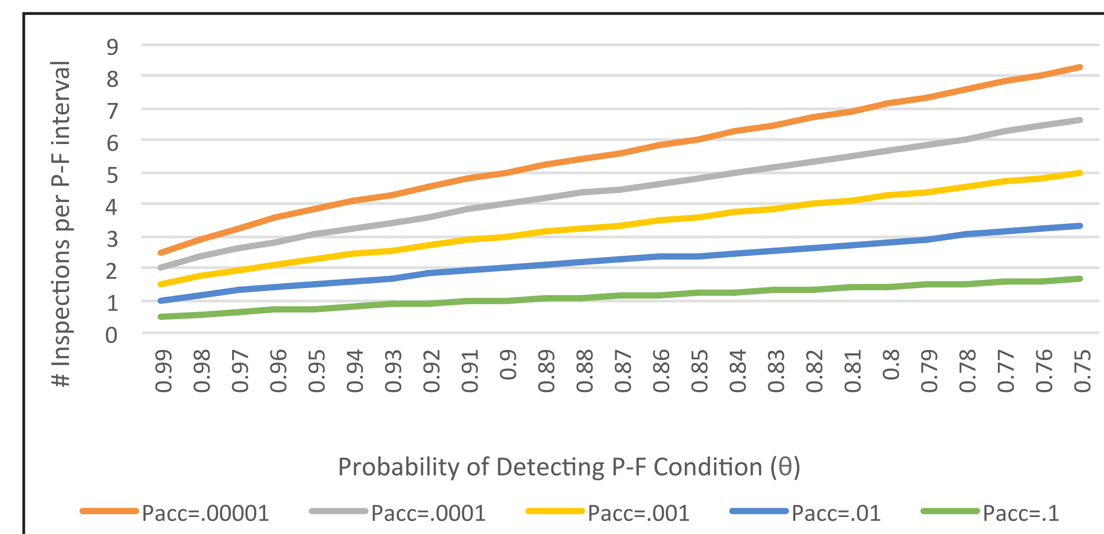


Figure 1: Calculated number of inspections versus probability of detecting the P-F

onset of failure could result in the review team settling on a 12 month task periodicity instead of the more technically defensible five to six months. Use of the equations rigorously account for the risk the failure mode presents to the organization and the effectiveness of the inspection method.

Figure 1 shows relationships between the probability of detecting a potential failure (θ, assuming the P-F condition exists) and the calculated number of inspections in the P-F interval (n), when varying θ and P_{acc}. The purpose of presenting this graph is to help explain some things that may not be instinctive.

Firstly, notice that when the failure mode consequences are relatively benign (P_{acc} =.1), the calculated *n* takes a long time to approach two, or one half the P-F interval. Secondly, when the P_{acc} is .001 or lower, θ becomes a bigger player in the task interval calculation than is probably intuitive to most of us. That's because *n* increases exponentially as θ is incrementally decreased. This exponential relationship becomes much more apparent if you were to continue decreasing θ to 0.50. The graph was not expanded to include θ less than 0.75 because it's hard to imagine that someone would specify an on-condition task that is expected to identify an existing P-F condition with less than 0.75 certainty. Thirdly, observe that none of the lines meet the Y-axis. That's because the equation mathematically falls apart when θ is equal to one. As Mr. Berneski remarks in his *Uptime* article: "Therefore, we cannot calculate a 100 percent confidence in our inspection detecting P-F, which is in agreement with practical experience."

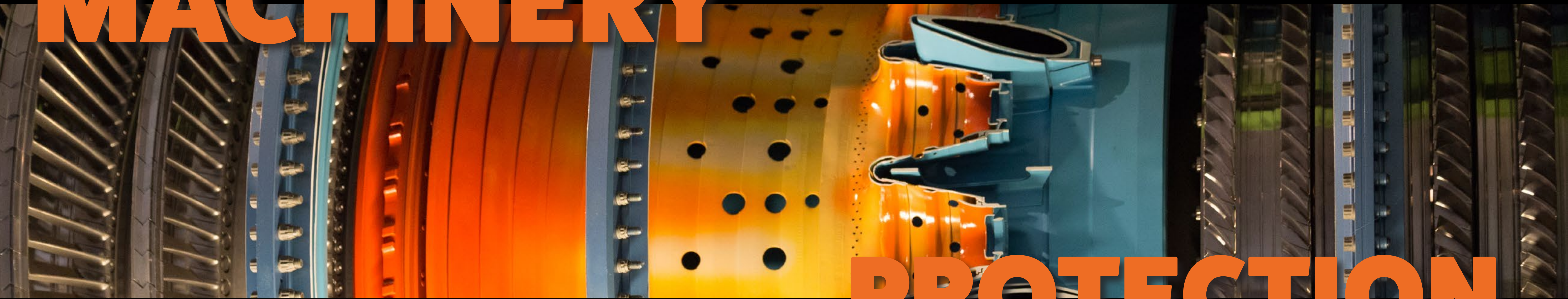
> "Therefore, we cannot calculate a 100 percent confidence in our inspection detecting P-F, which is in agreement with practical experience."

Summary

To detect a potential failure before it becomes a functional failure, the task frequency must be less than the P-F interval. For low-risk failure modes, it is entirely appropriate to select a task interval equal to half of the P-F interval. However, there may be occasions when it is appropriate to select a task interval that is a smaller fraction of the P-F interval. For high stakes failure modes (e.g., safety, environmental and even high impact operations consequences), due consideration of the failure's risk to the organization and the degree of uncertainty in identifying the onset of failure is wise. In those situations, Equations (1) and (2) provide a simple and straightforward methodology using the P-F interval, an acceptable probability of the failure mode and likely probability of detecting the potential failure condition for a risk-based approach in determining defensible, on-condition task intervals.

Gary West is a U.S. Navy submarine veteran. For the past 36 years, he has worked in maintenance of reactor plants, facilities, and spent nuclear fuel handling equipment. He is a graduate of Oregon State University with a Bachelor of Science degree in Mechanical Engineering.

The Role of MACHINERY PROTECTION SYSTEMS



In today's industrial environment, most turbomachinery has permanently installed machinery protection systems that incorporate vibration monitoring instrumentation. These systems typically utilize proximity probes to monitor both radial and thrust events (i.e., relative vibration measurements), case mounted seismic vibration transducers (i.e., absolute vibration measurements) and a shaft speed/phase reference measurement. By incorporating the pre-existing machinery protection systems' available measurement types into a routine vibration analysis program, technicians can determine specific fault types and machine condition based on signal amplitudes, frequency content and phase relationships between machine components. Additionally, these measurements can be acquired for machine commissioning purposes after mechanical repairs/inspections and utilized for machinery diagnostics with the use of multi-channel transient vibration analysis techniques.

By Allen Bailey

CASE ANALYSIS

In February 2008, a vibration analysis program for condition monitoring purposes was introduced at a cogeneration facility. This small facility consisted of only one gas turbine and generator assembly with associated support equipment. Discussions about which equipment should be included in the monthly vibration analysis program initially focused on just the support equipment since the gas turbine/generator had a machinery protection system "monitoring" its vibration amplitudes continuously. After some debate, it was finally decided that collecting the vibration data from the gas turbine and generator assembly with route-based analysis tools would not add to the monthly program cost. As such, it was incorporated into the facility's monthly vibration services.

The machine train consisted of a GE Frame 7EA gas turbine with three oil film bearings directly coupled to a GE 91 MW generator (60 Hz) assembly with two oil film bearings. The facility was using a gas turbine control system and a proximity transducer sensor system as part of its machinery protection system. These systems allowed for routine collection of the turbine's thrust via proximity probes, radial vibration via X and Y orthogonal proximity probes, machine speed/phase reference via a keyphasor and absolute vibration measurements via case mounted accelerometers.

Vibration analysis data collected through the beginning of September 2011 showed no significant changes, with no notable repair items isolated. As part of the machine's preventative maintenance schedule, a major inspection was started mid-September 2011. This procedure included the removal of the machine's rotors and all bearing components for detailed inspections. After these inspections were completed, the machine was reassembled and put back into full operation at the end of December 2011. During the machine's start-up, it was apparent to the vibration analysis group that there was a major difference in the #2 turbine bearing's vibration amplitudes even though the machinery protection system did not have any ***alert*** or ***alarm*** event notifications.

The machinery protection system was set up to ***alert*** the user of vibration levels over 2.5 mils pk-pk and be in an ***alarm*** state if amplitudes were above 3 mils pk-pk. The historical vibration data showed amplitudes at this bearing position averaging .685 mils pk-pk, with an increase to 1.515 mils pk-pk after being put back into service in December 2011.

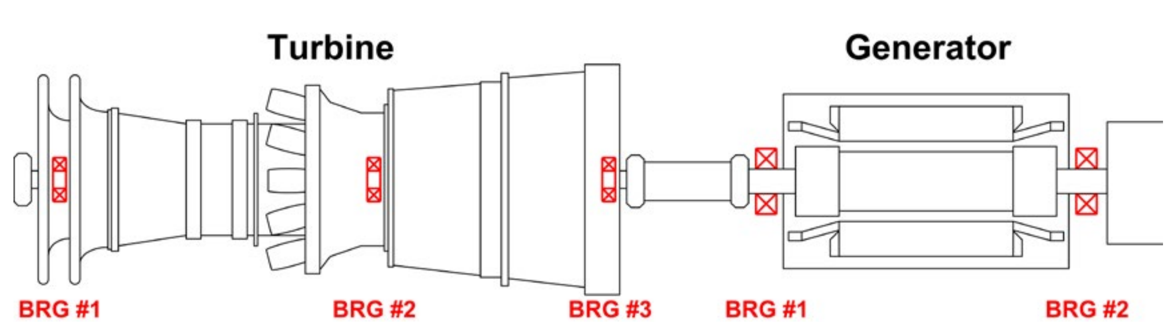


Figure 1: Gas turbine / generator top view

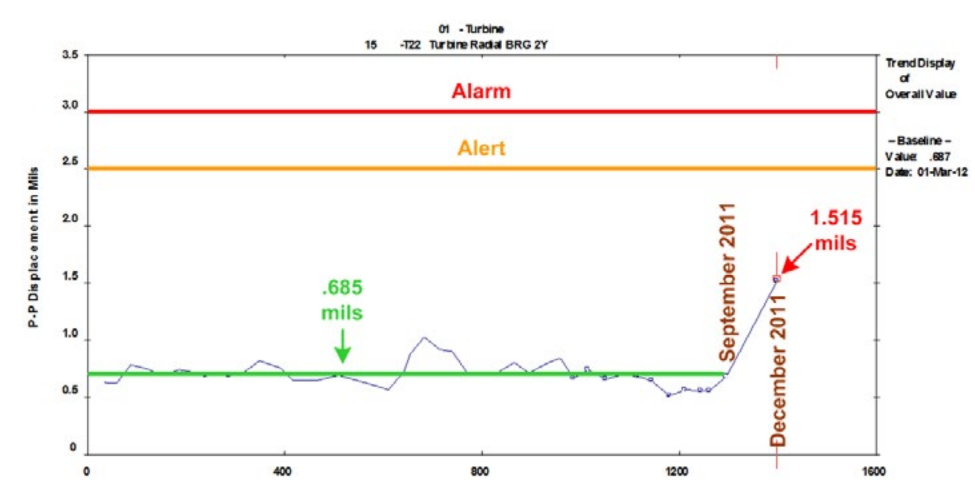


Figure 2: Condition monitoring data, turbine bearing 2

By reviewing the machine's archived data snapshots, technicians were able to produce orbit-based animations for comparative operating deflection shape (ODS) analysis that included all the radial proximity probe data. These comparisons allowed for common scaling of all the bearing positions monitored, resulting in a visual representation of the turbine and generator shaft vibration amplitudes and phase relationships. This ODS analysis clearly showed the #2 turbine bearing's relative increase in amplitude after the September 2011 major inspection and also indicated a phase relationship change across the turbine shaft.

As part of the predictive maintenance program's guidelines for this facility, multi-channel transient vibration data was collected on this machine train during start-ups after all major or minor inspections. This data was used as a secondary check to determine the relative phase relationship shifts between the turbine shaft bearing positions. The data was normalized to only include the 60 Hz frequency for waveform analysis of the proximity probe data. This analysis showed that prior to the September 2011 major inspection, the turbine shaft measurements were found to be in phase with each other, with significant changes observed in relative phase after the inspection.

The final analysis of the system's newly established vibration amplitudes, frequency distribution and phase reference data indicated the turbine shaft's bearing alignment was not within specification after the September 2011 major inspection. This information was relayed to plant maintenance and operations personnel for consideration. An internal review of the turbine's bearing inspection showed that the #2 turbine bearing housing was "adjusted" by the contractor who provided the major inspection services for the facility's outage. This adjustment to the bearing housing's horizontal position was isolated as the root cause for the increase in vibration amplitudes and phase changes noted for the machine after the September 2011 inspection.

Due to the facility's projected run schedule and customer demand, it was determined that the machine's vibration amplitudes and signature shifts could not warrant a system shutdown to incorporate the repairs necessary for returning the turbine's bearing alignments back to within specification. By catching and isolating the cause for increased vibration levels in the #2 turbine bearing after the facility's initial start-up, the plant's reliability and maintenance departments were able to make accommodations for performing a precision bore alignment through the entire machine train at the next scheduled major inspection, which has a six to seven year periodicity.

Currently, this machine is still operating below all machinery protection system ***alert*** and ***alarm*** levels, but is experiencing a slow increase in turbine #2's bearing vibration amplitudes. The ongoing monitoring of this machine (e.g., machinery protection system, route-based vibration analysis and multi-channel transient vibration testing) will be used to track the defect's severity over time to ultimately aid in determining if the next major inspection should be moved up to avoid a catastrophic failure of the turbine.

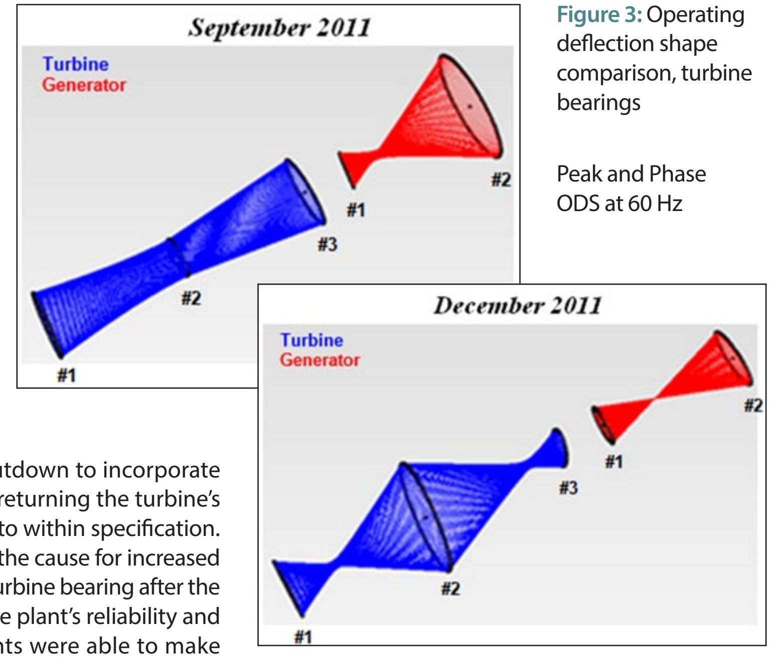


Figure 3: Operating deflection shape comparison, turbine bearings

Peak and Phase ODS at 60 Hz

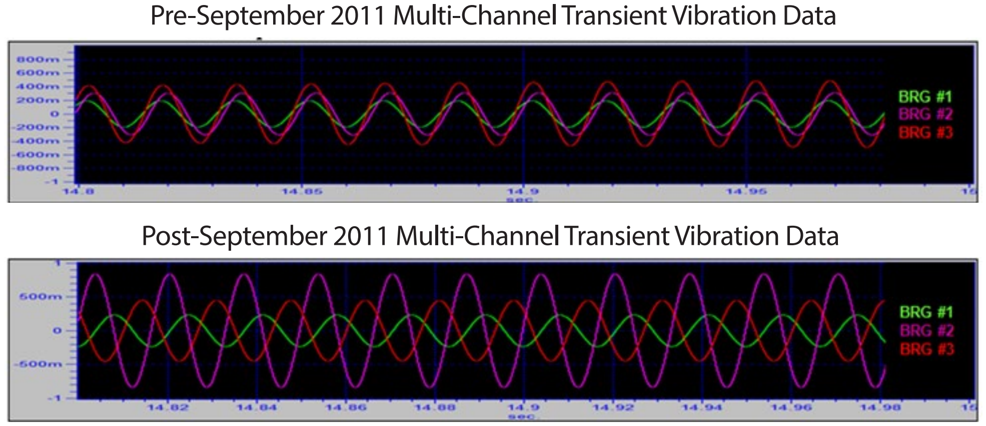


Figure 4: Time synchronous data, turbine bearings

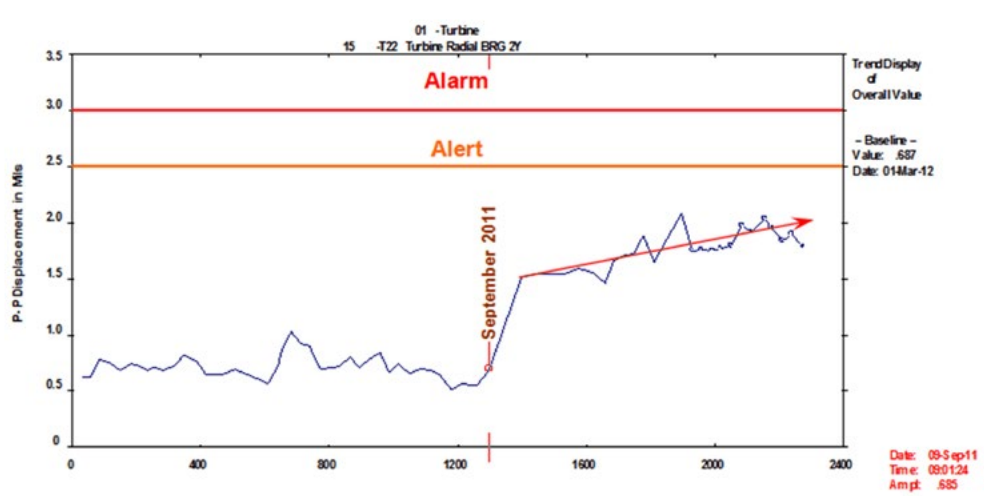
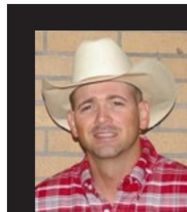


Figure 5: Condition monitoring data, turbine bearing 2

CONCLUSION

Machinery protection systems offer much needed protection for today's turbomachinery by aiding in automatic machine shutdowns or providing plant operations with feedback on events occurring at the machine level that require immediate attention. However, these systems are not typically suitable as a sole means for predictive maintenance on a machine with regards to its reliability. Ideally, these machines need to have routine vibration analysis data collected on them by competent technicians who can detect faults in the system prior to events becoming detrimental to a machine's health or affecting its reliability.



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Bristol-Myers Squibb Journey

Part 1

Initial Implementation and Prioritizing of Uptime Elements

(Dec/Jan 2016 p. 30)

Part 2

Aligning a Framework Within Our Sites

(Feb/Mar 2016 p. 26)

Part 3

The Central Team's Effort Aligned to Our Strategy

Part 4

Journey to 200 CRLs

A Journey to Shape Reliability Excellence at Bristol-Myers Squibb

by George Williams and Robert Bishop

This installment shows how the Bristol-Myers Squibb Company (BMS) aligned its central efforts with the reliability strategy. It continues the journey from Part 1 in *Uptime's* December/January 2016 issue describing the initial implementation of Uptime Elements at BMS and Part 2 in *Uptime's* February/March 2016 issue demonstrating how the sites began to adopt and utilize Uptime Elements as a communication tool to set strategy and align reliability efforts with their specific site goals. This seemingly hands-off approach helped to create an organic culture with a sense of ownership for the sites while still maintaining a consistent approach globally.

The Central Team's Effort Aligned to Our Strategy

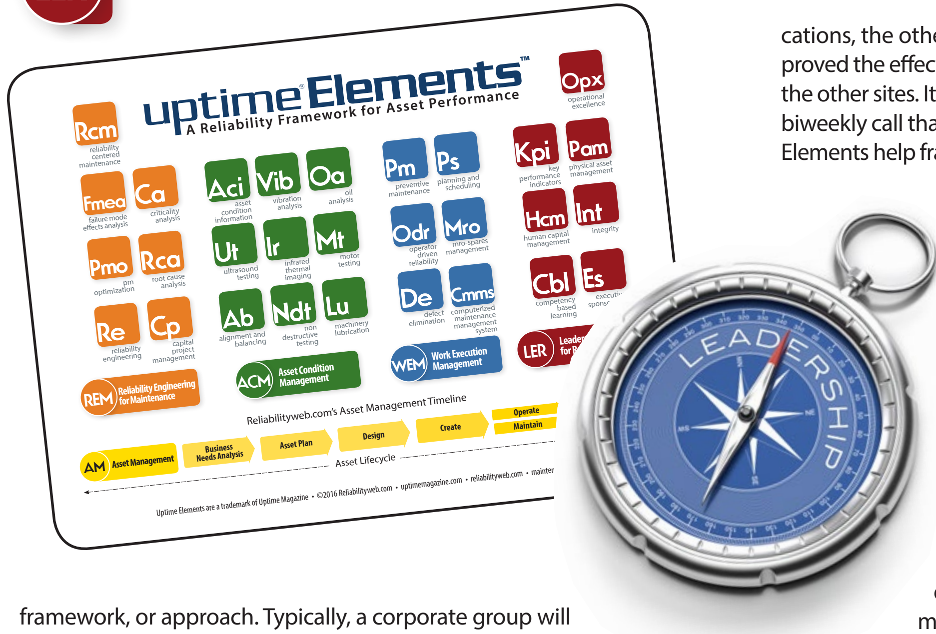
The central team at BMS felt strongly that ownership at the site level was critical to long-term reliability sustainability. Several key activities from the central team were designed to shape culture, such as site visits, conscious efforts to provide feedback and coaching to site reliability leaders, and hosting the internal conference detailed in Part 1 of this series. But more importantly, many activities normally associated with a corporate-driven reliability improvement initiative were avoided. The goal was to strike a balance between what is driven and what is desired.

Reliability as a term is a tangible calculation expressed as the probability of successful operations under stated conditions for a specified duration. However, reliability as a holistic strategy comprised of proper asset management systems, processes and tools, coupled with the efforts, expertise and culture of the people responsible with its achievement, is another animal. Think of growing plants as an analogy. Seeds require basic needs, such as soil quality, planting depth, water and sun. How well would seeds from different species do if you were to plant them all at the same depth or prescribe the same amount of water? Sure, some would grow, but others would not have the right conditions to thrive. If the conditions are right and the seed germinates, it begins a journey toward what it desires, the sun. To cultivate a reliability centric culture, it is imperative to provide the conditions necessary for everyone to thrive, for once they are in an environment where they know they can thrive, they simply will. The goal of a corporate team should not be to dictate, but to cultivate. This requires a balance between conditions and patience. As this approach is explained further, keep this balance in mind because it was a critical component to the success at BMS.

> To cultivate a reliability centric culture, it is imperative to provide the conditions necessary for everyone to thrive, for once they are in an environment where they know they can thrive, they simply will.

Most reliability road maps are an extensive manuscript detailing the opportunity and potential cost savings available through achievement. These reports focus heavily on identifying gaps and offering insight into technical tasks to help close them. Tasks, such as criticality analysis, failure mode and effects analysis (FMEA) or reliability-centered maintenance (RCM), preventive maintenance optimization (PMO), or predictive maintenance (PdM), are suggested to close gaps and achieve reliability. These recommendations greatly benefit organizations that are unaware of reliability concepts or are looking for an outside group to provide guidance. However, there are enough books and white papers to fill a library detailing the benefits of these techniques and still organizations struggle with reliability. For BMS, at the center, it was about finding a balance between empowering a culture and determining standardization of technical aspects.

The approach the BMS central team took was laser focused on people and empowerment. Ensuring decisions are made at the right level, BMS worked as a global community focused on continuous improvement. Several approaches were avoided; the most notable being the absence of a formal rollout. The introduction was an activity or an event, which helped employees recognize where they needed to focus their efforts to establish a robust foundation. There was no requirement for sites to perform similar exercises to understand their specific needs. Most importantly, there was no required action for sites to adopt this language,



framework, or approach. Typically, a corporate group will set expectations with deadlines for the sites to meet, but this was most definitely not the central team's approach. Furthermore, the sites were not required to align their updates at the biweekly update meetings with those of the Uptime Elements. While this approach is unorthodox, it is also critical to success.

The Uptime Elements framework was provided as a tool, a compass, but not a prescriptive list of requirements. The role of the central team was to provide this tool as an option. The nature of the framework is unique in that it provides the ability to visualize reliability; to discover how the elements are related, to self-explore which are dependent upon others and to draw one's own map. The central team did not want to provide turn-by-turn GPS instructions as this does not teach one to navigate. For example, if you are headed to the North Pole, you only need to know which way is north and how to walk. At BMS, the company goals are the North Pole, the Uptime Elements are the compass and the central team gets everyone to take steps in the right direction and provides the systems and tools to get there. The central team provides the compass, water, snowshoes, boat, machete, etc. Simply let the central team know when you need them and if you want training or a guide for their use. Along the way, keep a journal of the terrain you cover, lessons learned and benefits. The central team stores this knowledge so others can use it to navigate as well.

> At BMS, the company goals are the North Pole, the Uptime Elements are the compass and the central team gets everyone to take steps in the right direction and provides the systems and tools to get there.

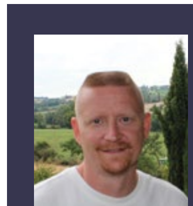
The sites adopted the framework on their own because it just made sense. It was easy for them to understand and they derived value from day one. As the sites began to incorporate the framework into their communications, the other sites saw the value in having a common language. It improved the effectiveness of the communications and aligned the thoughts of the other sites. It is important to recognize that there are many people on the biweekly call that don't speak English as their primary language. The Uptime Elements help frame the conversation for everyone and improve the efficiency of the central team's messages. The team also provided coaching and mentoring to the sites during this evolution to ensure presentations included lessons learned and tangible value derived from the sites' efforts.

As the weeks progressed, it was clear that the framework was working its way into all areas of reliability. With connections to other areas of the business and projects that stretched beyond reliability, the framework began to be recognized by the larger organization. The central team continued to facilitate communications and provide training when requested, but never required specific actions, only coaching and mentoring.

While the sites were on their own journey, the central team, in conjunction with site personnel, worked on the development of standards. Standards included lubrication management, storeroom management and organization, root cause failure analysis, and alignment and balancing. These standards were developed with teams comprised of representatives from several sites working with key vendors. In addition, a team of site representatives worked on updating corporate requirements for engineering projects to ensure they contained requirements that aligned with reliability best practices. The teams were led by volunteers from the global community and not the central team. Again, this approach is strategic as it keeps the global team connected and collaborating with each other in an effort to benefit the greater team. The central team could have hired vendors to provide standards, but the effect would not have been the same. The teams, while working together, get to know each other, make connections, learn experiences and continue to collaborate long after the standard is written. When BMS employees now get together as a group, they already know each other. They communicate directly and transparently, knowing that they do so in the spirit of continuous improvement. They are no longer a group of individuals, not even a team, they are a family.

With all these activities ongoing, the central team began to coordinate an effort to broaden the reach of reliability understanding through an agreement with the Reliability Leadership Institute and the development of certified reliability leaders (CRL). At its 2014 conference, BMS was successful in certifying about 30 individuals.

Details of BMS's efforts to develop 100 CRLs throughout its network will be presented in Part 4, which will be published in the June/July 2016 issue of *Uptime* magazine.



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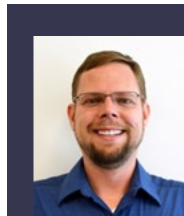


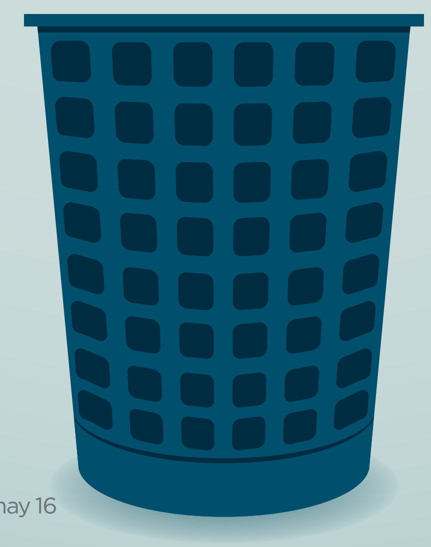
Robert Bishop, CRL, CMRP, *is a Maintenance Engineer for BMS, Syracuse. He has an undergraduate degree in Mechanical Engineering from the University of Rochester and an MS in Bioengineering from Syracuse University. Rob has worked for BMS for over 9 years, supporting equipment in several roles. He is an early adopter and loves to improve systems and our culture. Rob has the IAM Certificate for ISO55000. www.bms.com*

WITHOUT Accurate Failure Data

All You Have Is a **Work Order Ticket System**

by John Reeve

*More specifically, without **failure modes** all you have is a bunch of codes.* This may be the most overlooked data element as most computerized maintenance management system (CMMS) products do NOT capture the failure mode. This critical data element allows one to: (1) derive the ideal maintenance tactic, (2) quickly compare work order (WO) failure modes with RCM analysis failure modes, and (3) support drill-down on asset worst offenders for basic failure analysis. Failure data and failure analysis provide **a holistic process** in search of continuous improvement – **using the CMMS**. And, within the entire CMMS product, this may be the one feature's **greatest potential, return on investment**.



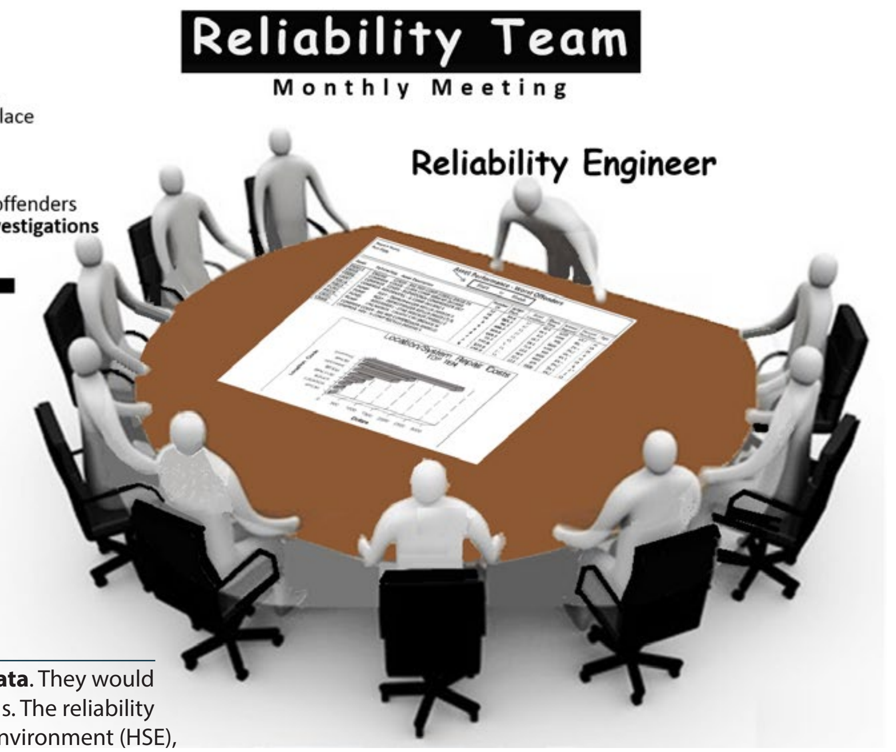
What Would a Reliability Team Do in Support of Asset Reliability?

Purpose

- Promote **asset reliability**
- Provide **asset criticality**
- Rank asset problems by **risk & consequence**
- Ensure **precision maintenance skills** are in place
- Oversee the **PdM program**
- Track **cost avoidance savings**
- Prioritize **RCA reviews**
- Review **CMMS failure history** Top 10 worst offenders
- Be deeply involved in **critical asset cause investigations**
- **Train & coach** reliability

Identify costly systems, and drill down.

1. Why is this system so **costly**?
2. Has anyone **walked it down**? What do O&M Techs say about this?
3. Are there **recurring problems**?
4. Do we have known **defects**, design flaws, safety/ergonomic issues? Are there specific **components** failing?
5. Do we need ***newer*** equipment?



Note: A best-in-class organization would **demand accurate failure data**. They would routinely leverage data in the CMMS to make more informed decisions. The reliability team would include representatives from operations, health, safety, environment (HSE), maintenance, and engineering.

Definitions

RCM Objectives - Simplified - The objectives of RCM analysis are to: (1) **Preserve asset value,** (2) **Identify failure modes** that can affect system function, (3) **Prioritize** the failure modes, and then (4) Select the applicable **maintenance task.**

Failure Modes Driven Strategy - This is a philosophy which determines maintenance tactics (stored in PM/PdM library) based on failure modes. Without this information, the maintenance and reliability staff must rely on OEM manuals and/or experienced staff for input.

Types of Failure Analysis - As to failure analysis, there are 2 techniques: root cause analysis (RCA) and **basic failure analysis.** The latter, basic failure analysis, is performed within the CMMS by running Pareto style reports which permit drill-down on component and problem followed by cause. The reliability team might utilize a Pareto style failure analytic each time they hold a meeting to focus on worst offenders.

Failure Code Hierarchy – At the Asset Level - This 4-level hierarchy is a common design by some CMMS products. This type of failure coding is usually at the asset level.

Level-1	Failure Classification	Examples include pump, boiler, autoclave, heat-exchanger, and fan.
Level-2	Problem Code	This should be the first sensory observation by the O&M technician, such as the pump is noisy.
Level-3	Cause Code	Note: Organizations differ as to how this field is to be used. Some enter the component, and, some might say, "Lack of lubrication."
Level-4	Remedy	Repair, replace, clean, etc.

Failure Mode - The failure mode contains 3 distinct pieces of information: **component-part**; **component problem**; and the **cause code**. Each individual piece should come from a validated field. All 3 pieces are then concatenated together on the work order at job completion.

Assumption: A work order exists and it is tied to an asset (e.g. fuel pump), whereby *the fuel pump has stopped running*. The technician discovered the **bearing** had **seized**. Upon further research, it was noted an error occurred due to a **lack of lubrication**.

Component-Part - This is the "failed" component. It is critical to the failure mode. This component is usually not known until the job is done. Examples include impeller vanes, bearing, casing, wear rings, drive belts, rotor, gauge, seal, shaft, fitting, and mounting nut. Note: It is best not to put the component as part of the failure code hierarchy due to a large variation.

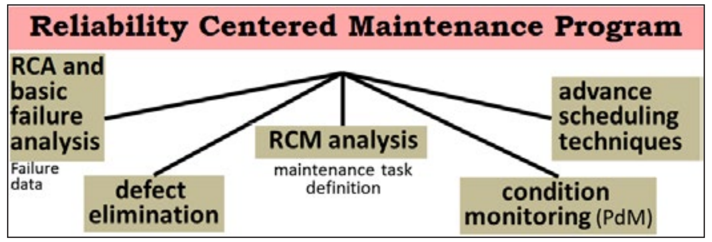
Component-Problem - The component-problem could also be different from the asset-problem and it needs to be its own field.

Cause Code Which Caused the Component Failure - This information may be the hardest to capture, but it is the most important. Without knowing the cause, it is quite possible the new bearing you just installed could fail 2-3 months later because the true cause was not resolved.

Maintenance Tactics - Maintenance tactics (strategies) are selected to address the failure modes. Inside the CMMS, these are part of the PM/PdM library.

From the above, it should be noted that new fields might be added to the work order main screen, such as failed component, component problem, and cause codes.

Basic Failure Analysis Is Part of Reliability-Centered Maintenance (RCM)



So, What's the Problem? Why Is Failure Data Being Overlooked?

Failure data includes many elements, such as asset condition, type failure, failure mode, downtime, and actual costs. These data elements are used within the failure analytics. But **70 percent** of all CMMS installations **have never successfully performed basic failure analysis** using Pareto style analytics. The fact that **this percentage has not changed for many decades should be an issue by itself.** Here are some possible reasons:

Failure mode is not understood
Within the CMMS community, the definition and importance of failure mode is not understood. Also note that the CMMS itself may not be set up to capture this data.

Failure analysis is not understood
The user community has different definitions for "failure analysis". To some, this could be reviewing a bunch of work orders in a conference room.

Failure analytic report does not exist
You should not assume the out-of-the-box CMMS has a decent failure analytic – if any. Therefore, the stakeholders have to define and build this report. This report should provide multiple ways to sort, select and drill-down on failure data, including MTBF, failure occurrences, downtime, age, or annual cost/replacement cost.

Reliability Team was not established
Without a reliability team, there really is **no one to give a failure analytic to**. This should be a formal event, occurring every month, which begins with analysis of the worst offenders – as indicated by the failure analytic.

Free-format fields were often used to store "failure data" in lieu of validated fields
Sometimes, the shop floor (O&M staff) believes that **free-format text** (describing exactly what they found and did) is adequate failure history. This may help the working level, but you cannot run failure analytics against text. Thus, 10 years of free-format text entry means 10 years of lost failure analytic capability (Pareto style).

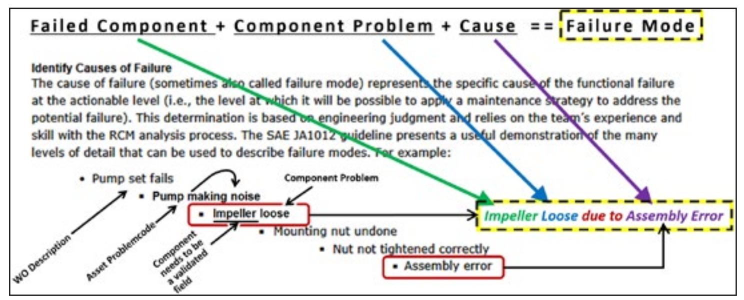
Please note: Free-format text is still encouraged for problem descriptions, actions performed, and future recommendations – coupled with validated failure data.

In the following diagram, you will see the five main components of RCM.

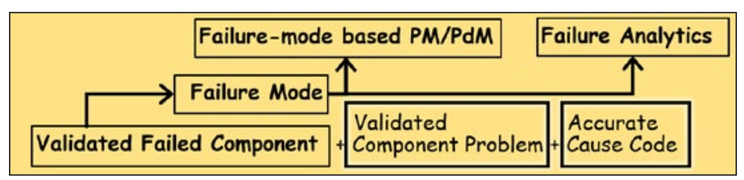
Basic failure analysis leverages **historical failure data** to help you identify the worst offenders in terms of recurring events. It is just one of several tools the reliability professionals use to eliminate defects.

Failure Mode Is Critical for Multiple Reasons

CMMS failure data includes many data elements, but the most important one is **failure mode**. The first significant benefit of using failure modes is to capture it on the work order at job completion so that ready comparisons can be made to the RCM analysis failure modes library.



Assuming the failure mode is established during RCM analysis, this information can be used to determine the maintenance tactic which feeds the CMMS PM/PdM library.



This illustration shows the three elements of the failure mode and how that information can be used.

CMMS Design

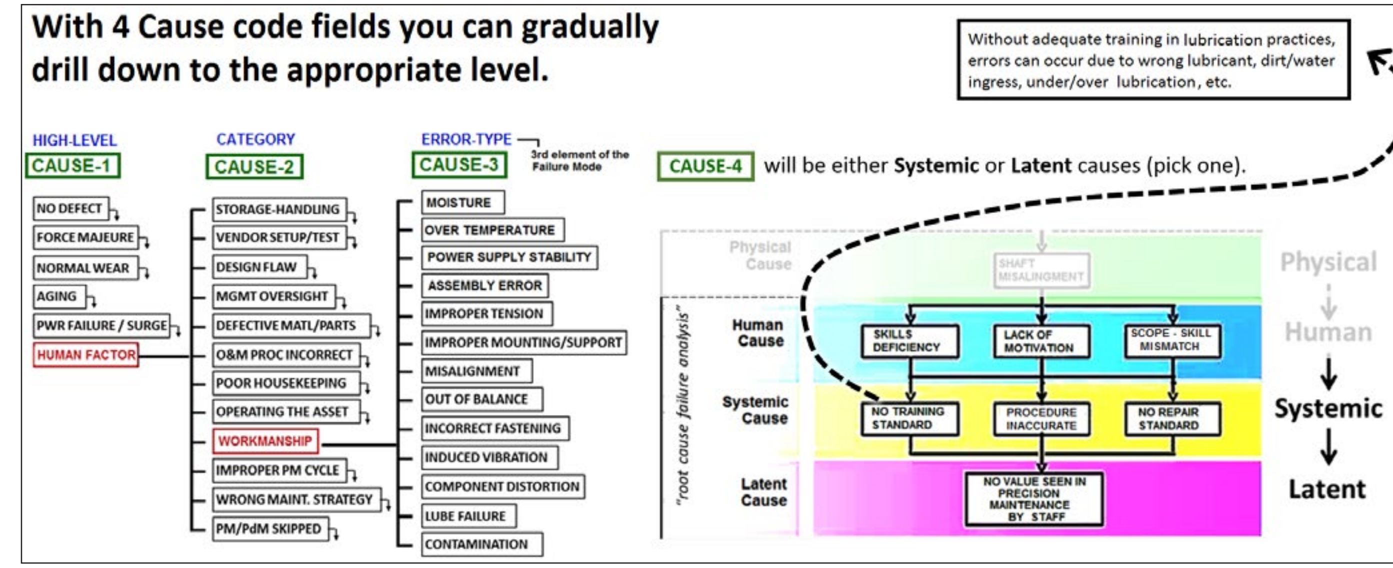
One might ask why the failure mode was never introduced to CMMS design. We may never know that answer. Although the work order is written to the asset, it is very important to identify the failed component.

Failure Code Hierarchy (FCH) design
To fully load a hierarchy for all possible failure classes with all possible components could require substantial time. And because of this complexity, the staff frequently decides not to build the complete hierarchy, let alone populate the work order.

Cause Codes
Due to the importance of capturing accurate cause codes, it helps the user to be able to "drill into" the true cause. And this design requires a cause code hierarchy.

Setting Up Cause Codes

The cause codes are very important as they are the third piece of the failure mode and, without the true cause, the failure will most likely happen again. The maintenance technician would fill-in Cause-1. The maintenance supervisor would fill in Cause-2. And the reliability engineer would fill in Cause-3. If the third cause code is filled in, then this completes the failure mode. One should also note that, unless Cause-4 is determined, this same failure might happen next month.



Unraveling the Puzzle

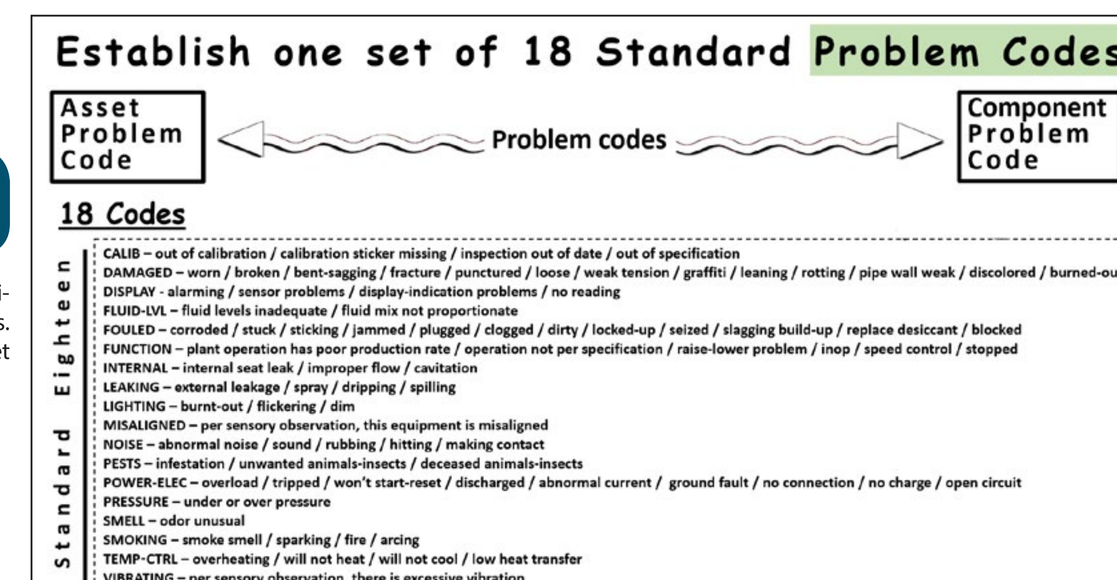
Validated fields are needed for capturing failure data. This approach prevents erroneous information. Failure data fields should be mandatory if a repair activity was performed (involving functional failure). Remember that every day that passes where work orders are completed (or closed-out), and missing failure data, it will be near impossible to go back and recover this information.

So that said, how do you move forward? Here is a set of instructions:

1. Configure the **work order screen to capture the failure mode** using three fields: component, component-problem, and cause codes.
   a. Establish a new failure hierarchy where level-1 = "ASSET." Apply this value to all assets.
   b. Build-out a generic list of problem codes which works for all types of assets.
   c. Utilize work order classification field as "Failed Component." Set up a three-level classification, e.g. PUMP\MECH\IMPELLER.
   d. Add a new field titled, "Suggested Add for Missing Component." When WO classification is missing component, then user fills this field in (which gets routed to planner for review).
   e. Add new field titled "Component-Problem." This uses same choice list as asset-problem.
   f. Add four new cause fields.
2. Design/build the failure analytic – called **asset offender report.** This report would dynamically build the failure mode by concatenating the component-part, component-problem, and cause together to make the failure mode.
3. Create a **new application to store failure modes** to which the WO completion data can be compared against.

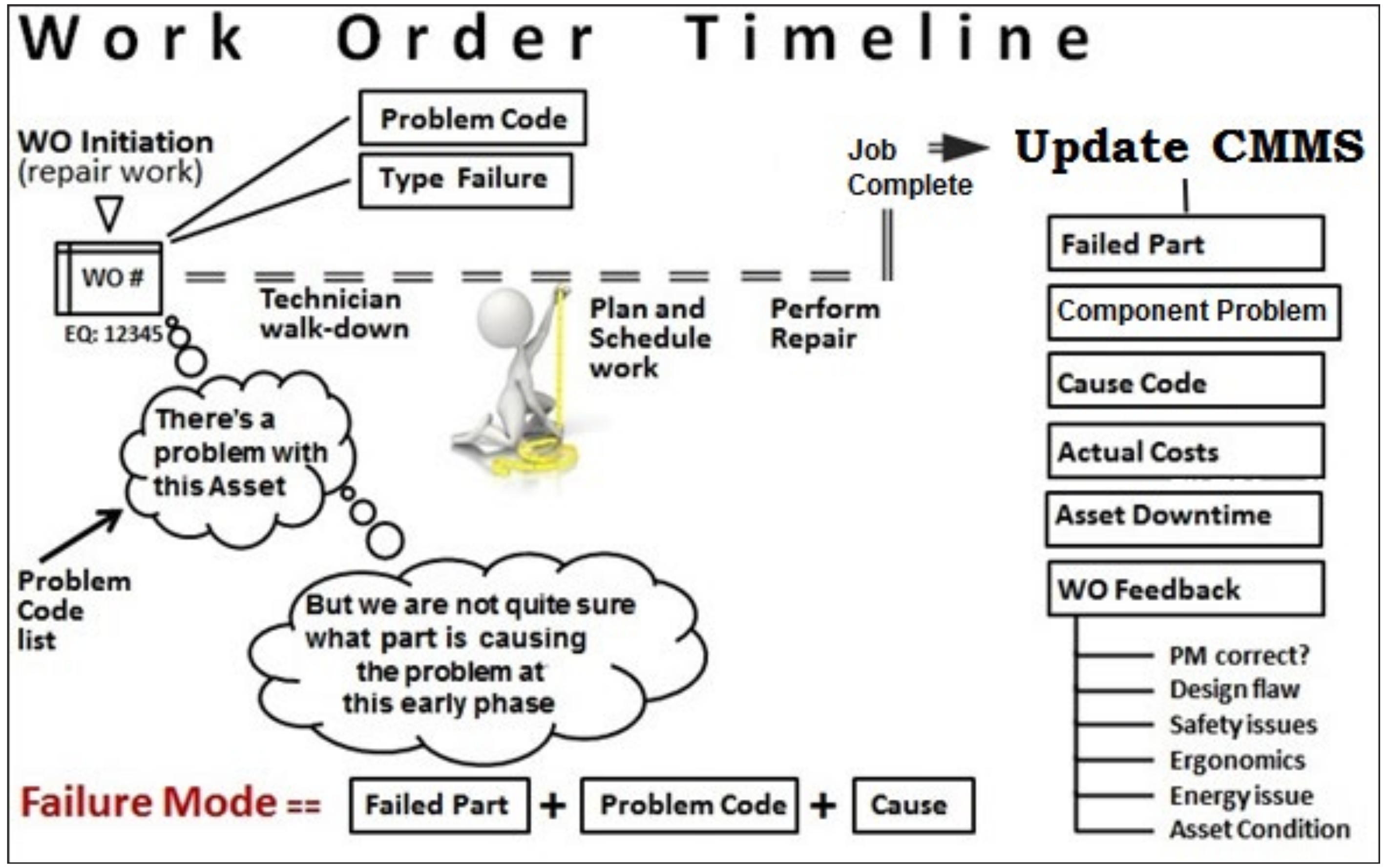
Setting Up Generic Problem Codes

The assumption here is that all assets basically have the same set of problem codes. You should be able to create a standard set of problems with under 20 choices.



Failure Data Timeline

It is important to note that failure data is captured at different points in the WO chronology – and by different people. The operations (or maintenance) staff creating the initial request would specify the WO number, problem description, asset number, asset-problem, type-failure (full, partial, potential, defect), and worktype (=Corrective Maintenance). At job completion, then the technician starts the failure mode capture, but the maintenance supervisor and reliability engineer may also be involved.



In Summary

There are multiple ways to have a successful reliability program. However, the CMMS is a key element to that success. The stakeholders (e.g. core team) have a **responsibility** for identifying/creating that vision - and road map - to get there. It's always best to create a long-range plan beginning with a clear endgame.

You might request a new project called reliability improvement. And as part of that effort, early setup of failure data fields, coupled with staff training, is encouraged. If it takes more time to get the failure analytic designed and a reliability team in place, so be it. At least the correct failure data will be there when you are ready. The final result is a maintenance reliability program that preserves asset performance, promotes work force productivity (and job safety), and optimizes O&M cost.

There are multiple ways to have a successful reliability program. CMMS is a key element to that success.

John Reeve is the Senior Business Consultant at Total Resource Management. Mr. Reeve is a seasoned professional and consultant with over 25 years of diverse industry experience, with expertise in work, asset and reliability management system design. Mr. Reeve obtained a United States Patent for maintenance scheduling. www.trmnet.com

How the Industrial INTERNET OF THINGS Is Shaping Manufacturing

by Chuck Wallace

With all the technology out there, all talking to each other, the world is increasingly becoming more and more connected – indeed, flat. The Industrial Internet of Things (IIoT) seems like a nebulous concept that encompasses everything from machine learning and robotics to drone delivery systems and intelligent point-of-use vending. There is more information available than ever before, but making sense of all this data can be daunting. This article will help bring clarity to how the IIoT can enhance all aspects of manufacturing.

Potential for IIoT in Manufacturing Is Huge

The manufacturing world is an asset lifecycle of Design > Operate > Maintain > Retire. Historically, companies focused on the design and maintain phases, but information from the operations realm, namely distributed control and the operators' rounds, wasn't being intelligently integrated. Now, with the IIoT connecting everything more seamlessly, companies are starting to deeply focus on the operations component to tie it all together and improve overall system reliability.

Machine learning is improving asset reliability from the way manufacturers operate their production lines to the optimization of their assets' lifecycles. For example, the IIoT makes it possible to analyze two years' worth of online data from a 25,000 horsepower compressor system and predict the parameters that will keep it reliable. Laser scanners and 3-D software allow you to scan a problem part from a production line and redesign it to make it stronger and work better in the line with twice the working life.

In this unpredictable world, various companies, such as those that specialize in purpose-built robotics or provide supply chain as a service for maintenance, repair and operations (MRO), are helping organizations create predictable value. These companies are taking advantage of the IIoT by finding patterns in the data and turning them into actionable information to either predict problems or solve problems in a new way.

But the data usage technology itself isn't necessarily new. For instance, some companies have had demand compression algorithms built into their intelligent industrial vending systems for over a decade. These algorithms render the traditional min/max replenishment systems obsolete since they fall short on spiky demand cycles that are so difficult to manage. They use trend multipliers that accommodate lead time variances to recalculate and recommend new reorder quantities and points. There are a number of other ways the system can analyze demand and predict where it should be setting its reorder points. These systems are also adaptive to line changes, with cellular systems making adjustments based on usage and production requirements.

The big advantages of this big data are:

- Reducing inventory by 30 percent;
- Eliminating stockouts;
- Ending the dead on arrival inventory that happens because the needs of the manufacturer change so rapidly;
- Moving away from the guessing game of min/max.

What's Inhibiting Progress?

If the technology is out there, why are manufacturers still experiencing downtime and stockouts of critical spares? Technology is like a wave. It takes time to ripple through manufacturing. There are always innovators and early adopters of technology, but the majority of people like to wait and see how it plays out. And, of course, there are always the laggards that will only shift their way of doing things when the old way is no longer available. How many people still have flip phones and are pressing the number nine four times to type a *Z* in their texts?

Innovator and early IIoT adopter Steve Pixley sees this every day with his machines. He founded a company that builds purpose-built robotics that speed workflow, cut costs and give manufacturers better control over their indirect materials in the harsh environments of the manufacturing world. Often, Steve is asked to disable some of the predictive technology in his systems – the equivalent of using a super computer to do basic addition. In the age of Google™, people have less and less interest in mastering the technology or even understanding it. They want the answer or the process and they want it immediately. They don't want to have to think about it again until they need it. But, without an understanding of how the technology works, they can't really tweak it to make it work best for them.

Training and education on technology and processes will go a long way in user adoption as people realize the aim is not to replace operators or maintenance mechanics, but rather to empower them to do their work better and make their company more competitive on a global scale.

Aside from the rate of technology adoption, nobody is really integrating what the operators do on the production floor with the actual needs of the equipment. Shifting perspectives from focusing solely on maintenance to reevaluating operations' impact on the assets will move the needle even further. Now, more than ever, understanding how organizations can operate to best optimize the lifecycle of their assets becomes an important question.

The Possibilities Are Endless

The future will see production schedules fed back into the demand process, anticipating the next week's needs and adapting supply, not only in vending, but in supply chain management in general.

It's clear that point-of-use technology will advance further in the next few years as information becomes even more integrated and actionable. These intelligent systems and machines can analyze data and adapt to it.

Yet, whether talking about intelligent vending or machine learning, there is one common theme. These intelligent systems are only as good as the intelligent humans that input all the variables, monitor the systems and configure them to adapt to their needs.

With an increased focus on the *operate* component of manufacturing, operations will become so steady that eventually parts will rarely fail. Operations will know there's a problem before it happens and will be able to act so a failure never occurs. Spares will be dispensed for planned maintenance projects only and unplanned downtime will be a distant memory from another era.

The chief enablers of the IIoT will be mobile technology and machine learning. New technology always exponentially increases the degrees of freedom and organizations, with the help of specialized service providers, will find ways to use it in ways never thought imaginable!

***Chuck Wallace** is the Vice President of Engineering Services for SDI, Inc. With more than 35 years of experience delivering exceptional engineering value in industrial plant environments, Chuck is a pioneer in the emerging field of complex adaptive systems. www.sdi.com*

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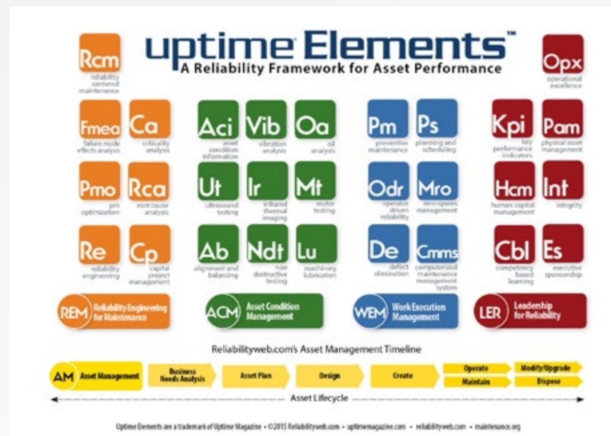

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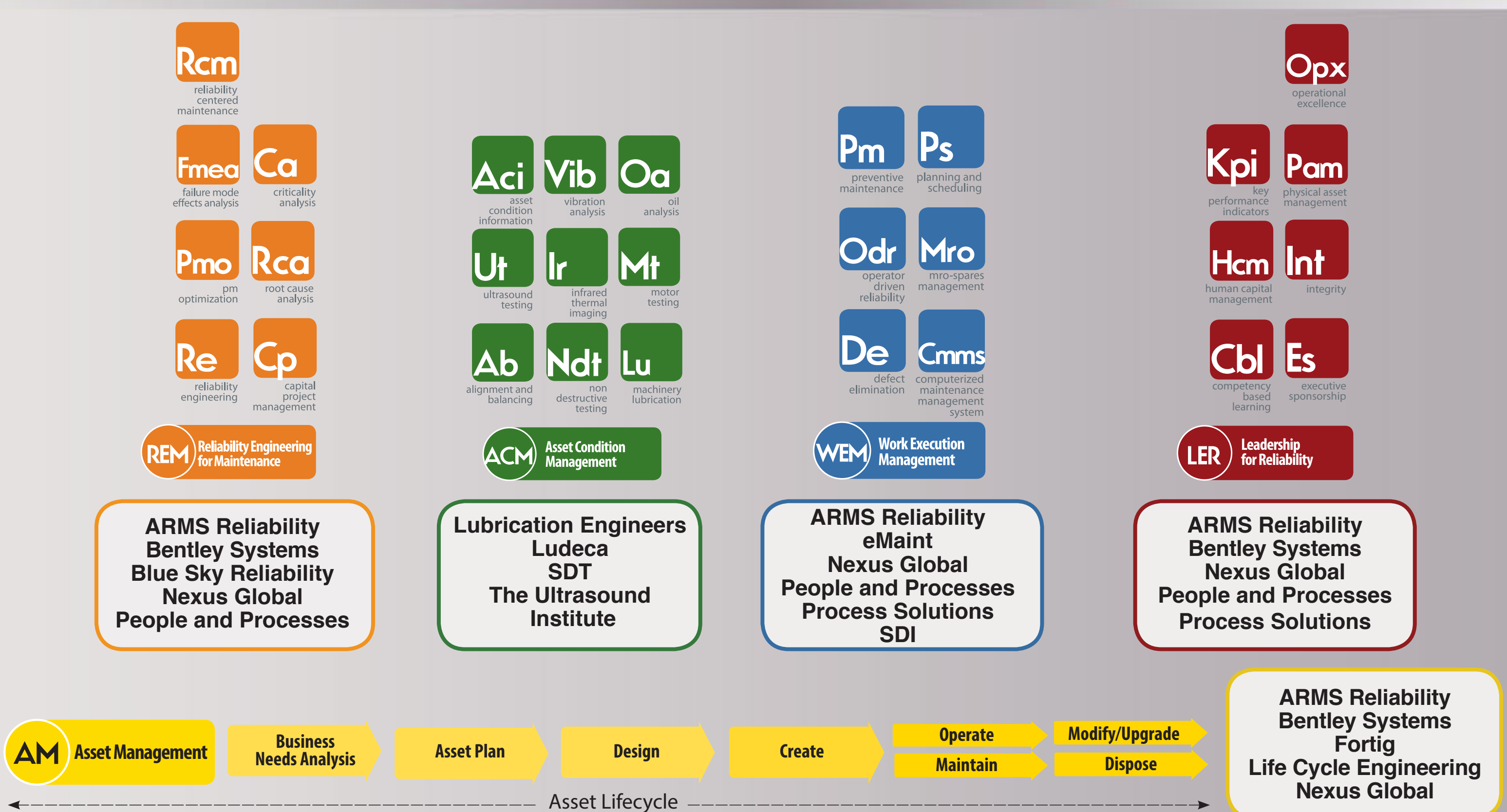

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Operational Analytics

Help Lower Maintenance and Energy Costs

by Richard Irwin

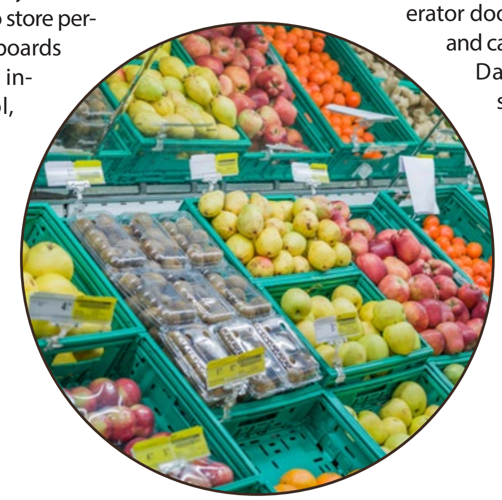
"Using operational analytics, Danfoss achieves complete visibility of an entire operation"

For some time, supermarkets have accepted that the costs for high customer volume, regulatory compliance and increasing energy rates were part of the business model. But the Danfoss Group, a Danish global producer of products and services used within infrastructure, food, energy and climate, has been providing a smart store solution for the past 10 years to help its customers across 5,000 stores worldwide optimize food safety and maximize energy efficiency. This solution also allows its customers to view their operations at a presentation level, create reports on alarms and performance, compare performance between stores, and reduce energy costs.

One of the Danfoss Group's main focus areas is within food retail, where it offers services in operational stability, food safety and energy savings around refrigeration systems. Specialized areas include cooling food, air conditioning, heating buildings, controlling electric motors, compressors and drives, and powering mobile machinery.

Within supermarkets, refrigeration consumes a significant and increasing amount of electricity, with the remaining from HVAC equipment, lighting and other utilities, such as in-house bakeries. These costs can escalate more quickly in warmer climates. Due to consumer safety concerns, food products are frequently stored below the required temperatures. This pursuit of improved quality and regulatory compliance results in higher than necessary refrigeration-related energy costs.

Central to the success of the smart store solution to keep food stored correctly and safely is how Danfoss helps their customers to continuously measure, monitor, analyze and implement the performance of their stores and the reliability of their equipment. Using Danfoss's own products, such as controllers, gateways and sensors, customers have access to store performance 24/7 via dashboards that provide them with insight into food control, temperatures, alarms, reports and much more.



There are many key solutions that enable Danfoss' customers to manage their supermarkets more efficiently and aid in their decision-making. Central to these is an alarm management system used to monitor food quality and energy efficiency, along with a visualization component to bring all the information together in one platform.

Alarm Management System

An underlying alarm management system automatically raises alarms when thresholds for potential equipment failures have been reached. The difficulty with this process is identifying which alarms actually need attention and which result from programmed defrost cycles or refrigerator doors accidentally left open and can therefore be dismissed. Danfoss uses a software system to count repeated similar alarms, identify which are real and which are false, and notify the appropriate people. This leads to a more proactive approach to maintenance as opposed to reacting after an incident. Eliminating false alarms from the system significantly cuts costs by reducing needless callouts to maintenance engineers. Alarm histories can also be used against the asset, the fault, or the site to highlight patterns, such as determining why a particular alarm is occurring against the same asset consistently across multiple stores.

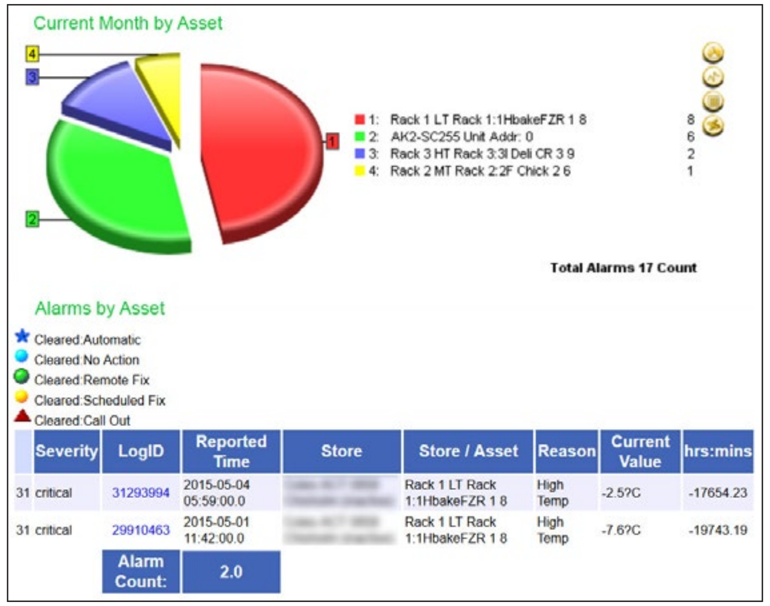


Figure 1: Alarm management system

HACCP Reporting

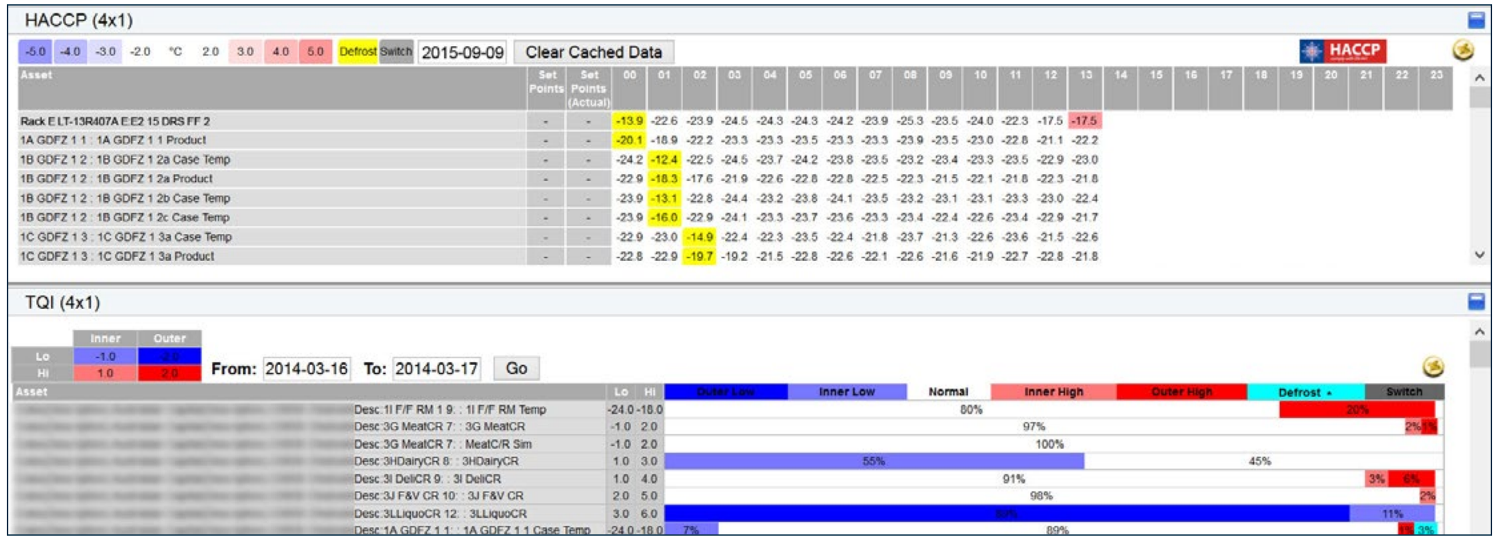
Danfoss addresses regulatory food compliance with hazard analysis and critical control points (HACCP) reports, a monitoring and reporting system that assures food production and storage facilities are safe. Using operational analytics software specifically for data collection, analysis and visualization, HACCP reports show the average temperature during an hour, typically in four, 15-minute intervals, of any asset containing food. These reports are displayed within dashboards so Danfoss and its customers can spot at a glance any differences in behavior in an asset's temperature by using color-coded boxes to indicate whether an asset is operating above or below its normal level. These reports can display historical data to prove that measures are taken to ensure food safety.

Coupled with a temperature quality index report, which displays the overall percentage for which an asset is performing within its set points, the reports bring a complete picture of asset performance in near to real time. This information enables maintenance teams to predict events and to take action prior to costly failures.

Load Shedding and Set Point Management

Automated load shedding for demand response and set point management help facilitate automatic switching on/off of certain assets by interfacing directly with the hardware, including HVAC systems and store and parking lot lighting. From the dashboard, levels can be set to send a signal to certain controllers, such as lighting zones, turning them off over a set period of time. Each level of load shedding can include any number of assets, from a few to all. These measures help reduce energy consumption while encouraging financial incentives from the energy provider.

Figure 2: HACCP reporting



Set point management automates corrections in hardware value points to ensure error control regulation of asset temperatures, switch status and alarm values. This means the software constantly checks values of specific hardware, like a switch or a set point, making sure they are correct. If a change occurs or is made accidently by a third party, it can be entered into an audit trail and automatically corrected to the original value. This ensures continuity to the operational performance of the store and peace of mind knowing that accidents will be avoided, further reducing callouts and loss of stock. Set points and schedules also can be changed for an entire location through one job.

Results

Using operational analytics, Danfoss achieves complete visibility of an entire operation, including energy usage against external parameters like outside/inside temperatures and other factors. By monitoring these patterns for its customers, Danfoss can regulate the environment in which the assets work. For example, refrigerators won't need to work as hard if the temperature or humidity in the store is controlled at an optimum level.

Through this alarm management system, Danfoss is able to determine that substantial energy savings can be achieved to affect its customers' bottom line. Key operational benefits include:

- Ensuring food safety and minimizing food loss
- Reducing energy consumption
- Anticipating failure of refrigeration equipment
- Filtering, identifying and notifying alerts and real service maintenance needs
- Prescriptive load shedding for optimal power reduction
- Prescriptive set point remapping when overriding settings

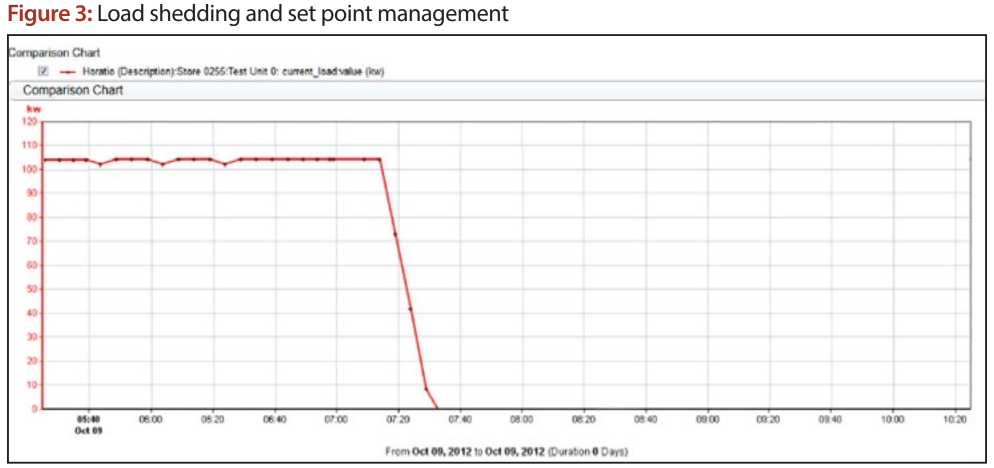
The alarm management system allows Danfoss's customers to monitor and track their assets and intervene when necessary if an asset triggers an alarm. With a variety of specialized alarms, such as threshold, percentage, or hold down, alarms can be filtered to only notify users of critical alarms, thus reducing false alarms and maintenance callouts.

Summary

With its smart store solution, Danfoss ensures its customers are ready and fully prepared to meet the challenges within the food retail sector, including climate change, new demands on energy efficiency and concerns about food safety and standards. Technological trends also bring their own concerns, including harnessing the Internet of Things (IoT) and the challenges presented by the rise in big data.

Using load shedding, Danfoss continues to maximize energy efficiency in food retail to help customers reduce energy consumption, with the eventual long-term goal of achieving stores with net zero consumption or even stores that give more than they take in energy consumption. Asset reliability is essential in adhering to food safety standards and reducing food loss to a minimum, while unnecessary downtime is significantly lessened. With solutions from Danfoss that predict failures and trigger just-in-time maintenance alerts, achieving these goals is becoming a reality.

Figure 3: Load shedding and set point management



***Richard Irwin** is a Senior Marketing Manager for Bentley Systems' Operational Analytics platform, Amulet, with over 10 years experience in working within the analytics industry. Based in the United Kingdom, Richard holds a Master's degree in Sociology from Aberdeen University and a Master's in IT from Heriot Watt, Edinburgh. www.bentley.com*

The True Value of RELIABILITY

by Marc Hoppenbrouwers

> “Reliability is affected by people, company culture and excellence in operations”

In the current economic climate, only the strongest businesses are likely to survive. That means companies who perform reliably with a healthy cost level and, therefore, are able to build a competitive advantage over weaker performers. This also allows them to maintain a positive margin even in a depressed market, while others fall into red figures.

Reliability is affected by people, company culture and excellence in operations, so multiple, fragmented approaches to reliability in manufacturing will not work. Often, companies struggle to identify the right initiatives and fail to make a serious impact on the bottom line. What is needed is a single, cohesive strategy with an integrated approach.

There are, in principle, four value levers that ensure reliability and add business value, as shown in Figure 1.

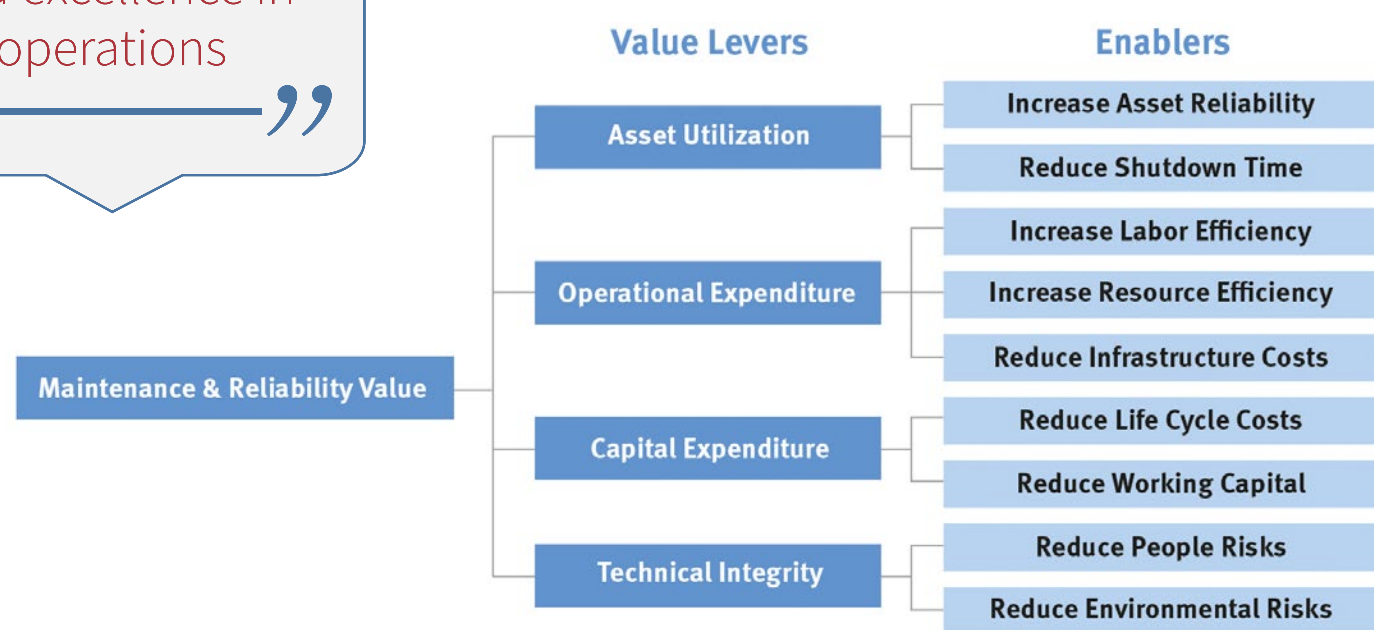


Figure 1: Value tree to achieve operational excellence

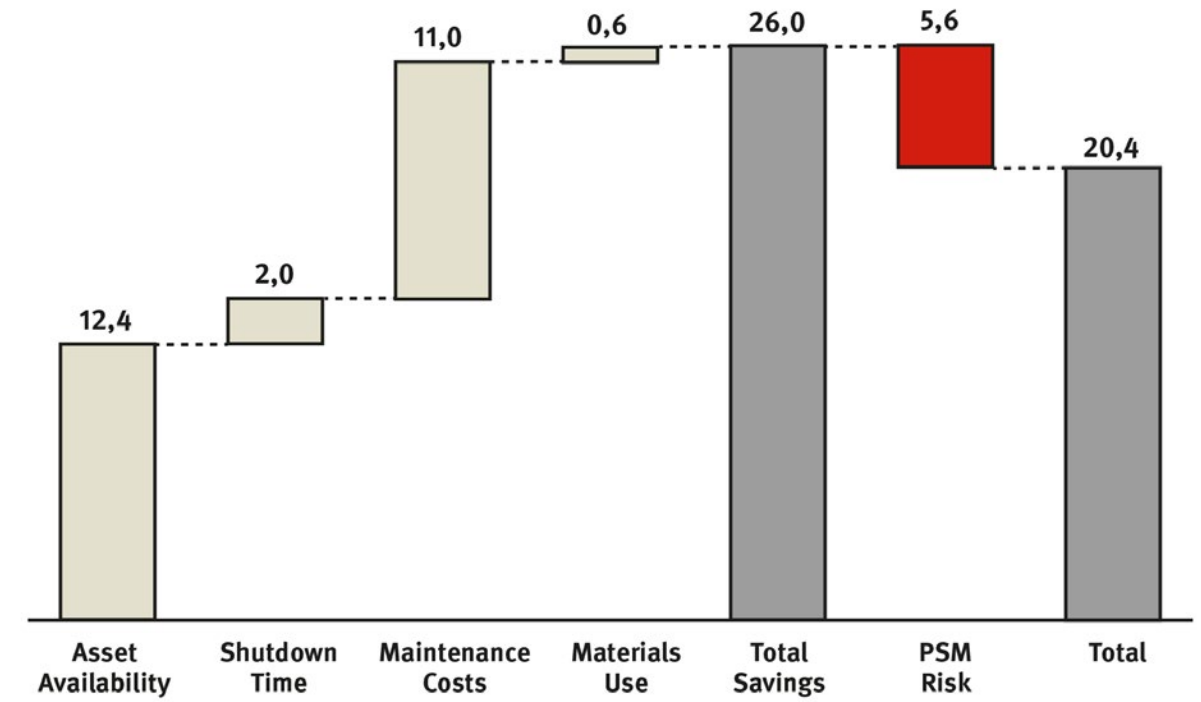


Figure 2: Waterfall diagram for a large mining site in South Africa

Value Identification

If opportunities are correctly identified, for example via the rapid value assessment method, it is possible to obtain a fingerprint of a company's current plant performance and culture, then quantify the value opportunities and risks. The waterfall diagram in Figure 2 sets out value opportunities for a mining company in South Africa in various areas of maintenance reliability on the left, giving a potential year over year value savings for each. On the right, the process safety management (PSM) risk of a serious incident occurring is quantified by effect likelihood. As the operational risk of a serious incident negatively affects value, this is displayed as a negative in the waterfall diagram.

People Drive Value

Decades of experience in manufacturing indicates that the reduction of operational risk and value generation is closely related through the culture on the work floor. Companies that succeed in creating a proactive risk culture can use their strength to focus on value generation, for example, in reliability or lean cultures.

The cultural maturity of a company can be categorized in four stages. In the first two stages, the culture is driven top-down by leadership. People follow example behavior and comply with rules in the dependent stage. However, what happens when management is not present? In the independent stage, people begin to realize that they themselves can benefit. They begin to internalize safe and more efficient behavior. In the interdependent stage, people network as an organization and correct each other's unsafe or value destroying behavior. Only at this stage is maximum value creation and operational risk reduction accomplished.

An Integrated Value Approach for Operational Excellence

The key to tackling value creation and reducing operational risk lies in strengthening a company's culture so employees are independent and empowered enough to generate value for the company.

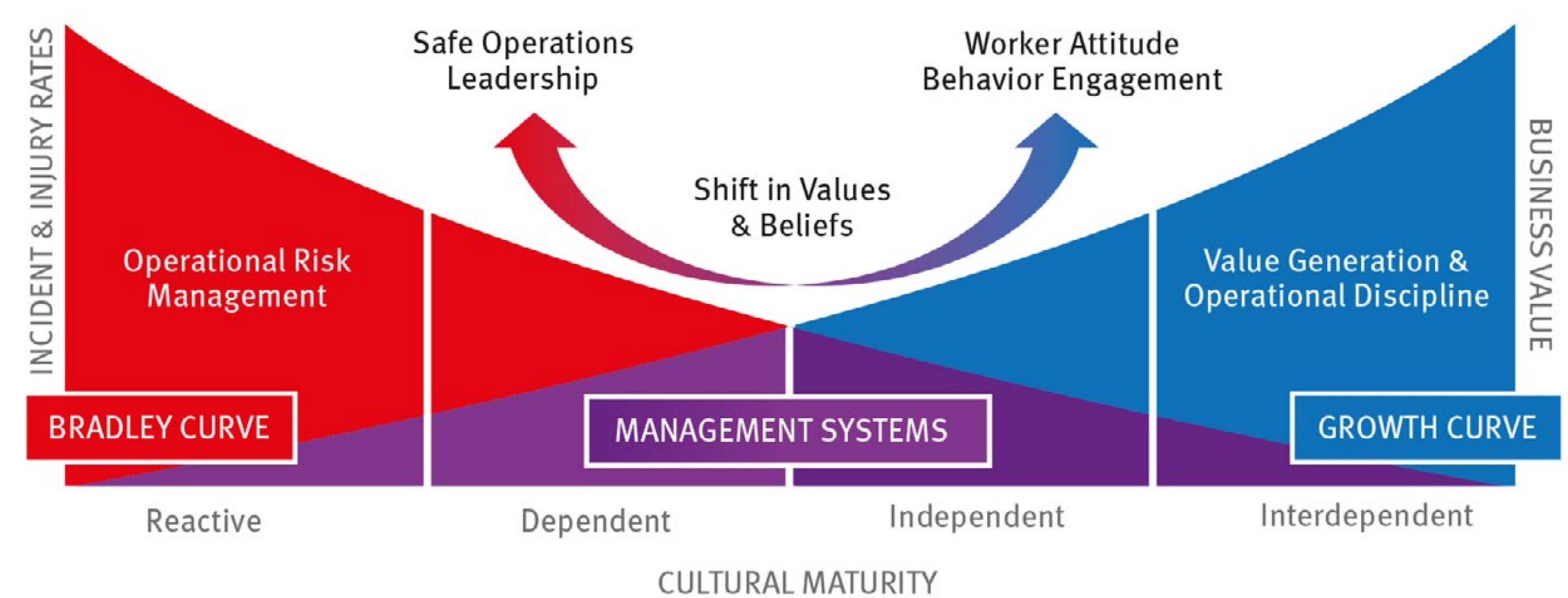


Figure 3: DuPont Bradley and growth curves

Once a rapid value assessment has provided insight into a company's performance, it is time to close the gaps using an integrated approach that moves the organization toward operational excellence. As shown in Figure 4, DuPont successfully implemented operational excellence at its own plants using a four-dimensional operational excellence model.

The three pillars of the model seek to improve technical skills through the creation of a maintenance reliability road map, with capabilities through a targeted, unified training program, as well as mind-sets and behaviors to achieve a cultural transformation. The management process linking the three pillars ensures successful delivery of the business value. These four dimensions are inseparable if a serious effort for attaining reliable operational excellence is to be made. Many examples exist of companies that focus on one or two pillars, but then fail to reach or sustain the desired operational performance level for long. An integrated approach and a clear leadership focus are required to achieve a real business transformation and sustainable operational excellence.

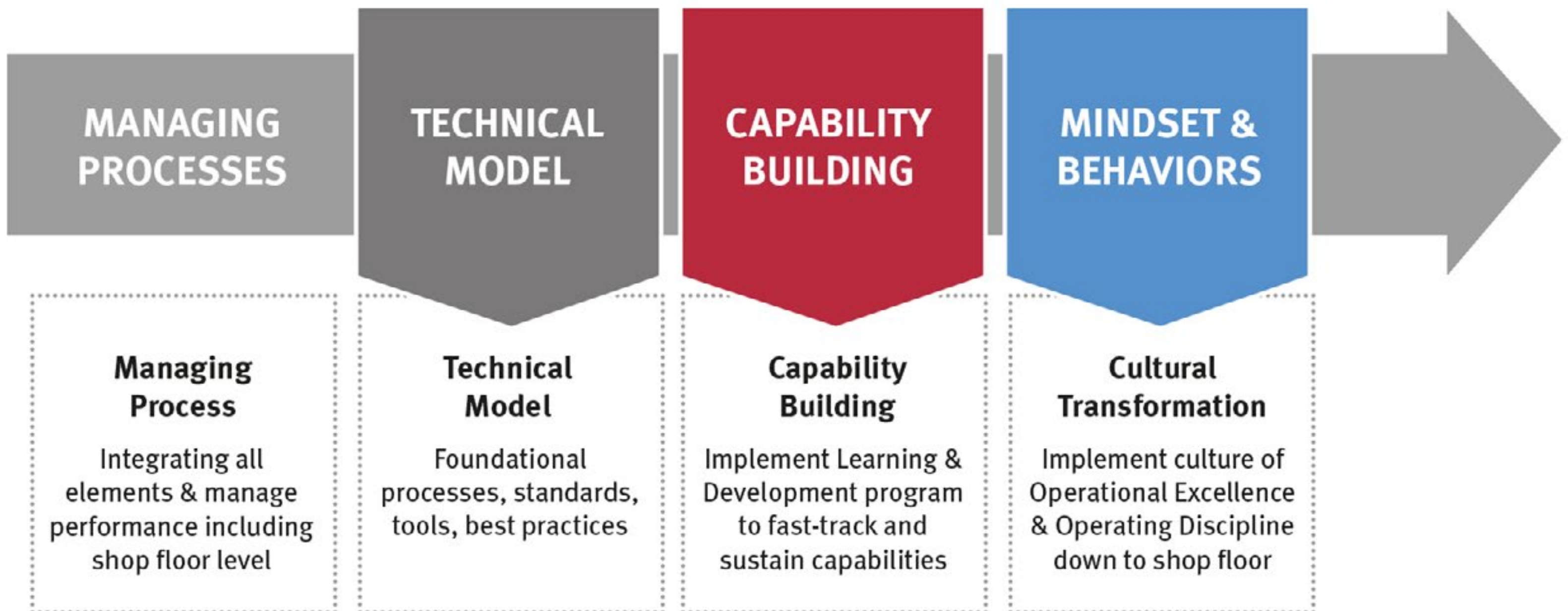


Figure 4: Four-dimensional operational excellence model

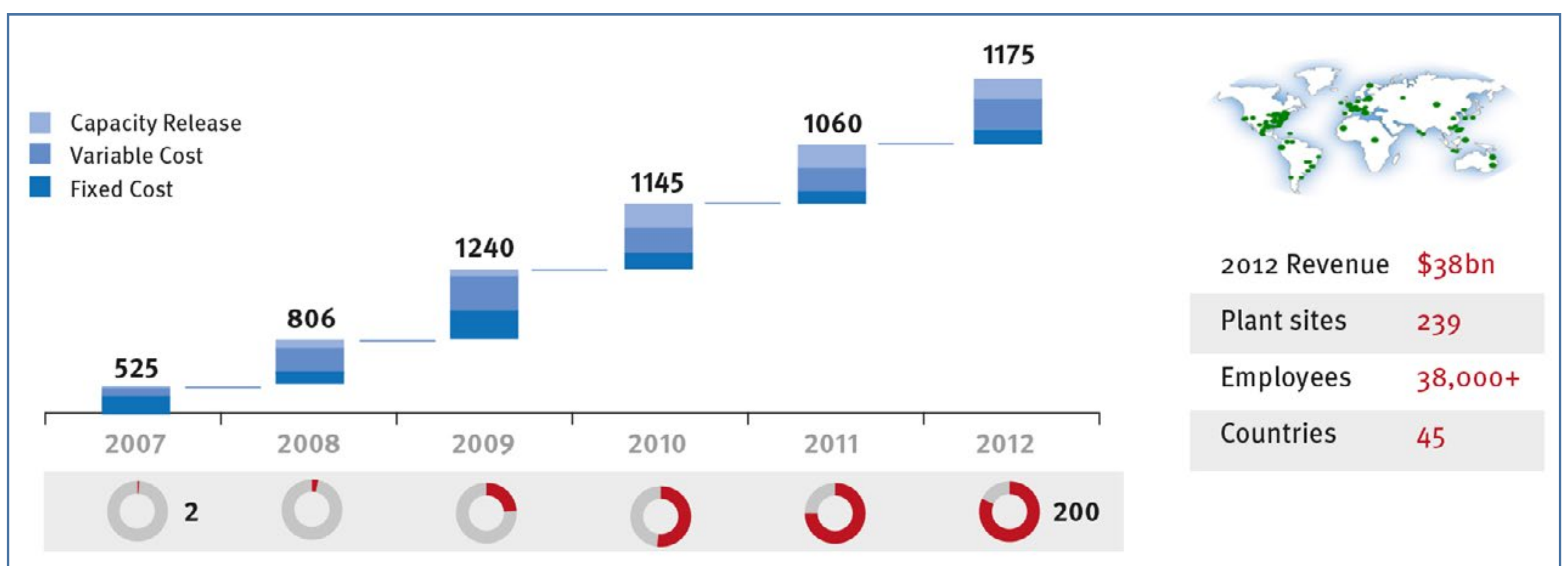


Figure 5: Results of DuPont's operational excellence program

> "Reliability is achievable. It just has to be tackled the right way."

Reliability Road Map

The key to achieving this long-term change, as well as maintenance reliability excellence, is the improvement road map. This should prioritize improvement actions required to achieve the desired level of excellence in a realistic time frame. Implementation of the road map requires commitment from senior management, strong project leadership and experienced transformation leaders. The right balance between the four dimensions of the operational excellence model is essential for keeping everyone in a company working at the same pace toward the same goal and changing the reliability culture from top management to plant floor.

Achieving Results

DuPont launched its own global operational excellence program in 2006. The transformation of over 200 sites was completed in just five years and has generated unsurpassed business results: $6 billion in value generation through capacity release and variable and fixed cost reduction, and $3 billion in working capital reduction.

These figures go to show that an integrated, cohesive approach to value generation can result in a steady performance even through times of economic uncertainty. Reliability is achievable. It just has to be tackled the right way.

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10 Components of a Successful VIBRATION PROGRAM

by Alan Friedman

Right Goals and Right Follow-Up and Review

Part 3 of this series focuses on setting goals and KPIs for condition monitoring.

Read Part 1: Right Goals   Read Part 2: Right People and Right Leadership

Figure 1: 10 components of a condition monitoring program

1. Right Goals	Having clearly defined and achievable goals that may evolve over time.
2. Right People	Having the right people in the right roles with the right training.
3. Right Leadership	Inspiring continuous improvement.
4. Right Tools	Having the right tools and technology to help reach the goal.
5. Right Understanding	Equipment audits, reliability and criticality audits, FMECA, maintenance strategies, etc.
6. Right Data Collection	Collecting the right data at the right time to detect anomalies, defects or impending failures.
7. Right Analysis	Turning data into defect or fault diagnoses.
8. Right Reporting	Turning data into actionable information and getting that information to those who need it at the right time and in the right format.
9. Right Follow-up and Review	Acting on reports, reviewing and verifying results, benchmarking, auditing and improving, etc.
10. Right Processes and Procedures	Tying together: people, technology, information, decision-making and review.

Maintenance personnel go to work and do their jobs taking measurements and writing reports, often with great care and skill. Their reports and recommendations then travel into a deep abyss from which they never return. Sound familiar? This situation is all too common in the condition monitoring (CM) world.

Machine condition reports are generated to help planners plan and schedulers schedule, but the planners and schedulers might never look at the reports or might not value them. A healthy machine might be replaced on a preventive maintenance (PM) schedule, even though there is nothing wrong with it. Another machine might fail catastrophically, even though there was plenty of evidence available to predict its impending failure.

A CM program needs to have clearly stated goals. A process of follow-up and review is required to verify the stated goals are being met. Thus, the *right* follow-up and review is directly linked to the *right* goals. Your goals should be aligned with the broader vision and mission of the company.

Many programs fail before they get started because the goals of the program are either not clearly defined or are not realistically achievable in the desired time frame. They may lack the necessary investment in funding, manpower, time, expertise, technology, etc. More often than not, a new tool or technology is purchased or a new initiative is begun with some vague hope that it will somehow solve one or all of your problems, even if it is not clear to anyone exactly what those problems are. Your goals may be as vague and lofty as the desire to reduce failures, reduce unplanned downtime, be more profitable, or reduce emergency repair work – all of which are valid goals if a bridge is created between these goals and the strategies, tactics and tools that will be used to reach them.

> Goals should be specific, measurable, achievable and time bound

As the expression goes, the way to eat an elephant is one bite at a time. This is an important concept to keep in mind when defining your goals. Goals should be specific, measurable, achievable and time bound. Since money inevitably will be invested in order to achieve the goal, it is helpful if the goal itself can be stated in financial terms so the return on investment can be easily calculated.

Start small with something you can easily achieve in a relatively short period of time. Start with something that has measurable results and a large return on investment. Start where you have areas of support, prove that your strategy is working and then expand. Break the task up into subtasks and understand that you will learn as you go. When setting up a vibration monitoring program, for example, start with simple machines that are easy to access and are always running. Complete all the stages of program setup for these machines before moving on to the next group. This allows you to make mistakes and learn and improve your process with minimal risk before you get into more complicated applications.

The right follow-up and review involves key performance indicators (KPIs). KPIs should be developed in accordance with the goals of the program. If a goal is to give planners a three-month lead time on a repair, then a KPI should exist to make sure this is happening. If a goal is to detect unbalance in fans at an early stage and balance the fans to extend the life of the bearings, then this needs to be measured (e.g., how many times has unbalance been detected, how many fans have been balanced, how has the mean time between failures (MTBF) increased in the fan bearings?).

The as-found condition report is an important aspect of the right follow-up and review. If the vibration analyst reports a motor bearing is defective and this prompts an overhaul of the motor, then the bearing needs to be cut open and inspected to verify that it was, in fact, bad. This does not have to be done for every single repair, but it should be done in a statistically meaningful way. Not only do you want to verify that the report is accurate, you also want to learn from the experience by determining if it was the best time to do the repair and if the bearing was not bad, then to understand how you misinterpreted the data. The as-found condition report is as much about learning as it is about assessing the efficacy of the program.

KPIs should not only address the technical accuracy of the diagnosis, but also the benefits to the plant in terms of increased uptime, less overtime work, higher planned to unplanned work ratio, fewer reworks, more lead time to purchase spares, fewer accidents, fewer injuries, fewer spills, etc. Again, the KPIs need to match the stated goals of the program. If you state that the program has a specific goal, then you need to measure if you are reaching that goal. If the goal of a vibration monitoring program is to reduce the number of non-compliance events per year, then a KPI needs to exist to see if you are achieving this goal. As with program goals, KPIs also should be measured in financial terms. Perhaps you were able to increase plant uptime by two percent since you started your CM program, but how does this translate in financial terms?

KPIs should exist to monitor the cost of the program. Costs come in the form of average time spent collecting data, number of points collected, training, analysis, reporting, cost of equipment, etc.

Lastly, KPIs should measure the outputs of the program or what is contained in the reports. How many faults were detected? What were their severity levels? What specific faults were detected? These KPIs help you understand where the problems are in the plant, especially when confirmed with as-found condition reports. If you diagnosed 50 motor bearing defects last year and 100 bearing defects this year, it implies that your motor bearings are becoming less reliable. Maybe it's because an ill-advised change was made to your lubrication procedures. If the numbers were reversed, it might indicate that new procedures are having a positive impact. In either case, you need to know what is going on, and if you don't measure it, you don't know.

A few cautions on selecting KPIs:

- Don't select too many KPIs.
- Don't measure it if the outcome of the measurement will not change your behavior.
- Don't use KPIs to make yourself look good. Use them to get to the truth.
- Make sure there is a cause and effect relationship between your action and the KPIs you are using to measure the results of your action.

> You always should be asking, **"How are we doing?"** and **"How can we improve?"**

Program audits and reviews should be an integral part of any program. You always should be asking, "How are we doing?" and "How can we improve?" But remember, this does not come naturally for most people. Most would rather say, "It's good enough, just leave me alone and let me do my job" or "Please don't look too closely at what I am doing!" This is why it is so important to integrate the follow-up and review process into the program itself so it does not feel like an accusatory intrusion into another's work. Responsibility and accountability should be expected. Continuous improvement should be business as usual. Sometimes, it is difficult to do an accurate self-assessment, which is why it is always a good idea to hire an objective outsider to come in and audit your program.

Right goals and right follow-up and review are only part of the puzzle. In order to have a successful program, you need to have all 10 components in place: Right goals, right people, right leadership, right tools, right understanding, right data collection, right analysis, right reporting, right follow-up and review, and right processes and procedures.

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USING PERFORMANCE AND DEVELOPMENT TO SUSTAIN PERFORMANCE IMPROVEMENTS

by Stephen Francis

The road to better manufacturing performance is littered with well-meaning improvement efforts that fall short. In some cases, initial progress fizzles out due to a lack of structure and incentives. In others, the workforce never embraces the desired change, viewing it as a top-down directive rather than an initiative they can truly own. Although executives often recognize emerging issues that impede improvement, developing and executing strategies that effectively address those issues have proved to be a recurring challenge.

Executives pursuing lasting improvements must take an inventory of their assets, then devise and implement a strategy that constantly reinforces the behavior of individuals along chosen dimensions. By addressing these areas in tandem with a performance and development (P&D) effort, companies can ensure that performance improvement efforts deliver value immediately and also stand the test of time.

> "The vital first step in linking better performance to financial targets is to perform a current state analysis"

Identify Assets and Needs

The vital first step in linking better performance to financial targets is to perform a current state analysis. Experience shows that this proven method for increasing operating income and cash flow typically delivers a 400 percent return on investment. A current state analysis also gives executives a baseline across different facilities, helping them set performance targets and measure improvements.

Even when the analysis doesn't turn up any surprises – often, executives know they have problems, but can't figure out how to fix them – it provides clarity and facilitates the development of a detailed road map to better performance. A thorough analysis evaluates the foundation of an operation, as well as gaps that need to be addressed, using two components: tactical analysis and P&D analysis.

Tactical analysis focuses on work tasks and tactics, such as processes and value-added and non-value-added movements. It examines any existing processes intended to promote efficiency and performance. The goal is to give executives an informed sense of their organization's capabilities by answering three questions:

1. Have performance targets been identified?
2. Do employees know what they're supposed to be doing?
3. Is performance measured?

P&D analysis evaluates management's people skills and organizational tactics. The former category refers to management's success in defining and reinforcing desired employee behaviors. The latter examines meeting structure and effectiveness, key performance indicators (KPIs), visual management and problem resolution and escalation systems to reinforce the desired behavior in employees.

Tactical and P&D analyses are complementary and provide executives with in-depth views of the operation from different angles. To gain a deeper understanding of where opportunities lie, both elements must be conducted concurrently.

Deploying an Integrated Tactical and P&D Plan

The findings from the current state analysis help companies develop and implement an integrated tactical and P&D plan. This resolves change management and operational issues, promotes optimal behavior and enables monitoring and evaluation of progress. Companies should follow a step-by-step process to incorporate and reinforce the importance of behavior in achieving better performance.

1. **Determine the organization's strategic goals.** Is the company pursuing transformation, seeking to improve margins in a commodity business, or looking to differentiate using the lowest total cost of ownership option? Well-run organizations would have already given much thought to these questions, but third-party experts can often ask probing questions to clarify objectives further.
2. **Devise an engineering intervention that provides a clear method for achieving strategic goals.** Typically, this intervention would be an industrial engineering process designed to improve throughput while containing or reducing cost. Value analysis/value engineering (VA/VE) or mechanical engineering also could be considered. As part of this step, the organization must identify local process owners.
3. **Identify critical sets of behaviors that owners must exhibit.** This step produces a roles and responsibilities document for all levels of management directly involved in executing the process. It's also important to avoid holding people accountable for outcomes they do not control, which can lead to stress, resentment and a passive resistance to change.
4. **Distill the roles and responsibilities to simple, observable behaviors and clearly communicate them to employees.** This framework defines for employees how they will be monitored and directly links incentives and consequences to performance, as reflected in day-to-day feedback and periodic performance reviews.
5. **Monitor employee performance on a regular basis.** By using a simple checklist, managers can monitor employees to see if the requested behavior was actually observed. Initially, employees are alerted when they are being reviewed. Essentially, the audit is an "open book test" to help employees get an "A," an approach that promotes the desired behaviors. After piloting the audit, the results should be checked against KPIs and adjusted accordingly.
6. **Promote the desired behaviors.** To instill a culture of continuous improvement, audits should occur at a reduced frequency and without prior notification. The results should be incorporated into HR evaluations, enabling fact-based appraisal and development and acting as a trigger for feedback and coaching.

> "The closer employees are to the process, the more frequent the measurement and feedback"

Once companies have completed these steps, they should take several actions to sustain their hard-won gains. Managers should schedule carefully structured meetings to encourage the exchange of ideas from all members by directing discussions toward root cause analysis and developing effective solutions to identified problems. An outperforming organization also will embed a sense of ownership in its culture. Once the best system is implemented, it must become embedded in the team culture as "the way we do things around here." This goal is achieved through careful, thorough reinforcement.

The closer employees are to the process, the more frequent the measurement and feedback, from quarterly to monthly all the way down to real-time data streams. The approach, which is very easy and requires no special training, is: simple, observable behaviors are logged and low scores result in constructive criticism, while high scores may prompt coaching to develop the employee as a mentor or leader. Similarly, audits will uncover areas in which the majority of the population would benefit from further training, which can be tightly targeted and thus highly cost-effective compared with more general management training offerings.

In addition, companies should embrace objective, scientific experimentation. The right systems are those that drive KPIs. As business needs evolve, the right system today may be a millstone tomorrow – business history abounds with such examples. A system for improving systems can provide a potential safeguard and emphasize certain enduring measures, such as labor efficiencies and inventory or work in process (WIP) inventory reduction.

Although executives may be tempted to rely solely on industry benchmarks to guide performance improvements, they would be wise to avoid doing so. After all, no two companies are the same and within a company, no two sites are the same. By pursuing a comprehensive change management effort that identifies assets and then focuses on the behavioral component, executives will be well positioned to achieve sustained performance gains.

Stephen Francis is a founding member of Argo, Inc.'s "Performance & Development" practice, where he co-created the "Argo Integrated Management System" (AIMS). He develops and implements tools that drive deep and rapid culture change for Argo's heavy industry clients. www.argoconsulting.com

The Impossible Is Possible: 30,000 Assets in 90 Days

A PMO Success Story

by Peter Schurmann

INTRODUCTION

In the 21st century, companies that focus on just design and operations will be left behind. Intelligent, efficient and optimized systems must keep evolving and need to be integrated into the ethos of how people work and think. This same thinking must be supported by management and designed to evolve based on proven intelligence, changing market demands and with the adoption of new equipment and technology. To achieve this, companies must initiate a proper asset performance management (APM) program to assess the operational performance and define a path to success.

To develop a sustainable APM program requires a level of understanding and expertise. This article explores a case study that uses elements of the strategy management domain from one MSAT provider's APM sustainability model to show the importance of preventive maintenance (PM) optimization in the development of a successful APM program. This company, Nexus Global, supports the Uptime Elements Framework to map the key areas of improvement within their five APM domains: leadership, work management, strategy management, investigation management and data management.

Figure 1: Five APM Sustainability Domains supporting the Uptime Elements Framework

BACKGROUND

In 2012, two investors funded the commissioning of two new 300MW steam turbines that use pulverized coal combustion technology in the Philippines. As part of the project, a key objective was to set up an improvement-driven work culture during the development and implementation phase of the asset management strategy. The new power plant design had close to 30,000 assets and an overall schedule that provided only 90 days to complete the project. Timely implementation of smart systems and investing in capable people were critical to setting the cultural direction for improvement.

CHALLENGE

From the very early stages of the project, the investors wanted to avoid what many maintenance organizations face all too often – an excessive level of reactive or breakdown maintenance. This is expensive in both maintenance cost and downtime consequences. Excessive reactive maintenance also contributes to a negative performance spiral that, at best, counters other valuable improvement initiatives and, in the worst case, leads to an almost completely reactive environment.

When breakdowns occur unexpectedly, resources are deployed to reactive work at the expense of preventive maintenance. PMs are missed due to scarce resources being consumed by breakdowns. As PMs are missed, more preventable failures occur, expanding the level of reactive maintenance. In many cases, the situation is compounded by band-aid maintenance and morale is adversely affected by long working hours under high pressure and continual "firefighting."

APPROACH

During the commissioning phase, work began on the asset management strategy development and continuous improvement systems. The window to complete the work was narrow and expectations were high.

Consultants and engineers worked with operators and maintainers on the basics of reliability-centered maintenance strategy development. Terms like hidden, evident, value adding, cost effective, potential to function failure (P-F curve) and return to service plan became second nature to all involved. The project manager had one rule: Complication creates confusion. Focus on fundamentals; give clear direction with simple instructions.

SOLUTION

The project manager's leadership was essential in the creation of the project charter and the formation of several natural working teams. Additionally, a work process was developed that contained eight simple steps (see right).

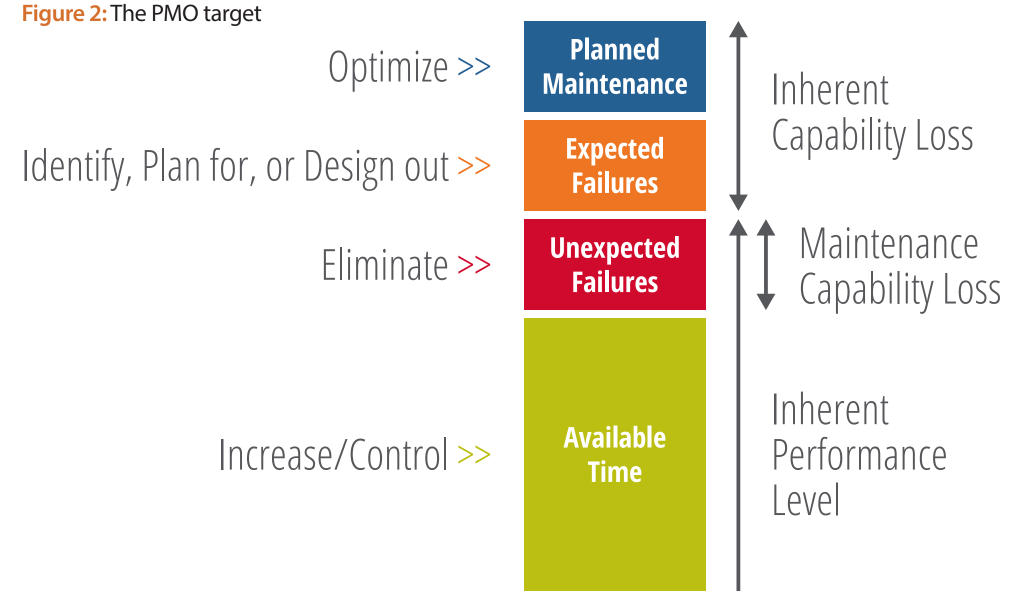
Step five is key because grouping data by failure mode easily identifies task duplication. Task duplication is where the same failure mode is managed by PM conducted by more than one section or task. It is most commonly found between operators and trades and trades and condition monitoring specialists. In this step, the team reviews the failure modes generated through the failure mode analysis and adds missing failures to the list. The list of missing failures is generated through an analysis of failure history, if available, technical documentation, or the experience of the team.

During each step, recommendations for strategy improvement were made. While all this was happening, tools and systems were being developed and implemented in parallel to collect data to validate the effectiveness of the PM strategy. Continuous improvement as a key change management process had begun.

All events, including breakdowns, PMs and planned outages that occurred during commissioning and thereafter, helped tune the strategy. Each occurrence was assessed as: Expected – no value adding/cost effective action could be done to minimize or eliminate the event; or Unexpected – event consequence was preventable or could be mitigated with good installation, maintenance, or operations practices. Unexpected events were not acceptable.

After an unexpected event, typically equipment failures, the strategy for that component is reviewed and all relevant equipment variants are updated. This simple action forms the basis for a continuous improvement culture. Every failure is assessed by maintainers and operators during commissioning and continues on today.

Figure 2: The PMO target



1. Train and educate engineers, maintainers, and operators in the PM Optimization processes
2. Apply the methodology; construct a component library of tasks for each equipment variant via workshops
3. Validate the component variant library with physical assets; tune the library with each iteration
4. Clone component variant tasks onto the asset structure
5. Group tasks into practical and achievable PM schedules
6. Final equipment walkover
7. Load PM schedules into Computerized Maintenance Management System (CMMS)
8. Implement the living program

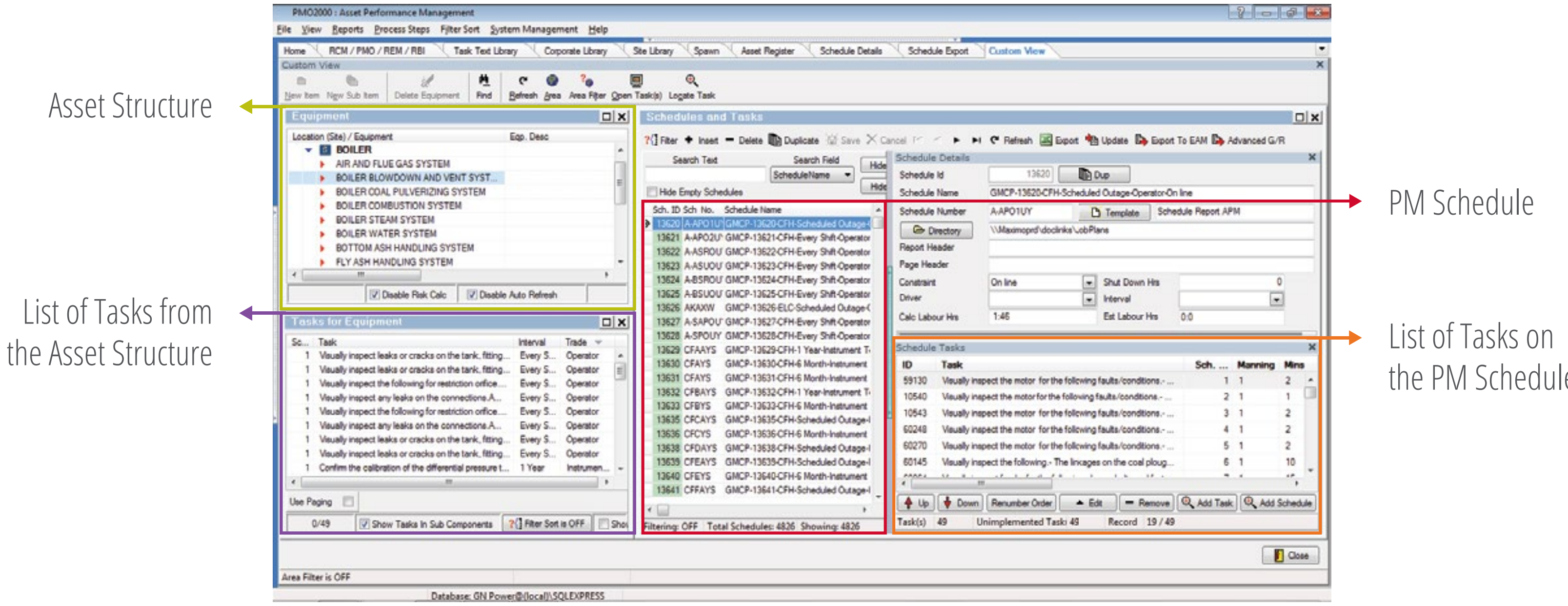


Figure 3: Creating PM schedules *(image provided by Nexus Global PMO2000®)*

RESULTS

The goal of implementing a computerized maintenance management system (CMMS) based asset management plan for 30,000 assets was achieved in 90 days. This included almost 5,000 PMs, plus 60,000 tasks and failure modes. Best of all, the business is currently focused on achieving best in class performance supported by a robust continuous improvement program.

Yes, the project had typical challenges, like missing or inaccurate asset information, personnel language barriers (e.g., English, Chinese, Tagalog) and delays due to other priorities, that affected staff availability and weather. However, these challenges were no match to the vision and objectives of the management team that extended its support to quickly overcome each individual hurdle.

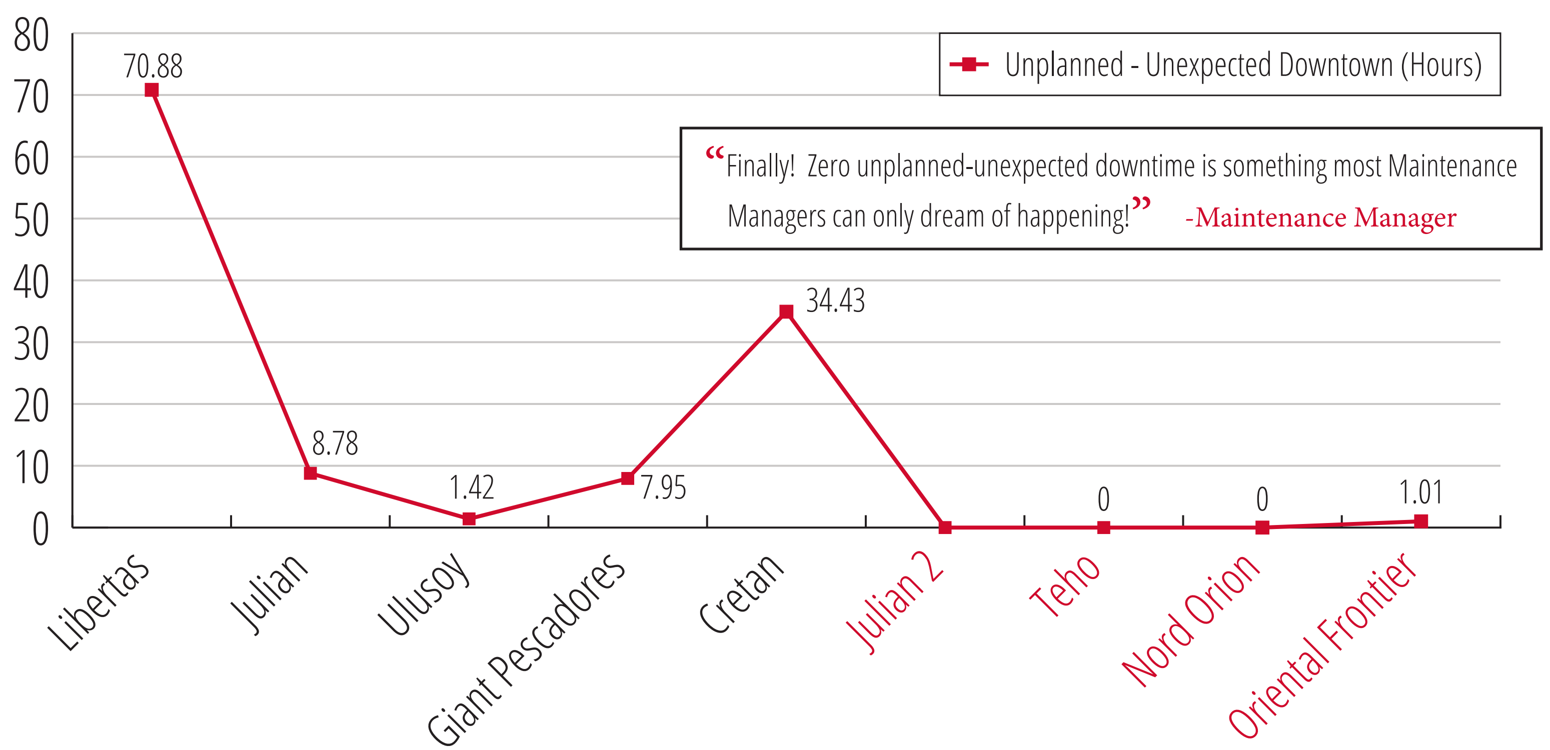


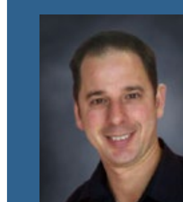
Figure 4: The end results in short time

> "Improvement is about working smarter, not harder."

CONCLUSION

There are always going to be a number of factors contributing to the difficulties faced by asset managers in the current business environment. Many maintenance organizations are caught in a vicious cycle of reactive maintenance that leaves them exposed to unknown risks of safety, environmental, or loss profit opportunities, like low plant performance, high maintenance costs and a workforce with low morale and motivation. To break this vicious cycle of reactive maintenance, experience has shown an effective approach is to focus on both equipment and labor productivity, while meeting the risk tolerance of the organization.

The manager of the business once said: "Improvement is about working smarter, not harder. I'll take a smart and lazy employee that gets the job done over a person who blindly follows instructions." Simple and effective systems to support and make work easier are like a smart, lazy employee. In this project, information management using a database with integrated continuous improvement systems was one of the smart, lazy employees on the team!



***Peter Schurmann** is Director of Australia for Nexus Global. For the past 15 years, he has shared his passion for assisting maintenance reliability engineers and practitioners to improve and transform maintenance programs. Peter has been directly involved in the development of the PMO2000® software, which is an essential element of the APM sustainability program offered by Nexus Global. www.nexusglobal.com*

Does Your Company Need a Maintenance Culture INTERVENTION?

by Jim Fitch

Let's face it, most companies need a culture intervention – something like a 12-step program. This article will explore behavioral issues that are often at the core of a culture of neglect and mediocracy. It borrows much from management science, leadership principles and conversations with individuals working in the field of maintenance reliability.

Traits of a Bad Maintenance Culture

It doesn't take long to recognize the signs of a bad maintenance culture, although the profile of this culture can vary considerably. The culture profile might be characterized by indifference, blame, tension between operations and maintenance, frustration or anger, distrust, pessimism, high staff turnover, waste of time and resources, excessive human errors, an aging work order backlog, frequent unscheduled maintenance events, crisis and unprofitability.

Breakdown maintenance and a bad maintenance culture also go hand in hand. Constantly reacting to machine failure demotivates maintenance staff. In such cases, the plant's machines control the work schedule, not the other way around.

As the phrase goes, "People quit their boss, not their job." Employees quit because they aren't properly managed or leadership hasn't created an appropriate organizational culture. Regardless, good culture is the remedy for it.

Machine reliability is a behavioral science, cascading down from management to the plant floor. Years of root cause analysis (RCA) confirms that bearings don't just die, they're murdered. They are murdered by people who don't know how or don't care to prevent these failures. Again, good culture changes behavior and enables reliability.

Turn to the Past to Change the Future

Of course, the best predictor of future behavior is past behavior. Past behavior establishes reputation, which many people use to judge others. You can judge culture in a similar way to help predict future maintenance reliability performance. Behavior, values and decisions are all components of employee engagement, which sharply impacts individual and business performance.

> "So how do you create an environment that fosters good culture?"

A positive, nurturing maintenance culture is a critical plant asset. For example, when people do good work, they feel good about themselves and their jobs. When people do bad work, they feel bad about themselves and their jobs. Feeling bad is a serious morale problem that multiplies and spreads. The simple solution is to enable people to do good work that is recognized and celebrated.

Culture drives behavior. Behavior influences quality of work. Quality work is fundamental to plant reliability and the cost of reliability. But why should you care? Because reliability fosters job security and builds shareholder value. Bad culture is dysfunctional and sparks a chain of despair for all stakeholders. No amount of expertise in machine reliability will overcome the destructive aftermath caused by a rotten maintenance culture. It has inertia that over time becomes increasingly difficult to change.

Good culture has inertia, too. It fuels a chain of reinforcing successes. Small successes beget larger and more sustainable successes. Creating a good culture starts and ends at the top, at the leadership level. When good leaders are in charge, everyone wins. When bad leaders are in charge, the culture becomes negative, hostile, stagnant, and everyone loses. Good culture also emerges from management's aspiration for improvement and the inherent desire to do good work. It relates to skills, tools, work plans and machine readiness.

8 PILLARS OF A GOOD MAINTENANCE CULTURE

Management and leadership both define and catalyze the culture of an organization, whether good or bad. Even bad culture that is rooted in high institutional inertia can be changed. This change may be more difficult and even somewhat disruptive, but it is far from impossible. Still, nothing happens without an unwavering management commitment to create a sustainable foundation for change.

Do you think culture is something that keeps your plant manager awake at night? Maybe this individual doesn't know how it's impacting the company's bottom line. Managers who understand and see plant reliability as a means to plant profitability have the desire to inspire and support culture initiatives that build charged up and prosperous maintenance teams. Stopping the management revolving door is also important.

The role of management on group behavior and culture has been the subject of countless books and publications. It relates to team building, engaged team members, empowerment, communications, goal setting, defining the mission, vision and values and so much more. It goes without saying that you can't cheerlead your way into sustained cultural transformation. Nor can you manage by memo.

Another way to find wisdom is to study the success of others. What are the common threads of a successful maintenance culture? There are several and most aren't specific to maintenance, but rather foundational to any operating organization. Because of this, you can leverage the experiences of numerous teams that have successfully tackled the culture transformation challenge. To get started, it's important to familiarize yourself with the eight pillars of a good maintenance culture.

1. The Right People

While employees are a company's most valuable asset, it is only true when the right people are in the right jobs. Incompetent or poorly matched people working in maintenance positions can present sizable operational and cultural risks, as opposed to being productive assets. Select, nurture and inspire the right people to build a prosperous maintenance culture.

2. Job Skills and Know-How

As previously mentioned, when people do good work, they feel good about themselves and their jobs. People want to do the right things right the first time and every time. However, many people suffer from unconscious incompetency. In other words, they are unaware or in denial of the level of their incompetency. Others are fully aware that their skills are desperately lacking.

A prosperous plant culture is a learning culture. Education, when effective, takes people out of their comfort zone. It not only builds intellectual capital, but over time, fosters a behavioral desire to do the right things right every time. It also builds team loyalty and dedication to achieving business goals. People learn differently, so don't assume knowledge is only acquired in a classroom. Certification instills pride and should be the capstone of each learning stage by providing visible recognition of skill competency.

Next, create a work environment of standardized work, also known as procedure-based maintenance. This takes the guesswork out of thousands of maintenance tasks that must be routinely and periodically performed. These shouldn't be just any old procedures or those found in machine service manuals. Instead, they should be refreshed with modern concepts in maintenance. Seek the help you need to get these procedures right.

3. The Tools

A lot of new technology has entered the world of machine maintenance in recent years. As the old-timers are retiring, so must many of their tools. Today's maintenance toolbox should be used beyond repair and corrective measures. It should also contain tools and devices that inspect and control conditions that might lead to failure or are incipient symptoms of failure. These include inspection tools, condition monitoring instruments, contamination control devices, etc.

An extremely good starting point is education and creating a culture of strategic training instead of reactive or just-in-time learning. Training programs that present modern and technology-based concepts in maintenance will also detail the tools that enable them. Education and tools bring about pride in one's work and profession. This is a precursor to a good maintenance culture, so don't skimp on them.

4. Machine Readiness

In addition to a change in your skills and toolbox, you need to change your machinery. You must ready your equipment for wellness and maintainability. Even today's new machines won't be equipped with the ancillary hardware to enable quality maintenance. Many machine modifications are often required. These include hardware and accessories related to inspection, safety, sampling, oil analysis, contamination control, oil handling, instrumentation and lubricant applications. Effective training programs will describe what changes are needed and why.

8 PILLARS OF A GOOD MAINTENANCE CULTURE [CONTINUED]

5. Planning, Scheduling and General Organization

In maintenance, there is a need for good workweek control. The "whack-a-mole" approach to maintenance workday scheduling is destructive and costly. Activities need rhythm with few surprises. While this requires proper planning and scheduling, it also demands a built-in early warning system. You can't plan and schedule corrective action if you can't proactively see the need. And an organization plagued by chronic, unscheduled maintenance is an organization that is suffering from a bad maintenance culture.

Condition monitoring includes both proactive maintenance and predictive maintenance. Proactive maintenance sees and responds to root causes of failure long before a repair is needed. A good maintenance culture is a proactive maintenance culture. Make breakdown events a rare exception.

Predictive maintenance is a companion to proactive maintenance. It sees and responds to failure symptoms, the earlier the better. Just as it is best to catch a disease early, so too is it important to catch faults and impending machine failure early. Thankfully, technology is available to allow machine condition monitoring at a very high level. When well executed, reactive maintenance is transformed to planned maintenance. This will help get work orders into compliance and reduce or eliminate the backlog of aging work orders.

6. Measurement

When you measure, you are communicating what is important. Likewise, those things that are not measured are assumed to be unimportant. Beware of what you don't measure. People subconsciously work the metric. They know how they are being evaluated and respond accordingly through their work behavior. Constant performance measurement, reporting and course corrections are signs of a good maintenance culture.

Measurement should come in many forms and at many different levels, including lagging indicators, leading indicators, macro indicators and micro indicators. Macro indicators are more holistic, providing a big picture view of plant reliability. General asset utilization numbers, such as overall equipment effectiveness (OEE), are good examples of macro metrics.

Micro indicators look at failure causes and symptoms. Overall machine vibration and lubricant cleanliness levels would be examples of micro metrics. Many of these performance indicators report what just happened (lagging indicators), while others report what is going to happen (leading indicators).

7. Motivation and Desire

Maintenance workers are more than just arms and legs performing mindless tasks. They are productive, knowledgeable workers who not only carry out the job plan, but also create, innovate and improve the quality and efficiency of the work performed. Empowerment amplifies a company's intellectual capital by stimulating the minds of its employees. When employees can act on their thoughts and opinions, they instill pride in their work and are the most productive. This is the definition of engagement.

Recognition and reward are also important to culture. Many companies fail to properly recognize and reward employees who have excelled at creating value. For example, it is way too common to see lube techs at the low end of the pay scale. Some companies enter the cycle of despair by hiring low skilled workers and paying them accordingly. Too often, companies use demeaning job titles, such as calling a lubrication technician an "oiler." An oil can is an oiler; it is an object that performs a mechanical and repetitive task. A lube tech is a thinking human being who has mastered the skills needed to perform the job and whose impact on a machine, team and organization is conveyed as important.

There are also many nonmonetary types of rewards. Companies that fail to celebrate when they don't have broken machines to fix lose out on this culture strengthening opportunity.

8. Investment

Organizations that are lean to the extreme harm their maintenance culture. Many who work in the maintenance field have the mind-set that there is always enough time and money to fix a problem, but never enough time or money to prevent it. At the core of the problem is procuring cheap material and cheap people instead of buying the proper tools, accessories, software and instruments. Too often, companies, especially publicly traded ones, are driven by the desire to see how much money they can earn between now and next Tuesday. Investment, however, is a long-term strategy that cultivates a productive culture.

CONCLUSION

Maintenance culture transformation is no easy task. Take ownership of the program by beginning the process of dismantling your bad maintenance culture and replacing it with the eight pillars of a good maintenance culture. Create a shared vision of what you are trying to achieve. What will it look like? How will the company benefit? How will team members benefit? Until you fix the culture issue, you cannot rise to the lofty state of excellence in maintenance reliability.

Jim Fitch *is the CEO and a co-founder of Noria Corporation. He has a wealth of experience in lubrication, oil analysis, tribology and machinery failure investigations. Since 2002, Jim has been director and board member of the International Council for Machinery Lubrication and currently serves as a U.S. delegate to the ISO tribology and oil analysis working group. www.noria.com*

Oil Analysis "House Calls"

Help Reduce Offshore Equipment Failures

by Chad Dyson

It's hard to think of another environment where an equipment failure could have an immense negative impact on employee safety and lost production than an offshore oil and gas production platform. Yet, offshore platforms are among the world's most difficult locations to operate and maintain equipment. In most cases, skilled people and supplies can only reach the platform by ship or helicopter, so the cost of bringing technical specialists, replacement equipment, spare parts and tools to the platform is very high. On nearly every offshore platform, oil analysis plays a critical role in alerting the maintenance team to problems that have the potential to damage a vital system and providing information that makes it possible to efficiently allocate scarce resources by planning maintenance based on actual need as opposed to simple intervals of time.

Nearly all offshore platforms take oil samples on the platform and ship them by helicopter to onshore labs where they are analyzed. The results are processed and sent back to the platform. The problem with this approach is that it might take a week for the sample to reach the lab, another week for the lab to perform the analysis, another week to process the results and get them back to the platform and, perhaps, one more week before technicians have the time to look at the results and take action. By the time the results are acted upon, it's possible that equipment may fail, in the worst case putting personnel at risk and causing production outages and, in the best case, requiring a replacement or spare parts to be flown or shipped to the rig at a very high cost.

A new approach to address this problem involves flying in a technician with a portable oil analysis solution to the rig. The technician samples all the equipment on the rig and provides instantaneous feedback on equipment that requires immediate action to avoid failure, equipment that requires maintenance, but not urgently, and equipment for which maintenance can safely be postponed to conserve scarce on-platform resources.

Value of Oil Analysis on Offshore Platforms

It costs more than $1 billion to operate a typical production platform over its 10- to 20-year lifecycle, so operating costs per day can be estimated at $100,000 to $300,000. A typical offshore platform contains millions of dollars of machinery that, at any moment, could become critical to the crew's safety and whose failure can easily put the platform out of operation until it is repaired or replaced. Oil analysis has long been the gold standard in the offshore industry for monitoring the condition of critical equipment. Oil analysis determines the amount of various metals in the oil, providing a fast and inexpensive way to gauge the amount of wear in the machinery. Oil analysis also helps determine the condition of the oil, such as by measuring solids formed by oil oxidation and the viscosity of the oil. Tracking the condition of the oil helps reduce the risk of catastrophic failure and the high cost of changing and disposing of oil in heavy machinery.

But, as with other activities, oil analysis is much more difficult to perform offshore than onshore. The crew operating the platform typically does not have the time or equipment needed to perform oil analysis themselves. They typically collect samples from the various rotating equipment on the platform, such as flooded screw compressors, turbo gas-powered generators, fire water pumps, diesel engines, gearboxes, pumps, crane engines, hydraulic systems, etc. They label the samples, put them on the helicopter for shipment to the onshore lab and wait for the results. One problem with this approach is that mechanics are very busy and work long hours on the platform, so there is always the potential for mislabeling a sample, which leaves the results subject to question. Another concern is when a positive result is received. Usually, action must be taken immediately, even when there is some doubt about the validity of the results, because it would take too long to analyze another sample from the same piece of equipment.

Figure 1: Oil analysis technician inserts sample into portable instrument

Figure 2: A four module portable analyzer *(image provided by Spectro Q5800)*

Moving From Onshore to Offshore Oil Analysis

One major oil producer using the onshore oil analysis approach sent an oil sample to a lab and approximately one month later received results that indicated a problem with an air compressor. Unfortunately, the compressor failed the day before the results were received and the company incurred a very high cost to replace the machine. The oil producer researched companies whose technicians could travel to its platforms with a portable oil analyzer and provide immediate oil analysis results. An industrial equipment distributor researched the available portable oil analysis instruments and selected a portable analyzer that is comprised of four modules:

- Infrared spectrometer with flip-top cell design tests for total acid number/total base number, water content, soot, oxidation and new fluid validation;
- Kinematic viscometer that determines viscosity without solvent and with a low sample volume;
- Filtration particle quantifier (FPQ) for providing solvent-free particle counting to less than 4 µm/ml;
- Element analysis module to perform wear metal and sand/dirt analysis to identify abnormal wear and contamination ingress using X-ray fluorescence (XRF) technology.

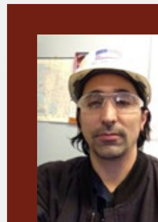
The oil producer then requested on-site oil analysis at its offshore platforms in the Gulf of Mexico. A technician flies by helicopter to the offshore oil platforms with a portable instrument that performs the same tests offered by full-service laboratories. The portable instrument provides the same accuracy as full-size laboratory instruments, yet it fits into a backpack so it can be easily carried on a small helicopter. The portable instrument provides immediate oil analysis results, so if there is an abnormal result, the platform personnel can take action immediately to resolve the problem. Another key advantage of the portable instrument is that the technician can immediately recheck every positive result for validation purposes to provide certainty that the initial test results were accurate. The ability to retest prevents false positives and has the potential to offer substantial savings by avoiding the need for repairs or replacements that are not actually needed.

Examples Where Offshore Oil Analysis Saved Time and Money

1. In the past year, there has been several cases where the savings from on-site oil analysis exceeded the full year's cost of the service. For example, technicians on one platform replaced the diesel engine on a crane. When the oil analysis technician visited the platform and tested the oil, the viscosity was 70 when it should have been 120. The technician ran additional tests that discovered the presence of diesel fuel in the oil. A mechanic put dye in the fuel supply and discovered a broken injector line was leaking diesel fuel into the oil sump. This leak had the potential to damage the engine or even cause a fire, which could have been catastrophic. The oil analysis results made it possible to fix the problem with only the small cost of replacing the injector line.
2. In another case, the oil analysis results on a large gas turbine compressor showed a high metal particle count. The technician queried the platform's maintenance team and discovered they had recently replaced a valve in the lube oil system. Wondering whether the oil particle count might have spiked in response to this maintenance, the technician flushed the lube system and ran another test. This time, the test showed a much lower particle count, although still above normal values. After discussing the situation with the maintenance foreperson, the decision was made to do nothing immediately, but to retest the equipment the following month. When the equipment was retested, the particle count had returned to normal levels. According to the maintenance foreperson, if the oil had been tested by an onshore lab, there would have been no chance to do an immediate follow-up study, so it would have been necessary, at the minimum, to perform vibration testing and possibly perform even more expensive repairs.

The results of offshore oil analysis are uploaded to a cloud-based information management system, which is optimized for laboratories that specialize in the analysis of in-service lubricants for machine condition monitoring. The results are available not only to the maintenance team on the platform, but also to onshore managers and analysts who can track trends that may be useful in making decisions, such as whether or not to invest in a certain piece of equipment.

The current oil analysis method used on most offshore platforms takes up to a month to send samples to a lab and get the results. On-site oil analysis has the potential to provide major improvements by flying a technician to the offshore rig, testing oil samples on the rig and providing immediate answers to the maintenance team. In some cases, faster results prevent breakdowns and in others, they avoid doing unnecessary maintenance. In both cases, of course, the savings are magnified by the extra costs of getting things done on an offshore rig.



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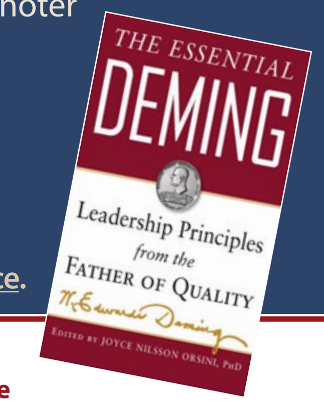
Q&A with Industry Leader

Joyce Orsini

Uptime magazine caught up with Joyce Orsini, Fordham University Professor and Deming expert. She is the author of *The Essential Deming: Leadership Principles from the Father of Quality, W. Edward Deming*. Professor Orsini is the Keynoter at The RELIABILITY Conference, April 14th in Las Vegas, Nevada.



Get a signed copy of Dr. Orsini's book at The RELIABILITY Conference.

Joyce Orsini, an associate professor of management systems, came to Fordham University Gabelli School of Business in 1986 with significant experience in the financial services industry, where she has held the titles of chief executive officer, chief operating officer, chief financial officer, chief human resources officer, comptroller, vice president of research and chief statistician. She has done consulting work on quality in manufacturing, service and government. Professor Orsini holds both a Ph.D. and M.S. degree in quantitative analysis from New York University and a B.S. degree in statistics from the City University of New York.

Professor Orsini authored the book, *The Essential Deming*, where she draws on a wealth of previously unavailable material to present the legendary thinker's most important management principles in one indispensable volume. The book is filled with articles, papers, lectures and notes touching on a wide range of topics, but which focus on W. Edwards Deming's overriding message: Quality and operations are all about systems, not individual performance; the system has to be designed so the worker can perform well.

Q: What are your thoughts on why Deming's philosophies were not accepted in America as quickly as they were in Japan? Do you think the 1980 NBC documentary, *If Japan Can... Why Can't We?* had an impact? (The documentary can be viewed at https://www.youtube.com/watch?v=vcG_Pmt_Ny4.)

The Japanese were in a rebuilding mode after the war, especially in the 1950s and 1960s. It was a good time for Deming's philosophies to take hold over there. However, after World War II, U.S. manufacturing was booming. Most American companies had pent-up demand for products. They didn't feel the need or pressure to change. But things changed and by 1980, American manufacturers saw many products or components made in other parts of the world.

By 1980, the Swiss, Germans and Japanese made products better and cheaper, which gave American manufacturers a wake-up call. Some changed and some didn't. America could be doing better in productivity today since productivity has not changed much since 1980. We have more knowledge today than we did back then and should be capitalizing on that.

In many cases human factors, such as personal interests, override the overall good of the company. The inability to apply Deming's thinking can actually be traced to some small part that a person disagreed with. Instead of using the part this person agreed with, the whole thing was rejected.

After the 1980 NBC documentary, Deming's phone rang off the hook. Executives wanted their companies to get better. Even many consultants tried to mirror Deming's approach. But the consultants did this only in isolation, trying to use just fragments of Deming's philosophy, implementing it in pieces only. Other consultants lacked the holistic picture, which prevented companies from getting the full benefits. It took 15 to 20 years for some to get the full picture.

Q: Why did it take so long for them to see the full picture and what changed so they could finally see the whole picture?

They may have gone off on a specific, particular point, such as market research or statistics. But around the year 2000, many companies started to get the full picture. Just before his death, Deming clarified many things. His book, *Out of the Crisis*, had the 14 points. However, many companies used them as point solutions and would pick and choose only one or two and then focus their efforts in only one area. This led Deming to broaden the thinking into fields of knowledge. The four fields of knowledge are:

1. The psychology of people;
2. Statistical variation;
3. The organization as a system, where coordination is important;
4. Theory of knowledge.

His contribution was the recognition of these four fields and how they applied holistically or as an integrated solution. Deming's message was that the focus should have been on a system of knowledge and not the pieces.

Q: What about in organizations today with rapid turnover?

Developing the proper culture and buy-in would be important. The new employees would have to be trained so as to be indoctrinated. Once people become comfortable in a system, they will resist change to another system. The training will make them comfortable in the new system.

Q: Can maintenance reliability professionals benefit from Dr. Deming's philosophies?

Reliability people understand systems thinking. This makes them get it quicker, so they can then adopt it more rapidly. The theory of knowledge contains the statement: "There is no such thing as true value." Leadership is more than just maintenance and monitoring. It is actively leading an organization.

Q: How is maintenance reliability viewed today?

Some in the organization may not understand how to get reliability. Many things have to come together for equipment to be reliable. The reliability organization will need fields of knowledge and clear understanding. Other internal departments need to understand this, too, so there is an appreciation for what the reliability professions do. No one part of the organization can be isolated. Take, for example, cross functional teams. When a cross functional team is put together, different groups realize how much the other groups actually know. For example, high-level managers soon realize how much low-level people know and understand. Different parts of the organization begin to appreciate the other parts of the organization. For example, engineering appreciates operations, or operations appreciates maintenance. Cross functional teams can help with this education and realization.

Q: What is meant in your book where it says, "Quality is made in the boardroom?"

Executives make decisions that impact quality. When they put together an organization where they "reward" employees versus "employee" competition, it weakens the organization. So much of what is wrong starts here – with the reward and recognition system. Employees will basically carry out what they are told.

Q: What is the main point from the chapter, "A System Must Be Managed?"

Some organizations only focus on their job, not knowing how they fit in with the big picture or the big system. People drift to their activity and do not see the whole system. Sometimes, people work counter to one another and don't know it.

Q: There's also a chapter that starts with, "there is no substitution for knowledge." What is the thinking behind that statement?

This was a Deming quote and actually one of his teachers used it. People will keep on doing what they have always done if they don't get additional knowledge. They can provide better service, but they need knowledge to be able to do a better job. They really need to know how.

For example, consider process variation. Equipment doesn't always produce quality products due to wear or improper setup. Operators introduce variation by making their own "personal" adjustments to compensate. They're actually trying to do a better job, but they are introducing product variation. Without this knowledge, they do their best and expect the equipment to do better, but ultimately this leads to failure.

Q: There is also a chapter on management is prediction. What is this chapter about?

It is about managing the future of the organization. It makes them answer the question: "What will your processes be required to do?" They will have to look into the future and know the number of workers that will be required, etc. You can't manage just for today.

Q: What is one piece of concluding advice you could provide our readers?

Some companies wait too long to make progress. They want to understand everything before they do anything. It is better to start by making improvements where you are comfortable. You will learn and understand more and more as you grow. Then, you can make improvements in the other areas.

Thank you, Dr. Orsini. We look forward to your keynote address on April 14, 2016, during The RELIABILITY Conference in Las Vegas.

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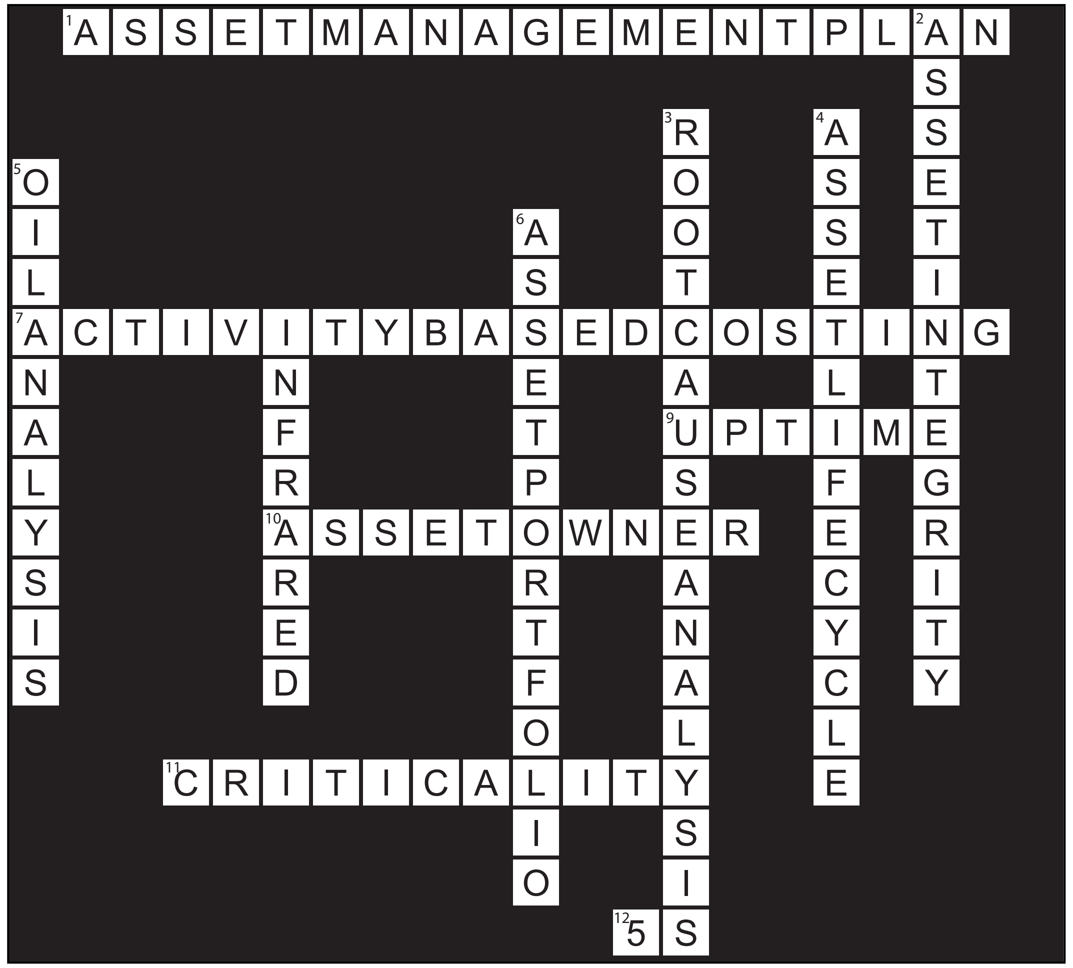
Crossword Puzzle

ANSWERS

Created by Ramesh Gulati



ACROSS

1 Documented information that specifies the activities, resources and timescales required for assets to achieve management objectives

7 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

9 The inverse of downtime

10 A person or group of people who have the total responsibility for the operation and maintenance of asset(s), including capital improvements

11 A ranking of assets according to potential operational impact

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

DOWN

2 The fitness of an asset to perform its intended function effectively and efficiently without being degraded while protecting health, safety and the environment

3 A methodology that leads to the discovery of the basic cause of a problem

4 Stages or phases involved in the management of an asset during its life

5 A predictive technology used to determine the quality of the lubricant oil and/or condition of equipment being lubricated

6 Assets within the scope of the asset management system

8 A predictive technology that detects thermal energy emitted from an object and displays an image of temperature distribution

Answers from page 7.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